



THE

# GENERAL SCIENCE

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# PHYSICS

## Chapter 1

# MEASUREMENTS & MOTION

## MEASUREMENTS

The process of comparing an unknown physical quantity with respect to a known quantity is known as measurement. When we say that the length of our bedroom is 10 feet it implies that the bedroom is 10 times the known quantity ‘foot’ (feet is the plural of foot). So, measurement of any physical quantity consists of two parts – (i) a numerical value and (ii) the known quantity. The known quantity is called the unit of that physical quantity. Measurement is an integral part of physics. Physics is the foundation on which engineering, technology and other sciences are based.

S. No.	Fundamental Physical quantity	Fundamental Unit	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Electric current	ampere	A
5.	Temperature	kelvin	K
6.	Luminous intensity	candela	cd
7.	Amount of substance	mole	mol

**Derived units:** Any unit which can be obtained by the combination of one or more fundamental units are called derived unit.

Examples: *Area, speed, density, volume, momentum, acceleration, force etc.*

Derived units of some physical quantities are as follows:

S. No.	Derived Physical quantity	Derived Unit
1.	Area	$m^2$
2.	Volume	$m^3$
3.	Density	$kg/m^3$
4.	Speed	$m/s$
5.	Acceleration	$m/s^2$
6.	Momentum	$kg\ m/s$
7.	Force	$kg\ m/s^2$ or newton
8.	Work	$kg\ m^2/s^2$ or joule
9.	Power	$kg\ m^2/s^3$ or watt
10.	Charge	ampere-sec or coulomb
11.	Potential	joule/coulomb or volt
12.	Resistance	volt/ampere or ohm

## Systems of Units

Depending upon the units of fundamental physical quantities, there are four main systems of units, namely

- **CGS** (Centimeter, Gramme or Gram, Second)
- **FPS** (Foot, Pound, Second)
- **MKS** (Meter, Kilogram, Second)
- **SI** (Système Internationale d' Unites)

The first three of these systems recognize only three fundamental quantities i.e. length (*L*), mass (*M*) and

## Kinds of Physical Quantities

There are two kinds of physical quantities

**Fundamental physical quantities:** Fundamental physical quantities are those which do not depend on other quantities and also independent of each other. They are seven in number viz; *length, mass, time, thermodynamic temperature, electric current, luminous intensity and amount of substance*.

**Derived physical quantities:** Derived physical quantities are those which are derived from fundamental physical quantities. For example, *velocity* is derived from the fundamental quantities length and time, hence it is a derived physical quantity.

## UNITS

To measure a physical quantity it is compared with a standard quantity. This standard quantity is called the unit of that quantity. For example, to measure the length of a desk, it is compared with the standard quantity known as ‘metre’. Thus, ‘metre’ is said to be the unit of length.

## Types of Units

There are two types of units :

**Fundamental units:** Fundamental units are those units which cannot be derived from any other unit, and they cannot be resolved into any basic or fundamental unit. Also, the units of fundamental physical quantities are called fundamental units. The following table shows the seven fundamental units of S.I. System.

time ( $T$ ) while the last one recognizes seven fundamental quantities. i.e. length ( $L$ ), mass ( $M$ ), time ( $T$ ), electric current ( $I$  or  $A$ ), thermodynamic temperature ( $K$  or  $\theta$ ), amount of substance (mol) and luminous intensity ( $I_v$ ). An international organization, the **Conference Générale des Poids et Mesures, or CGPM** is internationally recognized as the authority on the definition of units. In English, this body is known as "General Conference on Weights and Measures". The **Système International de Unités, or SI system** of units, was set up in 1960 by the CGPM.

### Characteristics of a Standard Unit

A standard unit must have following features to be accepted world wide. It should

- have a convenient size.
- be very well defined.
- be independent of time and place.

### Supplementary Units of SI System

The following table shows the two supplementary units of SI System.

S.No.	Physical quantity	Supplementary Unit	Symbol
1.	Plane angle	radian	rad
2.	Solid angle	steradian	sr

1. **radian (rad):** The radian is the plane angle between two radii of a circle that cut off on the circumference an arc equal in length to the radius.
2. **steradian (sr):** The steradian is the solid angle that, having its vertex at the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

### Practical Units of Length

**Astronomical unit, AU:** The average distance between the sun and the earth about  $1.49 \times 10^{11}$  m is called 1 AU.

**Parsec:** The parsec is defined to be the distance at which a star would have a parallax angle equal to one second of arc.

$$1 \text{ Parsec} = 3.08568025 \times 10^{16} \text{ m.}$$

**Light year :** The light year is the distance travelled by light in one year. All electromagnetic waves travel at a speed of  $299,792,458 \text{ ms}^{-1}$  and an average year being 365.25 days.

$$\text{One light year is } 299,792,458 \times 10^8 \text{ ms}^{-1} \times (365.25 \times 24 \times 60 \times 60 \text{ s}) = 9.46073 \times 10^{15} \text{ m. or } 9.46073 \times 10^{12} \text{ km.}$$

**Angstrom:** An angstrom is a unit of length used to measure small lengths such as the wavelengths of light, atoms and molecules. One angstrom,  $1 \text{ \AA} = 10^{-10} \text{ m.}$

**Fermi:** A unit of length used to measure nuclear distance =  $10^{-15}$  meter,  $1 \text{ fermi} = 10^{-15} \text{ m.}$

### PREFIXES FOR SI UNITS

In Physics we have to deal from very small (micro) to very large (macro) magnitudes. To express such large and small magnitudes simultaneously we use following prefixes:

When a prefix is placed before the symbol of unit, the combined prefix and symbol should be considered as one new symbol which can be raised to a positive or negative power without any bracket, e.g.,  $\text{km}^3$  means  $(10^3 \text{ m})^3$  but never  $10^3 \text{ m}^3$ .

### ERRORS IN MEASUREMENTS

Generally measured value of a quantity is different from the true value of the physical quantity. The difference between the true value and measured value is called error.  $\text{Error} = \text{true value} - \text{measured value}$

Before we discuss about errors let us understand two important terms :

**Accuracy :** It is the measure of how close the measured value is to the true value of the physical quantity.

**Precision :** It tells us about the limit or resolution upto which the quantity is measured.

### Significant Figures

Significant digits or figures give information about the accuracy of a measurement. It tells us about the number of digits in which we have confidence. Suppose a particular measurement is reported to be 9.28 cm, then the two digits 9 and 2 are reliable and certain while the digit 8 is uncertain. *The reliable and first uncertain digits are known as significant digits or figures.*

There are certain rules for counting significant digits or figure:

**Rule-1.** All the non-zero digits are significant—For example 2134 has four significant figures and 27184 has five significant figures.

**Rule-2.** All the zeros between two non-zero digits are significant, no matter where the decimal point is, if at all. For example 25089 has five significant figures, 12.0021 has six significant figures.

**Rule-3.** In a number which is less than one all zeros to the right of decimal point but to the left of a non-zero digit are not significant.

**Rule-4.** All the zeros on the right of last non-zero digits are significant in a number with a decimal point. For example in 3.500 there are four significant digits and in 0.079000 there are five significant figures.

**Rule-5.** All the zeros on the right on a non-zero digit are not significant in a number without decimal point. For example 15800 has only three significant figures, 18930000 has only four significant figures.

**Rule-6.** All the zeros on the right on a non-zero digit are taken to be significant when these come from a measurement. For example some distance is measured to be 7890 m then this number would have four significant figures.

**Rule-7.** A change of system of units does not change the number of significant digits in a measurement. Also when a number is written in scientific notation ( $a \times 10^b$ ) then the powers of 10 are irrelevant to the determination of significant figures.

### Least Count (L.C.)

The smallest division on the scale of the measuring instrument. It is an uncertainty associated with the resolution of the measuring instrument.

### DIMENSIONS OF A PHYSICAL QUANTITY

All physical quantities can be expressed in terms of the fundamental quantities. Consider the physical quantity force.

$$\begin{aligned} \text{Force} &= \text{mass} \times \text{acceleration} = \text{mass} \times \frac{\text{velocity}}{\text{time}} \\ &= \text{mass} \times \frac{\text{length / time}}{\text{time}} = \text{mass} \times \text{length} \times \text{time}^{-2} \\ \therefore \text{Unit of force} &= \text{unit of mass} \times \text{unit of length} \times (\text{unit of time})^{-2} \end{aligned}$$

Thus we can express the unit of force as products of different powers of the fundamental units of mass, length and time.

$$\text{i.e., Force} = [\text{MLT}^{-2}]$$

*Thus the dimensions of a physical quantity are the powers to which the fundamental quantities mass, length and time must be raised to represent it.*

### Science in Action

A spring balance on the moon will give different reading from that on Earth but a beam balance will give the same reading as spring balance requires gravity to measure. Mass remains same throughout but weight changes with gravity. Mass will only change if there is any change in the volume of matter in the body.

## MOTION

### REST AND MOTION

**Rest :** An object is said to be at rest if it does not change its position with respect to its surroundings with the passage of time.

**Motion :** A body is said to be in motion if its position changes continuously with respect to the surroundings (or with respect to an observer) with the passage of time.

*Rest and motion are relative terms.*

### Types of Motion on the basis of Dimensions

**One-Dimensional Motion:** It is the motion in which the position of the object changes only in one direction. In this case the object moves along a line. For example – motion of a train along a straight line, freely falling object under gravity, etc.

**Two-Dimensional Motion:** It is the motion in which the position of the object changes in two directions. In this case the object moves on a plane. For example – projectile motion.

**Three-Dimensional Motion:** It is the motion in which the position of the object changes in three directions. In this case the object moves in a space. For example – a bird flying in the sky.

### DISTANCE AND DISPLACEMENT

Motion is related to change of position. *The length travelled in changing position may be expressed in terms of distance*, i.e., the actual path length between two points.

Distance is a scalar quantity, which has only a magnitude with no direction.

*The direct straight line pointing from the initial point to the final point is called displacement* (change in position). Displacement only measures the change in position, not the details involved in the change in position.

Displacement is a vector quantity, which has both magnitude and direction.

The displacement can be zero, even if the distance is not zero. For example when a body is thrown vertically upwards from a point on the ground, after sometime it returns back to the same point, then the displacement of the body is zero but the distance travelled by the body is not zero, it is  $2h$  if  $h$  is the maximum height attained by the body.

Similarly, if a body is moving in a circular or closed path and reaches its original position after one revolution, then the displacement in one revolution is zero, but the distance travelled is equal to the circumference of the circular path =  $2\pi r$  if  $r$  is the radius of the circular path.

### Handy Facts

The actual distance travelled by an object in a given time interval can be equal to or greater than the magnitude of displacement. It can never be less than the magnitude of displacement.

The displacement of an object in a given time interval can be positive, zero or negative. However, distance covered by the object in a given time interval is always positive.

## UNIFORM AND NON-UNIFORM MOTION

### Uniform Motion

*It is a motion in which a body moves in a straight line (rectilinear) and covers equal distances in equal intervals of time.*

The path length of a body in a uniform rectilinear motion is equal to the magnitude of the displacement. Consequently, the path length(s) in the motion is equal to the magnitude of the velocity ( $v$ ) multiplied by the time ( $t$ ) i.e.,  $s = vt$ .

### Handy Facts

No force is required to keep an object in uniform motion. When an object has uniform motion along a straight line in a given direction, the magnitude of displacement is equal to actual distance covered.

### Non-Uniform Motion

*If a body covers unequal distances in equal intervals of time, it is said to be moving with a non-uniform motion.* It is a motion in which the velocity varies with time. The change in the velocity of a body in non-uniform motion is characterized by acceleration. Uniformly variable motion is a motion with a constant acceleration. Uniformly variable motion can be curvilinear like circular motion. If a uniformly variable motion is rectilinear, i.e., the velocity  $v$  changes only in magnitude, it is convenient to take the straight line in which a material point moves as one of the coordinate axes (say, the  $x$ -axis).

## THE RATE OF MOTION

### Average Speed

It is defined as *the total distance travelled divided by the time interval to travel that distance.*

Average speed  $V_{av} = \frac{d}{t}$ ,  $d$  is distance travelled, and  $t$  is time interval (change in time).

The average speed of Cheetah is 70 m/s for 30 seconds

### Instantaneous Speed

It is the speed at a particular time instant ( $t$  is infinitesimal small or close to zero).

### Uniform and Non-uniform Speed

A body is said to be moving with uniform speed if it covers equal distances in equal time intervals and with non-uniform or variable speed if covers unequal distances in the same time intervals.

## SPEED WITH DIRECTION (VELOCITY)

### Average Velocity

It is defined as *the ratio of change in position or displacement to the time taken.*

$$\bar{v} = v_{av} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

Here  $x_1$  and  $x_2$  are the positions of the particle at time  $t_1$  and  $t_2$  respectively. Also,  $\Delta x = x_2 - x_1$  = change in position and  $\Delta t = t_2 - t_1$  = change in time. Its unit is  $\text{ms}^{-1}$ ,  $\text{cms}^{-1}$  or  $\text{km h}^{-1}$ .

### Instantaneous Velocity

*Velocity of a body at a particular instant or moment of time* is called instantaneous velocity.

## RATE OF CHANGE OF VELOCITY [ACCELERATION]

**Positive acceleration:** If the velocity of an object increases in the same direction, the object has a positive acceleration.

**Negative acceleration (Retardation):** If the velocity of a body decreases in the same direction, the body has a negative acceleration or it is said to be retarding e.g. a train slows down.

## GRAPHICAL REPRESENTATION OF MOTION IN A STRAIGHT LINE

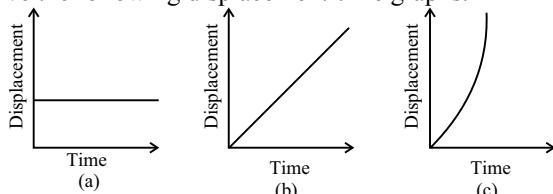
### Displacement-Time Graphs

A graph showing the displacement of the cyclist from  $A$  to  $C$ : This graph shows us how, in  $t$  seconds time, the cyclist has moved from  $A$  to  $C$ .

We know the gradient (slope) of a graph is defined as the change in  $y$  divided by the change in  $x$ , i.e.,  $\frac{\Delta y}{\Delta x}$ .

In this graph the gradient of the graph is just  $\frac{\Delta s}{\Delta t}$  and this is just the expression for velocity.

*The slope of a displacement-time graph gives the velocity.*  
The slope is the same all the way from  $A$  to  $C$ , so the cyclist's velocity is constant over the entire displacement he travels.  
Observe the following displacement-time graphs.



- Graph (a)** shows the object is stationary over a period of time. The gradient is zero, so the object has zero velocity.
- Graph (b)** shows the object is moving at a constant velocity. You can see that the displacement is increasing as time goes on. The gradient, however, stays constant so the velocity is constant. Here the gradient is positive, so the object is moving in the direction we have defined as positive.
- Graph (c)** shows the object is moving at a constant acceleration. You can see that both the displacement and the velocity (gradient of the graph) increases with time. The gradient is increasing with time, thus the velocity is increasing with time and the object is accelerating.

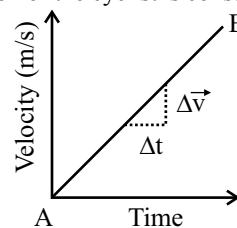
### Handy Facts

The x-t graph of an object having uniform motion is a straight line inclined to the time-axis. The slope of straight line x-t graph gives velocity of the uniform motion of the object.

## Velocity-Time Graphs

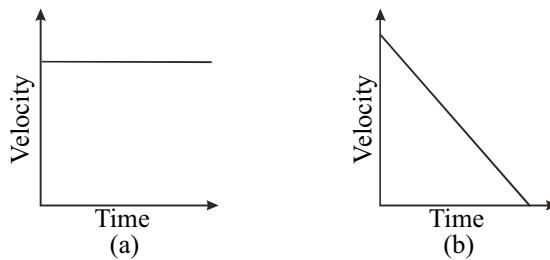
This is the velocity-time graph of a cyclist travelling from  $A$  to  $B$  at a constant acceleration, i.e. with steadily increasing velocity.

The gradient of this graph is just  $\frac{\Delta s}{\Delta t}$  and this is just the expression for acceleration. Because the slope is the same at all points on this graph, the acceleration of the cyclist is constant.



*The slope of a velocity-time graph gives the acceleration.*

Observe the following velocity-time graphs.

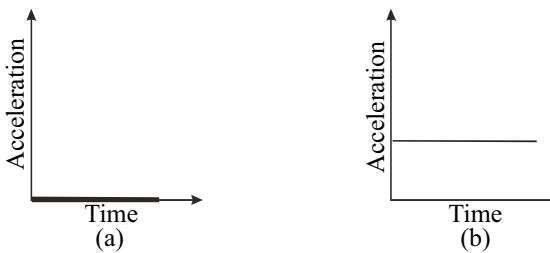


**Graph (a)** shows the object is moving at a constant velocity over a period of time. The gradient is zero, so the object is not accelerating.

**Graph (b)** shows an object which is decelerating. You can see that the velocity is decreasing with time. The gradient, however, stays constant so the acceleration is constant. Here the gradient is negative, so the object is accelerating in the opposite direction to its motion, hence it is decelerating.

## Acceleration-Time Graphs

Observe the following acceleration-time graphs.



**Graph (a)** shows an object which is either stationary or travelling at a constant velocity. Either way, the acceleration is zero over time.

**Graph (b)** shows an object moving at a constant acceleration. In this case the acceleration is positive - remember that it can also be negative.

## EQUATIONS OF MOTION

Kinematic equations can be used to describe the motion with constant acceleration.

**First equation (Equation for velocity-time relation) :**

Final velocity

$$= \text{initial velocity} + \text{acceleration} \times \text{time interval}$$

$$\text{or } v = u + at$$

**Second equation (Equation for position-time relation) :**

$$\text{Displacement} = \text{initial velocity} \times \text{time interval} + \frac{1}{2} \times \text{acceleration} \times \text{time interval}^2$$

$$\text{or } s = ut + \frac{1}{2}at^2$$

**Third equation (Equation for position-velocity relation) :**

$$v^2 = u^2 + 2as$$

$$\text{Final velocity}^2 = \text{initial velocity}^2 + 2 \times \text{acceleration} \times \text{displacement}$$

$$\text{or } v^2 = u^2 + 2as$$

**RELATIVE MOTION**

The motion of an object B w.r.t. object A which is moving or stationary is called as relative motion.

**Relative velocity** of an object B w.r.t. object A when both are in motion is the rate of change of position of object B w.r.t. object A.

Relative velocity of object B w.r.t. object A,  $\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

**MOTION UNDER GRAVITY**

It is a common experience that when a body is dropped from a certain height it experiences acceleration due to gravity and its motion is in a straight path. Similarly, when a body is thrown vertically up, it goes to a certain height and then starts falling again, experiencing acceleration due to gravity throughout the motion.

The value of acceleration due to gravity ( $g$ ) is taken as  $9.8 \text{ m/s}^2$ ,  $980 \text{ cm/s}^2$  or  $32 \text{ ft/s}^2$ .

Let us consider the three cases discussed below.

**Case-I: Body thrown downward :**

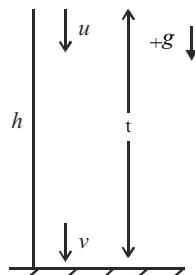
In this case, initial motion of the body is downward so according to the sign convention, downward direction will be taken as positive and upward direction as negative. So, the kinematic equations will be :

$$(i) v = u + gt$$

$$(ii) h = ut + \frac{1}{2}gt^2$$

$$(iii) v^2 = u^2 + 2gh$$

$$(iv) h^{\text{nth}} = h + \frac{1}{2}g(2n-1)$$



In a special case when the body is dropped/let falls i.e., initial velocity ( $u$ ) = 0, then equation becomes

$$v = gt ; h = \frac{1}{2}gt^2 ; v^2 = 2gh ; h^{\text{nth}} = \frac{1}{2}g(2n-1)$$

**Science in Action**

According to Galileo, when two bodies of different masses are dropped from the same height both will touch the floor at the same time in the absence of air resistance. If a ping pong and basket ball are dropped the floor from same height, they will hit at the same time in the absence of air resistance.

**Case-II: Body thrown upward:**

If a body is thrown vertically up with an initial velocity ( $u$ ).

Hence  $a = -g$ . Kinematic equations will be:

$$(i) v = u - gt \quad (ii) h = ut - \frac{1}{2}gt^2$$

$$(iii) v^2 - u^2 = -2gh \quad (iv) h_n = u - g\left(n - \frac{1}{2}\right)$$

**Maximum height reached by the body**

From equation  $v^2 = u^2 + 2gh$

$$H = \frac{u^2}{2g} \quad [ : v = 0 ]$$

Therefore, the maximum height reached by the body is directly proportional to the square of the initial velocity.

**Time of ascent ( $t_a$ ):** The time taken by a body thrown up to reach maximum height ' $h$ ' is called its time of ascent.

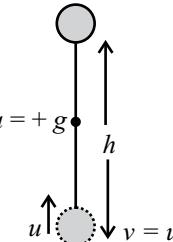
$$t_a = \frac{u}{g}$$

Hence time of ascent  $t_a$  is directly proportional to the initial velocity  $u$ .

**Time of descent ( $t_d$ ):** The time taken by a freely falling body to reach the ground is called the time of descent.

$$t_d = \sqrt{\frac{2h}{g}}$$

$$\text{and } h = \frac{v^2}{2g}, \quad t_d = \frac{v}{g}$$



But, we know that  $u = v$  i.e., projected velocity of a body is equal to the velocity of the body on reaching the ground.

$$\therefore t_d = \frac{u}{g} = \text{time of ascent } (t_a)$$

Time of ascent = time of descent

**Case-III: Body projected vertically up from the top of a tower :**

If a body is projected vertically up from the top of a tower of height ' $h$ ' with velocity ' $u$ '. Then

$$\text{Displacement after time } t \text{ is } s = ut - \frac{1}{2}gt^2$$

Velocity after time  $t$  is  $v = u - gt$ .

Velocity on reaching the ground is  $\sqrt{u^2 + 2gh}$

Maximum height above the ground is  $\{h + (u^2/2g)\}$

**PROJECTILE MOTION**

Projectile is the name given to a body thrown with some initial velocity in any arbitrary direction and then allowed to move under the influence of a constant acceleration. The motion of a projectile is called projectile motion.

**Example :** A football kicked by the player, a stone thrown from the top of building, a bomb released from a plane.

The path followed by a projectile is called its **trajectory**, mostly, the trajectory of a projectile is parabolic.

**Maximum height (H):** When a projectile moves, it covers a maximum distance in vertical direction. This maximum distance is called the maximum height attained by the projectile.

$$\text{Maximum height } H = \frac{u^2 \sin^2 \alpha}{2g}$$

**Horizontal range (R):** The horizontal distance between the point of projection and the point of landing of a projectile.

$$\text{Maximum range } R = \frac{u^2 \sin 2\alpha}{g}$$

**Time of flight (T):** The time taken by the projectile to reach the point of landing from the point of projection.

$$\text{Time of flight } T = \frac{2u \sin \alpha}{g}$$

### Science in Action

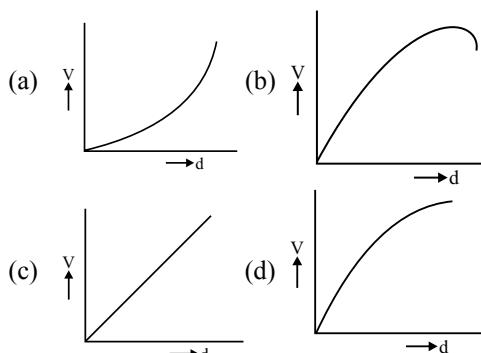
- An aeroplane flying at a constant speed, if it releases a bomb, the bomb moves away from the aeroplane and it will be always vertical below the aeroplane as the horizontal component of the velocity of the bomb will be same as that of the velocity of the aeroplane. And thus the horizontal displacement remain same at any instant of time.
- If two bullets are fired horizontally, simultaneously and with different velocities from the same place, both the bullets will hit the ground simultaneously as the initial velocity in the vertically downward direction is zero and same height has to be covered.

## EXERCISE

- Which of the following systems of units is not based on units of mass, length and time alone?
    - SI
    - MKS
    - CGS
    - FPS
  - Mass is the measure of
    - matter contained
    - weight
    - force
    - none of these
  - Among the following the derived quantity is
    - mass
    - length
    - density
    - time
  - Which of the following is not a fundamental unit?
    - newton
    - kilogram
    - metre
    - second
  - In SI units the number of basic physical quantities are
    - 3
    - 7
    - 9
    - 21
  - Light year is [SSC CGL]
    - light emitted by the sun in one year
    - time taken by light to travel from sun to earth
    - the distance travelled by light in free space in one year
    - time taken by earth to go once around the sun
  - One micron equals to
    - $10^{-3}$  m
    - $10^{-9}$  m
    - $10^{-6}$  m
    - $10^{-2}$  m
  - Practical unit of heat is
    - Calorie
    - Horse power
    - Joule
    - Watt
  - Match List I (Units) with List II (Physical quantity) and select the correct answer using the codes given below the lists. [CDS]
- | List I (Units) | List II<br>(Physical quantity) |
|----------------|--------------------------------|
| (A) Watt       | 1. Electric charge             |
| (B) Tesla      | 2. Power                       |
| (C) Coulomb    | 3. Luminous intensity          |
| (D) Candela    | 4. Magnetic field              |
- Codes
- | A     | B | C | D |
|-------|---|---|---|
| (a) 1 | 4 | 1 | 3 |
| (b) 1 | 2 | 3 | 4 |
| (c) 1 | 2 | 4 | 3 |
| (d) 2 | 4 | 3 | 1 |
- Assertion : Number of significant figures in 0.005 is one and that in 0.500 is three.  
Reason : This is because zeros are not significant.
    - If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
    - If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
    - If Assertion is correct but Reason is incorrect.
    - If Assertion is incorrect but Reason is correct.
  - Match List I (Physical quantity) with List II (Units) and select the correct answer using the codes given below the lists.
- | List I (Physical quantity) | List II (Units)                 |
|----------------------------|---------------------------------|
| A. Power                   | 1. $\text{kg ms}^{-1}$          |
| B. Energy                  | 2. $\text{kg m}^2\text{s}^{-1}$ |
| C. Momentum                | 3. $\text{Nm}^{-2}$             |
| D. Pressure                | 4. kW                           |
|                            | 5. kWh                          |
- Codes
- | A     | B | C | D |
|-------|---|---|---|
| (a) 4 | 5 | 1 | 3 |
| (b) 4 | 5 | 1 | 2 |
| (c) 5 | 4 | 1 | 2 |
| (d) 5 | 4 | 2 | 3 |
- What is the correct sequence in which the lengths of the following units increase?  
1. Angstrom    2. Micron    3. Nanometer  
Select the correct answer using the code given below: [NDA]
    - 1, 2, 3
    - 3, 1, 2
    - 1, 3, 2
    - 2, 3, 1
  - Which one of the following is not a dimension less quantity?
    - Strain
    - Relative density
    - Frequency
    - Angle
  - Match List I (Physical quantity) with list II (Dimension) and select the correct answer by using the codes given below the lists.
- | List I (Physical quantity) | List II (Dimension)             |
|----------------------------|---------------------------------|
| A. Density                 | 1. $[\text{MLT}^{-2}]$          |
| B. Force                   | 2. $[\text{ML}^{-3}]$           |
| C. Energy                  | 3. $[\text{MLT}^{-1}]$          |
| D. Momentum                | 4. $[\text{ML}^2\text{T}^{-2}]$ |

- Codes**
- | A     | B | C. | D |
|-------|---|----|---|
| (a) 3 | 2 | 4  | 1 |
| (b) 1 | 2 | 3  | 4 |
| (c) 2 | 1 | 4  | 3 |
| (d) 3 | 2 | 1  | 4 |
- 15.** 'Farad' is the unit of [SSC CGL]
- (a) resistance (b) conductance
  - (c) capacitance (d) inductance
- 16.** S.I. unit of surface tension is
- (a) degree/cm (b) N/m
  - (c) N/m<sup>2</sup> (d) N m
- 17.** Match List I (Physical quantity) with list II (Units) and select the correct answer by using the codes given below the lists.
- | List I (Physical quantity) | List II (Units)  |
|----------------------------|------------------|
| A. Solid angle             | 1. pascal        |
| B. Impulse                 | 2. steradian     |
| C. Viscosity               | 3. Newton-second |
| D. Pressure                | 4. Pascal-second |
- Codes**
- | A     | B | C. | D |
|-------|---|----|---|
| (a) 2 | 4 | 3  | 1 |
| (b) 2 | 3 | 4  | 1 |
| (c) 1 | 4 | 3  | 2 |
| (d) 1 | 3 | 4  | 2 |
- 18.** Which one of the following pairs does not have the same dimension? [NDA]
- (a) Potential energy and kinetic energy
  - (b) Density and specific gravity
  - (c) Focal length and height
  - (d) Gravitational force and frictional force
- 19.** Match List I (Items) with List II (Unit of length) and select the correct answer by using the codes given below the lists.
- | List I (Items)                      | List II (Units of length) |
|-------------------------------------|---------------------------|
| A. Distance between earth and stars | 1 Microns                 |
| B. Interatomic distances in a solid | 2 Angstroms               |
| C. Size of the nucleus              | 3 Light years             |
| D. Wavelength of infrared laser     | 4 Fermi                   |
|                                     | 5 kilometres              |
- Codes**
- | A     | B | C | D |
|-------|---|---|---|
| (a) 5 | 4 | 2 | 1 |
| (b) 3 | 2 | 4 | 1 |
| (c) 5 | 2 | 4 | 3 |
| (d) 3 | 4 | 1 | 2 |
- 20.** **Assertion :** Density is a derived physical quantity.  
**Reason :** Density cannot be derived from the fundamental physical quantities.
- (a) If both **Assertion** and **Reason** are correct and Reason is the **correct explanation** of Assertion.
  - (b) If both **Assertion** and **Reason** are correct, but Reason is **not the correct explanation** of Assertion.
  - (c) If **Assertion** is correct but **Reason** is incorrect.
  - (d) If **Assertion** is incorrect but **Reason** is correct.
- 21.** The numerical ratio of displacement to the distance covered is always.
- 22.** (a) less than one  
 (b) equal to one  
 (c) equal to or less than one  
 (d) equal to or greater than one
- 23.** An iron ball and a wooden ball of same radius are released from a height 'h' in vacuum. Which of the two balls would take more time to reach the ground?
- (a) Iron ball
  - (b) Both would take same time
  - (c) Wooden ball
  - (d) None of these
- 24.** If an object undergoes a uniform circular motion, then its [NDA]
- (a) acceleration remains uniform
  - (b) velocity changes
  - (c) speed changes
  - (d) velocity remains uniform
- 25.** Which one of the following remains constant while throwing a ball upward? [NDA]
- (a) Displacement (b) Kinetic energy
  - (c) Acceleration (d) Velocity
- 26.** A passenger in a moving train tosses a five rupee coin. If the coin falls behind him, then the train must be moving with a uniform
- (a) acceleration (b) deceleration
  - (c) speed (d) velocity
- 27.** Which of the following distance-time graph (x-t) represents one-dimensional uniform motion? [IAS Prelim]
- 
- (a) (b) (c) (d)
- 28.** A stone is thrown vertically upwards with an initial velocity  $u$  from the top of a tower of height  $\frac{12u^2}{g}$ . With what velocity does the stone reach the ground? [NDA]
- (a)  $u$
  - (b)  $4u$
  - (c)  $5u$
  - (d)  $2\sqrt{6} u$
- 29.** Which one of the following characteristics of the particle does the shaded area of the velocity-time graph shown represent? [NDA]
- 
- 30.** (a) Momentum (b) Acceleration  
 (c) Distance covered (d) speed

29. A parachutist jumps from a height of 5000 metre. The relationship between his falling speed,  $v$  and the distance fallen through  $d$  is best represented as : [IAS Prelim]



30. A spherical body moves with a uniform angular velocity ( $\omega$ ) around a circular path of radius  $r$ . Which one of the following statements is correct? [IAS Prelim]

- (a) The body has no acceleration
- (b) The body has a radial acceleration  $\omega^2 r$  directed toward centre of path
- (c) The body has a radial acceleration  $2/5\omega^2 r$  directed away from the centre of the path
- (d) The body has an acceleration  $\omega^2$  tangential to its path

31. If  $d$  denotes the distance covered by a car in time  $t$  and  $\bar{S}$  denotes the displacement by the car during the same time, then : [NDA]

- (a)  $d \leq |\bar{S}|$
- (b)  $d = |\bar{S}|$  only
- (c)  $d \geq |\bar{S}|$
- (d)  $d < |\bar{S}|$

32. The displacement of a particle at time  $t$  is given by

$$\bar{x} = a\hat{i} + b\hat{t}j + \frac{c}{2}t^2\hat{k} \text{ where } a, b \text{ and } c \text{ are positive constants.}$$

Then the particle is [NDA]

- (a) accelerated along  $\frac{18}{5}$  direction
- (b) decelerated along  $\frac{18}{5}$  direction
- (c) decelerated along  $j$  direction
- (d) accelerated along  $j$  direction

33. A body is projected vertically upwards with a velocity of 96 ft/s. What is the total time for which the body will remain in the air?

- (a) 3 s
- (b) 6 s
- (c) 9 s
- (d) 12 s

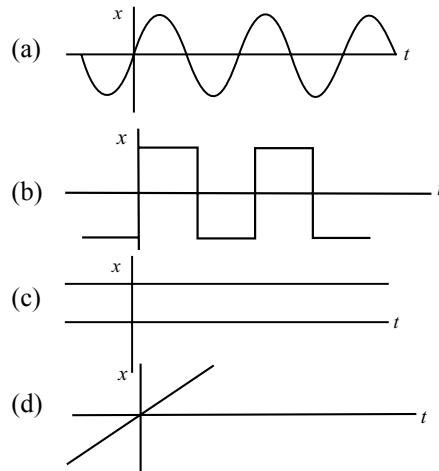
34. A motor vehicle is moving on a circle with a uniform speed. The net acceleration of the vehicle is [NDA]

- (a) zero
- (b) towards the centre of circle
- (c) away from the centre along the radius of the circle
- (d) perpendicular to the radius and along the velocity

35. A swinging pendulum has its maximum acceleration at [NDA]

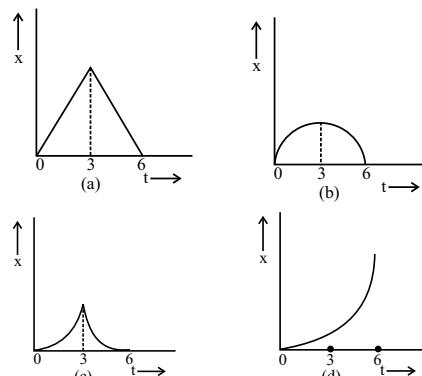
- (a) the bottom of the swing
- (b) the two extremities of the swing
- (c) every point on the swing
- (d) no particular portion of the pendulum

36. An object is in uniform circular motion on a plane. Suppose that you measure its displacement from the centre along one direction, say, along the  $x$ -axis. Which one among the following graphs could represent this displacement ( $x$ )? [NDA]

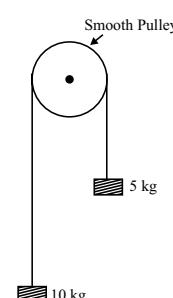


37. A particle starts from rest, accelerates uniformly for 3 seconds and then decelerates uniformly for 3 seconds and comes to rest.

Which one of the following displacement ( $x$ )-time ( $t$ ) graphs represents the motion of the particle? [NDA]



38. In the system shown, the masses are released from rest. What shall be the acceleration of the moving masses ? [NDA]



- (a)  $g$
- (b)  $2g/3$
- (c)  $g/3$
- (d)  $g/2$

#### ANSWER KEY

1.	(a)	2.	(a)	3.	(c)	4.	(a)	5.	(b)	6.	(c)	7.	(c)	8.	(a)	9.	(a)	10.	(c)
11.	(a)	12.	(c)	13.	(c)	14.	(c)	15.	(c)	16.	(b)	17.	(b)	18.	(b)	19.	(d)	20.	(c)
21.	(c)	22.	(b)	23.	(b)	24.	(c)	25.	(a)	26.	(d)	27.	(c)	28.	(c)	29.	(d)	30.	(b)
31.	(c)	32.	(a)	33.	(b)	34.	(b)	35.	(b)	36.	(a)	37.	(c)	38.	(c)				

## Chapter 2

# LAWS OF MOTION, FORCE, WORK, ENERGY & POWER, CENTRE OF MASS

## LAWS OF MOTION AND FORCE

Everybody in this universe stays in a state of rest i.e., no change in position of a body wrt time or of uniform motion i.e., change in position of a body wrt time. This chapter is concerned about the cause of rest or motion (i.e., force) and its effect (i.e., acceleration or deceleration) and their relationship.

### NEWTON'S LAWS OF MOTION

#### Newton's First Law of Motion

According to this law, *an object continues in a state of rest or in a state of motion at a constant speed along a straight line, unless compelled to change that state by a net force*. In other words, if a body is in a state of rest, it will remain in the state of rest and if it is in the state of motion, it will remain moving in the same direction with the same velocity unless an external unbalanced force is applied on it. This law is also called **law of inertia**. It gives qualitative definition of force.

#### Handy Facts

A common misconception about Newton's first law of motion is that a force is required to keep an object in motion. This is not so. Experiments done on air tracks (where there is a negligible friction) show that no force is required to keep an object moving with constant velocity. We get this misconception because friction is always present in *our everyday lives*.

#### Inertia and Mass

A greater net force is required to change the velocity of some objects than of others. The net force that is just enough to cause a bicycle to pick up speed will cause an imperceptible change in the motion of a freight train. In comparison to the bicycle, the train has a much greater tendency to remain at rest. Accordingly, we say that the train has more inertia than the bicycle. Quantitatively, the inertia of an object is measured by its mass. *Inertia is the natural tendency of an object to remain at rest or in motion at a constant speed along a straight line*. The mass of an object is a quantitative measure of inertia. The *greater the mass, the greater is the inertia of body*.

#### Types of Inertia

**Inertia of rest :** *The tendency of the body to continue in state of rest even when some external unbalanced force is applied on it is called inertia of rest.*

#### Science in Action

- **When a carpet is suddenly jerked the dust fly off,** because due to the sudden jerk the carpet moves but the dust on account of inertia of rest is left behind.
- **The passenger standing in a bus tends to fall backwards when the bus suddenly starts,** this is because his feet are in direct contact with the floor of the bus and the friction at the contact is high this friction does not allow the feet to slip on the floor, the feet therefore move forward with the floor and the upper part of the body is still at rest for a while thus the passenger gets a backward jerk.
- **Coin drops into the glass when sudden force is applied on the cardboard** (see figure).



It is because of the property of inertia of rest, the coin continues in the state of rest.

**Inertia of motion :** The tendency of the body to continue in its state of motion even when some unbalanced force is applied on it is called the inertia of motion.

#### Science in Action

- **It is dangerous to jump out of a moving vehicle (bus/train),** this is because inside the train/bus, complete body of the passenger is in a state of motion with the train/bus and

on reaching the ground his feet come to rest but upper part of the body continues to move with the speed of vehicle and the person falls forward on the ground. It is dangerous to jump out of a moving train and it is better to come out when it halts. However if in case of some emergency if some person wants to jump safely from a moving vehicle he should run for quite a while in the direction of motion of the vehicle after the jump so that his entire body remains in motion for sometime.

- **When a running car stops suddenly, the passenger is jerked forward.** The reason is that in a running car, the whole body of passenger is in the state of motion. As the car stops suddenly, the lower part of his body being

in contact with the car, comes to rest but his upper part remains in the state of motion due to the inertia of motion. Thus he gets jerked forward.

### Newton's Second Law of Motion

It states that *the rate of change of momentum of a body is directly proportional to the applied unbalanced force.*

i.e., Rate of change of momentum  $\propto$  force applied

$$\text{or, } F \propto \frac{\Delta p}{\Delta t}$$

If a body is moving with initial velocity  $u$  and after applying a force  $F$  on it. Its velocity becomes  $v$  in time  $t$ , then

$$F \propto \frac{m(v-u)}{t}$$

$$\text{Here } \frac{v-u}{t} = a \text{ (acceleration)}$$

So  $F \propto ma$  or  $F = k ma$ , where  $k$  is proportionality constant.

### Momentum

The momentum of a moving body is defined as the *product of its mass and velocity*. If we represent the mass and velocity of a body by  $m$  and  $\vec{v}$  respectively, then momentum is given by

$$\vec{p} = m \vec{v}$$

The direction of momentum of a body is same as that of its velocity.

The SI unit of momentum is kilogram meter per second (kgm/s).

### Impulse or Change in Momentum

From Newton's second law,  $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$ , one can derive the **impulse-momentum theorem**. This theorem states that impulse is equal to the change in momentum, or,  $\vec{F} \Delta t = \Delta \vec{p} = \vec{p} - \vec{p}_0$

where  $\vec{F} \Delta t$  is called impulse,  $\vec{F}$  is the average force and  $\Delta t$  is the time interval the force is in action.

### NEWTON'S THIRD LAW OF MOTION

It states that *to every action there is always an equal and opposite reaction.*

This law of motion states that 'if a body  $A$  exerts a force  $+F$  on a body  $B$ , then body  $B$  exerts a force  $-F$  on  $A$ , that is a force of the same magnitude and along the same line of interaction but in the opposite direction'.

#### Science in Action

- **Motor cars are able to move along a road** because the reaction of the road pushes the car along in response to the action of the wheels pushing on the road.
- **Swimming in a pond** – a swimmer pushes (or applies force) the water with his hands and feet to move in the forward direction in water. It is the reaction to this force that pushes the swimmer forward.
- **Propulsion of aeroplane.** The propellers of an aeroplane pushes the air backwards and the forward reaction of the air makes the aeroplane move forward.

### CONSERVATION OF MOMENTUM

The principle of conservation of momentum states that "if there is a direction in which there is zero unbalanced force acting on a system then the total momentum of that system in that direction is constant even if the bodies act on each other".

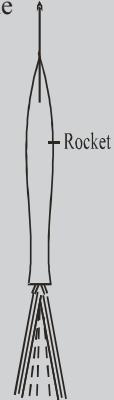
Also, the total momentum of the system remains constant, if no external force acts on a system of constant mass.

$$m_1 \vec{v}_1 + m_2 \vec{v}_2 + m_3 \vec{v}_3 + \dots = \text{constant}$$

**Ex.** The pull of the Earth, do act on the bodies, but the result can still be used if there is a direction in which the external forces are balanced.

#### Science in Action

- **Recoiling of a gun:** Guns recoil when fired, because of the law of conservation of momentum. The positive momentum gained by the bullet is equal to negative recoil momentum of the gun and so the total momentum before and after the firing of the gun is zero.
- **Propulsion of Jet and Rockets:** A rocket standing at the launching pad has zero momentum. When the propellants inside the rocket burn, a high velocity blast of hot gases is produced. These gases pass out through the tail nozzle of the rocket in downward direction with tremendous velocity. Therefore the rocket moves up with such a velocity so as to make the momentum of the system (rocket + emitted gases) zero.



### FORCE

A force is that physical quantity which tries to change or changes the state of rest or of uniform motion of a body.

**Units of force:** The S.I. unit of force is newton.

In C.G.S. system, the unit of force is dyne.

$$1 \text{ newton} = 10^5 \text{ dyne}$$

In MKS system, the unit of force is the kilogramme force (kgf).

$$1 \text{ kgf} = 9.8 \text{ newton (or } 9.8 \text{ N)}$$

### Basic Forces in Nature

There are four basic forces in nature and they are

- (i) **Gravitational Force:** Every body in the universe attracts each other, this force is known as gravitational force. This is the weakest force among all other forces which is existing.
- (ii) **Weak Nuclear Force:** These forces are  $10^{25}$  times stronger than gravitational force.
- (iii) **Electromagnetic Force:** The electromagnetic forces are the forces between the charged particles. When charges are at rest, then the force is called as electrostatic force. This force is much stronger than gravitational force and it dominates atomic and molecular phenomena.

## Laws of Motion, Force, Work, Energy & Power, Centre of Mass

- (iv) **Strong nuclear forces :** This is the strongest force found in nature. These forces acts between the proton and the neutron in order to bind them in the nucleus. This force is  $10^{38}$  times stronger than gravitational forces,  $10^2$  times stronger than electrostatic forces and  $10^{13}$  times stronger than weak nuclear forces.

### FRICITION

Friction is a resistance to the relative motion between two objects in contact (in case of solid objects) or the body and its surroundings (in case object is moving in a fluid). Actually, when two objects are kept in contact, a reaction force  $R$  acts between the two objects as shown in the figure.

This reaction force  $R$  has two components - $F$ , along the surface and  $N$ , perpendicular to the surface. The force  $F$  which acts along the surface is called the force of friction.

The results of experimental investigation into the behaviour of frictional forces confirm that:

- frictional force opposes the movement of an object across the surface of another with which it is in rough contact.
- the direction of the frictional force is opposite to the potential direction of motion.
- the magnitude of the frictional force is only just sufficient to prevent movement and increases as the tendency to move increases, up to a limiting value. When the limiting value is reached, the frictional force cannot increase any further and motion is about to begin (limiting equilibrium). When the frictional force  $F$  reaches its limit, its value then is related to the normal reaction  $N$  in the following way  $F = \mu N$  or  $\mu = F/N$

The constant  $\mu$  is called the coefficient of friction and each pair of surfaces has its own value for this constant.

### Types of Friction

**Static frictional force:** When there is no relative motion between the contact surfaces, frictional force is called static frictional force. It is a self-adjusting force, it adjusts its value according to requirement.

The maximum value of static friction is called **limiting friction**.

**Kinetic frictional force:** Once relative motion starts between the surfaces in contact, the frictional force is called as kinetic frictional force. The magnitude of kinetic frictional force is also proportional to normal force

$$\text{i.e., } f_k = \mu_k N$$

- **Sliding friction:** When one body slides over the surface of another body, the resistance to its motion is called as sliding friction. It is always more than rolling friction.
- **Rolling friction:** When one body rolls over the surface of another body, the resistance to its motion is termed as rolling friction. Friction in this case is very small.

The coefficient of rolling friction ( $\mu_R$ ) is the least and coefficient of static friction is maximum, i.e.,  $\mu_R < \mu_k < \mu_s$ .

### Friction: A necessary Evil

Friction is **necessary** for doing various activities in our daily life.

- We could not hold articles such as glass tumbler and other things without friction. It becomes very difficult to hold a greasy glass.
- We could not write with pen or pencil if there is no friction.

- Friction helps objects to move, stop or to change the direction of motion. We cannot walk without friction.

### Friction is an evil

- It causes wear and tear. For example, soles of shoes, ball bearings, steps of a stair, parts of machines etc.
- Friction produces heat. When a machine is operated, heat generated causes damage to the machinery.

### Science in Action

Fast moving objects such as cars, bullet trains, aeroplanes are all streamlined-designed with curved and sloping surfaces to cut through the air and reduce drag. Boats can also be streamlined to reduce water resistance.

### Motion in a Lift

The weight of a body is simply the force exerted by earth on the body. If body is on an accelerated platform, the body experiences fictitious force, so the weight of the body appears changed and this new weight is called apparent weight. Let a man of weight  $W = Mg$  be standing in a lift.

**Case (a):** If the lift is moving with constant velocity  $v$  upwards or downwards.

Apparent weight,  $W' = \text{actual weight } W$

**Case (b):** If the lift is accelerated i.e.,  $a = \text{constant}$  and in upward direction.

Apparent weight,

$$W' = W + F_0 = Mg + Ma = M(g + a)$$

**Case (c):** If the lift is accelerated downward with acceleration  $a < g$ :

Apparent weight,

$$W' = W + F_0 = Mg - Ma = M(g - a)$$

**Case (d):** If the lift is accelerated downward with acceleration  $a > g$ :

Apparent weight,  $W' = M(g - a)$  is negative.

### CENTRIPETAL FORCE

If  $m$  be the mass of object then it experiences a force which directs towards the centre of the circular path and has a magnitude given by

$$F_c = ma_c = \frac{mv^2}{r} \quad \text{or} \quad F = mr\omega^2 \quad [\because v = r\omega]$$

This force is known as centripetal force.

### CENTRIFUGAL FORCE

The virtual force which balances the centripetal force in uniform circular motion is called as centrifugal force. It is not the real force as it is due to the acceleration of rotating frame. When a body is rotating in a circular path and the centripetal force vanishes, the body would leave the circular path.

### Science in Action

- **Cream Separator :** It is device which works on the principle of centrifugal force. It contains a vessel which has milk, when it rotated the lighter particles i.e. the cream is collected in a cylindrical layer around the axis and the milk is drained through an outlet attached to the vessel.
- **Washing Machine Drier :** When wet clothes are packed tightly in a cylindrical vessel with perforated walls and rotated with very high speed, water particles move out through the walls of the vessel.

## CIRCULAR MOTION

Motion of a particle along a circle or circular path is called a circular motion. If the body covers equal distances along the circumference of the circle, in equal intervals of time, the motion is said to be a **uniform circular motion**. A uniform circular motion is a motion in which speed remains constant but direction changes so velocity.

**Examples** of uniform circular motion are

- motion of moon around the earth.
- motion of satellite round its planet.

## BANKING OF ROAD

The tilting of the vehicle is achieved by raising the outer edge of the circular track, slightly above the inner edge. This is known as banking of curved track.

## CONDITION OF OVERTURNING

If speed is greater than limiting speed, then condition of overturning is occurred.

### Science in Action

- When a vehicle moves on a curved road it requires centripetal force. Outer edge of the curved road is raised above the inner edge in order to provide centripetal force.
- Electrons which moves around the nucleus requires centripetal force.
- Earth experiences centripetal force in order to move around the sun.

**Work done by a force can be positive, negative or zero** as the value of  $\cos \theta$  is positive, negative or zero.

( $\because F$  and  $s$ , being magnitudes, are always positive)

- Work is a scalar quantity but you can have positive and negative work.

### Science in Action

#### Zero work :

- A coolie with a luggage on his head, moving on a horizontal platform, does no work, since the direction of force is vertically up and displacement horizontal i.e., angle  $\theta$  between them is  $90^\circ$  (even though he might feel physically tired).

#### Positive work:

- When a horse pulls a cart, the applied force and the displacement are in the same direction. So, work done by the horse is positive.

#### Negative work:

- When brakes are applied to a moving vehicle, the work done by the braking force is negative. This is because the braking force and the displacement act in opposite directions.

## ENERGY

Energy is defined as the capacity to do work.

The SI unit of energy is the joule (J) same as that of work. The commonly used unit for electrical-energy consumption is the **kilowatt-hour (kWh)**.

Thus,  $1\text{kWh} = 1\text{ kW} \times 1\text{ hour}$

$$\begin{aligned} &= (1000\text{ W}) \times (3600\text{ s}) \\ &= (1000\text{ J/s}) \times (3600\text{ s}) \\ &= (3600000\text{ joules}) = 3.6 \times 10^6\text{ J}. \end{aligned}$$

For electrical-energy consumption in houses, factories, shops, etc., kilowatt-hour is simply called 'unit' (Board of trade unit B.O.T.U.).

## Kinetic Energy (K.E.)

Energy possessed by a body by virtue of its state of motion is called kinetic energy. Kinetic energy is always positive and is a scalar.

$$\text{K.E.} = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

## Potential Energy (P.E.)

Potential energy is energy due to position. If a body is in a position such that if it were released it would begin to move, it has potential energy.

$$\text{P.E.} = mgh$$

For example, energy of water in a water tank on the roof, energy of small spring in ball-pen, etc.

## Gravitational potential energy

When an object is allowed to fall from higher level to a lower level it gains speed due to gravitational pull, i.e. it gains kinetic energy.

The magnitude of its gravitational potential energy is equivalent to the amount of work done by the weight of the body in causing the descent.

## WORK, ENERGY AND POWER

The meaning of work in physics is different from its meaning in common language. Actually, in physics work has a meaning only when a displacement is caused in a body by the applied force on it. If there is no displacement in a body by an applied force in the direction of force, no work is said to be done.

## WORK

Work is defined as the product of the force and displacement in the direction of applied force or product of displacement and force in the direction of displacement.

$$W = \text{Force} \times \text{displacement in the direction of force}$$

$$= FS = FS \cos \theta$$

where  $\theta$  is the angle between  $F$  and  $S$ .

The SI unit of work is newton-metre is also called joule (J)

$$1\text{ joule} = 10^7\text{ erg}$$

## Work done by a force applied at an angle

$$W = \text{component of force in the direction of displacement} \times \text{magnitude of displacement} = F \cos \theta s$$

## Laws of Motion, Force, Work, Energy & Power, Centre of Mass

If a mass  $m$  is at a height  $h$  above a lower level, the P.E. possessed by the mass is  $mgh$ .

Since  $h$  is the height of an object above a specified level, an object below the specified level has negative potential energy.

### Work-Energy Theorem

According to the work-energy theorem, total work done on a system by forces equals to the change in kinetic energy.

### LAW OF CONSERVATION OF ENERGY

According to this law, energy can only be converted from one form to another, it can neither be created nor destroyed. The total energy before and after the transformation always remains the same.

### Transformation of Energy

The conversion of one form of energy to the other form is termed as transformation of energy. The phenomenon in which energy is transformed from useful from to useless form is known as dissipation of energy.

#### Science in Action

- When a boy runs, the internal energy in his body is converted into kinetic energy.
- When we thrown an object, the muscular energy stored in our body is converted into kinetic energy.
- Electric energy into light energy -Electrical Bulb.
- Chemical energy into electrical energy-Cell.
- Electrical energy into heat energy- Heater.
- Electrical into mechanical - Electrical motor
- Mechanical into electrical - Dynamo
- Sound energy into electrical energy - Microphone

### Mass-Energy equivalence Relation

According to this relation mass ( $m$ ) and energy ( $E$ ) are interconvertible

$$E = mc^2$$

Where,  $c = 3 \times 10^8 \text{ ms}^{-1}$  is the velocity of light in vaccum or air.

### POWER

The time rate of doing work is defined as power ( $P$ ). If equal works are done in different times, power will be different. More quickly work is done, power will be more.

$$\text{Power (P)} = \frac{\text{work (W)}}{\text{time(t)}}$$

The S.I. unit of power is the *joule per second* and is called the *watt (W)*. 1 H.P (Horse power) = 746 W

### COLLISIONS

Collision is an event in which two or more than two bodies interact with one another for a short time and exchange momentum and kinetic energy. Collisions are of two types :

- Elastic collision
- Inelastic collision

#### Handy Facts

Linear momentum is always conserved, in collision whereas kinetic energy is conserved only in elastic collision.

### Elastic Collision

A collision in which there is no loss of kinetic energy is called elastic or perfectly elastic collision. The basic characteristics of perfectly elastic collision are

- linear momentum is conserved
- kinetic energy is conserved
- total energy is conserved
- coefficient of restitution is unity ( $e = 1$ )

#### Handy Facts

The collision in one dimension is also known as head-on collision.

### Inelastic Collision

In an inelastic collision kinetic energy is lost during collision. The basic characteristic of an inelastic collision are :

- linear momentum is conserved
- kinetic energy is not conserved
- total energy is conserved
- coefficient of restitution is  $0 < e < 1$

*In case of perfectly inelastic collision* the two bodies get stuck together and move with common velocity, that is why for perfectly inelastic collision.

## CENTRE OF MASS AND ROTATIONAL MOTION

The motion through space in which the position of the centre of mass of the object changes is considered as translational motion.

### CENTRE OF MASS (COM)

For a system of particles, **centre of mass**, is that point at which its total mass is supposed to be concentrated.

#### Rigid Body

A body which does not deform on the application of whatsoever large force is called a rigid body. Ideally such type of body will not exist but practically, large, extended object can be treated as rigid body. For example, door is a rigid body.

### Centre of Mass of Some Symmetrical Regular Shaped Objects

When bodies are symmetrical in shape and have uniform densities then their centre of mass would lie on their geometrical centres.

The position of centre of mass depends on following two factors:

- The geometrical shape of the body
- The distribution of mass in the body

## ROTATIONAL MOTION

A rigid body performs a pure rotational motion, if each particle of the body moves in a circle, and the centre of all the circles lie on a straight line, called the axis of rotation.

**Examples :** Motion of a ceiling fan, motion of a potter's wheel, etc.

### Angular Displacement ( $\Delta\theta$ )

The change in position of a particle moving in a circular path with respect to the center is known as its angular displacement.

Its SI unit is radian.

### Angular Velocity ( $\omega$ )

The rate of change of angular displacement of a body.

$$\text{Average angular velocity } \omega = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta\theta}{\Delta t}$$

Also, angular velocity,  $\omega = 2\pi n$  where,  $n$  = number of revolutions per second.

Its SI unit is radian/s

### Relation between angular velocity ( $\omega$ ), linear velocity ( $v$ ) and radius of circular path ( $r$ )

$$v = r\omega \quad \text{or} \quad \omega = \frac{v}{r}$$

## MOMENT OF INERTIA

The property of a body by virtue of which it opposes any change in its state of rest or of rotational motion is defined as its moment of inertia. The moment of inertia of a particle in rotational motion is equal to the product of its mass (m) and square of its distance (r) from the axis.

Moment of inertia,  $I = mr^2$

It is neither a scalar nor a vector but it is considered as a tensor.

Its SI unit is  $\text{kg m}^2$

## TORQUE

Torque is the turning or twisting action on a body about the axis of rotation due to a force  $\vec{F}$ .

$$\vec{\tau} = (\vec{r} \times \vec{F}) \hat{n},$$

### Rigid body in Equilibrium

A rigid body is in equilibrium, if it has zero translational acceleration and zero angular acceleration.

### Principle of Moments for a Lever

$\text{Load} \times \text{load arm} = \text{effort} \times \text{effort arm}$

Mechanical advantage (M.A.) of lever

$$= \frac{\text{load}}{\text{effort}} = \frac{\text{effort arm}}{\text{load arm}}$$

### Couple

When two equal and parallel forces having different line of action acts on a body then it makes a couple. It has always the unidirectional rotational effect.

$\text{Couple} = \text{force} \times \text{force arm}$

### Science in Action

- A handle or knob is provided at the free edge on the plank of the door as torque is maximum, when d is maximum. Thus we can close or open the door easily by applying less force at the edge of the door.
- When we open the lid of a bottle by turning it, our fingers are applying a couple to the lid.

## ANGULAR MOMENTUM

In translational motion the measure of quantity of motion possessed by a body is linear momentum and the physical quantity analogous to it in rotational motion is angular momentum, it is represented by  $L$  and it is a vector quantity. Angular momentum  $L = I\omega$ . Its S.I. unit is joule-second.

### Relation Between Torque ( $\tau$ ) and Angular Momentum ( $L$ )

$$\frac{dL}{dt} = \tau \quad (\text{As } \tau = I\alpha)$$

### Conservation of Angular momentum

Suppose on a system of particles of a rigid body no external force is acting then its angular momentum remains conserved, this is known as conservation of angular momentum.

### Science in Action

- The angular velocity of a planet revolving in an elliptical orbit around the sun increases, when it comes near the sun and vice-versa. When the planet moving along its elliptical orbit is near the sun, its moment of inertia about the axis through the sun decreases and therefore its angular speed increases. On the other hand, when it is far away from the sun, its moment of inertia increases and hence angular speed decreases.
- An ice-skater or a ballet-dancer can increase her angular velocity by folding her arms and bringing the stretched leg close to the other leg.

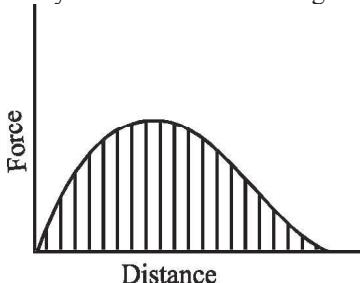
## EXERCISE

1. The working principle of a washing machine is : **[IAS Prelim]**
  - (a) centrifugation
  - (b) dialysis
  - (c) reverse osmosis
  - (d) diffusion
2. Newton's laws of motion do not hold good for objects
  - (a) at rest
  - (b) moving slowly
  - (c) moving with high velocity
  - (d) moving with velocity comparable to velocity of light
3. A jet engine works on the principle of conservation of **[NDA]**
  - (a) linear momentum
  - (b) angular momentum
  - (c) energy
  - (d) mass
4. Which one among the following is correct for resultant of balanced forces? **[NDA]**
  - (a) It is zero
  - (b) It is non-zero
  - (c) It varies continuously
  - (d) None of the above
5. When a moving bus suddenly applies brakes, the passengers sitting in it fall in the forward direction. This can be explained by **[NDA]**
  - (a) the theory of relativity
  - (b) Newton's first law
  - (c) Newton's second law
  - (d) Newton's third law
6. A book is kept on the surface of a table. If the gravitational pull of the earth on the book is the force of action, then the force of reaction is exerted by **[NDA]**
  - (a) the book on the table
  - (b) the book on the earth
  - (c) the table on the book
  - (d) the table on the earth
7. The pressure exerted on the ground by a man is greatest **[CDS]**
  - (a) when he lies down in the ground
  - (b) when he stands on the toes of one foot
  - (c) when he stands with both feet flat on the ground
  - (d) all of the above yield the same pressure
8. If a ship moves from freshwater into seawater, it will **[CDS]**
  - (a) sink completely
  - (b) sink a little bit
  - (c) rise a little higher
  - (d) remain unaffected
9. A man is at rest in the middle of a horizontal plane of perfectly smooth surface of ice. He can move himself to the shore by making use of Newton's **[NDA]**
  - (a) first law of motion
  - (b) second law of motion
  - (c) third law of motion
  - (d) first, second and third laws of motion
10. If an object having mass of 1 kg is subjected to a force of 1 N it moves with **[CDS]**
  - (a) a speed of 1 m/s
  - (b) a speed of 1 km/s
  - (c) an acceleration of  $10 \text{ m/s}^2$
  - (d) an acceleration of  $1 \text{ m/s}^2$
11. An athlete diving off a high springboard can perform a variety of exercises in the air before entering the water below. Which one of the following parameters will remain constant during the fall? **[CDS]**
  - (a) The athlete's linear momentum
  - (b) The athlete's moment of inertia
  - (c) The athlete's kinetic energy
  - (d) The athlete's angular momentum
12. **Statement A :** While drawing a line on a paper, friction force acts on paper in the same direction along which line is drawn on the paper.  
**Statement B :** Friction always opposes motion.
  - (a) Statement A is correct.
  - (b) Statement B is correct.
  - (c) Both statements are correct.
  - (d) Both statements are incorrect.
13. **Assertion (A) :** A man standing on a completely frictionless surface can propel himself by whistling.  
**Reason (R) :** If no external force acts on a system, its momentum cannot change. **[IAS Prelim]**
  - (a) Both A and R are true and R is the correct explanation of A
  - (b) Both A and R are true but R is not a correct explanation of A
  - (c) A is true but R is false
  - (d) A is false but R is true
14. A spherical body moves with a uniform angular velocity ( $\omega$ ) around a circular path of radius  $r$ . Which one of the following statements is correct? **[IAS Prelim]**
  - (a) The body has no acceleration
  - (b) The body has a radial acceleration  $\omega^2 r$  directed toward centre of path
  - (c) The body has a radial acceleration  $2/5\omega^2 r$  directed away from the centre of the path
  - (d) The body has an acceleration  $\omega^2$  tangential to its path
15. On the basis of following features identify the correct option.
  - A. It is measured in units of  $\text{kg m/s}$ .
  - B. Its direction is same as that of velocity of body.
  - (a) Momentum
  - (b) Inertia
  - (c) Both A and B
  - (d) Neither A and B
16. Ball bearings are used in bicycles, cars, etc., because **[IAS Prelim]**
  - (a) the actual area of contact between the wheel and axle is increased
  - (b) the effective area of contact between the wheel and axle is increased
  - (c) the effective area of contact between the wheel and axle is reduced
  - (d) None of the above statements is correct

- 17.** In cricket match, while catching a fast moving ball, a fielder in the ground gradually pulls his hands backwards with the moving ball to reduce the velocity to zero. The act represents [CDS]
- Newton's first law of motion
  - Newton's second law of motion
  - Newton's third law of motion
  - Law of conservation of energy
- 18. Statement A:** Pulling a lawn roller is easier than pushing it. **Statement B :** Pushing increases the apparent weight and hence the force of friction. [CDS]
- Statement A is correct.
  - Statement B is correct.
  - Both statements are correct.
  - Both statements are incorrect.
- 19.** It is difficult to cut things with a blunt knife because [CDS]
- the pressure exerted by knife for a given force increases with increase in bluntness
  - a sharp edge decreases the pressure exerted by knife for a given force
  - a blunt knife decreases the pressure for a given force
  - a blunt knife decreases the area of intersection
- 20. Statement A :** When a gun is fired it recoils, i.e., it pushes back, with much less velocity than the velocity of the bullet. **Statement B :** Velocity of the recoiling gun is less because the gun is much heavier than the bullet. [CDS]
- Statement A is correct.
  - Statement B is correct.
  - Both statements are correct.
  - Both statements are incorrect.
- 21.** Two teams are pulling a rope with equal and opposite forces each of 5 kN in a tug of war so that a condition of equilibrium exists. What will be the tensile force in the rope? [NDA]
- Zero
  - 2.5 kN
  - 5 kN
  - 10 kN
- 22.** **Column-I**                   **Column-II**
- |                                    |                                    |
|------------------------------------|------------------------------------|
| A. Rocket propulsion               | P. Force                           |
| B. Agent which causes acceleration | Q. Momentum                        |
| C. Product of mass and velocity    | R. S.I. unit of force              |
| D. Newton                          | S. Law of conservation of momentum |
- $A \rightarrow S; B \rightarrow P; C \rightarrow R; D \rightarrow Q$
  - $A \rightarrow P; B \rightarrow S; C \rightarrow R; D \rightarrow Q$
  - $A \rightarrow S; B \rightarrow P; C \rightarrow Q; D \rightarrow R$
  - $A \rightarrow P; B \rightarrow S; C \rightarrow Q; D \rightarrow R$
- 23. Statement A :** While walking on ice, one should take small steps to avoid slipping. **Statement B :** This is because smaller steps ensure smaller friction.
- Statement A is correct.
  - Statement B is correct.
  - Both statements are correct.
  - Both statements are incorrect.
- 24.** Thomas and Mary are playing carom board. They arrange the seeds in the vertical order. Thomas strikes on the seeds with the striker, with a great speed. He finds that, the stakes do not fall down. On the other hand, when he strikes the seeds with less speed, all the seeds of the stakes fell down.
- Which property of force this shows?
- Newton's third law
  - Motion
  - Inertia
  - Reaction of force
- 25.** A man getting down a running bus, falls forward because-
- due to inertia of rest, road is left behind and man reaches forward
  - due to inertia of motion upper part of body continues to be in motion in forward direction while feet come to rest as soon as they touch the road
  - he leans forward as a matter of habit
  - of the combined effect of all the three factors stated in (a), (b) and (c)
- 26.** The work done becomes zero if
- force perpendicular to the displacement
  - displacement is zero
  - force acting on the body is zero
  - All of the above
- 27.** When an incandescent electric bulb glows [CDS]
- the electric energy is completely converted into light
  - the electric energy is partly converted into light energy and partly into heat energy
  - the light energy is converted into electric energy
  - the electric energy is converted into magnetic energy
- 28.** The sum of the change in kinetic and potential energy is always [SSC CGL]
- Zero
  - Positive
  - Negative
  - None of the above
- 29.** The potential energy is always the same for an object with the same
- Velocity
  - Speed
  - Acceleration
  - Position
- 30.** If velocity of a body is twice of previous velocity, then kinetic energy will become [NDA]
- 2 times
  - 1/2 times
  - 4 times
  - 1 times
- 31.** In case of negative work the angle between the force and displacement is
- $0^\circ$
  - $45^\circ$
  - $90^\circ$
  - $180^\circ$
- 32.** How much time will it take to perform 440 J of work at a rate of 11 W?
- 50 s
  - 40 s
  - 30 s
  - 20 s
- 33.** When a stone tied to a string is whirled in a circle, the work done on it by the string is
- positive
  - negative
  - zero
  - undefined
- 34.** Match the Column I and Column II.
- Column-I**                   **Column-II**
- |                              |   |
|------------------------------|---|
| A. Electric motor            | P. Electrical energy to sound energy      |
| B. Electric bell             | Q. Electrical energy to mechanical energy |
| C. Electric bulb electrical  | R. Light energy to energy                 |
| D. Photoelectric mechanical  | S. Heat energy to cell energy             |
| E. Steam engine light energy | T. Electric energy to                     |

- (a) A-P; B-Q; C-T; D-R; E-S
- (b) A-Q; B-P; C-T; D-T; E-S
- (c) A-Q; B-P; C-T; D-S; E-R
- (d) A-Q; B-P; C-T; D-R; E-S

35. Which one of the following physical quantities is represented by the shaded area in the given graph?



- (a) Torque
- (b) Impulse
- (c) Power
- (d) Work done

36. Two masses  $m$  and  $9m$  are moving with equal kinetic energies. The ratio of the magnitudes of their momenta is

- (a)  $1 : 1$
- (b)  $1 : 3$
- (c)  $3 : 1$
- (d)  $1 : 9$

37. A particle oscillates in one dimension about the equilibrium position subject to a force  $F_x(x)$  that has an associated potential energy  $U(x)$ . If  $k$  is the force constant, which one of the following relations is true? [NDA]

- (a)  $F_x(x) = -kx^2$
- (b)  $F_x(x) = -kx$
- (c)  $U(x) = \frac{1}{2}kx$
- (d)  $U(x) = \frac{1}{2}k^2x$

38. If a light body and a heavy body have equal momentum, then [NDA]

- (a) the lighter body has greater energy than the heavier body
- (b) the lighter body has lesser kinetic energy than the heavier body
- (c) the kinetic energy of the lighter body is equal to the kinetic energy of the heavier body
- (d) the kinetic energy of both the bodies are independent of momentum.

39. A rubber ball dropped from 24 m height loses its kinetic energy by 25%. What is the height to which it rebounds.

- (a) 6 m
- (b) 12 m
- (c) 18 m
- (d) 24 m

40. The potential energy of a freely falling object decreases progressively.

- (a) The law of conservation of energy is violated
- (b) Potential energy gets converted into kinetic energy progressively
- (c) Sum of Potential Energy and Kinetic Energy at any point during the free fall remains constant
- (d) Both (b) and (c)

41. In which of the following examples, work done is negative?

- (a) Work done by the force of gravity on a moving aeroplane
- (b) Work done by the force of gravity on a ball thrown upwards
- (c) Work done by the force of gravity on a freely falling object
- (d) Work done by the force of gravity on a satellite revolving around the earth

42. Assertion : A man gets completely exhausted in trying to push a stationary wall.  
Reason : Work done by the man on the wall is zero.

- (a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
- (b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
- (c) If Assertion is correct but Reason is incorrect.
- (d) If Assertion is incorrect but Reason is correct.

43. A boy has four options to move a body through 3m as indicated. In which case is maximum work done?

- (a) Push over an inclined plane
- (b) Lift vertically upwards
- (c) Push over smooth rollers
- (d) Push on a plane horizontal surface

44. An electrical appliance of 500 W is used for 5 hours per day. Energy consumed in 30 days will be

- (a) 2.5 kW h
- (b) 25 kW h
- (c) 75 kW h
- (d) None of these

45. Two persons do the same amount of work, one in 10 s and the other in 20 s. Find the ratio of the power used by the first person to that by the second person.

- (a) 6 : 4
- (b) 2 : 1
- (c) 5 : 2
- (d) 4 : 3

46. Rahul takes 1 minute to raise a box to a height of 1 metre and Rohan takes 1/2 minute to do so. Comment on the energy by the two.

- (a) Energy spent by the Rahul is more.
- (b) Energy spent by both Rahul and Rohan is same.
- (c) Energy spent by the Rohan is more
- (d) Cannot be said

47. Gravitational potential energy of an object will

- (a) increase by increasing the path along which the object is moved
- (b) decrease by increasing the path along which the object is moved
- (c) not effected by changing the path, provided the overall height is same
- (d) None of these

48. When you compress a coil spring you do work on it. The elastic potential energy

- (a) increases
- (b) decreases
- (c) disappears
- (d) remains the same

49. No work is done when

- (a) a nail is plugged into a wooden board
- (b) a box is pushed along a horizontal floor
- (c) there is no component of force parallel to the direction of motion
- (d) there is no component of force normal to the direction of force

50. Two identical particles move towards each other with velocity  $2v$  and  $v$  respectively. The velocity of centre of mass is

- (a)  $v$
- (b)  $v/3$
- (c)  $v/2$
- (d) zero

51. A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same which one of the following will not be affected ?  
 (a) Angular velocity  
 (b) Angular momentum  
 (c) Moment of inertia  
 (d) Rotational kinetic energy
52. A couple is acting on a two particle systems. The resultant motion will be  
 (a) purely rotational motion  
 (b) purely linear motion  
 (c) both a and b  
 (d) neither of a and b
53. A simple machine helps a person in doing: [IAS Prelim]  
 (a) less work  
 (b) the same amount of work with lesser force  
 (c) the same amount of work slowly  
 (d) the same amount of work much faster
54. The wide handle of screw is based upon  
 (a) Newton's second law of motion  
 (b) law of conservation of linear momentum  
 (c) turning moment of force  
 (d) None of these
55. For a particle revolving in a circular path, the acceleration of the particle is [NDA]  
 (a) along the tangent  
 (b) along the radius  
 (c) zero  
 (d) along the circumference of the circle
56. A fan is moving around its axis. What will be its motion regarded as ?
57. Pure rolling  
 (a) Rolling with slipping  
 (b) Skidding  
 (c) Pure rotation
58. A composite disc is to be made using equal masses of aluminium and iron so that it has as high a moment of inertia as possible. This is possible when  
 (a) the surfaces of the disc are made of iron with aluminium inside  
 (b) the whole of aluminium is kept in the core and the iron at the outer rim of the disc  
 (c) the whole of the iron is kept in the core and the aluminium at the outer rim of the disc  
 (d) the whole disc is made with thin alternate sheets of iron and aluminium
59. During summersault, a swimmer bends his body to  
 (a) increase moment of Inertia  
 (b) decrease moment of Inertia  
 (c) decrease the angular momentum  
 (d) reduce the angular velocity
60. For a given mass and size, moment of inertia of a solid disc is  
 (a) more than that of a ring  
 (b) less than that of a ring  
 (c) equal to that of a ring  
 (d) depend on the material of ring and disc
61. A gymnast takes turns with her arms & legs stretched. When she pulls her arms and legs [CDS]  
 (a) the angular velocity decreases  
 (b) the moment of inertia decreases  
 (c) the angular velocity stays constant  
 (d) the angular momentum increases

ANSWER KEY																			
1.	(a)	2.	(d)	3.	(a)	4.	(a)	5.	(b)	6.	(c)	7.	(b)	8.	(c)	9.	(c)	10.	(d)
11.	(d)	15.	(c)	16.	(b)	14.	(b)	15.	(a)	16.	(c)	17.	(b)	18.	(a)	19.	(c)	20.	(a)
21.	(c)	22.	(c)	23.	(a)	24.	(c)	25.	(c)	26.	(d)	27.	(b)	28.	(a)	29.	(d)	30.	(c)
31.	(d)	32.	(b)	33.	(c)	34.	(d)	35.	(d)	36.	(b)	37.	(b)	38.	(c)	39.	(c)	40.	(d)
41.	(b)	42.	(a)	43.	(b)	44.	(c)	45.	(b)	46.	(b)	47.	(c)	48.	(a)	49.	(d)	50.	(c)
51.	(b)	52.	(a)	53.	(b)	54.	(c)	55.	(b)	56.	(d)	57.	(b)	58.	(b)	59.	(b)	60.	(b)

# Chapter

# 3

# FORCE OF GRAVITY, SOLIDS & FLUIDS

## FORCE OF GRAVITY

Earth attracts every body towards itself with a force known as ‘gravity’. Due to the force of gravity the ball thrown upwards doesn’t go upwards but it falls downwards after covering some vertical distance. Actually, every object attracts every other object towards itself with a force. This force is called the gravitational force. Gravitational force is one among the four fundamental forces. It is always attractive in nature.

### NEWTON’S UNIVERSAL LAW OF GRAVITATION

Newton came to the conclusion that any two objects in the Universe exert gravitational attraction on each other.

Any two particles of matter anywhere in the universe attract each other with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them,

$$\text{i.e. } F \propto \frac{m_1 m_2}{r^2} \quad \text{or} \quad F = \frac{G m_1 m_2}{r^2}$$

Here, the constant of proportionality  $G$  is known as the **universal gravitational constant**. It is termed a “universal constant” because it is thought to be the same at all places and all times.

$$G = 6.673 \times 10^{-11} \text{ Nm}^2/\text{kg}^2.$$

#### Handy Facts

The value of universal gravitational constant,  $G$  is very small—hence gravitational force is very small, unless one (or both) of the masses is huge.

### Important Characteristics of Gravitational Force

- Gravitational forces are always attractive and always acts along the line joining the two masses.
- Gravitational force is a mutual force hence it is action-reaction force, i.e.,  $\vec{F}_{12} = -\vec{F}_{21}$ .
- Value of  $G$  is small, therefore, gravitational force is weaker than electrostatic and nuclear forces.
- Gravitational force is a central force because  $F \propto \frac{1}{r^2}$ .
- The gravitational force between two masses is independent of the presence of other objects and medium between the two masses.

### Importance of the Universal Law of Gravitation

The universal law of gravitation successfully explained several phenomena which were believed to be unconnected.

- the force that binds us to the earth
- the motion of the moon around the earth
- the motion of planets around the Sun and
- the tides due to the moon and the Sun.

### MASS AND WEIGHT

The quantity of matter in a body is known as the mass of the body. Mass is quantitative measure of inertia. Mass is an intrinsic property of matter and does not change as an object is moved from one location to another.

Weight, in contrast, is the gravitational force that the earth exerts on the object and can vary, depending on how far the object is above the earth’s surface or whether it is located near another body such as the moon.

The relation between weight  $W$  and mass  $m$

$$W = \frac{GM_E m}{r^2}; \quad W = mg$$

As  $g_{\text{moon}} = \frac{1}{6} g_{\text{earth}}$  therefore,

$$w_{\text{moon}} = \frac{1}{6} w_{\text{earth}}$$

### Inertial and Gravitational Mass

The mass of a body is the quantity of matter possessed by a body.

**Inertial Mass:** Inertial mass of a body is related to its inertia of linear motion, and is defined by Newton’s second law of motion.

$$F = m_i a \quad \text{or} \quad m_i = \frac{F}{a}$$

The mass  $m_i$  of the body in this sense is the inertial mass of the body.

Infact, inertial mass of a body is the measure of the ability of the body to oppose the production of acceleration in its motion by an external force.

#### Properties of inertial mass

- It is proportional to the quantity of matter contained in the body.
- It is independent of size, shape and state of the body.
- It does not depend upon the temperature of the body.

#### Gravitational Mass

Gravitational mass of a body is related to gravitational pull on the body and is defined by Newton’s law of gravitation.

If a body of mass  $m_G$  is placed on the surface of earth of radius  $R$  and mass  $M$ , then gravitational pull on the body is given by

$$F = \frac{GMm_G}{R^2} \Rightarrow m_G = \frac{F}{(GM/R^2)}$$

The mass  $m_G$  of the body in this sense is the gravitational mass of the body.

## ACCELERATION DUE TO GRAVITY OF THE EARTH

When a body is dropped from a certain height above the ground, it begins to fall towards the earth under gravity. The acceleration produced in the body due to gravity is called the acceleration due to gravity. It is denoted by  $g$ . Its value close to the Earth's surface is  $9.8 \text{ m/s}^2$ .

$$g = \frac{F}{m} \quad \text{or} \quad g = \frac{GM}{R^2}$$

This is the **relation between acceleration due to gravity (g) and universal gravitational constant (G)**.

Acceleration due to gravity,

$$g = \frac{GM}{R^2} \quad \text{or} \quad g = \frac{4}{3}\pi G R \rho$$

## VARIATION IN ACCELERATION DUE TO GRAVITY

The value of 'g' acceleration due to gravity, varies from place to place on the surface of earth. It also varies as we go above or below the surface of the Earth.

**Variation in g with height or altitude:**

$$g' = g \left(1 - \frac{2h}{R_e}\right)$$

i.e. The decrease in the value of  $g$  on going up a height 'h' above the surface of earth by a factor  $\left(1 - \frac{2h}{R_e}\right)$

**Variation in g with depth:**

$$g' = g \left(1 - \frac{d}{R_e}\right)$$

Thus the value of  $g$  decreases by a factor  $\left(1 - \frac{d}{R_e}\right)$  as we go down below the surface of the earth.

### Science in Action

- As the skydiver falls, his speed increases along with the increase in air resistance. Now this force of air resistance increases until it reaches the magnitude of force of gravity. Once this force is more than the force of gravity then forces are balanced and it reaches a terminal velocity. Then it no longer accelerates.
- A clock which is controlled by a pendulum when taken from the plains to a mountain it becomes slow but the wrist-watch which is simply controlled by spring remains the same. This is due to the variation in the value of  $g$ . Spring remains unaffected whereas the value of  $g$  decreases in the mountain and thus the time period of the pendulum increases.

## ESCAPE SPEED

Escape speed is the minimum speed that should be given to the body to enable it to escape away from the gravitational field of earth.

If the mass of the planet is  $M$  and its radius is  $R$ , then the escape speed from its surface will be

$$V_e = \sqrt{(2GM/R)} \quad \text{or} \quad V_e = \sqrt{(2gR)}$$

Escape speed from the surface of earth is  $11.2 \text{ Km/sec.}$

### Handy Facts

The escape velocity of a body from a planet depends upon the size (mass and radius) of the planet and hence the value of acceleration due to gravity on its surface. It does not depend upon mass of the body. To throw an ant or an elephant out of the gravitational field, the required velocity of projection is same.

## KEPLER'S LAWS OF PLANETARY MOTION

Kepler worked out three laws, which govern the motion of planets and are known as *Kepler's laws of planetary motion*.

**Law of orbits (first law) :** All planets revolve in elliptical orbits around the sun and the sun is situated at one of the two foci of the elliptical path.

## SATELLITES

Just as the planets revolve around the sun, in the same way few celestial bodies revolve around these planets. These bodies are called 'Satellites'.

For example moon is the natural satellite of Earth. Artificial satellites are launched from the Earth. Such satellites are used for telecommunication, weather forecast etc. The path of these satellites are elliptical with the centre of Earth at a focus.

### Characteristics of Motion of Satellites

**Orbital velocity ( $v_0$ ) :** Let a satellite of mass  $m$  revolves around the Earth in circular orbit of radius  $r$  with speed  $v_0$ . The gravitational pull between satellite and earth provides the necessary centripetal force.

$$\text{Orbital velocity } (v_0) = \sqrt{(Gm/R)} = \sqrt{(gR)}$$

**Relation between escape speed ( $v_e$ ) and orbital speed ( $v_0$ ) :**  
 $v_e = \sqrt{2}v_0$

- Value of orbital velocity does not depend on the mass of satellite but it depends on the mass and radius of the planet around which the rotation is taking place.
- The orbital velocity for a satellite near the surface of earth is  $7.92 \text{ km/sec.}$
- Energy of satellite :** A satellite revolving around a planet has both kinetic and potential energy.

**Kinetic energy :** The kinetic energy of the satellite is due to motion of the satellite.

$$K = \frac{GMm}{2r}$$

**Potential energy :** Potential energy of the satellite,

$$U = -\frac{GMm}{r}$$

The negative sign is because of zero potential energy at infinity.

- Binding energy :** The energy required to remove the satellite from its orbit to infinity is called binding energy of the system.

$$\text{Binding energy of satellite, } E = \frac{GMm}{2r}$$

- When the satellite is orbiting in its orbit, then no energy is required to keep it in its orbit.
- When the energy of the satellite is negative then it moves in either a circular or an elliptical orbit.

## TYPES OF SATELLITES

### Geo-stationary Satellite

A satellite which appears to be stationary for a person on the surface of the Earth is called geostationary satellite.

It is also known as Communication Satellite or Synchronous Satellite.

#### Features of Geo-stationary Satellite

- The orbit of the satellite must be circular and in the equatorial plane of the Earth.
- The angular velocity of the satellite must be in the same direction as the angular velocity of rotation of the earth i.e., from west to east.
- The period of revolution of the satellite must be equal to the period of rotation of earth about its axis.  
i.e., 24 hours =  $24 \times 60 \times 60 = 86400$  sec.
- Height from the surface of the earth is nearly 35600 km.
- The orbital velocity of this satellite is nearly 3.08 km/sec.
- The relative velocity of geostationary satellite with respect to earth is zero. This type of satellite is used for communication purposes. The orbit of a geostationary satellite is called '*Parking Orbit*'.

#### Applications of Geo-stationary Satellite

- In weather forecasting, broadcasting and in predictions of the flood and droughts.
- In telecommunication and radio transmissions.

### Polar Satellite

Polar Satellites go around the poles of the earth in north-south direction and the earth rotates around its axis in east-west direction. The altitude of polar satellite is around 500 to 800 km and its time period is around 100 minutes.

### FREE FALL

The motion of a body under the influence of gravity alone is called a free fall. When a body falls freely towards the earth, its velocity continuously increases. The acceleration developed in its motion is called acceleration due to gravity (g).

$$g = \frac{GM}{R^2}$$

This gives the acceleration due to gravity on the surface of the earth.  $g = 9.8 \text{ m/s}^2$

### WEIGHTLESSNESS

The phenomenon of "weightlessness" occurs when there is no force of support on your body.

## SOLIDS AND FLUIDS

This chapter deals with an introduction to the mechanical properties of materials-solids: how they stretch and compress, fatigue, break and shear.

**Liquids** and **gases** flow, and we call both fluids. Their atoms and/or molecules can move around fairly freely.

**Viscosity** is the internal resistance or friction, offered to an object moving through a fluid.

### ELASTICITY

The property of the body by virtue of which it tends to regain its original shape and size after removing the deforming force is

called **elasticity**. If the body regains its original shape and size completely, after the removal of deforming forces, then the body is said to be **perfectly elastic**.

The property of the body by virtue of which it tends to retain its deformed state after removing the deforming force is called **plasticity**. If the body does not have any tendency to recover its original shape and size, it is called **perfectly plastic** e.g., putty and mud.

#### Science in Action

- Bridges are designed using the concept of elasticity so that it can withstand heavy load of traffic and force of strongly blowing wind.
- The thickness of the metallic rope used in the crane in order to lift a given load is decided from the knowledge of elastic limit of the material.

## STRESS AND STRAIN

### Stress

The internal restoring force acting per unit area of a body is called stress.

i.e., Stress = Restoring force / Area

#### Handy Facts

Materials behave differently under stress. When dropped, a glass tumbler shatters into pieces, a rubber ball deforms then bounces back and a metal suffers dents.

### Strain

When a deforming force is applied on a body, there is a change in the configuration of the body. The body is said to be strained or deformed. The ratio of change in configuration to the original configuration is called strain.

$$\text{i.e., Strain} = \frac{\text{Change in configuration}}{\text{Original configuration}}$$

Strain being the ratio of two like quantities has **no units** and **dimensions**.

### HOOKE'S LAW

Elastic limit is the upper limit of deforming force up to which, if deforming force is removed, the body regains its original form completely and beyond which if deforming force is increased, the body loses its property of elasticity and gets permanently deformed.

Within the elastic limit, stress is proportional to strain.

i.e., Stress  $\propto$  strain or, stress = E  $\times$  strain

This constant E is known as **modulus of elasticity** or **coefficient of elasticity**. It depends upon the nature of the materials.

### Types of Modulus of Elasticity

Corresponding to three types of strain, there are three types of modulus of elasticity:

#### Young's Modulus of Elasticity (Y)

$$Y = \frac{\text{normal stress}}{\text{longitudinal strain}}$$

#### Bulk or Volume Modulus of Elasticity (K)

$$K = \frac{\text{Normal stress}}{\text{Volumetric strain}}$$

If  $p$  is the increase in pressure applied on the spherical body then,  $F/A = P$

The reciprocal of bulk modulus of elasticity of a material is called its **Compressibility**.

$$\text{Compressibility} = \frac{1}{K}$$

### **Brittle, Ductile and Malleable solids**

There are some materials which break as soon as the stress is increased beyond the elastic limit. They are called **brittle**, e.g. glass, ceramics etc.

Materials which have large plastic range of extension are called **ductile**. Using this property, materials can be drawn into thin wires, e.g. copper, aluminium etc.

Materials which can be hammered into thin sheets are called **malleable** e.g. gold, silver, lead, etc.

**Elastomers** : Rubber has a large elastic region. It can be stretched several times its original length. On the removal of stress it returns to its original state. But the stress-strain graph is not a straight line. This means, it does not obey Hooke's law e.g. rubber, elastic tissue of aorta etc.

#### **Handy Facts**

Metals are polycrystalline materials. They are elastic for small strains and for large strains, metals become plastic.

## **FLUIDS**

Fluids include liquids and gases. They begin to flow when a shearing stress is applied. Fluids have no definite shape. They assume the shape of containing vessel.

### **Density ( $\rho$ )**

Mass per unit volume is defined as **density**.

$$\text{Density, } \tau = \frac{\text{mass (m)}}{\text{volume (V)}}$$

SI unit :  $\text{kg/m}^3$

### **Specific Weight or Weight Density (W)**

$$\text{Specific weight, } W = \frac{\text{Weight}}{\text{Volume}}$$

$$= \frac{mg}{V} = \left[ \frac{m}{V} \right] g = \rho g$$

S I Unit:  $\text{N/m}^3$

Specific weight of pure water at  $4^\circ\text{C}$  is  $9.81 \text{ kN/m}^3$

### **Relative Density**

$$\text{Relative density (R.D.)} = \frac{\text{Density of given liquid}}{\text{Density of pure water at } 4^\circ\text{C}}$$

The density of water is maximum at  $4^\circ\text{C}$  and is equal to  $1.0 \times 10^3 \text{ kg m}^{-3}$ .

### **Specific Gravity**

It is defined as the ratio of the specific weight of the given fluid to the specific weight of pure water at  $4^\circ\text{C}$ .

Specific gravity =

$$\frac{\text{Specific weight of given liquid}}{\text{Specific weight of water at } 4^\circ\text{C}}$$

Specific weight of pure water at  $4^\circ\text{C}$  ( $9.81 \text{ kN/m}^3$ )

$$= \frac{\rho_\ell \times g}{\rho_w \times g} = \frac{\rho_\ell}{\rho_w} = \text{R.D. of the liquid}$$

## **PRESSURE IN A FLUID**

The pressure exerted by a fluid is defined as the force per unit area at a point within the fluid.

$$P_{av} = \frac{\Delta F}{\Delta A}$$

When the force is constant over the surface, the above equation reduces to  $P = F/A$

The **SI unit** of pressure is  $\text{Nm}^{-2}$  and is also called pascal ( $\text{Pa}$ ).

The other common pressure units are *atmosphere and bar*.

$1\text{atm} = 1.01325 \times 10^5 \text{ Pa}$ ,  $1\text{ bar} = 1.00000 \times 10^5 \text{ Pa}$ ,

$1\text{atm} = 1.01325 \text{ bar}$

### **Expression for liquid pressure and total pressure**

The liquid pressure at a depth  $h$  is given by

$P = \rho gh$  where  $\rho$  is the density of the liquid.

and the total pressure at the same depth  $h$

$P_{\text{total}} = P_{\text{atm}} + \rho gh$ , where  $P_{\text{atm}}$  is atmospheric pressure.

## **ATMOSPHERIC PRESSURE, ABSOLUTE PRESSURE AND GAUGE PRESSURE**

### **Atmospheric Pressure**

Force exerted by air column on unit cross-section area of sea level is called *atmospheric pressure* ( $P_0$ )

$$P_0 = \frac{F}{A} = 101.3 \text{ kN/m}^2$$

**Barometer** is used to measure atmospheric pressure which was discovered by Torricelli.

Atmospheric pressure varies from place to place and at a particular place from time to time.

### **Absolute Pressure**

Sum of atmospheric and gauge pressure is called absolute pressure.

$$\begin{aligned} P_{\text{abs}} &= P_{\text{atm}} + P_{\text{gauge}} \\ \Rightarrow P_{\text{abs}} &= P_0 + h \rho g \end{aligned}$$

### **Pascal's Law**

According to Pascal's law – A pressure applied to a confined fluid at rest is transmitted equally undiminished to every part of the fluid and the walls of the container. This principle is used in a hydraulic presses, brakes, jack or lift, etc.

#### **Science in Action**

- Passengers when travelling in an aeroplane remove ink from their fountain pen as the atmospheric pressure decreases when the aeroplane is up in the sky.
- Bleeding from nose is caused when a person is there at higher altitudes, as the atmospheric pressure is less compared with blood pressure. Thus the blood vessels exposed inside the nose are more likely to burst and can cause bleeding.

## **ARCHIMEDES' PRINCIPLE**

A body immersed in a fluid partly or wholly experiences an upward buoyant force equivalent to the weight of the fluid displaced by it. The buoyant force acts through the centre of gravity of the displaced fluid. The phenomenon of force exerted by fluid on the body is called buoyancy and the force is called buoyant force.

A body experiences buoyant force whether it floats or sinks, under its own weight or due to other forces applied on it.

Body **float**, if weight of it is less than buoyant force and **sink**, if weight of the body is greater than buoyant force.

## SURFACE TENSION

Surface tension can be defined in the form of an imaginary line on the liquid surface or by relating it to the work done. The force acting per unit length of an imaginary line drawn on the free liquid surface at right angles to the line and in the plane of liquid surface, is known as surface tension.

$$\text{Surface tension, } T = \frac{F}{L}$$

Its SI unit : N/m or J/m<sup>2</sup>.

### Examples of surface tension

- Raindrops are spherical in shape.
- The hair of a shaving brush cling together when taken out of water.
- Oil spread on cold water but remains as a drop on hot water etc.

### Factors Affecting Surface Tension

- Cohesive force      • Impurities
- Temperature        • Electrification

## Surface Energy

According to molecular theory of surface tension the molecules in the surface have some additional energy due to their position. This additional energy per unit area of the surface is called surface energy.

$$\text{i.e., Surface energy} = \frac{\text{Work done}}{\text{Increase in surface area}}$$

### Angle of Contact

The angle enclosed between the tangent plane at the liquid surface and the tangent plane at the solid surface at the point of contact inside the liquid is termed as the **angle of contact**.

The angle of contact depends on the nature of the solid and liquid in contact.

**Shape of liquid surface :** When a liquid is brought in contact with a solid surface, the surface of the liquid becomes curved (concave or convex) near the place of contact.

The free surface of a liquid which is near the walls of a vessel and which is curved because of surface tension is known as **meniscus**. Meniscus concave for glass water and meniscus convex for glass-mercury.

Angle of contact depends upon the surfaces in contact.

**Water proofing agent :** Angle of contact increases due to water proofing agent. It gets converted from acute to obtuse angle.

## Capillary Rise

A glass tube with fine bore and open at both ends is known as **capillary tube**. The property by virtue of which a liquid rise or fall in a capillary tube is known as **capillary rise or fall or capillarity**. Rise or fall of liquid in tubes of narrow bore (capillary tube) is called *capillary action*.

### Handy Facts

When the capillary tube is of insufficient length, the liquid will not overflow. It rises upto the top end of the tube and then adjusts the radius of curvature of its meniscus.

## FLOW OF LIQUID

### Streamline Flow

When a liquid (fluid) flows, such that each particle of the liquid passing a point moves along the same path and has the same velocity as its predecessor then the flow is called stream line flow. It is also called laminar flow.

## Turbulent Flow

When the velocity at a point in the liquid changes with time the flow is called unsteady flow.

## BERNOULLI'S THEOREM

When incompressible, non-viscous, irrotational liquid i.e., ideal liquid flow from one position to other in streamline path then in its path at every point, the sum of pressure energy, kinetic energy and potential energy per unit volume remains constant.

### Science in Action

**Dynamic lift :** The wings of the aeroplane are having tapering. Due to this specific shape of wings when the aeroplane runs, air passes at higher speed over it as compared to its lower surface. This difference of air speeds above and below the wings, in accordance with Bernoulli's principle, creates a pressure difference, due to which an upward force called 'dynamic lift' acts on the plane. If this force becomes greater than the weight of the plane, the plane will rise up. During **storms**, the wind blows with very high speed which leads to blowing off the tinned roofs. This is because the pressure above the roof is less than the pressure below the roof.

## VISCOSITY

"The property of a fluid by virtue of which it opposes the relative motion between its different layers is known as viscosity and the force that is into play is called the *viscous force*".

### Effect of Temperature and Pressure on Viscosity

**Effect of temperature:** On increasing temperature viscosity of a liquid decreases.

**Effect of pressure:** On increasing pressure viscosity of a liquid increases except water whose viscosity decreases with pressure rise.

### Science in Action

An oil, when used as lubricant in a machine, forms a thin layer of the oil over the metallic parts of the machinery. During working of the machinery, the metallic parts do not come in direct contact with each other. The friction between solid-solid surfaces gets converted into friction between solid-liquid surfaces. So that the oil layer is effective as lubricant for a long time, the oil should be of high viscosity.

## Stoke's Law

When a solid moves through a viscous medium, its motion is opposed by a viscous force depending on the velocity and shape and size of the body.

### Importance of Stoke's law

- It is used in the determination of electronic charge with the help of Millikan's experiment.
- It accounts the formation of clouds.
- It accounts why the speed of rain drops is less than that of a body falling freely with a constant velocity from the height of clouds.
- It helps a man coming down with the help of a parachute.

### Terminal Velocity

It is the maximum constant velocity acquired by the body while falling freely in a viscous medium.

## EXERCISE

1. The value of acceleration due to gravity
    - (a) is same on equator and poles
    - (b) is least on poles
    - (c) is least on equator
    - (d) increases from pole to equator
  2. Two objects of different masses falling freely near the surface of moon would
    - (a) have same velocities at any instant
    - (b) have different accelerations
    - (c) experience forces of same magnitude
    - (d) undergo a change in their inertia
  3. Which one among the following is the correct value of the gravitational force of the Earth acting on a body of mass 1 kg?
 

(a) 8. 9 N	(b) 9. 8 N
(c) 89 N	(d) 98 N
  4. A geostationary satellite
    - (a) can move about any axis
    - (b) must move about the polar axis
    - (c) must move on an axis in the equatorial plane
    - (d) Both (b) and (c)
  5. An astronaut in the orbit in a spacecraft feels weightlessness
    - (a) due to the absence of gravity inside
    - (b) due to the fact that space craft has no energy
    - (c) because acceleration in the orbit is equal to acceleration of gravity outside
    - (d) there is no gravity outside
  6. The weight of a body is 9.8 N at the place where  $g = 9.8 \text{ ms}^{-2}$ . Its mass is [NDA]

(a) zero	(b) 9.8 kg
(c) 10 kg	(d) 1 kg
  7. If the moon is to escape from the gravitational field of the earth forever, it will require a velocity [SSC CGL]

(a) 11.2 km/s	(b) less than
(c) slightly more than 111.2 km/s	
(d) 22.4 km/s	
  8. In respect of the difference of the gravitational force from electric and magnetic forces, which one of the following statements is true ?
    - (a) Gravitational force is stronger than the other two.
    - (b) Gravitational force is attractive only, whereas the electric and the magnetic forces are attractive as well as repulsive.
    - (c) Gravitational force has a very short range.
    - (d) Gravitational force is a long range force, while the other two are short range forces.
- Directions (Qs. 9):** Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.
- (a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
  - (b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
  - (c) Assertion is correct, reason is incorrect
  - (d) Assertion is incorrect, reason is correct.
9. **Assertion :** The tidal waves in sea are primarily due to the gravitational effect of earth.  
**Reason :** The intensity of gravitational field of earth is maximum at the surface of earth.
  10. Consider the following statements: [NDA]
    1. The gravitational force exerted by the sun on the moon is greater than the gravitational force exerted by the earth on the moon.
    2. A heavy body falls at a faster rate than a light body in vacuum.

Which of the following statements given above is/are correct ?

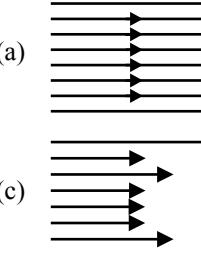
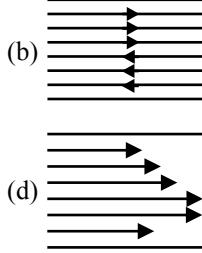
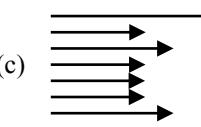
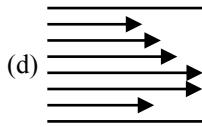
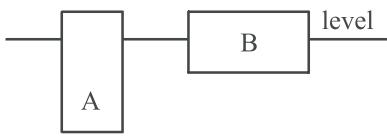
    - (a) 1 only
    - (b) 2 only
    - (c) Both 1 and 2
    - (d) Neither 1 nor 2
  11. A body weighs 5 kg on equator. At the poles it is likely to weight [NDA]

(a) 5 kg	(b) less than 5 kg but not zero
(c) 0 kg	(d) more than 5 kg
  12. A spring balance is graduated on sea level. A body of mass 1 kg is weighed at consecutively increasing heights from the earth's surface, then what would be the weight indicated by the balance?
    - (a) Weight will go on increasing continuously
    - (b) Weight will go on decreasing continuously
    - (c) Weight will remain same
    - (d) Weight will first increase and then decreases
  13. The mass of a body on earth is 100 kg (acceleration due to gravity,  $g_e = 10 \text{ m/s}^2$ ). If acceleration due to gravity on the moon is  $g_e / 6$ , then the mass of the body on the moon is : [IAS Prelim]

(a) $100/6 \text{ kg}$	(b) 60 kg
(c) 100 kg	(d) 600 kg
  14. Match the columns I and II.
 

Column I	Column II
(A) Weight	(1) Minimum
(B) $g_{\text{equator}}$	(2) Zero
(C) $g_{\text{poles}}$	(3) Vector
(D) $g_{\text{centre}}$	(4) Maximum
(a) (A) $\rightarrow$ (2) ; (B) $\rightarrow$ (1) ; (C) $\rightarrow$ (3) ; (D) $\rightarrow$ (4)	
(b) (A) $\rightarrow$ (2) ; (B) $\rightarrow$ (2) ; (C) $\rightarrow$ (4) ; (D) $\rightarrow$ (3)	
(c) (A) $\rightarrow$ (3) ; (B) $\rightarrow$ (1) ; (C) $\rightarrow$ (4) ; (D) $\rightarrow$ (2)	
(d) (A) $\rightarrow$ (4) ; (B) $\rightarrow$ (3) ; (C) $\rightarrow$ (1) ; (D) $\rightarrow$ (2)	
  15. **Assertion (A) :** The weight of a body decreases with the increase of altitude on earth.  
**Reason (R) :** The earth is not a perfect sphere. [IAS Prelim]
    - (a) Both A and R are true and R is the correct explanation of A
    - (b) Both A and R are true but R is not a correct explanation of A
    - (c) A is true but R is false
    - (d) A is false but R is true

16. If the radius of the earth were to shrink by one percent, its mass remaining the same, the value of  $g$  on the earth's surface would: [IAS Prelim]  
 (a) increase by 0.5% (b) increase by 2%  
 (c) decrease by 0.5% (d) decrease by 2%
17. An artificial satellite orbiting the earth does not fall down because the earth's attraction  
 (a) is balanced by the attraction of the moon  
 (b) vanishes at such distances  
 (c) is balanced by the viscous drag produced by the atmosphere  
 (d) produces the necessary acceleration of its motion in a curved path
18. Consider the following statements:  
 A body weighs less at the equator than at the poles because: [NDA]  
 1. earth rotates about its axis.  
 2. the ice cap at the poles increases gravitational pull.  
 3. equatorial diameter is greater than the polar diameter.  
 4. of some unknown facts.  
 Which of the statements given above is/are incorrect?  
 (a) 1 and 2 (b) 3 only  
 (c) 1 and 3 (d) 4 only
19. **Assertion (A)** Gravitational attraction is a central force and therefore in motion of planets in the solar system, the angular momentum is conserved.  
**Reason (R)** In the motion of planets of the solar system, equal areas are swept in equal time.  
 (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not the correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
20. Which one of the following statements regarding artificial satellite of the earth is incorrect?  
 (a) The orbital velocity depends on the mass of the satellite  
 (b) A minimum velocity of 8 km/s is required by a satellite to orbit quite close to the earth  
 (c) The period of revolution is large if the radius of its orbit is large  
 (d) The height of a geostationary satellite is about 36000 km from the earth.
21. **Assertion (A)** : Space rocket are usually launched in the equatorial line from west to east  
**Reason (R)** : The acceleration due to gravity is minimum at the equator.  
 (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not the correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
22. A body is at rest on the surface of earth. Which of the following statements is correct? [SSC CGL]  
 (a) Only weight of the body acts on it.  
 (b) Only upward force acts on the body.  
 (c) Frictional force acts on the body.  
 (d) Net upward force is equal to the net downward force.
23. Consider a satellite going round the earth in a circular orbit. Which of the following statements is wrong?  
 (a) It is a freely falling body.  
 (b) It is moving with constant speed  
 (c) It is acted upon by a force directed away from the centre of the earth which counter-balances the gravitational pull.  
 (d) It is an accelerated motion
24. **Assertion** : The value of ' $g$ ' is greater at the equator than at the poles.  
**Reason** : Radius is more at the equator than at the poles.  
 (a) If both **Assertion** and **Reason** are **correct** and **Reason** is the **correct explanation** of **Assertion**.  
 (b) If both **Assertion** and **Reason** are **correct**, but **Reason** is not the **correct explanation** of **Assertion**.  
 (c) If **Assertion** is **correct** but **Reason** is **incorrect**.  
 (d) If **Assertion** is **incorrect** but **Reason** is **correct**.
25. The substance which exhibits practically no elastic effect is  
 (a) rubber (b) quartz  
 (c) Fe (d) Cu
26. Kerosene oil rises up in a wick of lantern because of  
 (a) capillarity  
 (b) buoyant force  
 (c) diffusion of oil through the wick  
 (d) None of the above
27. The tendency of a liquid drop to contract and occupy minimum area is due to : [IAS Prelim]  
 (a) surface tension (b) viscosity  
 (c) density (d) vapour pressure
28. Which type/types of pen uses/use capillary action in addition to gravity for flow of ink? [CDS]  
 (a) Fountain pen  
 (b) Ballpoint pen  
 (c) Gel pen  
 (d) Both ballpoint and gel pens
29. When pressure exerted on an enclosed liquid or gas at rest, is transmitted equally in all the directions, is in accordance with:  
 (a) Pascal's law  
 (b) Boyle's law  
 (c) Archimedes' principle  
 (d) Principle of floatation
30. Purity of a metal can be determined with the help of  
 (a) Pascal's law  
 (b) Boyle's law  
 (c) Archimedes principle  
 (d) Conservation of mass principle
31. Flow velocities in an incompressible fluid can be measured with which one of the following? [NDA]  
 (a) Barometer (b) Venturi tube  
 (c) Strain gauge (d) Manometer
32. If a gas is heated at constant pressure its isothermal compressibility  
 (a) increases with temperature  
 (b) remains constant  
 (c) decreases with temperature  
 (d) decreases inversely with temperature

33. A liquid is flowing in a streamlined manner through a cylindrical pipe. Along a section containing the axis of the pipe, the flow profile will be : [IAS Prelim]
- (a) 
- (b) 
- (c) 
- (d) 
34. For which one of the following is capillarity not the reason? [IAS Prelim]
- (a) Blotting of ink  
 (b) Rising of underground water  
 (c) Spread a water drop on a cotton cloth  
 (d) Rising of water from the roots of a plant to its foliage
35. In scuba-diving, while ascending towards the water surface, there is a danger of bursting the lungs. It is because of [CDS]
- (a) Archimedes' principle  
 (b) Boyle's law  
 (c) Gay-Lussac's law of combining volumes  
 (d) Graham's law of diffusion
36. The specific gravity of a substance is measured by a hydrometer at the sea level. If the measurement is done at the top of a mountain, what would be the specific gravity ? [NDA]
- (a) Zero  
 (b) More than that measured at the sea level  
 (c) Less than that measured at the sea level  
 (d) Same as that measured at the sea level
37. A block of ice is floating in a beaker containing liquid of specific gravity greater than one. When ice melts completely what happens to the level of liquid in the beaker? [NDA]
- (a) It will remain the same as before  
 (b) It will go down  
 (c) It will rise up  
 (d) It may or may not change depending upon size of beaker
38. Assertion (A) : With the increase of temperature, the viscosity of glycerine increases. [NDA]  
**Reason (R)** : Rise of temperature increases kinetic energy of molecules.
- (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
39. Three identical vessels A, B and C are filled with water, mercury and kerosene respectively up to an equal height. The three vessels are provided with identical taps at the bottom of the vessels. If the three taps are opened simultaneously, then which vessel is emptied first?
- (a) Vessel B [IAS Prelim]  
 (b) All the vessels A, B and C will be emptied simultaneously  
 (c) Vessel A  
 (d) Vessel C
40. Consider the following statements : [IAS Prelim]
- If there were no phenomenon of capillarity
1. it would be difficult to use a kerosene lamp
  2. one would not be able to use a straw to consume a soft drink
  3. the blotting paper would fail to function
  4. the big trees that we see around would not have grown on the Earth
- Which of the statements given above are correct?
- (a) 1, 2 and 3 only      (b) 1, 3 and 4 only  
 (c) 2 and 4 only      (d) 1, 2, 3 and 4
41. Raw mangoes shrivel when pickled in brine. The phenomenon is associated with [CDS]
- (a) osmosis  
 (b) reverse osmosis  
 (c) increase of surface tension of fluid  
 (d) decrease of surface tension of fluid
42. **Assertion (A)** : An iron ball floats on mercury but gets immersed in water.  
**Reason (R)** : The specific gravity of iron is more than that of mercury. [IAS Prelim]
- (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
43. A liquid is kept in a regular cylindrical vessel upto a certain height. If this vessel is replaced by another cylindrical vessel having half the area of cross-section of the bottom, the pressure on the bottom will [CDS]
- (a) remain unaffected  
 (b) be reduced to half the earlier pressure  
 (c) be increased to twice the earlier pressure  
 (d) be reduced to one-fourth the earlier pressure
44. Dirty cloths containing grease and oil stains are cleaned by adding detergents to water. Stains are removed because detergent [CDS]
- (a) reduces drastically the surface tension between water and oil  
 (b) increases the surface tension between water and oil  
 (c) increases the viscosity of water and oil  
 (d) decreases the viscosity in detergent mixed water
45. A liquid rises to a certain length in a capillary tube. The tube is inclined to an angle of  $45^\circ$ . The length of the liquid column will [NDA]
- (a) increase  
 (b) decrease  
 (c) remain unchanged  
 (d) first decrease and then increase
46. Two identical blocks of ice, A and B, float in water as shown in the figure given below. Which one among the following statements in this regard is correct? [NDA]
- 
- (a) Block A displaces a greater volume of water since the pressure acts on a smaller bottom area

- (b) Block A displaces a greater volume of water since its submerged end is lower in the water.  
 (c) Block B displaces a greater volume of water since its submerged end has a greater area in water  
 (d) The two blocks displace equal volumes of water since they have the same specific gravity and same mass
- 47.** When a ship floats on water [NDA]  
 (a) it displaces no water  
 (b) the mass of water displaced is equal to the mass of the ship  
 (c) the mass of water displaced is lesser than the mass of the ship  
 (d) the mass of water displaced is greater than the mass of the ship
- 48.** Why do two ice blocks join to form one block when pressed together? [NDA]  
 (a) Melting point of ice is lowered with increase in pressure  
 (b) Melting point of ice increases with increase in pressure  
 (c) Melting point of ice remains unchanged with increase in pressure  
 (d) Melting point of ice is 0°C
- 49.** Consider two hollow glass spheres, one containing water and the other containing mercury. Each liquid fills about one-tenth of the volume of the sphere. In zero gravity environment [NDA]  
 (a) water and mercury float freely inside the sphere  
 (b) water forms a layer on the glass, while mercury floats  
 (c) mercury forms a layer on the glass, while water floats  
 (d) water and mercury both form a layer on the glass
- 50.** **Assertion (A) :** A beaker filled with water at 4°C overflows if the temperature is decreased or increased.  
**Reason (R) :** Density of water is maximum at 4°C.  
 (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true

## ANSWER KEY

1.	(b)	2.	(a)	3.	(b)	4.	(c)	5.	(c)	6.	(d)	7.	(a)	8.	(b)	9.	(d)	10.	(a)
11.	(d)	12.	(b)	13.	(c)	14.	(c)	15.	(b)	16.	(b)	17.	(d)	18.	(b)	19.	(a)	20.	(a)
21.	(b)	22.	(d)	23.	(c)	24.	(d)	25.	(b)	26.	(a)	27.	(a)	28.	(a)	29.	(a)	30.	(c)
31.	(b)	32.	(b)	33.	(a)	34.	(b)	35.	(b)	36.	(c)	37.	(c)	38.	(d)	39.	(d)	40.	(b)
41.	(a)	42.	(c)	43.	(a)	44.	(a)	45.	(c)	46.	(d)	47.	(d)	48.	(a)	49.	(b)	50.	(a)

# Chapter 4

# SOUND, OSCILLATIONS HEAT & THERMODYNAMICS

Sound is a form of energy that we hear. A vibrating object i.e., anything that moves back and forth, to-and-fro from side to side, in and out and up and down produces sound, as the object (vibrating) has a certain amount of energy. Sound requires material medium-a solid, a liquid or a gas to travel.

If there is no medium to vibrate then no sound is possible, sound cannot travel in a vacuum. Air is a poor conductor of sound compared with solids and liquids.

## WAVE

Due to the vibratory motion of the particles of the medium a periodic disturbance is produced in a material medium. This is called a **wave**. In the absence of medium solid, liquid or gas sound wave is not being propagated but light (electromagnetic) waves travel through the vacuum.

## Types of Waves

On the basis of the requirement of medium, waves are of two types

### Mechanical Waves

A mechanical wave is a periodic disturbance which requires a material medium for its propagation. The properties of these waves depend on the medium so they are known as *elastic waves*, such as sound-waves, water waves, waves in stretched string etc. On the basis of motion of particles the mechanical waves are classified into two parts.

**Transverse wave:** When the particles of the medium vibrate in a direction perpendicular to the direction of propagation of the wave, the wave is known as the *transverse wave*. For example, waves produced in a stretched string, waves on the surface liquid. These waves travel in the form of crests and troughs. These waves can travel in solids and liquids only.

**Longitudinal wave:** When the particles of the medium vibrate along the direction of propagation of the wave then the wave is known as the longitudinal wave. For example sound wave in air, waves in a solid rod produced by scrapping etc. These waves travel in the form of compressions and rarefactions. These waves can travel in solids, liquids and gases.

### Electromagnetic Waves

The waves which do not require medium for their propagation are called electromagnetic waves. This means that these waves can travel through vacuum also. For example, light waves, X-rays,  $\gamma$ -rays, infrared waves, radio waves, microwaves, etc. These waves are transverse in nature.

### Difference between sound waves and electromagnetic waves

- Sound waves are longitudinal whereas electromagnetic waves are transverse.
- Sound waves travel at a speed of 340 m/s whereas

- electromagnetic waves travel at a speed of  $3 \times 10^8$  m/s
- Sound waves do not pass through a vacuum but electromagnetic waves (light) do.

## Basic Terms Related to Sound Waves

**Time Period (T):** Time taken in one complete vibration (full cycle) is called it's time period.

**Frequency (v):** Frequency is defined as the number of vibrations (or oscillations) completed by a particle in one second.

$$\text{Frequency, } v = \frac{1}{T}$$

Its SI unit is hertz

**Wavelength ( $\lambda$ ):** The distance travelled by the wave during the time in which any one particle of the medium completes one vibration about its mean position.

**Amplitude:** The maximum displacement of the wave particle from its mean position.

**Wave Velocity:** The distance i.e., wavelength ( $\lambda$ ) covered by a wave in one time period

$$\text{Therefore, Wave velocity} = \frac{\text{wavelength}}{\text{time taken}}$$

$$\text{or } v = \lambda/T = v\lambda$$

or      Wave velocity = Frequency  $\times$  Wavelength  
Speed of sound is maximum in solids and minimum in gas.

## Factors Affecting the Speed of Sound

**Temperature:** Speed of sound is directly proportional to the square root of absolute temperature i.e.,  $v \propto \sqrt{T}$ .

**Pressure:** The speed of sound is independent of pressure.

**Density:** Speed of sound is inversely proportional to the square root of density of the gas.

$$v = \sqrt{\frac{\gamma P}{\rho}} \Rightarrow v \propto \frac{1}{\sqrt{\rho}} \text{ or, } \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

**Humidity:** Humid air is lighter than dry air that is why speed of sound increase as humidity increases.

## CHARACTERISTICS OF SOUND

### Pitch

Pitch is the sensation (brain interpretation) of the frequency of an emitted sound and is the characteristic which distinguishes a shrill (or sharp) sound from a grave (or flat) sound. Faster the vibration of the source, higher is the frequency and higher is the pitch. Similarly low pitch sound corresponds to low frequency. A high pitch sound is called a shrill sound (humming of a bee, sound of guitar).

A low pitch sound is called a hoarse sound (roar of a lion, car horn, etc.)

The pitch of female voice is higher than the pitch of male voice.

### Loudness

Loudness or softness of a sound wave is the sensation that depends upon its amplitude. The loudness of sound is a measure of the sound energy reaching the ear per second. When we strike a table top with more force, it vibrates and produces loud sound waves which have more amplitude.

The loudness depends on intensity as well as upon the sensitiveness of ear.

Loudness of sound is co-related with the sound level measured in **decible (dB)**.

Sound above 80dB is unpleasant for human ear.

### Quality (Timbre)

Quality or timbre of a sound wave is that characteristic which helps us in distinguishing one sound from another having same pitch and loudness. We recognise a person (without seeing) by listening to his sound as it has a definite quality. (*A pure sound of single frequency is called a tone*). An impure sound produced by mixture of many frequencies is called a **note**. It is pleasant to listen. Notes of the same pitch played upon different musical instruments are distinguished from each other by their quality. The quality of a note depends on the wave form. The waves produced by different instruments differ in their forms.

### REFLECTION OF SOUND

It is a common experience that when we shout into a well or inside an empty hall, or inside a dome, we hear our own sound after a short time. It happens because our sound is reflected from the walls. When sound waves strike a surface, they return back into the same medium. This phenomenon is called reflection of sound.

### Laws of Reflection of sound

- Angle of incidence  $\angle i$  is equal the angle of reflection  $\angle r$ .
- The incident wave, the reflected wave and the normal all lie in the same plane.

### ECHO

The Phenomenon of hearing back our own sound is called an *echo*. It is due to successive reflection from the surfaces of obstacles.

### Conditions for the formation of Echoes

- The minimum distance between the source of sound and the reflecting body should be 17.2 metres.
- The wavelength of sound should be less than the height of the reflecting body.
- The intensity of sound should be sufficient so that it can be heard after reflection.

### Science in Action

**Speaking tube or megaphone:** You must have seen in fairs or tourist spots, people using megaphones addressing a group of people. Megaphone is simply a horn-shaped tube. The sound waves are prevented from spreading out by successive reflections and are confined to the air in the tube. For the same reason, loud speakers also have horn-shaped.

### REVERBERATION

*Persistence of sound after its production is stopped, is called reverberation.* When a sound is produced in a big hall, its waves reflect from the walls and travel back and forth. Due to this, energy does not reduce and the sound persist.

### RANGE OF HEARING

Normal human ears can hear the sound of frequency 20 Hz to 20,000 Hz. Sound of frequency less than 20 Hz is called **infrasonic**. Sound of frequency greater than 20,000 Hz is called **ultrasonic**. Children under the age of five and dogs, owls can hear upto 25 kHz. Whales and elephants produce sound in the infrasonic range. Rhinoceroses make communication between themselves by using a frequency as low as 5 Hz.

### Handy Facts

Supersonic refers to the speed greater than speed of sound

### Ultrasound

Frequencies higher than 20,000 Hz are called ultrasound. Ultrasound can be produced by Galton's whistle. Some animals, such as dolphins can produce ultrasound. Bats can produce and hear ultrasound. On being high frequency waves, ultrasound possesses high intensity, and therefore can penetrate any solid or liquid medium.

### SONAR

SONAR stands for **s**ound **n**avigation **a**nd **r**anging. SONAR is a device which is used to find depth of sea or to detect the position of submarine hidden inside water. Sonar consists of a transmitter and a detector.

### INTERFERENCE OF WAVES

When two waves of equal frequency and nearly equal amplitude travelling in same direction having same state of polarisation in medium superimpose, then intensity is different at different points. At some points intensity is large, whereas at other points it is nearly zero.

#### For Constructive Interference (Maximum Intensity)

Phase difference,  $\phi = 2n\pi$  or path difference =  $n\lambda$   
where  $n = 0, 1, 2, 3, \dots$

#### For Destructive Interference (Minimum Intensity)

Phase difference,  $\phi = (2n + 1)\pi$ , or path difference =  $(2n - 1)\frac{\lambda}{2}$   
; where  $n = 0, 1, 2, 3, \dots$

## STATIONARY LONGITUDINAL WAVES AND AIR COLUMNS

When two longitudinal waves of same frequency and amplitude travel in a medium in opposite directions then by superposition, standing waves are produced. These waves are produced in air columns in cylindrical tube of uniform diameter. These sound producing tubes are called **organ pipes**.

### Vibration of Air Column in Closed Organ Pipe

The tube which is closed at one end and open at the other end is called **closed organ pipe**.

If  $\ell$  is length of pipe and  $\lambda$  be the wavelength and  $v$  be the velocity of sound in organ pipe then,

$$\text{Case (a), } L = \frac{\lambda}{4} \Rightarrow \lambda = 4L \Rightarrow n_1 = \frac{v}{\lambda} = \frac{v}{4L}$$

Fundamental frequency or first harmonic.

$$\text{Case (b), } L = \frac{3\lambda}{4} \Rightarrow \lambda = \frac{4L}{3} \Rightarrow n_2 = \frac{v}{\lambda} = \frac{3v}{4L}$$

First overtone or third harmonic

$$\text{Case (c), } L = \frac{5\lambda}{4} \Rightarrow \lambda = \frac{4L}{5} \Rightarrow n_3 = \frac{v}{\lambda} = \frac{5v}{4L}$$

Second overtone or fifth harmonic.

### Vibration of Air Column in Open Organ Pipe

The tube which is open at both ends is called an **open organ pipe**.

$$\text{Case (a), } L = \frac{\lambda}{2} \Rightarrow \lambda = 2L \Rightarrow n_1 = \frac{v}{\lambda} = \frac{v}{2L}$$

Fundamental frequency or first harmonic.

$$\text{Case (b), } L = \frac{2\lambda}{2} \Rightarrow \lambda = \frac{2L}{2} \Rightarrow n_2 = \frac{v}{\lambda} = \frac{2v}{2L}$$

First overtone or second harmonic.

$$\text{Case (c), } L = \frac{3\lambda}{2} \Rightarrow \lambda = \frac{2L}{3} \Rightarrow n_3 = \frac{v}{\lambda} = \frac{3v}{2L}$$

When open organ pipe vibrate in  $m^{\text{th}}$  overtone then

$$L = (m+1) \frac{\lambda}{4} \text{ so, } \lambda = \frac{4L}{m+1} \Rightarrow n = (m+1) \frac{v}{2L}$$

Second overtone or third harmonic.

Hence frequency of overtones i.e. of both odd and even harmonics and is given by the relation

$$n_1 : n_2 : n_3 \dots = 1 : 2 : 3 \dots$$

## BEATS

When two sound waves of nearly same frequency are produced simultaneously, then the intensity of resultant sound wave increases and decreases with time. This change in the intensity of sound is called as the phenomenon of '**beats**'.

The time interval between two successive beats is called **beat period** and the number of beats per second is called the **beat frequency**.

If  $f_1$  and  $f_2$  are the frequencies ( $f_1 > f_2$ ) of the two waves, then the beat frequency

$$b = f_1 - f_2$$

## Important Features

- At frequency difference greater than about 6 or 7 Hz, we no longer hear individual beats.

## SIMPLE HARMONIC MOTION (S.H.M.)

Oscillatory motion in which the acceleration of the particle is directly proportional to the displacement and directs towards a fixed point in a direction opposite to displacement is called simple harmonic motion abbreviated as S.H.M.

If a particle performs oscillatory motion such that its acceleration ( $a$ ) and displacement ( $x$ ) are related as below

$$a \propto -x,$$

then the motion of particle is simple harmonic.

The force ( $F$ ) acting on the particle is obviously proportional to  $x$  and directs in opposite to it. i.e.,

$$F \propto -x$$

or  $F = -kx$ , where  $k$  is a constant force law

This force  $F$  is known as the restoring force as it always restore the position of the particle.

### Handy Facts

An oscillatory motion is always periodic i.e., the motion that repeats itself in equal intervals of time but a periodic motion may not be oscillatory.

### Equation of S.H.M.

The equation of S.H.M. represents the displacement ( $x$ ) of the particle at any time ( $t$ ).

It is generally given by

$$x = A \sin(\omega t + \phi) \quad \text{or} \quad x = A \cos(\omega t + \phi)$$

Here,  $A$  = amplitude and  $\omega$  = angular frequency

$\phi$  = phase constant or initial phase

**Amplitude (A):** It is the maximum distance on the either side of the mean position of oscillating particle. It is represented by  $A$ , its S.I. unit is metre (m).

**Phase:** Phase of a vibrating particle at any instant is the state of the vibrat ing particle regarding its displacement and direction of vibration at that particular instant.

The **cosine** in equation  $x = A \cos(\omega t + \phi_0)$  gives the phase of oscillation at time  $t$ .

### Velocity

The displacement of a particle executing S.H.M. is given by

$$x = A \sin(\omega t + \phi)$$

**Time period:** It is the time taken by the oscillating particle to complete one oscillation. It is represented by  $T$ .

**Kinetic energy:** A particle executing SHM possesses kinetic energy by virtue of its motion.

$$KE = mv^2 = \frac{1}{2} m \omega^2 (A^2 - x^2) \quad (v = \omega \sqrt{A^2 - x^2})$$

**Potential energy :** A particle executing SHM possesses potential energy due to its displacement from its mean position.

$$P.E. = \frac{1}{2} k x^2 \Rightarrow P.E. = \frac{1}{2} m \omega^2 x^2 \quad (k = m \omega^2)$$

At mean position,  $x = 0 \Rightarrow P.E. = 0$

At extreme position,  $x = A$

$$\Rightarrow (P.E.)_{\max} = \frac{1}{2} m \omega^2 A^2 = \frac{1}{2} k \omega^2 A^2$$

## Simple Pendulum

An ideal simple pendulum consists of a heavy point mass (bob) suspended by a weightless, inextensible and perfectly flexible string from a rigid support about which it is free to oscillate.

Time period of a simple pendulum,

$$T = 2\pi \sqrt{\frac{l}{g}} \text{ where, } l = \text{length of pendulum}$$

and  $g$  = acceleration due to gravity.

**Time period** of second pendulum is 2 seconds.

## Resonance

The phenomenon of increase in amplitude when the driving force is close to the natural frequency of the oscillator.

### Science in Action

- Resonance-while swinging in a swing to greater heights lies in the synchronisation of the rhythm of pushing against the ground with the natural frequency of the swing.
- Marching soldiers break steps while crossing a bridge.

## HEAT AND THERMODYNAMICS

Heat is a form of energy which is responsible for the change in thermal condition of a body. It is also described as energy flow due to difference in temperature. The branch of science which deals with the conversion of heat into mechanical work and vice-versa is *Thermodynamics*.

## HEAT

Heat or thermal energy is the sum of all types of kinetic energies (translational, vibrational, rotational) of all the molecules of the body.

The SI unit of heat energy is joule (J), practical unit of heat energy is Calorie. "One calorie is the amount of heat required to raise temperature of one gram of water from 14.5°C to 15.5°C."

$$1 \text{ Calorie} = 4.186 \text{ joule}$$

### Science in Action

The relative humidity during rainy season increases and the rate of vaporisation decreases. This is why clothes dry earlier in winter than in rainy season.

## TEMPERATURE

Temperature is defined as the degree of hotness or coldness of a body. To measure temperature above 800°C, we use **Pyrometer**.

### Absolute Temperature

The lowest temperature of  $-273.16^{\circ}\text{C}$  at which a gas is supposed to have zero volume and zero pressure and at which entire molecular motion stops is called absolute zero temperature. A new scale of temperature starting with  $-273.16^{\circ}\text{C}$  by Lord Kelvin as zero. This is called Kelvin scale or absolute scale of temperature.

$$T(\text{K}) = t^{\circ}\text{C} + 273.16$$

## Temperature Scale

In order to measure the temperature, two-points are fixed, the lower fixed point is ice point and upper fixed point is boiling point of water.

**Celsius Scale ( $^{\circ}\text{C}$ )**: This scale was designed by Andre Celsius in 1710. In this scale the melting point of ice is taken as  $0^{\circ}\text{C}$  and the boiling point of water is taken as  $100^{\circ}\text{C}$  and the space between the two points is divided into 100 equal parts.

**Fahrenheit Scale ( $^{\circ}\text{F}$ )**: This scale was designed by Gabriel Fahrenheit in 1717. In this scale the melting point of ice is taken as  $32^{\circ}\text{F}$  and the boiling point of water is taken as  $212^{\circ}\text{F}$  and the space between the points is divided equally into 180 parts.

**Kelvin Scale (K)**: This was designed by Kelvin. In this scale the melting point of ice is taken as  $273\text{K}$  and boiling point of water is taken as  $373\text{K}$  and the space between the points is divided equally into 100 parts.

### Relation between various temperature scales

$$\left( \frac{C}{5} = \frac{F - 32}{9} = \frac{K - 273}{5} \right)$$

### Handy Facts

- At  $-40^{\circ}$  temperature, the celsius and fahrenheit scales read the same.
- At  $574.25^{\circ}$  temperature, the fahrenheit and kelvin scales read the same.

## TRIPLE POINT OF WATER

The state at which three phases of water-ice, liquid water and water vapour are equally stable and co-exist in equilibrium. It is unique because it occurs at a specific temperature of  $273.16\text{ K}$  and a specific pressure of  $0.46\text{ cm of Hg column}$ .

## HUMIDITY

**Absolute Humidity** : It is the amount of water vapour present in a unit volume of air.

**Relative humidity**: It is defined as the ratio of the amount of water vapour present in a given volume of air at a given temperature to the amount of water vapour required to saturate the same volume of air at the same temperature.

### Science in Action

The relative humidity during rainy season increases and the rate of vaporisation decreases. This is why clothes dry earlier in winter than in rainy season.

## IDEAL-GAS EQUATION

The equation  $PV = nRT$ , where  $n$  = no. of moles in the sample of gas,  $R$  = Universal gas constant ( $= 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ ) is known as *ideal-gas equation*.

It is the combination of following three laws.

**Boyle's Law**: When temperature is held constant, the pressure is inversely proportional to volume.

$$\text{i.e., } P \propto \frac{1}{V} \text{ (at constant temperature)}$$

**Charle's Law**: When the pressure is held constant, the volume of the gas is directly proportional to the absolute temperature. i.e.,  $V \propto T$  (at constant pressure)

**Avogadro's Law:** When the pressure and temperature are kept constant, the volume is directly proportional to the number of moles of the ideal gas in the container.

i.e.,  $V \propto n$  (at constant pressure and temperature)

## THERMAL EXPANSION

When a body (almost all) is heated it expands. The expansion can take place in the length, area or volume of the body. Depending upon the expansion in length, area or volume we have three types of expansion.

### Linear Expansion

Let  $l_1$  be the length of a wire at temperature ' $\theta_1$ ' when temperature is increased to  $\theta_2$ , length increases to  $l_2$  then

$$\alpha = \frac{\Delta l}{l_1 \Delta \theta} \quad \text{or} \quad l_2 = l_1(1 + \alpha \Delta \theta)$$

( $\Delta l = l_2 - l_1$  change in length & change in temperature

$$\Delta \theta = \theta_2 - \theta_1$$

Where  $\alpha$  is **coefficient of linear expansion**. Its unit is  $^{\circ}\text{C}$  or  $/\text{K}$ . It depends upon the nature of material. The value of ' $\alpha$ ' also depends on temperature but very slightly.

### Superficial or Areal Expansion:

Increase in surface area of a solid when temperature is increased. If  $A_1$  and  $A_2$  be the surface area at temperature  $\theta_1$  and  $\theta_2$  respectively then

$$\beta = \frac{\Delta A}{A_1 \Delta \theta} \quad \text{or}, \quad A_2 = A_1 (1 + \beta \Delta \theta)$$

' $\beta$ ' is **coefficient of superficial expansion** of a solid. Its unit is  $^{\circ}\text{C}$  and  $/\text{K}$ , it depends upon nature of material.

### Cubical or Volume Expansion:

Increase in volume of a substance on heating. If  $V_1$  and  $V_2$  are volumes of a substance at temperature  $\theta_1$  and  $\theta_2$  respectively, then

$$\gamma = \frac{\Delta V}{V_1 \Delta \theta} \quad \text{or}, \quad V_2 = V_1(1 + \gamma \Delta \theta)$$

Where ' $\gamma$ ' is **coefficient of cubical expansion** of solid. Its unit is  $^{\circ}\text{C}$  or  $/\text{K}$  and it depends upon the nature of material.

$$\begin{aligned} \text{The relation between } (\alpha, \beta \text{ and } \gamma) \text{ is } \alpha &= \frac{\beta}{2} = \frac{\gamma}{3} \\ \Rightarrow \alpha : \beta : \gamma &= 1 : 2 : 3 \end{aligned}$$

### Science in Action

- A small gap is left between the iron nails of railway tracks.
- Space is left between the girders used for supporting bridges.
- Clock pendulums are made of invar. Invar has extremely small temperature coefficient of expansion, so the length of invar pendulum does not change with the change of season. i.e., temperature.

## EXPANSION OF LIQUIDS

When we heat a liquid which is kept inside a container then liquid as well as the container both expand. In this case the observed expansion of liquid will be apparent expansion. But if the container were not expand then the expansion will be real

expansion.

Coefficient of real expansion  $\gamma_r$ ,

$$= \frac{\text{real increase in volume}}{\text{original volume} \times \Delta \theta}$$

Coefficient of apparent expansion  $\gamma_a$

$$= \frac{\text{apparent increase in volume}}{\text{original volume} \times \Delta \theta}$$

If  $\gamma_g$  is coefficient of volume expansion of material of container then

$$\gamma_r = \gamma_g + \gamma_a$$

### Anomalous Expansion of Water

Almost all liquids expand on heating but water when heated from  $0^{\circ}\text{C}$  to  $4^{\circ}\text{C}$  its volume decreases and hence density increases until its temperature reaches  $4^{\circ}\text{C}$  as its density is maximum at  $4^{\circ}\text{C}$  and on further heating its density decreases. This behaviour of water is called anomalous behaviour of water.

This allows aquatic animals to remain alive and move freely near the bottom.

## CALORIMETRY

We know that there is spontaneous transfer of heat from a hot body to colder body. If heat exchange with the surrounding is negligible then the total heat lost by a hot body is always equal to the heat gained by the cold body, this is the **principle of calorimetry or, law of mixture**.

### Specific Heat Capacity

When we supply heat to a body, its temperature rises. If  $m$  is mass,  $\Delta \theta$  is temperature rise and  $Q$  is the heat supplied, then

$$Q \propto M \Rightarrow Q \propto \Delta \theta \text{ or } Q = Ms\Delta \theta \Rightarrow s = \frac{Q}{M \Delta \theta}$$

Where 's' is constant called **specific heat** which depends upon the nature of material and its surrounding.

Specific heat capacity of a material is equal to the heat required to raise temperature of unit mass from  $14.5^{\circ}\text{C}$  to  $15.5^{\circ}\text{C}$ .

### Molar Heat Capacity and Heat Capacity

**Molar heat capacity** of a substance is the amount of heat required to raise the temperature of one mole of a substance by unit degree.

$$s_m = \frac{Q}{n \Delta \theta} \quad n = \text{number of moles}$$

**Heat capacity** of a substance is the amount of heat required to raise temperature of a body by unit degree. It is represented by  $C$ , its unit is  $\text{J}/^{\circ}\text{C}$  or  $\text{cal}/^{\circ}\text{C}$ . Heat capacity depends upon nature of material and its mass.

$$\text{Heat capacity}, \quad C = \frac{Q}{\Delta \theta} = ms$$

### Water Equivalent and Latent Heat

**Water Equivalent** of a body is defined as the mass of water which has the same heat capacity as that of the body. It is represented by  $W$ .

**Latent Heat or Hidden Heat:** When state of a substance changes, change of state takes place at constant temperature (m.pt. or B. pt.) heat is released or absorbed and is given by  $Q = mL$  where  $L$  is latent heat. The S.I. unit of latent heat is J/kg.

**Latent heat of fusion or melting ( $L_f$ ):** It is the amount of heat required to change unit mass of solid into liquid state at its melting point. It is represented by  $L_f$ . For ice its value is 80 cal g<sup>-1</sup>.

$$Q = mL_f$$

**Latent heat of vaporisation or boiling ( $L_v$ ):** It is the amount of heat required to change unit mass of liquid into its vapors at its boiling point. It is represented by  $L_v$ . For water  $L_v = 540$  cal g<sup>-1</sup>.

$$Q = mL_v$$

**Sublimation:** It is the conversion of a solid directly into vapours.



### Regelation

The phenomenon in which ice melts when pressure is increased and again freezes when pressure is removed is called *regelation*.

#### Science in Action

- Skating is possible due to regelation. Water layer below the skates is formed due to the increase of pressure and it acts as a lubricant.
- By pressing snow in our hand, we can transform it into a snow-ball.

## HEAT TRANSFER

Heat energy can be transferred from a body at higher temperature to a body at lower temperature by three different ways viz. conduction, convection and radiation.

### Conduction

**Conduction** is the process in which heat is transmitted from one point to the other through the substance without the actual motion of the particles. When one end of a metal is heated, the molecules at the hot end start vibrating with higher amplitudes (kinetic energy) and transmit this K.E. to the next molecule and so on. However, the molecules still remain in their mean positions of equilibrium. This process of conduction is prominent in the case of solids.

### Convection

**Convection** is the process in which heat is transmitted from one place to the other by the actual movement of the vibrating particles. It is prominent in the case of liquids and gases.

**Land and sea breezes and trade winds** are formed due to convection. Convection plays an important part in ventilation, gas filled electric lamps and heating of buildings by hot water circulation.

It is the process of transfer of heat in a fluid by the movement of the fluid itself.

### Radiation

**Radiation** is the process in which heat is transmitted from one place to the other directly without the necessity of any intervening medium. We get heat radiations directly from the sun without affecting the intervening medium. Heat radiations can pass through vacuum. Heat radiations are a part of the electromagnetic spectrum.

#### Radiation has the following properties

- Radiant energy travels in straight line and when some object is placed in the path, it's shadow is formed at the detector.
- It is reflected and refracted or can be made to interfere. The reflection or refraction are exactly as in case of light.
- It can travel through vacuum.
- Intensity of radiation follows the law of inverse square.
- Thermal radiation can be polarised in the same way as light by transmission through a nicol prism.

## THERMAL CONDUCTIVITY

It is the measure of ability of the solid to conduct heat through it. Examples: silver, copper, etc. are good conductors of heat and glass, wood are bad conductors of heat.

The coefficient of thermal conductivity (K) is defined as the amount of heat flowing in unit time across the opposite faces of a cube of side having unit length maintained at unit temperature difference.

$$\text{Coefficient of thermal conductivity } K = \frac{(\Delta Q / \Delta t)}{(A \Delta T / \Delta x)}$$

#### Science in Action

- During the winter season, birds often swell their feathers, this encloses the air between the body and feathers and thus stops the flow of heat from its body to the surroundings.
- Metallic handles of doors during winter season appear colder as it is a good conductor, heat flows from the body to the handle.

## KIRCHHOFF'S LAW

According to Kirchhoff's law the ratio of emissive power to absorptive power corresponding to the certain wavelength is the same for all bodies at a given temperature and is equal to the emissive power of a black body at that temperature.

## Wien's Displacement Law

According to Wien's displacement law, wavelength corresponding to highest intensity ( $\lambda_m$ ) is inversely proportional to the absolute temperature of the body.

### Black Body

A black body absorbs the entire thermal radiation incident on it. Practically there is no body which absorbs 100% radiations incident on it. Ferry designed a black body which a spherical enclosure painted black from inside with a small hole in the wall. Any radiation through this hole goes inside and get absorbed after multiple reflections. There is cone directly opposite to the hole due to which incident radiation is not reflected back through the hole.

## THERMODYNAMIC PROCESSES

Thermodynamic process is said to take place if some change occurs in the state of a thermodynamic system, i.e. the thermodynamic variables of the system – pressure, volume, temperature and entropy change with time.

In practice, the following types of thermodynamic processes can take place :

**Isothermal process:** A thermodynamic process that takes place at constant temperature.

**Isobaric process:** A thermodynamic process that takes place at constant pressure.

**Isochoric process:** A thermodynamic process that takes place at constant volume.

**Adiabatic process:** A thermodynamic process in which no heat enters or leaves the system.

**Cyclic process:** A thermodynamic process in which the system returns to its original state.

## LAWS OF THERMODYNAMICS

### Zeroth Law of Thermodynamics

If objects A and B are separately in thermal equilibrium with a third object C then objects A and B are in thermal equilibrium with each other.

### First Law of Thermodynamics

If some quantity of heat is supplied to a system capable of doing external work, then the quantity of heat absorbed by the system is equal to the sum of the increase in the internal energy of the system and the external work done by the system.

$$\text{i.e.,} \quad \Delta Q = \Delta U + \Delta W$$

The first law of thermodynamics is essentially a restatement of the law of conservation of energy i.e., energy can neither be created nor be destroyed but may be converted from one form to another.

### Second Law of Thermodynamics

**Kelvin-Planck statement :** It is impossible for an engine working between a cyclic process to extract heat from a reservoir and convert completely into work. In other words, 100% conversion of heat into work is impossible.

## HEAT ENGINES

Heat engine is a device which converts heat energy into work. A heat engine, in general, consists of three parts :

- A source or high temperature reservoir at temperature  $T_1$ .
- A working substance.
- A sink or low temperature reservoir at temperature  $T_2$ .

The efficiency of internal combustion engine is approximately 40% to 60%.

### Refrigerators and Heat Pumps

A **refrigerator** is the reverse of a heat engine. A heat pump is the same as a refrigerator.

### Carnot Theorem

No irreversible engine (I) can have efficiency greater than Carnot reversible engine (R) working between same hot and cold reservoirs.

# EXERCISE

1. In SONAR, we use  
 (a) ultrasonic waves  
 (b) infrasonic waves  
 (c) radio waves  
 (d) audible sound waves
2. An oscilloscope is an instrument which allows us to see waves produced by  
 (a) Visible light      (b) X-rays  
 (c) Sound              (d) Gamma rays
3. The sound travels fastest in  
 (a) solids              (b) liquids  
 (c) gases              (d) none of these
4. Two identical piano wires have same fundamental frequency when kept under the same tension.  
 What will happen if tension of one of the wire is slightly increased and both the wires are made to vibrate simultaneously?  
 (a) Noise              (b) Beats  
 (c) Resonance          (d) Non-linear effects
5. The turntable of a gramophone is rotated at a constant speed of  $x$  revolutions/minute. Which one of the following values of the revolutions per minute is not used ?  
 (a) 78 r.p.m.           (b) 56 r.p.m.  
 (c) 45 r.p.m.           (d) 33 r.p.m.
6. Why is sound heard with more intensity through  $\text{CO}_2$  than through the air ?  
 (a) Density of  $\text{CO}_2$  is more than that of air  
 (b) Density of  $\text{CO}_2$  is less than that of air  
 (c) Air is bad conductor of heat  
 (d)  $\text{CO}_2$  is a compound, but air is a mixture of gases.
7. How does time period ( $T$ ) of a seconds pendulum vary with length ( $l$ )?  
 (a) (b)  
 (c) (d)  $T$  does not depend on  $l$
8. Which one of the following properties distinguishes ultrasound from normal audible sound?  
 (a) Intensity              (b) Speed of propagation  
 (c) Frequency              (d) Quality
9. Consider the following statements :  
 If the same note is played on a flute and a sitar, one can still distinguish between them because they differ in  
 1. frequency              2. intensity  
 3. quality  
 Which of the statements given above is/are correct?  
 (a) 1 and only              (b) 2 and 3 only  
 (c) 3 only                  (d) 2 only
10. Consider the following statements :  
 Sound waves can undergo  
 1. reflection              2. refraction  
 3. interference  
 (a) 1 and 2 only           (b) 2 and 3 only  
 (c) 1 and 3 only           (d) 1, 2 and 3
11. Consider the following parts of spectra  
 1. Visible                  2. Infrared  
 3. Ultraviolet              4. Microwave
- [CDS]
12. In a sitar wire which one of the following types of vibration is produced?  
 (a) Progressive longitudinal  
 (b) Stationary longitudinal  
 (c) Progressive transverse  
 (d) Stationary transverse
13. Which one of the following is not electromagnetic in nature?  
 (a) Cathode-rays           (b) X-rays  
 (c) Gamma-rays           (d) Infrared-rays
14. 'Pitch' is a characteristic of sound that depends upon its  
 (a) intensity              (b) frequency  
 (c) quality                (d) None of these
15. Timbre is called the quality of sound. One can recognise the voice of a familiar human being or instrument without actually seeing them. This quality is associated with  
 (a) material of the body  
 (b) overtones present in the sound  
 (c) shape of the body  
 (d) all of the above
16. Match the column - I and Column - II.
- | <b>Column-I</b>                        | <b>Column-II</b>          |
|--|---------------------------|
| A. Audible range in humans             | P. greater than 20,000 Hz |
| B. Ultrasonic waves                    | Q. 20 Hz – 20,000 Hz      |
| C. Infrasonic waves                    | R. 1498 m/s               |
| D. Speed of sound in water (distilled) | S. 343.2 m/s              |
| E. Speed of sound in air               | T. less than 20 Hz        |
| (a) A-Q; B-P; C-T; D-S; E-R            |                           |
| (b) A-Q; B-P; C-T; D-R; E-S            |                           |
| (c) A-P; B-Q; C-T; D-R; E-S            |                           |
| (d) A-Q; B-T; C-P; D-R; E-S            |                           |
17. Suppose a tunnel is dug along a diameter of the earth. A particle is dropped from a point, a distance  $h$  directly above the tunnel, the motion of the particle is  
 (a) simple harmonic      (b) parabolic  
 (c) oscillatory           (d) non-periodic
18. Which one of the following types of waves are used in a night vision apparatus?  
 (a) Radio waves           (b) Microwaves  
 (c) Infra-red waves      (d) None of the above
- 19.
-

- Figure given above shows the part of a long string in which transverse waves are produced. Which pair of points is in phase? [NDA]
- (a) A and E      (b) B and J  
 (c) D and J      (d) C and G
20. Consider the following statements with reference to observations made by an astronaut on the surface of moon:
1. The astronaut finds that a simple pendulum continues to oscillate for a much longer time, than that on the earth.
  2. No atmosphere exists there.
- Which of the statements given above is/are correct ? [NDA]
- (a) Only 1      (b) Only 2  
 (c) Both 1 and 2      (d) Neither 1 nor 2
21. If the length of second's pendulum is increased by 2%, how many seconds will it lose per day? [NDA]
- (a) 3600 s      (b) 3456 s  
 (c) 1728 s      (d) 846 s
22. A man standing between two parallel hills fires a gun and hears two echoes, one 2.5 s and the other 3.5 s after the firing. If the velocity of sound is  $330 \text{ ms}^{-1}$ , how long will it take him to hear the third echo? [NDA]
- (a) 4 s      (b) 5 s  
 (c) 6 s      (d) 8 s
23. The simple harmonic motion of a particle is given by  $y = 3 \sin \omega t + 4 \cos \omega t$ . Which one of the following is the amplitude of this motion? [NDA]
- (a) 1      (b) 5  
 (c) 7      (d) 12
- 24.
- The standing wave pattern along a string of length 60 cm is shown in the above diagram. If the speed of the transverse waves on this string is 300 m/s, in which one of the following modes is the string vibrating ? [NDA]
- (a) Fundamental      (b) First overtone  
 (c) Second overtone      (d) Third overtone
25. A sonometer wire having a length of 50 cm is vibrating in the fundamental mode with a frequency of 100Hz. Which of the following is the type of propagating wave and its speed? [NDA]
- (a) Longitudinal, 50 m/s      (b) Transverse, 50 m/s  
 (c) Longitudinal, 100 m/s      (d) Transverse, 100 m/s
26. The Visible light has a wavelength range from about 380 nm (violet) to 780 nm (red). If an excited object emits light with wavelength of 15 nm, to which one of the following ranges does it belongs? [NDA]
- (a) X-ray      (b) Gamma ray  
 (c) Infrared      (d) Ultraviolet
27. Which one among the following statements is not correct? [NDA]
- (a) In progressive waves, the amplitude may be constant and neighbouring points are out of phase with each other  
 (b) In air or other gases, a progressive antinode occurs at a displacement node and a progressive node occurs at a displacement antinode  
 (c) Transverse wave can be polarised while longitudinal wave cannot be polarised  
 (d) Longitudinal wave can be polarised while transverse wave cannot be polarised
28. Sound moves with higher velocity if [NDA]
- (a) pressure of the medium is decreased  
 (b) temperature of the medium is increased  
 (c) humidity of the medium is increased  
 (d) Both (b) and (c) above
29. Bats can ascertain distance, directions, nature and size of the obstacles at night. This is possible by reflection of the emitted [NDA]
- (a) ultrasonic waves from the bat  
 (b) ultrasonic waves from the distant objects  
 (c) supersonic waves from the bat  
 (d) supersonic waves from the distant objects
30. The regions of compressions and rarefractions of sound wave are established because
- (a) the sound wave undergoes diffraction behind obstacles  
 (b) the reflected sound wave at fixed end interferes with the incident wave  
 (c) the longitudinal movement of air molecules produce pressure fluctuations  
 (d) the speed of the sound wave changes as it travels through a medium
31. **Assertion (A)** : A jet aircraft moving at Mach Number equal to 1 travels faster at an altitude of 15 km than while moving at Mach Number equal to 1 near the sea level.  
**Reason (R)** : The velocity of sound depends on the temperature of the surrounding medium. [IAS Prelim]
- (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
32. **Assertion (A)**: Radio waves bend in a magnetic field.  
**Reason (R)**: Radio waves are electromagnetic in nature. [IAS Prelim]
- (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
33. The sound from an open pipe is more pleasant than the sound from a closed pipe. This is because :
- (a) sound is heard from both the sides of an open pipe  
 (b) there are more overtone combinations in an open pipe than in a closed one  
 (c) it is very easy to operate an open pipe  
 (d) the length of the open pipe is shorter

34. Which one of the following is the mode of heat transfer in which warm material is transported so as to displace a cooler material ? [NDA]  
 (a) Conduction only  
 (b) Convection only  
 (c) Radiation  
 (d) Both conduction and convection

35. Low temperatures (cryogenics) find application in : [IAS Prelim]

- (a) space travel, surgery and magnetic levitation  
 (b) surgery, magnetic levitation and telemetry  
 (c) space travel, surgery and telemetry  
 (d) space travel, magnetic levitation and telemetry

36. Which zone of a candle flame is the hottest ? [NDA]  
 (a) Dark innermost zone  
 (b) Outermost zone  
 (c) Middle luminous zone  
 (d) Central zone

37. Which one among the following denotes the smallest temperature? [NDA]  
 (a)  $1^{\circ}$  on the Celsius scale  
 (b)  $1^{\circ}$  on the Kelvin scale  
 (c)  $1^{\circ}$  on the Fahrenheit scale  
 (d)  $1^{\circ}$  on the Reaumur scale

38. **Assertion (A):** Steam is more harmful for human body than the boiling water in case of burn.

**Reason (R) :** Boiling water contains more heat than steam.

[CDS]

- (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true, but R is not the correct explanation of A  
 (c) A is true, but R is false  
 (d) A is false, but R is true

39. **Assertion (A):** In a pressure cooker food is cooked above boiling point.

**Reason (R):** Boiling point of water increases as the pressure increases.

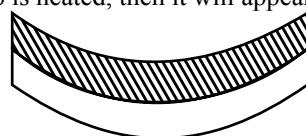
[CDS]

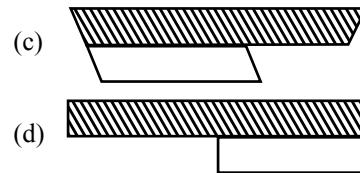
- (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true, but R is not the correct explanation of A  
 (c) A is true, but R is false  
 (d) A is false, but R is true

40. Strips of two metals A and B are firmly jointed together as shown in the figure. [IAS Prelim]



On heating, A expands more than B does. If this jointed strip is heated, then it will appear as

- (a)   
 (b) 



41. Which one among the following statements about thermal conductivity is correct ? [NDA]

- (a) Steel > Wood > Water  
 (b) Steel > Water > Wood  
 (c) Water > Steel > Wood  
 (d) Water > Wood > Steel

42. Cloudy nights are warmer compared to clear cloudless nights, because clouds: [IAS Prelim]

- (a) prevent cold waves from the sky from descending on earth  
 (b) reflect back the heat given off by earth  
 (c) produce heat and radiate it towards earth  
 (d) absorb heat from the atmosphere and send it towards earth

43. A solid is melted (above the melting point) and allowed to cool down at normal condition. Its variation of temperature as a function of time is as shown in the figure given below. What is the reason for the plateau (flat position) in the central region of the cooling curve as shown in the figure? [NDA]

- (a) Latent heat of fusion of the solid  
 (b) Specific heat of the solid  
 (c) Thermal conductivity of the solid  
 (d) Thermal capacity of the solid.

44. If the door of a running refrigerator in a closed room is kept open, what will be the net effect on the room? [CDS]

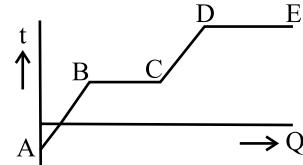
- (a) It will cool the room  
 (b) It will heat the room  
 (c) It will make no difference on the average  
 (d) It will make the temperature go up and down

45. The surface of a lake is frozen in severe winter, but the water at its bottom is still liquid. What is the reason ? [IAS Prelim]

- (a) Ice is a bad conductor of heat.  
 (b) Since the surface of the lake is at the same temperature as the air, no heat is lost.  
 (c) The density of water is maximum at  $4^{\circ}\text{C}$ .  
 (d) None of the statements (a), (b) and (c) given is correct.

46. Which of the following properties are most desirable for a cooking pot ? [NDA]

- (a) High specific heat capacity and low conductivity  
 (b) Low specific heat capacity and high conductivity  
 (c) High specific heat capacity and high conductivity  
 (d) Low specific heat capacity and low conductivity



- 47.

The graph given above indicates change in temperature ( $\Delta t$ ) when heat (Q) was given to a substance. Which among the following parts of the graph correctly depict the latent heat of the substance? [NDA]

- (a) AB and BC      (b) BC and DE  
 (c) CD and DE      (d) DE and AB
- 48.** Consider the following statements: . [CDS]  
 1. Steam at 100°C and boiling water at 100°C contain same amount of heat.  
 2. Latent heat of fusion of ice is equal to the latent heat of vaporization of water.  
 3. In an air-conditioner, heat is extracted from the room air at the evaporator coils and is rejected out at the condenser coils.  
 Which of these statements is/are correct?  
 (a) 1 and 2      (b) 2 and 3  
 (c) Only 2      (d) Only 3
- 49.** Mr X was advised by an architect to make outer walls of his house with hollow bricks. The correct reason is that such walls [CDS]  
 (a) make the building stronger  
 (b) help keeping inside cooler in summer and warmer in winter  
 (c) prevent seepage of moisture from outside  
 (d) protect the building from lightning
- 50.** Why are inner lining of hot water geysers made up of copper? [CDS]  
 (a) Copper has low heat capacity  
 (b) Copper has high electrical conductivity  
 (c) Copper does not react with steam  
 (d) Copper is good conductor of both heat and electricity
- 51.** A Centigrade thermometer and Fahrenheit thermometer are dipped in boiling water. The temperature of water is lowered till the Fahrenheit thermometer registers half of its upper fixed point. What is the corresponding fall temperature registered by the Centigrade thermometer? [NDA]  
 (a) Half of its range of temperature between the upper and the lower fixed points  
 (b) Approximately 41°C  
 (c) Approximately 59°C  
 (d) 18°C
- 52.** When water is heated from 0°C to 20°C, how does its volume change?  
 (a) It shall increase  
 (b) It shall decrease  
 (c) It shall first increase and then decrease  
 (d) It shall first decrease and then increase
- 53.** Thermal conductivity of aluminium, copper and stainless steel increases in the order  
 (a) Copper < Aluminium < Stainless Steel  
 (b) Stainless Steel < Aluminium < Copper  
 (c) Aluymium < Copper < Stainless Steel  
 (d) Copper < Stainless Steel < Aluminium
- 54.** Which of the following statements is/ are false about mode of heat transfer?  
 I. In radiation, heat is transferred from one medium to another without affecting the intervening medium  
 II. Radiation and convection are possible in vacuum while conduction requires material medium.  
 III. Conduction is possible in solids while convection occurs in liquids and gases.  
 (a) I only      (b) II only  
 (c) II and III      (d) I, II and III
- 55.** When pressure on piece of ice is increases its melting point  
 (a) decreases  
 (b) increases  
 (c) remains unchanged  
 (d) first increases and then decreases
- 56.** Consider the following three statements  
 1. Heating 1 kg of water from 10°C to 50°C  
 2. Melting 600 g of ice at 0°C  
 3. Converting 300 g of ice at 0°C to water at 50°C  
 Which one of the following shows the correct arrangement of the quantity of heat required in the above process in increasing order of magnitude?  
 Choose the correct answer from the codes give below  
 (a) 1, 2, 3      (b) 2, 1, 3  
 (c) 3, 2, 1      (d) 3, 1, 2
- 57.** **Assertion (A) :** The boiling point of water decreases as the altitude increases.  
**Reason (R) :** The atmospheric pressure increases with altitude. [IAS Prelim]  
 (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
- 58.** **Assertion (A) :** A piece of copper and a piece of glass are heated to the same temperature. When touched, thereafter, the copper piece appears hotter than the glass piece.  
**Reason (R) :** The density of copper is more than that of glass. [IAS Prelim]  
 (a) Both A and R are true and R is the correct explanation of A  
 (b) Both A and R are true but R is not a correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true

## ANSWER KEY

1.	(a)	2.	(c)	3.	(a)	4.	(c)	5.	(b)	6.	(a)	7.	(a)	8.	(c)	9.	(c)	10.	(d)
11.	(d)	12.	(d)	13.	(a)	14.	(b)	15.	(d)	16.	(b)	17.	(c)	18.	(c)	19.	(d)	20.	(c)
21.	(d)	22.	(c)	23.	(b)	24.	(c)	25.	(d)	26.	(a)	27.	(a)	28.	(d)	29.	(a)	30.	(c)
31.	(d)	32.	(d)	33.	(b)	34.	(b)	35.	(a)	36.	(b)	37.	(b)	38.	(c)	39.	(a)	40.	(b)
41.	(b)	42.	(b)	43.	(a)	44.	(b)	45.	(a)	46.	(b)	47.	(b)	48.	(d)	49.	(b)	50.	(d)
51.	(b)	52.	(d)	53.	(b)	54.	(b)	55.	(b)	56.	(d)	57.	(c)	58.	(b)				

# Chapter 5

# ELECTRICITY, MAGNETISM & LIGHT

## ELECTRICITY, MAGNETISM

Electricity is the branch of physics in which we study electric charges, at rest (electrostatics or static electricity) and in motion (current electricity).

When we switch on the bulb of our rooms, it glows immediately. An electric signal in a conductor travels at a speed of light in vacuum. An electric current flowing in a conductor produces a magnetic field or magnetism around it.

### ELECTRIC CHARGES

*Charge is something associated with matter due to which it produces and experiences electric and magnetic effects.*

Every atom contains two types of charged particles:

(i) *Positive charge* (Proton) and (ii) *Negative charge* (electron)

The magnitude of elementary positive or negative charge is same and is equal to  $1.6 \times 10^{-19}$  C.

Charge is a scalar quantity and its **SI unit** is ampere second or **coulomb** (C).

#### Basic Properties of Electric Charge

- (i) *Similar charges repel and opposite charges attract.*
- (ii) Charge is conserved i.e., the charge can neither be created nor be destroyed but it may simple be transferred from one body to other. Charge is transferable.

### CONDUCTORS AND INSULATORS

*The materials which allow electric charge (or electricity) to flow freely through them are called conductors.*

*The materials which do not allow electric charge to flow through them are called nonconductors or insulators.*

Examples of good conductors are metals, impure water etc.

Examples of insulators are quartz, glass, air, rubber, etc.

*Silver is the best conductors of electricity.*

### CLOUD FORMATION, THUNDERING AND LIGHTNING

Clouds are very small droplets of water in the form of vapour. Clouds roam about in the sky with the wind. Generally, a patch of cloud develops an electric charge on it by friction. As a result of friction the upper layers of cloud (which are away from earth) get positively charged and the lower layers of cloud (which are facing earth) get negatively charged.

Dry air and pure water are bad conductors of electricity, hence clouds continue to carry the charge on them till the intensity of charge between the two gets too high.

When two patches of cloud bearing different charges come face

to face they get attracted to one another and the electrons from negatively charged cloud jump to the positively charged cloud. The jumping of electrons between the clouds results in a big spark. The heat from the spark results in sudden expansion of air setting the air in violent waves which are heard by us as **thunder**. The spark is seen as a flash of **lightning** first and then followed by a thunder, a little later.

To protect tall buildings from damage by lightning, a lightning conductor is fixed on them.

### COULOMB'S LAW

The force exerted by one *point charge* (when separation between charged bodies is much larger than their linear sizes) on another, acts along the line joining the two charges and it varies inversely as the square of the distance separating the charges and is proportional to the product of the charges. The force is repulsive if the charges have the same sign and attractive if the charges have opposite signs.

$$\text{i.e., } F = \frac{k|q_1 q_2|}{r^2}$$

Where  $k$  is an experimentally determined constant called the Coulomb constant, which has the value

$$k = 9 \times 10^9 \text{ Nm}^2 / \text{C}^2$$

It is common practice to express  $k$  in terms of another constant  $\epsilon_0$ , by writing  $k = 1/(4\pi\epsilon_0)$ ;  $\epsilon_0$  is called the **permittivity of free space** or **absolute electrical permittivity** and has a value of  $\epsilon_0 = 1/(4\pi k) = 8.85 \times 10^{-12} \text{ C}^2 / (\text{Nm}^2)$ .

### ELECTRIC POTENTIAL AND CURRENT

#### Electric Potential

*Potential at a point can be physically interpreted as the work done by the field in displacing a unit + ve charge from some reference point to the given point.*

$$\text{i.e., } V = \frac{w}{q_0}$$
$$V = - \int_{\infty}^{E} d\vec{s} \quad \text{i.e. } E = - \frac{dv}{dr}$$

It is a scalar quantity.

Its **SI unit** is volt or joule coulomb $^{-1}$ .

**Electrostatic potential produced by a point charge,**

$$V = \frac{Kq}{r}$$

#### Electric current

*The time rate of flow of charge or electrons through any cross-section is called electric current.*

Current through the conductor is,  $I = \frac{q}{t} = \frac{ne}{t}$

where  $n$  is an integer.

Charge of one electron is  $1.6 \times 10^{-19}$  C.

Number of electrons flowing through a conductor in  $t$  second is  
 $n = \frac{I \times t}{e}$

Electric current is measured in **ampere (A)**. It is a scalar fundamental physical quantity.

## OHM'S LAW

According to Ohm's law "The current passing through a conductor is directly proportional to the potential difference between its ends, provided the physical conditions such as temperature of conductor remain unchanged."

$$\text{i.e., } V \propto I \quad \text{or} \quad V = RI$$

where  $R$  is a constant which is called **resistance** of the material. Resistance of a material depends on its length, area of cross-section, and nature of material etc.

$$\text{i.e., } R = \rho \frac{l}{A} \text{ where, } \rho = \text{resistivity of material.}$$

The **SI unit** of resistance is ohm ( $\Omega$ ).

The conductors, which obey the Ohm's law are called the ohmic conductors or linear resistances. All metallic conductors (such as silver, aluminium, copper, iron, etc.) are the **ohmic conductors or linear resistances**.

The conductors, which do not obey the Ohm's law are called the **non-ohmic conductors or non-linear resistances**. Examples are, diode valve, triode valve, transistors, electrolyte, etc.

## Electroplating

Electroplating is the process of depositing a thin film (coating a layer) of finer (non-corrosive and costly) metal over the objects made from corrosive and cheaper metal with the passing of electric current through an electrolyte.

The objective of electroplating is to

- protect the surface of the corrosive and cheaper metal.  
For example chromium and nickel plating of bicycle handlebar made from iron. Tin plating of iron containers for storing food articles (oil and picles).
- decoration by giving a shine to the objects. For example silver or gold coating on cutlery.
- Making of artificial jewellery and zari for embroidery from copper or other cheaper metals electroplated with silver or gold.

## COMBINATION OF RESISTORS – SERIES AND PARALLEL

### Series Combination of Resistors

$$R_s = R_1 + R_2 + R_3 + \dots + R_n$$

The equivalent resistance is greater than largest of individual resistance.

### Parallel Combination of Resistors

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

The equivalent resistance is smaller than smallest of individual resistance.

### Science in Action

- Special resistors are commonly used as single-use fuse. The conductive material in the fuse gets completely destroyed when threshold current is reached. These are used to protect various electrical appliances.
- Resistors are also used as sensors for various applications like gas sensors, lie detectors etc.

## MEASURING INSTRUMENT

### Galvanometers

These are instruments used for detection and measurement of small currents.

### Ammeter

An ammeter is a low resistance galvanometer used to measure strength of current in an electrical circuit.

- An ammeter is always connected in series in a circuit because, when an ammeter is connected in series it does not appreciably change the resistance of circuit and hence the main current flowing through the circuit.
- An ideal ammeter has zero resistance.

### Conversion of galvanometer into ammeter :

A galvanometer can be converted to an ammeter by connecting a low resistance or shunt in parallel to coil of galvanometer.

### Voltmeter

A voltmeter is a high resistance galvanometer used to measure potential difference.

- A voltmeter is connected in parallel to a circuit element because, when connected in parallel it draws least current from the main current. So it measures nearly accurate potential difference.
- An ideal voltmeter has infinite resistance.

### Conversion of galvanometer into voltmeter :

A galvanometer is converted to a voltmeter by connecting a high resistance in series with the coil of galvanometer.

## HEATING EFFECT OF ELECTRIC CURRENT

**Joule's Law of Heating:** When a current  $I$  is made to flow through a conductor of resistance  $R$  for time  $t$ , heat  $Q$  is produced such that,

$$\text{i.e., } Q = I^2 R t = P \times t = VIt = \frac{V^2}{R} t$$

**SI unit** of electric heat or energy is joule.

$$\text{Electric Power : } P = VI = \frac{V^2}{R} = I^2 R \quad \text{SI unit : Watt}$$

### Science in Action

Bulbs fuse because when they are switched on, its temperature increases due to which the strength of its filament decreases. After long period of time the strength of the filament becomes very low, thus the filament burns off.

## HOUSEHOLD CIRCUITS

### Switches

A switch is a key in a circuit which is used to make or break the circuit. It is always connected in the live wire of the circuit so that when it is off, you can safely touch the exposed live wire.

## Safety Fuse

A fuse is a device containing short length of thin wire which melts and breaks the circuit if the current exceeds a safe value. The fuse wire is made up of a material which has *high resistance and low melting point* so that as soon as excessive current passes through, it gets melted. Generally, an **alloy of tin and lead** is used to make a fuse wire.

## Earthing

Earthing is a safety process which is used to prevent the shocks due to leakage, short circuiting, etc. The cable coming from an appliance has three wires. One is live, the other neutral and the third one is earth. The earth wire is connected to the outer part of body metallic framework of the appliance.

## Short Circuit and Overloading

Short circuit is a condition in which live wire comes in direct contact with a neutral wire and excessive current flows in the circuit.

When a large current (as compared to normal current) flows in a circuit which causes overheating, the circuit is said to be overloading of the electrical circuit.

Excessive continued overloading of an electrical circuit may lead to electric fires.

## PERMANENT MAGNETS AND ELECTROMAGNETS

The **permanent artificial magnets** are made of some metals and alloys like Carbon-steel, Alnico, Platinum-cobalt, Alcomax, Ticonal etc. The permanent magnets are made of ferromagnetic substances with large coercivity and retentivity and can have desired shape like bar-magnet, U shaped or horse-shoe magnet and magnetic needle etc. These magnets retain its attracting power for a long time.

The **temporary artificial magnets** like electromagnets are prepared by passing current through coil wound on soft iron core. These cannot retain its strength for a long time. Electromagnets are stronger than permanent magnet.

The **strength of an electromagnet** depends on

- the number of turns in the coil (n)
- the strength of current (I)
- the nature of the core material.

## Properties of magnet

- A freely suspended magnet always points in the north-south direction (directive property)
- Like magnetic poles repel each other and unlike magnetic poles attract each other.
- Magnetic poles always exist in pairs. It is not possible to have either S-pole alone or N-pole alone.

## Uses of Magnets

Magnets have their lot of applications in daily life.

- In the refrigerators to keep the door close.
- In the Electric bells, speakers which can convert the electrical energy into sound energy.
- In telephones and in tape recorders.
- Electromagnets are used for removing pieces of iron and steel from the non-magnetic heap of metal scrap.
- Doctors use the magnets to cure arthritis, gout, and to stimulate the nerves in human body.

## MAGNETIC EFFECT OF CURRENT

Magnetic effect of electric current means-an electric current flowing in a conductor produces a magnetic field in the space around it. In 1820, Hans Christian Oersted Showed that electricity and magnetism are related phenomena.

Oersted discovered a magnetic field around a conductor carrying electric current.

- A magnet at rest produces a magnetic field around it while an electric charge at rest produces an electric field around it.
- A current carrying conductor has a magnetic field and not an electric field around it. On the other hand, a charge moving with a uniform velocity has an electric as well as a magnetic field around it.

Burglar Alarms, Microphones, loud speakers, car horns and electric bells, A.C. generator, D.C. motor, transformer, etc. are based on magnetic effect of electric current.

## A.C. Generator or Dynamo

An a.c. generator or dynamo is a device which converts mechanical energy into electrical energy, an electric generator is based on the principle of electromagnetic induction, according to which *if a closed coil is rotated about an axis perpendicular to a uniform magnetic field, an induced e.m.f. is set up across the coil whose direction is governed by Fleming's right hand rule*.

## DC Motor

*A D.C. motor converts direct current energy from a battery into mechanical energy of rotation.*

It is based on the fact that when a coil carrying current is held in a magnetic field, it experiences a torque, which rotates the coil.

## Uses of D.C Motor :

- The D.C. motors are used in D.C. fans (exhaust, ceiling or table) for cooling and ventilation.
- They are used for pumping water.
- Big D.C. motors are used for running tram-cars and even trains.

## Transformer

*It is a device used for transforming a low alternating voltage of high current into a high alternating voltage of low current and vice versa, without increasing power or changing frequency.*

**Principle :** It works on the phenomenon of mutual induction.

If a low voltage is to be transformed into a high voltage, then the number of turns in secondary is more than those in primary. The transformer is called a **step-up transformer**.

If a high voltage is to be transformed into a low voltage, then the number of turns in secondary is less than those in primary. The transformer is called a **step-down transformer**.

*Transformation ratio of the transformer,*

$$K = \frac{\text{Number of turns in secondary } (N_s)}{\text{Number of turns in primary } (N_p)}$$

## THE EARTH'S MAGNETISM

The branch of Physics which deals with the study of earth's magnetic field is called **terrestrial magnetism**.

### Some Definitions

**Geographic axis :** It is straight line passing through the geographic poles of the earth. It is the axis of rotation of the earth. It is known as polar axis.

**Geographic meridian :** It is a vertical plane passing through geographic north and south pole of the earth.

**Geographic equator :** A great circle on the surface of the earth in a plane perpendicular to geographical axis is called geographic equator. All places on geographic equator are at equal distances from geographical poles.

**Magnetic axis :** It is a straight line passing through the magnetic poles of the earth. It is inclined to geographic axis at nearly  $17^\circ$ .

**Magnetic meridian :** It is a vertical plane passing through the magnetic north and south pole of the earth.

**Magnetic equator :** A great circle on the surface of the earth in a plane perpendicular to magnetic axis is called magnetic equator. All places on magnetic equator are at equal distance from magnetic poles.

### Elements of Earth's Magnetic Field

**Angle of declination ( $\phi$ ) :** The angle between the magnetic meridian and geographical meridian at a place is called angle of declination.

- Isogonic lines :** Lines drawn on a map through places that have same declination are called isogonic lines.
- Agonic lines :** The lines drawn on a map through places that have zero declination is known as an agonic lines.

**Angle of dip or inclination ( $\theta$ ) :** The angle through which the N pole dips down with reference to horizontal is called the angle of dip. At magnetic north and south pole, angle of dip is  $90^\circ$ . At magnetic equator, the angle of dip is  $0^\circ$ .

**Horizontal component of earth's magnetic field :** The total intensity of the earth's magnetic field makes an angle  $\theta$  with horizontal. It has

- component in horizontal plane called **horizontal component  $B_H$** .
- component in vertical plane called **vertical component  $B_V$** .

### DIA, PARA AND FERROMAGNETIC SUBSTANCES

#### Diamagnetic Substances

The substances which when placed in a magnetic field are feebly magnetised in a direction opposite to that of the magnetising field are called diamagnetic substances. e.g., Cu, Zn, Bi, Ag, Au, Pb, He, Ar, NaCl, H<sub>2</sub>O, marble, glass etc.

#### Paramagnetic Substances

The substances which when placed in a magnetic field are feebly magnetised in the direction of magnetising field are called paramagnetic substances.e.g., -

Al, Na, Sb, Pt, CuCl<sub>2</sub>, Mn, Cr, liquid oxygen etc.

#### Ferromagnetic Substances

The substances which when placed in a magnetic field are strongly magnetised in the direction of the magnetising field are called ferromagnetic substances. Iron, cobalt, nickel etc. are some examples of ferromagnetic substance.

## LIGHT

The branch of physics which deals with nature, source, properties and the effects of light is called **optics**. It is mainly through light and the sense of vision that we know and interpret the world around us.

### LIGHT AND ITS CHARACTERISTICS

Light is a form of energy that produces the sensation of vision on our eyes. It is an electromagnetic radiation, such as that emitted by the Sun, which acts like a wave in a wavelength range from 400 nm to 750 nm that the human eye can perceive. It is a combination of electric and magnetic oscillations in mutually perpendicular directions, but the light wave itself propagates in a direction perpendicular to both the oscillations.

#### Characteristics of Light

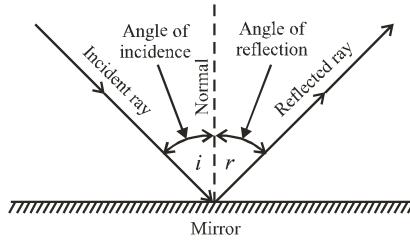
- Light travels along a straight line in a medium or vacuum. The path of light changes only when the medium changes. This is also called the rectilinear propagation of light. The path is *called a ray of light*, and bundle of such rays constitutes *a beam of light*.
- Light travels with a speed nearly equal to  $3 \times 10^8$  m/s in vacuum. According to current theories, no material particle can travel at a speed greater than the speed of light.
- The speed of light depends on the medium through which they pass.
- Light shows different behaviour such as reflection, refraction, interference, diffraction, polarisation etc.

#### Science in Action

The casting of shadows and eclipses are due to the rectilinear propagation of light.

### REFLECTION OF LIGHT

The turning back of light in the same medium is called reflection of light.



#### Laws of Reflection

- The angle of incidence ( $i$ ) is always equal to the angle of reflection ( $r$ ). i.e.,  $\angle i = \angle r$
- The incident ray, the normal, and the reflected ray all lie in the same plane.

### Characteristics of Image Formed by Plane Mirror

- A plane mirror always forms virtual and erect image of the object.
- Distance of object from mirror = distance of image from mirror.
- The image is laterally inverted (better word pversion),

i.e., the left of the object becomes the right of the image and vice versa.

- (iv) The size of the image is the same as that of the object.

### Spherical Mirror, Its Types and Uses

A highly polished curved surface whose reflecting surface is a cut part of a hollow sphere of a glass or any polished metal is called spherical mirror. Spherical mirrors are of two types:

#### Concave or Convergent Mirrors

Imagine a sphere of hollow glass. If we cut out a spherical cap and polished it with silver on the outside, we have a concave mirror.

#### Convex or Divergent Mirrors

If we polished the inner surface of a concave mirror with silver and look at the outward bulge, we have a convex mirror.

### Image Formed by Convex Mirror

The image is always virtual, erect, smaller than the object and is located between the pole and the focus no matter where in front of the mirror the object is placed.

#### Terms Related to Spherical Mirror

**Centre of curvature (C)** : It is the centre of sphere of which the mirror is a part.

**Radius of curvature (R)** : It is the radius of the sphere of which the mirror is a part.

**Pole (P)** : It is the geometrical centre of the spherical reflecting surface. All distances are measured from the pole.

**Principal axis** : It is the straight line joining the centre of curvature to the pole.

**Focus (F)** : When a narrow beam of rays of light, parallel to the principal axis and close to it ( known as paraxial rays), is incident on the surface of a mirror, the reflected beam is found to converge ( concave mirror) or appear to diverge ( convex mirror) from a point on principal axis. This point is called focus.

**Focal length (f)** : It is the distance between the pole and the principal focus. For spherical mirrors,  $f = R/2$ .

#### Uses of Concave Mirror

Makeup and shaving mirrors are concave mirrors. Concave mirrors are also used in a new method for displaying the speed of a car, as a dentist mirror, in floodlight, in solar cooker etc.

#### Uses of Convex Mirror

Convex mirrors, give a wider field of view than do other types of mirrors. Therefore, they are often used for security purposes and rear view mirror in vehicles.

## MIRROR FORMULA AND MAGNIFICATION

#### Mirror Formula

A relationship among the object distance ( $u$ ), the image distance ( $v$ ) and the focal length ( $f$ ) of a mirror

$$\text{i.e., } \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

#### Magnification

If the mirror is plane, the size of the image is always equal to the size of the object i.e., **magnification is unity**. But the case is different for a curved mirror. The size of the image is different from the size of the object in such a 'mirror'. Image may be greater or smaller in size than the object depending upon the

nature of the mirror or the location of the object.

Let  $I$  and  $O$  be the size of the image and the object respectively then

$$\text{Magnification, } m = \frac{I}{O} = -\frac{v}{u}$$

This is also called linear magnification.

## REFRACTION OF LIGHT

The bending of the light ray from its path in passing from one medium to the other medium is called refraction of light.

If the refracted ray bends towards the normal relative to the incident ray (Passing obliquely), then the second medium is said to be denser than the first medium. But if the refracted ray bends away from the normal, then the second medium is said to be rarer than the first medium.

If a ray of light passing normally i.e., at right angles from one medium to another optical medium then it does not bend or deviate from its path.

**Cause of refraction of light:** Refraction of light takes place due to change in the speed of light as it enters from one medium to another medium.

#### Laws of Refraction

There are two laws of refraction

- The incident ray, the refracted ray, and the normal to the refracting surface at the point of incidence are in the same plane.
- The ratio of *sine* of angle of incidence to the *sine* of angle of refraction is constant for a pair of media

$$\text{i.e., } \frac{\sin i}{\sin r} = \text{constant } ({}^1\mu_2)$$

where  ${}^1\mu_2$  is the refractive index of medium 2 w.r.t. medium 1. This law is also known as **snell's law**.

## REFRACTIVE INDEX

Light travels through a vacuum at a speed  $c = 3.00 \times 10^8$  m/s. It can also travel through many materials, such as air, water and glass. Atoms in the material absorb, remit and scatter the light, however. Therefore, light travels through the material at a speed that is less than  $c$ , the actual speed depending on the nature of the material.

To describe the extent to which the speed of light in a material medium differs from that in a vacuum, we use a parameter called the index of refraction (or refractive index).

The ratio of speed of light in free space  $c$  to that in a given medium  $v$  is called **absolute refractive index**

$$\text{i.e., } \mu \text{ or } n = \frac{c}{v}$$

**Relative refractive index :** When light passes from one medium to the other, the refractive index of medium 2 relative to 1 is

$$\text{written as } {}^1\mu_2 \text{ and is defined as } {}^1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{(c/v_2)}{(c/v_1)} = \frac{v_1}{v_2}$$

#### Real and Apparent Depths

When an object is seen from other medium, we don't see its actual or real depth or height. The depth we see is called

apparent depth.

- When object in denser medium and observer in rarer medium, then

$$\mu = \frac{\text{real depth}}{\text{apparent depth}}$$

And in this case,

real depth > apparent depth

- When object in rarer medium and observer in denser medium, then

$$\mu = \frac{\text{apparent depth}}{\text{real depth}}$$

And in this case,

apparent depth > real depth

#### **Science in Action**

Refraction causes many illusions. One of them is the apparent bending of a stick that is partially submerged in water.

The submerged part appears closer to the surface than it actually is. The same is true when you look at a fish in water. The fish appears nearer to the surface and closer than it really is. If we look straight down into water, an object submerged 4 meters beneath the surface appears to be only 3 meters deep. Because of refraction, submerged objects appear to be magnified.

## **TOTAL INTERNAL REFLECTION**

When a light ray, travelling from a denser medium to a rarer medium is incident at the interface at an angle of incidence greater than critical angle ( $c$ ) i.e., the angle of incidence in a denser medium for which the angle of refraction in rarer medium becomes  $90^\circ$ , then light rays reflected back into the denser medium. This phenomenon is called total internal reflection (TIR).

*Sparkling of diamond, optical fibres etc. are the applications of total internal reflection.*

**Critical angle:** The angle of incidence in a denser medium for which the angle of refraction in rarer medium becomes  $90^\circ$  is called critical angle.

Refractive index of denser medium  $\mu = \frac{1}{\sin c}$

#### **Science in Action**

- Optical fibre – based on total internal reflection, is used in telecommunication, and to send laser light rays inside the human body.
- Brilliance of diamond is based on total internal reflection. Critical angle for diamond and air interface =  $24^\circ$  is very small. Thus by cutting diamond suitably, multiple total internal reflection are made to occur.
- Mirage is an optical illusion of water which appears in the desert in hot summer. This is due to total internal reflection.

## **LENS**

A lens is a piece of transparent material with two refracting surfaces such that at least one is curved and refractive index of used material is different from that of the surroundings.

**Convex lens:** A thin spherical lens with refractive index greater

than that of surrounding behaves as a convergent or convex lens i.e. converges parallel rays. Its central (i.e. paraxial) portion is thicker than marginal one.

**Concave lens:** If the central portion of a lens (with  $\mu_L > \mu_M$ ) is thinner than marginal, it diverges parallel rays and behaves as a divergent or a concave lens.

## **Uses of Convex Lens and Concave Lens**

**Uses of convex lens :** As a magnifying glass, search lights, spotlights in the theatres, in microscope, telescope, photographic camera etc.

**Uses of concave lens :** In spectacles for the correction of myopia, Gallilean telescope etc.

## **TERMS RELATED TO THIN SPHERICAL LENS**

**Optical centre (O)** - It is the geometrical centre of the lens or a point for a given lens through which any ray passes undeviated.

**Principal axis ( $C_1C_2$ )** - It is a line passing through optical centre and perpendicular to the lens. The centre of curvature of curved surface always lie on the principal axis.

**Principal focus (F)** - A lens has two surfaces and hence two focal points, first focal point is an object point on the principal axis for which image is at infinity while second focal point is an image point on the principal axis for which object is at infinity.

**Focal length (f)** - The distance between optical centre of a lens and the principal focus.

**Aperture** - In reference to lens, aperture means to effective diameter of its light transmitting area so that brightness i.e. intensity of image formed by a lens which depends on the light passing through the lens will depend on the square of aperture. i.e.  $I \propto (\text{aperture})^2$

#### **For Divergent or Concave lens**

- If object is at infinity image will be formed at focus on the same side of the lens as the object, virtual, erect and point sized.
- If object is in front of lens, anywhere between the optical centre and infinity image will be formed between focus and the optical centre, on the same side of the lens, highly diminished, virtual and erect.

## **LENS FORMULA**

If an object is placed at a distance  $u$  from the optical centre 'O' of a lens and its image is formed at a distance  $v$  (from the optical centre) and focal length of this lens is  $f$  then

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

## **MAGNIFICATION**

If a thin object of linear size  $O$  situated vertically on the axis of a lens at a distance  $u$  from the optical centre and its image of size  $I$  is formed at a distance  $v$  (from the optical centre) then

$$\text{Magnification}, m = \frac{I}{O} = \frac{v}{u}$$

## **POWER OF A LENS**

If focal length of a lens is measured in metre ( $m$ ) then its

## Electricity, Magnetism & Light

reciprocal gives the power ( $P$ ) of the lens.

$$\text{i.e., Power of a lens, } P = \frac{1}{f(\text{in m})}$$

The S.I. unit of power is diopter (D).

Power of a combination of lenses:

$$P = P_1 + P_2 + \dots + P_n$$

## INTERFERENCE OF LIGHT

When two light waves of exactly same frequency travels in a medium, in the same direction simultaneously then due to their superposition, the intensity of light is maximum at some points while the intensity is minimum at some other points. This phenomenon is called interference of light. *The colours in soap bubbles and oil slicks are due to this property of light.*

## DIFFRACTION OF LIGHT

The wavelength of light is of the order of angstroms. So, when light waves encounter obstacles of very small sizes, the light waves bend around the edges of the obstacle and travel. This is known as diffraction of light.

## POLARISATION OF LIGHT

An ordinary source of light such as bulb consists of a large number of waves emitted by atoms or molecules in all directions symmetrically. Such light is called unpolarized light

### Science in Action

- In order to avoid glare in observing very minute particles, the objectives of microscopes are fitted with Polaroids.
- Polaroids are used in holography (three dimensional motion pictures).
- In polar regions where magnetic compass cannot be operated, polarization of scattered sunlight is used for navigation.

## THE HUMAN EYE

The eye allows us to see and interpret the shapes, colors, and dimensions of objects by processing the light they reflect or emit. The eye is able to see in bright light or in dim light, but it cannot see objects when light is absent.

**Eye lens :** It is a convex lens made of transparent and flexible jelly like material. Its curvature can be adjusted with the help of ciliary muscles.

### Power of Accommodation

The ability of the eye lens to change its shape to focus near and distant objects clearly is called *power of accommodation*.

The minimum distance, at which objects can be seen most distinctly without strain, is called the least distance of distinct vision. It is also called the near point(N.P.) of the eye. For a young adult with normal vision, the near point is about 25 cm.

## DEFECTS OF VISION AND THEIR CORRECTION

### Myopia or Short-Sightedness

A person with myopic eye can see nearby objects clearly but cannot see far off objects distinctly.

**Remedy:** This defect can be corrected by using a concave lens of suitable focal length. A concave lens diverges the rays coming from the object so that they get focused at the retina.

### Hypermetropia or Far-sightedness

A person with hypermetropic eye can see far off objects clearly but cannot see nearby objects clearly.

**Remedy:** Eyeglass with convex lens is used to rectify this problem.

### Presbyopia

Presbyopia is due to a lessening of flexibility of the crystalline lens, as well as to a weakening of the ciliary muscles which control lens focusing, both attributable to the ageing process.

**Remedy:** Person suffering from presbyopia require bifocal lenses. A common type of bi-focal lenses consists of both concave and convex lenses. The upper portion consists of a concave lens. It facilitates distant vision. The lower part is a convex lens. It facilitates near vision.

### Astigmatism

Astigmatism is the most common problem responsible for blurry vision.

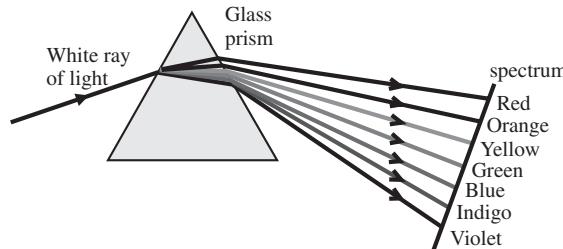
**Remedy:** cylindrical lens is use to correct astigmatism.

### Cataract

A cataract is a clouding of the lens in the eye.

## DISPERSION OF WHITE LIGHT BY A GLASS PRISM

The *phenomenon of decomposition of the white light into seven component colours when passing through a prism or through a transparent object delimited by non parallel surfaces is called dispersion of light.* A beam of light containing all the visible spectrum of the light is white, because the sum of all the colors generates the white color. Normally the light we use is white. It's the light containing all the colors mixed together. The light is decomposed in all the component colours, i.e., Violet, Indigo, Blue, Green, Yellow, Orange and Red, called as VIBGYOR.



## RAINBOW

A rainbow is a natural spectrum of sunlight in the form of bows appearing in the sky when the sun shines on raindrops after the rain. Rainbows are generated through refraction and total internal reflection of light in small rain drops. The sun is always behind you when you face a rainbow, and that the center of the circular arc of the rainbow is in the direction opposite to that of the sun.

After rain, there are still some tiny water droplets remained in the air. If there is sunshine, a white sunbeam will be reflected and refracted by these tiny droplets. Different colors of light have different refractivity. They will be reflected in slightly different directions inside a water droplet. Since, water is more dense than

air, light is refracted as it enters the drop-red is bent less, blue more. Some of the light will reflect off the back of the drop if the angle is larger than the critical angle ( $48^\circ$  for water).

The light is then refracted again as it leaves the drop (act like a small prism), the colours of white light have been dispersed.

- Violet light will leave the drop at an angle of  $40^\circ$  from the beam of sunlight
- Red light will leave the drop at an angle of  $42^\circ$  from the beam of sunlight.

## ATMOSPHERIC REFRACTION

The density of air in the atmosphere is not the same everywhere. It is greatest at the earth's surface and goes on decreasing as we move higher. The refractive index of air depends on its density—higher the density of air, greater its refractive index. The changes in refractive index of earth's atmosphere or air give rise to many phenomena like twinkling of stars, advance sunrise and delayed sunset etc.

## Twinkling of Stars

The scientific name for the twinkling of stars is stellar scintillation (or astronomical scintillation). Stars twinkle when we see them from the Earth's surface because we are viewing them through thick layers of turbulent (moving) air in the Earth's atmosphere. Stars (except the Sun) appear as tiny dots in the sky; as their light travels through the many layers of the Earth's atmosphere, the light of the star is bent (refracted) many times in random directions (light is bent when it hits a change in density-like a pocket of cold air or hot air). This random refraction results in the twinkling of stars.

## Advance Sunrise and Delayed Sunset (Approximately 2 minutes)

The actual sunrise takes place when the sun is just above the horizon. When the sun is just below the horizon, the light rays coming from it, on entering the earth's atmosphere suffer atmospheric refraction from a rarer medium to a denser medium. So, they bend towards the normal at each refraction. Due to the continuous refraction of light rays at each layer of the atmosphere, it follows a curved path as shown in Figure and reaches the eyes of the observer at O.

## SCATTERING OF LIGHT

The interplay of light with objects around us gives rise to several spectacular phenomena in nature like the blue colour of the sky, colour of water in deep sea, the reddening of the sun at sunrise and the sunset etc. When sunlight enters the earth atmosphere, air and water vapour molecules absorb part of the light and reradiate it to all directions. This is called *scattering of light*.

## Tyndall Effect

When a beam of sunlight enters a dusty (or smoke filled) room through a window then path becomes visible due to scattering of light by dust or smoke particles this phenomenon is called tyndall effect.

## The reddening of the Sun at Sunrise and Sunset

At noon, the light of sun travels relatively shorter distance

through earth's atmosphere thus appears white as only a little of blue and violet colours are scattered. Near the horizon, most of the blue and green light and shorter wavelengths are scattered and hence the sun appears reddish at sunrise and sunset.

## OPTICAL INSTRUMENTS

### Simple Microscope (Magnifying Glass or Reading Lens)

It consists of a convergent lens with object between its focus and optical centre and eye close to it. The image formed by it is erect, virtual, enlarged and on same side of lens between object and infinity.

#### Magnification by a simple microscope

The magnifying power (MP) of a simple microscope

$$MP = \frac{\text{Visual angle with instrument}}{\text{Max. visual angle for unaided eye}} = \frac{\theta}{\theta_0}$$

### Compound Microscope

It consists of two convergent lenses  $f_{\text{eye lens}} > f_{\text{objective}}$  and  $(\text{diameter})_{\text{eyelens}} > (\text{diameter})_{\text{objective}}$  arranged co-axially. The separation between objective and eye-piece can be varied.

#### Magnification produced by a compound microscope :

$$M = m_{\text{objective}} \times m_{\text{eye piece}}$$

### Telescope

It is used to provide angular magnification of distant objects. i.e., to see far off objects.

### Astronomical Telescope (Refracting Type)

It consists of objective, i.e., a converging lens, of larger focal length  $f_0$  and larger aperture, and an eyepiece, also a converging lens, of smaller focal length  $f_e$  and smaller aperture, placed coaxially.

#### Magnifying Power (M)

Magnifying power (M), also called angular magnification of a telescope is defined as the ratio of the visual angle subtended by the final image at the eye and the visual angle subtended by the object when the object lies in the actual position.

Astronomical telescope is used to see heavenly bodies and terrestrial telescope to see far off objects on earth.

## PRIMARY AND SECONDARY COLOURS OF LIGHT

### Primary colours

The group of colours which can be used to form all other colours by mixing.

**Examples:** red, green, blue., White = Blue + Green + Red

### Secondary colours

These are created by combining two or more primary colours.

**Examples :** Red + Blue = Magenta,

Red + Green = Yellow, Blue + Green = Cyan

# EXERCISE

1. The polarity of an unmarked horse shoe magnet can be determined by using [NDA]
  - (a) a charged glass rod
  - (b) a magnetic compass
  - (c) an electroscope
  - (d) another unmarked bar magnet
2. The earth's magnetic field is approximately [NDA]
  - (a) 1 Tesla
  - (b) 2 Gauss
  - (c)  $10^4$  Tesla
  - (d) 1 Gauss
3. An electric lamp of 100 watt is used for 10 hours per day. The 'units' of energy consumed in one day by the lamp is [NDA]
  - (a) 1 unit
  - (b) 0.1 unit
  - (c) 10 units
  - (d) 100 units
4. The main power supply in India is at 220 V, whereas that in the US is at 110 V. Which one among the following statements in this regard is correct? [NDA]
  - (a) 110 V is safer but more expensive to maintain
  - (b) 110 V is safer and cheaper to maintain
  - (c) 110 V leads to lower power loss
  - (d) 110 V works better at higher latitudes
5. Two pieces of conductor of same material and of equal length are connected in series with a cell. One of the two pieces has cross-sectional area double that of the other. Which one of the following statements is correct in this regard ? [NDA]
  - (a) The thicker one will allow stronger current to pass through it.
  - (b) The thinner one would allow stronger current to pass through it.
  - (c) Same amount of electric current would pass through both the pieces producing more heat in the thicker one.
  - (d) Same amount of electric current would pass through both the pieces producing more heat in the thinner one.
6. Magnetism of a bar magnet can be destroyed if it is [NDA]
  - I. kept in the magnetic meridian.
  - II. placed in a direction opposite to that of the Earth's horizontal intensity.
  - III. heated to a temperature known as Curie temperature.

Select the correct answer using the code given below

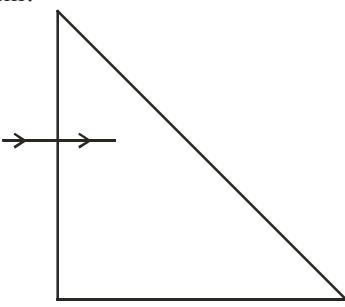
  - (a) I and III only
  - (b) II only
  - (c) II and III only
  - (d) I, II and III
7. What is the order of magnitude of electric resistance of the human body (dry) ? [IAS Prelim]
  - (a)  $10^2$  ohm
  - (b)  $10^4$  ohm
  - (c)  $10^6$  ohm
  - (d)  $10^8$  ohm
8. A wire of resistance 16 W is bent in the form of a circle. What is the effective resistance between diametrically opposite points? [NDA]
  - (a) 1 W
  - (b) 2 W
  - (c) 4 W
  - (d) 8 W
9. Fluorescent tubes are fitted with a choke. The choke coil : [IAS Prelim]
  - (a) steps up the line voltage
  - (b) steps-down the line voltage
10. (c) reduces current in the circuit  
 (d) chokes low frequency current
11. Electrically charged particles from space travelling at speeds of several hundred km/sec can severely harm living beings if they reach the surface of the Earth. What prevents them from reaching the surface of the Earth? [IAS Prelim]
  - (a) The Earth's magnetic field diverts them towards its poles
  - (b) Ozone layer around the Earth reflects them back to outer space
  - (c) Moisture in the upper layers of atmosphere prevents them from reaching the surface of the Earth
  - (d) None of the statements (a), (b) and (c) given above is correct
12. Match List I with List II and select the correct answer using the code given below the Lists : [NDA]
 

List I <b>(Magnet)</b>	List II <b>(Property)</b>
A. Artificial magnet	1. Long lived
B. Permanent magnet	2. Last for infinitely long period
C. Temporary magnet	3. Short lived
D. Earth as a magnet	4. Induced magnet
<b>A    B    C    D</b>	
(a) 3    1    4    2	
(b) 3    4    1    2	
(c) 2    1    4    3	
(d) 2    4    1    3	
13. Consider the following statements regarding a motor car battery: [IAS Prelim]
  1. The voltage is usually 12 V.
  2. Electrolyte used is hydrochloric acid.
  3. Electrodes are lead and copper.
  4. Capacity is expressed in ampere-hour.

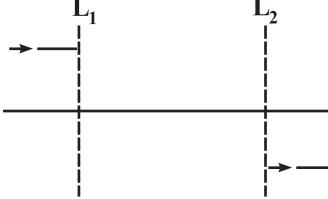
Which of the above statements are correct?

  - (a) 1 and 2
  - (b) 2 and 3
  - (c) 3 and 4
  - (d) 1 and 4
14. From a power station, the power is transmitted at a very high voltage because –
  - (a) it is generated only at high voltage
  - (b) it is cheaper to produce electricity at high voltage
  - (c) electricity at high voltage is less dangerous
  - (d) there is less loss of energy in transmission at high voltage
15. What is the number of neutral points for a bar magnet with its north pole pointing geographical north? [NDA]
  - (a) Zero
  - (b) One
  - (c) Two
  - (d) Infinite
16. Magnets attract magnetic substances are iron, nickel, cobalt, etc. They can also repel [NDA]
  - (a) paramagnetic substances
  - (b) ferromagnetic substances
  - (c) diamagnetic substances
  - (d) non-magnetic substances

16. Which one among the following is the correct order of power consumption for light of equal intensity? [NDA]  
 (a) CFL tube < Fluorescent tube < Incandescent bulb < Light emitting diode  
 (b) Light emitting diode < CFL tube < Fluorescent tube < Incandescent bulb  
 (c) CFL tube < Fluorescent tube < Light emitting diode < Incandescent bulb  
 (d) Incandescent bulb < Light emitting diode < Fluorescent tube < CFL tube
17. Two pieces of metallic wire having equal lengths and equal volume placed in air have different resistances. The two wires must [NDA]  
 (a) have different cross-sections  
 (b) have different temperatures  
 (c) be of different materials  
 (d) be of same density
18. Graphene is frequently in news recently. What is its importance? [IAS Prelim]  
 1. It is a two-dimensional material and has good electrical conductivity.  
 2. It is one of the thinnest but strongest materials tested so far.  
 3. It is entirely made of silicon and has high optical transparency.  
 4. It can be used as 'conducting electrodes' required for touch screens, LCDs and organic LEDs.  
 Which of the statements given above are correct?  
 (a) 1 and 2 only (b) 3 and 4 only  
 (c) 1, 2 and 4 only (d) 1, 2, 3 and 4
19. If the electrical resistance of a typical substance suddenly drops to zero then the substance is called [NDA]  
 (a) superconductor (b) semiconductor  
 (c) conductor (d) insulator
20. Which one of the following is correct?  
 Lightning is formed, when [NDA]  
 (a) similar charges of electricity rush towards each other and then get repelled  
 (b) clouds strike against impurities in air and the friction burns up these impurities  
 (c) strong opposite charges in different clouds break down the resistance offered by intervening air  
 (d) water vapour produces electricity in the clouds
21. Consider the following statements:  
 An ordinary light bulb has a rather short life because the: [IAS Prelim]  
 1. filament wire is not uniform.  
 2. bulb cannot be evacuated completely.  
 3. wires supporting the filament melt at high temperatures.  
 Which of the above statements are correct?  
 (a) 1 and 3 (b) 2 and 3  
 (c) 1 and 2 (d) 1, 2 and 3
22. Consider the following statements regarding a motor car battery: [IAS Prelim]  
 1. The voltage is usually 12 V.  
 2. Electrolyte used is hydrochloric acid.  
 3. Electrodes are lead and copper.  
 4. Capacity is expressed in ampere-hour.  
 Which of the above statements are correct?  
 (a) 1 and 2 (b) 2 and 3  
 (c) 3 and 4 (d) 1 and 4
23. In which one of the following cases Ohm's law is not valid? [NDA]  
 (a) Wire bound resistor  
 (b) Potentiometer  
 (c) Junction diode  
 (d) Electric bulb
24. Which one of the statements given below is **not** correct? [NDA]  
 (a) A vertical plane passing through the axis of a freely suspended magnet is called the magnetic meridian  
 (b) A vertical plan passing through the axis of rotation of the Earth is called the geographical meridian  
 (c) The degree to which the magnetic field can penetrate a medium is known as the relative permeability of the medium  
 (d) The relative permeability is not a dimensionless quantity
25. A current  $I$  flows through a potential difference  $V$  in an electrical circuit containing a resistance  $R$ . The product of  $V$  and  $I$ , i.e.,  $VI$  may be understood as [NDA]  
 (a) resistance  $R$   
 (b) heat generated by the circuit  
 (c) thermal power radiated by the circuit  
 (d) rate of change of resistance
26. A coin in a beaker filled with water appears raised. This phenomenon occurs because of the property of [NDA]  
 (a) reflection of light  
 (b) refraction of light  
 (c) total internal reflection of light  
 (d) interference of light
27. When light waves travel from air to glass, which variables are affected? [NDA]  
 (a) Wavelength, frequency and velocity  
 (b) Velocity and frequency only  
 (c) Wavelength and frequency only  
 (d) Wavelength and velocity only
28. Consider the following statement:  
 The principle of total internal reflection is applicable to explain the [NDA]  
 1. Formation of mirage in desert.  
 2. Formation of image in microscope.  
 3. Colour of evening sky.  
 4. Operation of optical fibres.  
 Which of the statement given above are correct?  
 (a) 1 and 4 (b) 3 and 4  
 (c) 2 and 3 (d) 1 and 2
29. When an optician prescribes a  $-5\text{D}$  lens, what does it mean? [NDA]  
 (a) Concave lens of 20 cm focal length  
 (b) Convex lens of 5 cm focal length  
 (c) Concave lens of 5 cm focal length  
 (d) Convex lens of 5 cm focal length
30. Which one of the following is the correct angle between the incident and reflected rays when a ray of light incident normally on a plane mirror? [NDA]  
 (a)  $180^\circ$  (b)  $90^\circ$   
 (c)  $45^\circ$  (d)  $0^\circ$

31. A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a [NDA]
- converging lens
  - diverging lens
  - plano-converging lens
  - plano-diverging lens
32. What is the phenomenon of the moon to appear bigger in size as it approaches the horizon, called ? [NDA]
- Atmospheric refraction of light
  - Diffraction of light
  - Scattering of light
  - Total internal reflection of light by water vapours
33. Which one among the following is used to make periscope? [NDA]
- Concave lens
  - Concave mirror
  - Plane mirror
  - None of the above
34. What is the essential difference between a terrestrial telescope and an astronomical telescope? [NDA]
- One of the lenses in a terrestrial telescope is concave
  - The final image formed in a terrestrial telescope is virtual
  - A terrestrial telescope forms an erect image while an astronomical telescope forms an inverted image
  - A terrestrial telescope forms an inverted image while an astronomical telescope forms an erect image
35. A ray of light is incident normally on one of the faces of right angled isosceles prism as shown above. It undergoes total internal reflection from hypotenuse. Which one of the following is the minimum refractive index of the material of the prism? [NDA]
- 
- 1.0
  - 1.33
  - 1.414
  - 1.6
36. A far-sighted person has a near point at 100 cm. What must be the power of the correcting lens? [NDA]
- 0.8 D
  - 3.0 D
  - +0.8 D
  - +3.0 D
37. An object is kept 5 cm in front of a concave mirror of focal length 15 cm. What will be the nature of the image? [NDA]
- Virtual, not magnified
  - Virtual, magnified
  - Real, not magnified
  - Real, magnified
38. The ratio of the focal length of the objective to the focal length of the eyepiece is greater than one for [NDA]
- a microscope
  - a telescope
  - both microscope and telescope

39. (d) neither microscope nor telescope



In the figure shown above,  $L_1$  and  $L_2$  are two lenses and are kept along the same axis. A parallel beam of light falling on  $L_1$  leaves  $L_2$  as a parallel beam: [NDA]

Consider the following statements.

- Both  $L_1$  and  $L_2$  can be convex lenses.
- The distance between the two lenses can be equal to sum of their focal lengths.

Which of the statements given above is/are correct?

- Only 1
- Only 2
- Both 1 and 2
- Neither 1 nor 2

40. Refractive index of an optical medium changes with  
1. the nature of the medium.

- the change in the angle of incidence of the ray.
- colour of the incident ray.

Select the correct answer using the code given below:

- 1 and 3 only
- 2 and 3 only
- 1 and 2 only
- 1, 2 and 3

41. Yellow colour light is used as fog light because yellow colour [NDA]

- light is most scattered by fog
- has the longest wavelength among all colours
- has the longest wavelength among all colours except red and orange but the red colour is already used for brake light and stop light whereas orange colour is avoided due to its similarity with red
- has the shortest wavelength among all colours not already reserved for other purpose

42. A refracting telescope consists of [NDA]

- one concave mirror and one convex lens
- two convex lenses of equal focal length
- two concave mirrors of different focal lengths
- two convex lenses of unequal focal lengths

43. An object is placed at the focus of a concave mirror. The image will be [NDA]

- real, inverted, same size at the focus
- real, upright, same size at the focus
- virtual, inverted, highly enlarged at infinity
- real, inverted, highly enlarged at infinity

44. Consider the following statements [CDS]

- Clear sky appears blue due to poor scattering of blue wavelength of visible light.
- Red part of light shows more scattering than blue light in the atmosphere.
- In the absence of atmosphere, there would be no scattering of light and sky will look black.

Which of the statements given above is/are correct?

- Only 1
- 1 and 2
- Only 3
- All of these

45. Assertion (A) : A myopic person is advised to use concave lens.

Reason (R) : The eye lens of a myopic person focuses the parallel rays coming from distant objects in front of the retina. [NDA]

- (a) Both A and R are individually true and R is the correct explanation of A  
 (b) Both A and R are individually true but R is NOT the correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
- 46.** If the focal length of the biconvex lens is 25 cm, then the power of the lens will be [NDA]  
 (a) + 4 dioptre      (b) - 4 dioptre  
 (c) + 0.04 dioptre    (d) - 0.04 dioptre
- 47.** Two thin convex lenses of focal lengths 4 cm and 8 cm are separated by a distance of 4 cm in air. The combination will have the focal length [NDA]  
 (a) 4 cm              (b) 8 cm  
 (c) 12 cm             (d) 32 cm
- 48.** **Assertion (A) :** Convex mirror is used as a driver mirror.  
**Reason (R) :** Images formed by convex mirror are diminished in size. [NDA]  
 (a) Both A and R are individually true and R is the correct explanation of A  
 (b) Both A and R are individually true but R is NOT the correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true
- 49.** Match the column - I and Column - II.
- | <b>Column-I</b>  | <b>Column-II</b>    |
|------------------|---------------------|
| A. Myopia        | P. Convex lens      |
| B. Hypermetropia | Q. Concave lens     |
| C. Presbyopia    | R. Cylindrical lens |
| D. Astigmatism   | S. Bifocal Lens     |
- (a) A-P; B-Q; C-S; D-R  
 (b) A-P; B-Q; C-R; D-S  
 (c) A-Q; B-P; C-S; D-R  
 (d) A-Q; B-P; C-R; D-S
- 50.** **Assertion (A) :** A person stands at a distance of 1m in front of a concave mirror. If the radius of curvature of the mirror is 4m, the image of the person lies at a distance 2m behind the mirror.  
**Reason (R) :** The general mirror equation confirms the location of the image from the mirror and it could be a real image. [NDA]
- (a) Both A and R are individually true and R is the correct explanation of A  
 (b) Both A and R are individually true but R is NOT the correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true

ANSWER KEY																			
1.	(b)	2.	(d)	3.	(a)	4.	(a)	5.	(d)	6.	(c)	7.	(b)	8.	(c)	9.	(c)	10.	(a)
11.	(a)	12.	(d)	13.	(b)	14.	(c)	15.	(c)	16.	(b)	17.	(c)	18.	(c)	19.	(a)	20.	(c)
21.	(d)	22.	(d)	23.	(c)	24.	(d)	25.	(c)	26.	(b)	27.	(d)	28.	(a)	29.	(a)	30.	(d)
31.	(b)	32.	(a)	33.	(c)	34.	(c)	35.	(c)	36.	(d)	37.	(b)	38.	(b)	39.	(c)	40.	(d)
41.	(c)	42.	(d)	43.	(d)	44.	(c)	45.	(a)	46.	(a)	47.	(a)	48.	(b)	49.	(c)	50.	(c)

# Chapter

# 6

# MODERN PHYSICS & SOURCES OF ENERGY

## MODERN PHYSICS

The basic building blocks of all the electronic circuits are the devices in which a controlled flow of electrons can be obtained. This chapter deals with the components of electronics such as semiconductors, diodes, transistors, integrated chips. Also describes the discovery of electron, proton, neutron and explains the latest technologies of the communication system such as Internet, Mobile Telephony etc.

### STRUCTURE OF THE ATOMIC NUCLEUS

An atom (size  $10^{-10}$  m) consists of a positively charged nucleus (size  $10^{-15}$  m) which is surrounded by electrons moving around it in different shells. Nucleus of an atom consists of protons and neutrons together called **nucleons** i.e., mass number (A) Radius of nucleus is related to mass number as  $R = R_0 A^{1/3}$  where constant  $R_0 = 1.25 \times 10^{-15}$  m.

#### Electron

Electron ( $e^-$ ) was discovered by sir J.J. Thomson in 1897 when he was studying the properties of cathode rays.

- (i) Electrons are negatively charged particles with e/m ratio  $1.76 \times 10^8$  c/g
- (ii) The charge of an electron was measured by R. Millikan in oil drop experiment as  $-1.6 \times 10^{-19}$  C
- (iii) Mass of an electron is  $9.1 \times 10^{-28}$  gram.
- (iv) Electron is approximately 2000 times lighter than hydrogen

#### Proton

In 1909, Rutherford discovered proton ( $p^+$ ) in his gold foil  $\alpha$ -particle scattering experiment

- (i) Protons are positively charged particles.
- (ii) The charge of a proton is  $+1.6 \times 10^{-19}$  C (same as magnitude of an electron).
- (iii) Mass of a proton is  $1.672 \times 10^{-24}$  gram.
- (iv) The atomic number of an element represents the number of protons in the nucleus.

#### Neutron

In 1932, James Chadwick discovered neutron ( $n$ ).

- (i) Neutron is an uncharged particle.
- (ii) Mass of neutron is  $1.674 \times 10^{-24}$  gm
- (iii) The mass number is the sum of number of protons and neutrons.

### PHOTOELECTRIC EFFECT

The phenomenon of emission of electrons from the surface of metal when light of suitable frequency falls on it is called photoelectric effect.

The ejected electrons are called **photoelectrons** and the current produced due to emitted electrons is called **photocurrent**.

#### Einstein's photoelectric equation

$$\frac{1}{2} mv_{\max}^2 = h(v - v_0) = hc \left( \frac{1}{\lambda} - \frac{1}{\lambda_0} \right) = eV_S$$

The Einstein's photoelectric equation is in accordance with conservation of energy.

### MASS ENERGY RELATION AND NUCLEAR BINDING ENERGY

Einstein established the equivalence of mass and energy through a relation known as **Einstein's mass-energy equivalence relation**.

$$E = mc^2$$

where  $C = 3 \times 10^8$  m/s (speed of light in vacuum)

This relation supports both the *law of conservation of mass* and *law of conservation of energy*.

#### Nuclear Binding Energy

The energy required to break a nucleus into its constituent nucleons and place them at infinite distance is called nuclear binding energy or binding energy. This is the energy with which the nucleons are held together.

The difference between the rest mass of nucleus and sum of rest masses of nucleons constituting the nucleus is known as **mass defect**.

#### Binding Energy per Nucleon

The binding energy per nucleon of a nucleus is the average energy required to extract a nucleon from the nucleus.

##### Binding energy per nucleon

$$\bar{B} = \frac{\text{Total binding energy}}{\text{Total number of nucleons}} = \frac{BE}{A} = \frac{\Delta mc^2}{A}$$

### RADIOACTIVITY

The phenomenon of spontaneous emission of radiations  $\alpha$ ,  $\beta$  or  $\gamma$ -rays from a substance is called radioactivity.

**Radioactivity is a spontaneous process** which is independent of all external conditions. It is not affected by temperature, pressure, electric or magnetic field.

The number of decays per unit time or decay rate is called activity.

$$\text{Activity } A = N\lambda$$

where  $N_0 \lambda = A_0$  is initial activity

**Half life** is the time in which activity of radioactive substance is reduced to half.

$$T_{1/2} = \frac{0.693}{\lambda}$$

### Radioactive Series

- The heavy natural nuclides can decay to stable end products by four paths. The four paths have mass number given as  $4n$ ,  $4n + 1$ ,  $4n + 2$  and  $4n + 3$  where  $n$  is integer.
- Last element of series is stable and has a decay constant zero.

### Properties of $\alpha$ , $\beta$ & $\gamma$ -rays

#### (A) Properties of $\alpha$ -rays

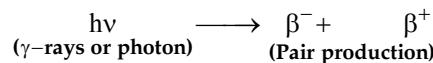
- It is a positively charged particle ( ${}^4_2\text{He}^{2+}$ ) and contains a charge of  $3.2 \times 10^{-19}$  coulomb(exactly double the charge of electron).
- The mass of  $\alpha$ -particles is  $6.645 \times 10^{-27}$  kg (It is equal to mass of a helium nucleus). Actually  $\alpha$ -particle is nucleus of helium, hence it is called doubly ionised helium.
- They ( $\alpha$ -particles) get deflected in both electric and magnetic fields.
- The velocity of  $\alpha$ -particle is very less than the velocity of light i.e.,  $v_\alpha \approx \frac{c}{10}$ , where  $c$  is velocity of light.
- The penetrating power of  $\alpha$  particle is lowest (in comparison to  $\beta$  and  $\gamma$  particles). It is 1/100 times of  $\beta$ -particles & 1/10,000 times of  $\gamma$ -rays.

#### (B) Properties of $\beta$ rays or $\beta$ -particles

- The beta particles (i.e.,  $\beta^-$ ) are electrons contain  $-1.6 \times 10^{-19}$  C of charge. Actually  $\beta^-$  is electron and  $\beta^+$  is positron.
- They get deflected in both electric and magnetic field.
- The velocity of  $\beta$ -particle varies between  $0.01c$  to  $.99c$ , where  $c$  is velocity of light.
- The mass of  $\beta$  particle is relativistic, because its velocity is comparable to velocity of light
- They have both ionisation and penetration power. Ionisation power less than  $\alpha$ -particle and penetration power more than  $\alpha$ -particle and less than  $\gamma$ -ray.

#### (C) Properties of $\gamma$ -rays (or gamma radiation)

- They are electromagnetic waves as x-rays.
- They are not deflected in electric and magnetic field, it means that they are chargeless.
- The velocity of  $\gamma$ -particle is equal to velocity of light.
- The ionisation power of gamma rays is less than  $\beta$  and  $\alpha$  rays but penetration power more than  $\beta$  and  $\alpha$ -rays.
- When  $\gamma$ -rays photon strikes nucleus then it gives rise to a phenomenon of pair production i.e.,



### Uses of Radioactive Isotopes

#### In medicine

- $\text{Co}^{60}$  for treatment of cancer
- $\text{Na}^{24}$  for circulation of blood
- $\text{I}^{131}$  for thyroid problem or goitre
- $\text{Sr}^{90}$  for treatment of skin and eye
- $\text{Fe}^{59}$  for location of brain tumor

#### In industries

- for detecting leakage in water and oil pipe lines
- for investigation of wear and tear, study of plastics and alloys, also in thickness measurement.

#### In agriculture

- ${}^6\text{C}^{14}$  to study plant photosynthesis
- ${}^{15}\text{P}^{32}$  to find nature of phosphate which is best for given soil and crop
- ${}^{27}\text{Co}^{60}$  for protecting potato crop from earthworm
- For pest control

#### In scientific research

- $\text{K}^{40}$  to find age of meteorites
- $\text{S}^{35}$  in factories

#### In carbon dating

- It is used to find age of earth and fossils
- The age of earth is found by Uranium disintegration and fossil age by disintegration of  $\text{C}^{14}$

### X-RAYS

- The X-rays were discovered by Prof. Roentgen, a German scientist in 1885. He was awarded Nobel Prize for this discovery in 1901. X-rays are electromagnetic waves.
- The modern apparatus for the production of X-rays was developed by Dr. Coolidge in 1913.
- X-rays are produced when fast moving electrons are suddenly stopped on a metal of high atomic number.

### Properties of X-rays

- They are not deflected by electric or magnetic field.
- They travel with the speed of light.
- There is no charge on X-rays.
- X-rays show both particle and wave nature.
- They are invisible.

### Applications of X-rays

Following are some important and useful applications of X-rays.

**Scientific applications:** Various diffraction patterns are used to determine internal structure of crystals.

**Industrial applications:** Since X-rays can penetrate through various materials, they are used in industry to detect defects in metallic structures in big machines, railway tracks and bridges.

**In radio therapy:** X-rays can cause damage to the tissues of body (cells are ionized and molecules are broken). So X-rays damages the malignant growths like cancer and tumors which are dangerous to life, when is used in proper and controlled intensities.

**In medicine and surgery:** The cracks or fracture in bones can be easily located. Similarly intestine and digestive system abnormalities are also detected by X-rays.

### Harmful Effects of Radiation

- The loss of hair quickly and in clumps occurs with radiation exposure.

2. Radiation kills nerve cells and small blood vessels and can cause seizures and immediate death.
3. The thyroid gland is susceptible to radioactive iodine. Insufficient amount of radioactive iodine can destroy all or part of the thyroid
4. Blood's lymphocyte cell count will be reduced and an increase long term risk for leukemia and lymphoma due to high level of radiations.

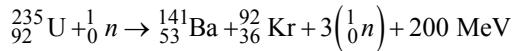
### Safety Precautions while Handling Radioactive source or Radiation

- The workers should be asked to wear lead lined aprons or special film badges. These badges can absorb nuclear radiations and can be tested to find the amount of radiation to which a particular worker is exposed.
- The radioactive contamination of the work area should be avoided at all costs.

## NUCLEAR REACTIONS

### Nuclear Fission

*Nuclear fission is the disintegration (Splitting) of a heavy nucleus upon bombardment by a projectile, such that the heavy nucleus splits up into two or more lighter nuclei of comparable masses with an enormous release of energy. 200 MeV per fission of U<sup>235</sup> nuclei.*



It is the principle of **atom bomb** (destructive use).

**Nuclear reactor** has been devised for this purpose.

**The main parts of nuclear reactor are**

- (a) **Nuclear fuel :** U<sup>233</sup>, U<sup>235</sup>, Pu<sup>239</sup> etc.
- (b) **Moderator :** Graphite, heavy water (D<sub>2</sub>O). To slow down the neutrons (or slow down the nuclear reaction).
- (c) **Control rods :** (Cadmium, boron). To absorb excess neutrons. It controls the chain reaction.
- (d) **Coolant :** (water etc). To remove the heat produced in the core to heat exchanger for production of electricity.

### Nuclear Fusion :

*It is the fusion of two or more light nuclei to form a heavy nucleus with a release of huge amount of energy.*

The nuclear fusion reaction, which is the source of the energy of sun/ star are proton-proton cycle.

## SEMICONDUCTORS

The materials whose conductivity lies between conductors ( $10^2 - 10^8 \text{ sm}^{-1}$ ) and insulators ( $10^{-11} - 10^{-19} \text{ sm}^{-1}$ ) are called semiconductors ( $10^5 - 10^{-6} \text{ sm}^{-1}$ )

There are two types of semiconductor.

**Intrinsic Semiconductor:** These semiconductors are pure in which the thermal vibrations of the lattice have liberated charge carriers (i.e., electrons and holes). In intrinsic semiconductor, the number of electrons are equal to the number of holes. i.e.,  $n_i = n_e = n_h$  e.g. Si, Ge,

**Extrinsic Semiconductor:** They are impure semiconductors in which traces of impurity introduces mobile charge carriers

[which may be + ve (holes) or -ve (electrons)] in addition to those liberated by thermal vibration.

Again there are two types of extrinsic semiconductors

- (i) N-type semiconductor
- (ii) P-type semiconductor.

### N-type Semiconductor

When a pure semiconductor (Si or Ge) is doped by pentavalent impurity (P, As, Sb, Bi) then four electrons out of the five valence electrons of impurity take part in covalent bonding, with four silicon atoms surrounding it and the fifth electron is set free. These impurity atoms which donate free e<sup>-</sup> for conduction are called as **donor impurity** (N<sub>D</sub>). Here free e<sup>-</sup> increases very much so it is called as n-type semiconductor and impurity ions known as "**immobile donor positive ions**". Free e<sup>-</sup> called as majority charge carriers and holes called as minority charge carriers.

### P-type Semiconductor

When a pure semiconductor (Si or Ge) is doped by trivalent impurity (B, Al, In, Ga) then outer most three electrons of the valence band of impurity take part, in covalent bonding with four silicon atoms surrounding it and one electron from semiconductor makes hole in semiconductor. These impurity atoms which accept bonded e<sup>-</sup> from valence band are called as **acceptor impurity** (N<sub>A</sub>). Here holes increases very much so it is called as p-type semiconductor and impurity ions known as "**immobile acceptor negative ions**". Free e<sup>-</sup> are called as minority charge carriers and holes are called as majority charge carriers.

## P-N JUNCTION DIODE

When a P-type semiconductor is suitably joined to an N-type semiconductor, then resulting arrangement is called P-N junction or P-N junction diode.

### Forward and Reverse Biasing

**Forward biasing :** If we apply a voltage V such that P-side of the P-N junction diode is positive and N-side is negative then it is called forward biasing.

**Reverse biasing :** If we apply a voltage V such that P-side is negative and N-side is positive then it is called reverse biasing.

### P-N Junction Diode as a Rectifier

Rectifier is a device which converts ac to unidirectional pulsating output. In other words it converts ac to dc. It is of following types.

- (i) Half wave rectifier
- (ii) Full wave rectifier

### P-N Junction diode as an Inverter

It is a device which converts direct current (d.c) to alternating current (a.c.)

## TRANSISTOR

Transistor in general is known as bipolar junction transistor. It is a current operated device. It consists of three main regions

**Emitter (E):** It provides majority charge carriers by which current flows in the transistor. Therefore the emitter semiconductor is heavily doped.

**Base (B):** The based region is lightly doped and thin.

**Collector (C):** The size of collector region is larger than the two other regions.

### Transistors are of Two Types

**N-P-N Transistor :** If a thin layer of P-type semiconductor is sandwiched between two thick layers of N-type semiconductor is known as NPN transistor.

**P-N-P Transistor :** If a thin layer of N-type of semiconductor is sandwiched between two thick layer of P-type semiconductor is known as PNP transistor.

### Transistor as an Amplifier

A device which increases the amplitude of the input signal is called amplifier.

### Transistor as a switch

Transistors can be used in an electronic circuit as a simple switches. A transistor conducts current across the collector emitter path only when a voltage is applied to the base. When no base voltage is present, the switch is off when base voltage is present, the switch is on.

### Transistor as an Oscillator

**Oscillator** is a device which delivers a.c. output wave form of desired frequency from d.c. power even without input signal excitation.

Transistors are used in variety of applications such as

- High current transistors are used in car power inverters.
- Audio equipment uses transistors.
- Transistors are used in hearing aids.

## OPTOELECTRONIC DEVICES

**Zener diode :** A properly doped crystal diode which has sharp breakdown voltage is known as Zener diode. It is always connected in reverse bias condition. It is used as a voltage regulator. In forward biased case, it works as a simple diode.

**Photodiode :** A junction diode made from light or photosensitive semiconductor is called a photodiode.

**Light emitting diode (LED) :** When a junction diode is "forward biased" energy is released at junction in the form of light due to recombination of electrons and holes. In case of Si or Ge diode, the energy released is in infra-red region.

In the junction diode made of GaAs, InP etc. energy is released in visible region such a junction diode is called "light emitting diode" (LED).

LEDs are used in various real life projects such as

- Solar powered LED street light.
- LED based automatic emergency light.
- Displaying dialed telephone numbers on seven segment display, etc.

## INTEGRATED CIRCUITS

An integrated circuit (IC), sometimes called a **chip** or **microchip**, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors and transistors are fabricated. An IC can function as an amplifier, oscillator, timer, counter, computer memory or microprocessor.

### Uses of ICs

- (i) In cars (automotive controls) televisions, computers, microwaves, laptops, MP3, play stations, cellular phones, aeroplanes, space crafts etc.
- (ii) In switching telephone circuits, data processing, military equipments.
- (iii) In digital watchs, scientific calculator and computers (flip-flops, logic gates, temperature sensors etc.)

## COMMUNICATION

*Communication means transmission of information.* Every communication system has three essential elements-*Transmitter, medium/channel and receiver*.

Transmitter, converts the message signal produced by the source of information into a form suitable for transmission through the channel and receiver receives transmitted signal.

### Modes of Communication

**There are two basic modes of communication:**

- (i) **Point-to-point communication mode :** In this mode, communication takes place over a link between a single transmitter and receiver as in telephone.
- (ii) **Broadcast mode of communication :** In this mode, there are a large number of receivers corresponding to a single transmitter. Radio and television are most common examples of broadcast mode of communication.

### Modulation and Demodulation

**Modulation :** The original low frequency message/information signal cannot be transmitted to long distances. So, at the transmitter end, information contained in the low frequency message signal is superimposed on a high frequency wave, which acts as a carrier of the information. This process is known as modulation.

**Demodulation:** The process of retrieval of original information from the carrier wave at the receiver end is termed as demodulation. This process is the reverse of modulation.

## WAVE PROPAGATION

### Ground Wave or Surface Wave Propagation

The radio waves which travel through atmosphere following the surface of earth are known as **ground waves or surface waves** and their propagation is called **ground wave propagation or surface wave propagation**.

The ground wave propagation is suitable for low and medium frequency i.e., upto 20 MHz only.

### Sky Wave Propagation

The sky waves are the radiowaves of frequency between 2MHz to 30 MHz.

The highest frequency of radio waves which when sent straight i.e., normally towards the layer of ionosphere gets reflected from ionosphere and returns to the earth is called **critical frequency**.

### Space Wave Propagation

The space waves are the radiowaves of very high frequency i.e., between 30 MHz to 300 MHz or more.

## INTERNET AND MOBILE TELEPHONY

### Internet

The Internet is a worldwide, publicly accessible series of interconnected computer networks that transmit data by packet switching using the standard Internet Protocol (IP).

**File transfer :** In computing, file transfer is a generic term for referring to the act of transmitting files over a computer network. While the term "file transfer" is often linked to the File Transfer Protocol (FTP), there are numerous ways to transfer files over a network. Servers which provide a file transfer service are often called file servers.

#### There are 2 Types of file transfers:

"Pull-based" file transfers where the receiver initiates a file transmission request.

"Push-based" file transfers where the sender initiates a file transmission request.

Some protocols for file transfer may provide both of these, and they are often referred to as "uploading" or "downloading", from the client's perspective.

**The World Wide Web** (commonly shortened to the www) is a system of interlinked hypertext documents accessed via the Internet. The World Wide Web was created in 1989 by Sir Tim Berners-Lee, working at CERN in Geneva, Switzerland and released in 1992.

### Mobile Telephony

The central concept of this system is to divide the service area into a suitable number of cells centred on an office called MTSO (Mobile Telephone Switching Office). Each cell contains a low-power transmitter called a base station and customers. When a mobile receiver crosses the coverage area of one base station, it is necessary for the mobile user to be transferred to another base station. This procedure is called handover or handoff. This process is carried out very rapidly, to the extent that the consumer does not even notice it. Mobile telephones operate typically in the UHF range of frequencies about 800-950 MHz.

## SOURCES OF ENERGY

Everything we do is connected to energy in one form or another, Energy, defined as "the ability to do work."

Various forms of energy includes: Biomass energy - energy from plants, Electricity, Geothermal energy, Fossil Fuels - Coal, Oil and Natural gas, Hydro power Ocean energy, Nuclear energy, Wind energy etc.

Energy sources are divided into two groups -- renewable and non-renewable Renewable and non-renewable energy sources can be used to produce secondary energy sources including electricity.

### GOOD SOURCES OF ENERGY

A source of energy is that which can provide adequate usable energy at a steady rate over a long period of time. A good source of energy possesses the following characteristics: (i) large amount of work per unit volume or mass (ii) be easily accessible, (iii) be easy to store and transport, and (iv) be economical. So evaluation criteria for good source of energy are:

Capital costs, Operating costs, Efficiency, Is it renewable?, Energy storage requirements, Pollution, Environmental modification, Levelized cost to the consumer, Feasibility on large scale, Unit capacity, Proper ignition temperature, High calorific value etc.

#### Handy Facts

- Calorific value of a fuel is the amount of heat produced by unit mass or unit volume of that fuel.
- Ignition temperature of fuel is the temperature at which the fuel starts burning or producing energy.

## CLASSIFICATION OF SOURCES OF ENERGY (on the basis of recycling period)

### Renewable Sources of Energy

**Renewable sources of energy** are those which can be generated by us or which are constantly being generated by natural processes or whose supply is unlimited. Examples : The sun, wind, flowing water, etc.

### Non-Renewable Sources of Energy

Non-renewable sources of energy are those which were produced in the past by natural processes, whose supply is limited and which we cannot generate again in short interval of time, these will be exhausted in future. Examples : Coal, petroleum, natural gas, etc.

## CONVENTIONAL SOURCES OF ENERGY

The sources of energy which are extensively used by man due to their easy availability .

For example : Fossil fuels, wind energy, energy from biomass etc.

### Fossil Fuels

Fossil fuels are hydrocarbon based natural resources that were formed over 300 hundred millions of years ago by the fossilization of prehistoric plants and animals. There are three major forms of fossil fuels: coal, oil and natural gas.

### Drawbacks of Fossils Fuels

- Fossil fuels are non-renewable resources and are limited.
- Global warming is directly associated with the increase in greenhouse gases produced from the burning of fossil fuels.
- On burning fossil fuels releases acidic oxides which leads to acid rain and thus affecting soil and water resources.
- Environmental pollution : Burning of fossil fuels causes air pollution

#### Science in Action

Hydrogen is considered as a clear fuel than CNG because burning of CNG is gives out CO and CO<sub>2</sub> but H<sub>2</sub> does not give any harmful gases and calorific value of H<sub>2</sub> is higher than CNG.

## Thermal Power Plant

A thermal power station comprises all of the equipment and systems required to produce electricity by using a steam generating boiler fired with fossil fuels or biofuels to drive an electrical generator. Such power stations are most usually constructed on a very large scale and designed for continuous operation.

## Hydro Power Plant

Hydro power means making electricity from water power. It is the largest source of renewable power worldwide. A quarter of our energy requirement in India is met by hydro-power plants. Hydroelectric power uses the kinetic energy of moving water to make electricity. Dams can be built to stop the flow of river. Water behind a dam often forms a reservoir.

The water from the high level is carried through pipes in order to rotate the turbine. As the turbine rotates, the armature of the generator also rotates and thus produces electricity.

About 20% of the power generated in India comes from hydroelectric power stations.

### Advantages of Hydroelectricity

- This technique does not cause any environmental pollution.
- It is one of the cheapest sources of energy.
- Dams constructed on rivers helps in irrigation and also in controlling floods.

## BIO-MASS

Biomass is a renewable energy source because the energy it contains comes from the sun. Through the process of photosynthesis, chlorophyll in plants captures the sun's energy and converting carbon dioxide from the air and water from the ground into carbohydrates, complex compounds composed of carbon, hydrogen, and oxygen. When these carbohydrates are burned, they turn back into carbon dioxide and water and release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy. As long as biomass is produced sustainably with only as much used as is grown then this battery will last indefinitely.

### Bio-mass as a Fuel :

- Wood as a fuel. i.e., firewood.
- Animal dung as a fuel.

## BIO-GAS

Bio-gas is made from organic waste matter after it is decomposed. The decomposition breaks down the organic matter, releasing various gases. The main gases released are methane, carbon dioxide, hydrogen and hydrogen sulphide. Bacteria carry out the decomposition or fermentation.

### Uses :

- In industries and also as a domestic fuel for cooking, lighting, etc.
- In pumping sets used for irrigation.

## Advantages of Bio-gas

- It causes less pollution, as burns without smoke.
- High Calorific i.e., heat producing value.
- It is a clean fuel as it leaves no residue.
- This method is environment friendly as it is an efficient method of waste disposal and supplies energy and manure.

## WIND ENERGY

Along with sun, it was the air, which showed man its power. Even before the solar energy, it was the wind energy that man used for his work. Initially, it was used in two main ways; to drive wind mills on land and to drive sailboat at sea. The first use of windmills were to grind food grains and to run pumps to irrigate. Farmers have been using wind energy for many years to pump water from wells using windmills. Now with the advancement of science and technology, we have windmills generating electricity. Naturally, now this energy can be used for many more works.

### Advantages of Wind Energy

- It is a renewable source of energy.
- It does not cause pollution.
- It does not require any recurring expenses.

### Disadvantages or Limitations of Wind Energy

- It requires high maintenance and large area for installation.
- These farms can be established in the areas where wind blows for most part of the year.

## NON-CONVENTIONAL SOURCES OF ENERGY

### Solar Energy

The energy obtained from the sun is called solar energy. The inner temperature of the sun is very high ( $10^7$ K). Energy of the sun reaching every year on earth is about  $1.6 \times 10^8$  KWh (Kilo watt hour). Value of energy used by all the living beings on the earth is  $7 \times 10^{13}$  KWh per year.

### Solar Cell

Solar cell is such a device which converts solar energy into electric energy. Solar cells are also known as photo or photoelectric cell (PV cell) because it works on the principle of photo-voltaic effect. Solar cells can be found on many small appliances, like calculators, and even on spacecraft. They are made of silicon, a Semi-conductor. Silicon (Si) is abundant in nature but availability of the special grade silicon for making solar cells is limited. A single cell of  $4 \text{ cm}^2$  silicon develops a voltage of 0.5-1V and can produce about 0.7 W of electricity when exposed to sun.

The group of solar cells connected in specific pattern to produce desired potential difference and magnitude of solar cell panel.

## Applications of Photoelectric Cells

- In television cameras for telecasting scenes and photo telegraphy.
- In production of sound in motion pictures.
- To switch on and off the street lights automatically.
- To control temperature in furnaces and chemical reactions.
- In fire and burglar's alarm, to open and close the doors automatically and in counting devices.

## Solar Cooker

A solar cooker is a device that uses the energy in sunlight to generate sufficient temperatures to be able to cook food. Swiss naturalist Horace de Saussure was known to have been experimenting with solar cookers as early as 1767. Three basic solar cooker designs exist:

- Parabolic Reflector • Box Cookers • Panel Cookers

### *Handy Facts*

The earth receives about 1.4 kW of direct solar radiations per square meter per second is called solar constant.

## ENERGY FROM THE SEA

### Tidal Energy

Tide arise due to the gravitational pull of mainly the moon on the water and spinning earth. The tide moves a huge amount of water twice each day, and harnessing it could provide a great deal of energy. Tide is the alternate rise and fall in the water level of oceans and seas.

**Advantages :** (i) It is an inexhaustible and renewable source of energy.

(ii) It does not cause any environmental pollution.

(iii) It does not produce any harmful waste.

### Wave Energy

Kinetic energy exists in the moving waves of the ocean. Waves are a powerful source of energy. That energy can be used to power a turbine. There are several methods of getting energy

from waves, but one of the most effective works like a swimming pool wave machine in reverse.

## Ocean Thermal Energy

The energy from the sun heats the surface water of the ocean. In tropical regions, the surface water can be 40° celsius or more degrees warmer than the deep sea water. This temperature difference can be used to produce electricity.

The energy available due to the difference in the temperature between the water at the surface and water at depths is called ocean thermal energy (OTE).

## Geothermal Energy

Energy present in the depth of the earth is called *geothermal energy*. Temperature in the earth at a distance of 10 kilometres is about 120°C and it increases to 300°C at the depth of 320 kilometres. It is evident that temperature increases with depth. Melted liquid, **magma** is present in the depth of earth. It is surrounded by various layers of soil, sand and water. Whenever there is some passage, it comes in contact with water present between these layers and converts this water into the steam of sufficient pressure. This vapour pressure can be used for production of energy.

### *Science in Action*

In Iceland, virtually every building in the country is heated with hot spring water. In fact, Iceland gets more than 50 per cent of its energy from geothermal sources. In Reykjavik, (population 115,000), hot water is piped in from 25 kilometers away, and residents use it for heating and for hot tap water.

## Nuclear Energy

Nuclear power is an alternative energy source that can be obtained from either the splitting of the bigger nucleus of atoms (nuclear fission) or the combining of the lighter nuclei of atoms (nuclear fusion).

**Atom bomb** is based on the principle of nuclear fission and

**Hydrogen bomb** is based on the principle of nuclear fusion.

## EXERCISE

1. Chadwick was awarded the 1935 nobel prize in physics for his discovery of the
  - (a) electron
  - (b) proton
  - (c) neutron
  - (d) positron
2. The process of superimposing signal frequency (i.e., audio wave) on the carrier wave is known as
  - (a) Transmission
  - (b) Reception
  - (c) Modulation
  - (d) Detection
3. Electromagnetic radiations are emitted by which of the following? [NDA]
  - (a) Only by radio and television transmitting antennas
  - (b) Only by bodies at temperature higher than their surroundings
  - (c) Only by red-hot bodies
  - (d) By all bodies
4. If an a-particle is projected normally through a uniform magnetic field, then the path of the a-particle inside the field will be [NDA]
  - (a) circular
  - (b) parabolic
  - (c) elliptical
  - (d) a straight line
5. Which one of the following is correct?
 

The wavelength of the X-rays [NDA]

  - (a) is longer than the wavelength of sound waves
  - (b) is longer than the wavelength of the yellow sodium light
  - (c) is longer than the wavelength of radio waves
  - (d) is of the order of 0.1 nanometer
6. Light Emitting Diode (LED) converts [CDS]
  - (a) light energy into electrical energy
  - (b) electrical energy into light energy
  - (c) thermal energy into light energy
  - (d) mechanical energy into electrical energy
7. Television signal cannot be received generally beyond a particular distance due to [CDS]
  - (a) curvature of the Earth
  - (b) weakness of antenna
  - (c) weakness of signal
  - (d) absorption of signal in air
8. Sun emits energy in the form of electromagnetic radiation. The following help in the generation of solar energy. Arrange them in the right sequence beginning from the starting of the cycle : [NDA]
  1. Hydrogen is converted to helium at very high temperatures and pressures.
  2. The energy finds its way to sun's surface.
  3. A vast quantity of energy is generated by nuclear fusion.

Select the correct answer using the code given below.

  - (a) 1-2-3
  - (b) 2-3-1
  - (c) 3-2-1
  - (d) 1-3-2
9. Consider the following statements: [IAS Prelim]  
At the present level of technology available in India, solar energy can be conveniently used to :
  1. Supply hot water to residential buildings.
  2. Supply water for minor irrigation projects.
  3. Provide street lighting.
  4. Electrify a cluster of villages and small towns.
  - (a) 1, 2, 3 and 4 are correct
  - (b) 2 and 4 are correct
  - (c) 1 and 3 are correct
  - (d) 1, 2 and 3 are correct
10. The neutron, proton, electron and alpha particle are moving with equal kinetic energies. How can the particles be arranged in the increasing order of their velocities? [NDA]
  - (a) alpha particle-neutron-proton-electron
  - (b) proton-electron-neutron-alpha particle
  - (c) electron-proton-neutron-alpha particle
  - (d) neutron-proton-electron-alpha particle
11. Match the Column I and Column II.
 

Column – I	Column – II
(A) Isotopes	(1) Mass number same but different atomic number
(B) Isobars	(2) Atomic number same but different mass number.
(C) Isotones	(3) Number of neutrons plus number of protons
(D) Nucleons	(4) Number of neutrons same but different atomic number

  - (a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
  - (b) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
  - (c) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
  - (d) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
12. Select the correct statement(s) from the following.
  - I. In conductors, the valence and conduction bands may overlap.
  - II. Substances with energy gap of the order of 10 eV are insulators.
  - III. The resistivity of a semiconductor increases with increase in temperature.
  - IV. The conductivity of a semiconductor increases with increase in temperature.
  - (a) I and II only
  - (b) I and III only
  - (c) I, II and IV
  - (d) I, II, III and IV
13. Which of the following cannot be fabricated on an IC? [CDS]
  - (a) Transistors
  - (b) Inductors and transformers
  - (c) Diodes
  - (d) Resistors
14. At absolute zero, Si acts as
  - (a) non-metal
  - (b) metal
  - (c) insulator
  - (d) None of these

15. Telephony is an example of \_\_\_\_\_ mode of communication  
 (a) point-to-point (b) broadcast  
 (c) both (a) and (b) (d) None of these
16. **Column – I**      **Column – II**  
 (A) Hydrogen bomb (1) Fission  
 (B) Atom bomb (2) Fusion  
 (C) Binding energy (3) Critical mass  
 (D) Nuclear reactor (4) Mass defect  
 (a) (A) → (3); (B) → (2); (C) → (1); (D) → (4)  
 (b) (A) → (2); (B) → (1); (C) → (4); (D) → (3)  
 (c) (A) → (3); (B) → (1); (C) → (2); (D) → (4)  
 (d) (A) → (4); (B) → (2); (C) → (3); (D) → (1)
17. Which of the following statements is/are correct ?  
 I. Pure Si doped with trivalent impurities gives a p-type semiconductor  
 II. Majority carriers in a n-type semiconductor are holes  
 III. Minority carriers in a p-type semiconductor are electrons  
 IV. The resistance of intrinsic semiconductor decreases with increase of temperature  
 (a) I only (b) I, III and IV  
 (c) I and IV (d) II only
18. The active component in an IC are  
 (a) Resistors  
 (b) Capacitors  
 (c) Transistors and diodes  
 (d) None of these
19. The waves used in telecommunication are [SSC]  
 (a) IR (b) UV  
 (c) Microwave (d) Cosmic rays
20. Audio signal cannot be transmitted because  
 (a) the signal has more noise  
 (b) the signal cannot be amplified for distance communication  
 (c) the transmitting antenna length is very small to design  
 (d) the transmitting antenna length is very large and impracticable
21. Television signals are  
 (a) frequency modulated  
 (b) amplitude modulated  
 (c) both frequency and amplitude modulated  
 (d) phase modulated
22. Repeaters used in telephone links are: [NDA]  
 (a) Rectifiers (b) Oscillators  
 (c) Amplifiers (d) Transformers
23. The transistor are usually made of [CDS]  
 (a) metal oxides with high temperature coefficient of resistivity  
 (b) metals with high temperature coefficient of resistivity  
 (c) metals with low temperature coefficient of resistivity  
 (d) semiconducting materials having low temperature coefficient of resistivity
24. A moderator is used in nuclear reactors in order to  
 (a) slow down the speed of the neutrons  
 (b) accelerate the neutrons  
 (c) increase the number of neutrons  
 (d) decrease the number of neutrons
25. The main constituent of biogas is  
 (a) methane (b) carbon dioxide  
 (c) hydrogen (d) hydrogen sulphide
26. \_\_\_\_\_ is used as a fuel in space ships.  
 (a) Hydrogen (b) Alcohol  
 (c) Petrol (d) Diesel
27. Propane is used instead of natural gas on many farms and in rural areas. Why is propane often used instead of natural gas?  
 (a) It's safer (b) It's portable  
 (c) It's cleaner (d) It's cheaper
28. Which one of the following is the correct sequence of the wavelengths of radiations ? [NDA]  
 (a) UV > Green > IR > Hard X-rays  
 (b) IR > Green > UV > Hard X-rays  
 (c) UV > Hard X-rays > IR > Green  
 (d) IR > Hard X-rays > Green > UV
29. The most familiar form of radiant energy in sunlight that causes tanning and sunburning of human skin, is called [CDS]  
 (a) ultraviolet radiation  
 (b) visible radiation  
 (c) infrared radiation  
 (d) microwave radiation
30. Which one among the following radiations carries maximum energy? [NDA]  
 (a) Ultraviolet rays (b) Gamma-rays  
 (c) X-rays (d) Infra-red rays
31. In a hydro power plant  
 (a) potential energy possessed by stored water is converted into electricity  
 (b) kinetic energy possessed by stored water is converted into potential energy  
 (c) electricity is extracted from water  
 (d) water is converted into steam to produce electricity
32. Which part of the solar cooker is responsible for green house effect?  
 (a) Coating with black colour inside the box  
 (b) Mirror  
 (c) Glass sheet  
 (d) Outer cover of the solar cooker
33. A perfect black body has the unique characteristic feature as [CDS]  
 (a) a good absorber only  
 (b) a good radiator only  
 (c) a good absorber and a good radiator  
 (d) neither a radiator nor an absorber
34. The phenomenon of high and low tides and the difference in sea levels give \_\_\_\_\_.  
 (a) Hydel energy (b) Tidal energy  
 (c) Wave energy (d) Thermal energy
35. Which of the following does NOT allow harmful ultraviolet radiations from the sun to reach the earth?  
 (a) O<sub>2</sub> (b) NO<sub>2</sub>  
 (c) CO<sub>2</sub> (d) O<sub>3</sub>

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**ANSWER KEY**

ANSWER KEY																			
1	(c)	2	(c)	3	(d)	4	(a)	5	(d)	6	(b)	7	(a)	8	(d)	9	(a)	10	(a)
11	(b)	12	(c)	13	(b)	14	(c)	15	(a)	16	(b)	17	(b)	18	(c)	19	(c)	20	(d)
21	(c)	22	(c)	23	(a)	24	(c)	25	(a)	26	(a)	27	(b)	28	(b)	29	(a)	30	(b)
31	(a)	32	(c)	33	(c)	34	(b)	35	(d)	36	(d)	37	(b)	38	(d)	39	(d)	40	(d)

## Chapter 1

# CHEMISTRY, MATTER & ITS COMPOSITION

## CHEMISTRY AND ITS IMPORTANCE

Chemistry is the study of matter and the changes that material substances undergo.

### Handy Facts

New branches in chemistry are emerging because of research being carried in the quest to make life more comfortable. One good example is **Green Chemistry**, which deals with development of safer products and manufacturing processes for a sustainable future.

## THE IMPORTANCE AND SCOPE OF CHEMISTRY

Chemistry plays an important role in every aspect of our daily lives. It is a central science that connects all the other sciences and helps them to achieve what they do.

### Food Science

Food science is the study of the physical, biological, and chemical make-up of food and the concepts underlying food processing. The contribution of chemistry to Food Science has been manifold.

#### Science in Action

Not all additives added to food are healthy. For example, potassium bromate ( $KBrO_3$ ) used in bread-making is an oxidizing agent that is used to "mature" bread flour, which helps strengthen the dough and improve rising, giving it more volume.

### Agriculture

In the field of Agriculture, chemistry has provided:

- Better understanding of the processes like photosynthesis, nitrogen fixation, etc. This has led to development of more productive plants.
- Chemical fertilizers like urea, potash, etc. have led to increase food production helping countries to fight food shortage.
- Insecticides, pesticides and fungicides that are used to protect crops.

### Medicine

Chemistry has contributed towards the science of Medicine in a number of ways:

- It has given life saving drugs to control dreaded diseases. For example, cis-platin and taxol are useful in cancer therapy. AZT (Azithothymidine) is used for AIDS victims.

- Some other categories of medicines synthesized are:
  - (i) **Analgesics**: reduce pain, e.g. paracetamol, aspirin, etc.
  - (ii) **Antibiotics**: cure infections and cure many diseases, e.g. Chloromycetin, streptomycin, etc.
  - (iii) **Tranquillizers**: reduce tension and bring about calm and peace to mental patients, e.g. chlorpromazine, diazepam (Valium), etc.
  - (iv) **Antiseptics**: stop infection of wounds, e.g. Dettol
  - (v) **Anaesthetics**: make patients senseless before surgical operations, e.g. Barbiturates, Benzodiazepines, etc.

#### Science in Action

Chemistry is providing new materials for medical use. Diseased or weakened arteries can be replaced surgically with tubes made of *Dacron polymers*.

### Energy

The use of chemistry in the field of energy has been found contributing in:

- Proper utilization of the fossil fuels – coal and petroleum by understanding its properties. For example, chemistry helps to measure the standard rating- *octane number* of engine or aviation fuel.
- Exploitation of alternate sources of energy like solar and nuclear, etc. Chemistry helped to synthesize uranium hexafluoride making possible for the enrichment of nuclear fuel U-235. Semiconductor materials like gallium arsenide, silicon, etc. are used in making solar panels.

### Environmental Science

Environmental changes and chemistry are inextricably linked.

- Chemistry can explain the origin and impacts of phenomena such as air pollution, ozone layer depletion, and global warming.
- Chemistry can help in finding substitution and replacement of gases and products causing above effects. For example, like helping in replacing the refrigerants like chlorofluorocarbons (CFCs) with other environment-friendly products, etc.

### Biology and Biotechnology

Chemistry has helped

- in the discovery of the DNA's molecular structure and many of its roles in heredity. This has resulted in major advances in biology and biotechnology.
- to understand biotech processes like *fermentation* used to produce different liquor industry products (*wine, beer*, etc.), various *antibiotics* (e.g. penicillin), antibodies, therapeutic proteins, food products (e.g cheese, curd, bread, etc), enzymes and others.

## Geology

In geology, chemical techniques are mostly required:

- To be used to analyze and identify rock samples in order to locate new mineral or oil deposits.
- To explain the formation of certain minerals, such as hematite, etc.

## Oceanography

In Oceanography, chemistry is mostly used to:

- To track ocean currents
- Determine the flux of nutrients into the sea, and measure the rate of exchange of nutrients between ocean layers.

## Archaeology

Archaeology yields information and develops theories about past human activity by means of a study of ancient material remains.

Some applications of chemistry in this field are in the :

- Bronze and copper items generally corrode due to oxidation. *Electrolytic reduction* is used to restore these antiquities.
- Carbon dating* is one of the most widely used methods for the detection of the age of the old artifacts or fossils.

## Forensic Science

Forensic science means applications of scientific procedures to legal problems particularly during investigations. Chemical methods are used to analyze sample of investigation.

### Science in Action

Chemistry has made our life easy by giving innumerable materials. Steel, bronze and brass are mixtures that have been used since ancient times as structural materials. Tiles made from *ceramic* are used on a space shuttle help to protect it from overheating. *Optical fiber* is used in communication. It is made mainly from *silicon dioxide* ( $SiO_2$ ) which is found in sand. The *chip* used in computers is also made up of silicon. .

### Handy Facts

Linus Pauling is the only person to be awarded two unshared Nobel Prizes-one in 1954 for Chemistry and the other in Peace in 1962.

## CHEMICALS OF COMMON USE

There are many chemicals that are most essential in daily life. These chemicals are used either in combined form or as some reagents. The list of few chemicals and their most common uses is given in the following table:

Common Name	Molecular Formula (Chemical name)	Common Uses as/in
Baking powder	$NaHCO_3$ ( sodium bicarbonate)	Baking & cooking,
Soap	Esters	Bathing & Washing
Detergent	Sodium sulphate, sodium hydroxide & phosphate compounds	Washing clothes
Table Salt	$NaCl$ (Sodium Chloride)	Kitchen Salt
Vinegar	$C_2H_4O_2$ (Ethanoic acid)	Preservative
Graphite	C (Carbon)	Pencil
Bleaching Powder	Sodium hypochlorite ( $NaOCl$ )	Cleaning & sterilizing drinking water, swimming pools, etc.
Sugar	Sucrose( $C_{12}H_{22}O_{11}$ )	Sweetener
Aspirin	$C_9H_8O_4$ ( Acetyl salicylic acid)	Medicine
Peroxide	$H_2O_2$ (Hydrogen peroxide)	Mouthwash (hygiene)
Caustic soda, Lye	$NaOH$ ( Sodium hydroxide)	Cleaning, unblocking sinks drains and toilets in different industries, etc.
Moth balls	$C_6H_4C_{12}$ (1,4-dichlorobenzene)	Dispel moths(an insect)
Green vitriol	$FeSO_4 \cdot 5H_2O$ (Ferrous Sulphate)	Anemic patients for supplementing iron
Sodium Fluoride	NaF	Toothpaste
Glucose	$C_6H_{12}O_6$ (D-glucose)	Energy source for organisms
Ammonia	$NH_3$	Manufacturing urea
Butane	$C_4H_{10}$ (n-butane)	A component of LPG
Sulphuric Acid	$H_2SO_4$ (Sulphuric acid)	Industrial Product
Marsh gas/Natural gas	$CH_4$ (Methane)	Fuel
Saccharine	$C_7H_5NO_3S$	Artificial Sweetener

Tartaric acid	$C_4H_6O_6$ ( 2,3-dihydroxybutanedioic acid)	Fermentation of grapes
Laughing Gas	$N_2O$ (Nitrous Oxide)	Laughing gas
Citric Acid	$C_6H_8O_7$ (2-hydroxypropane-1,2,3-tricarboxylic acid)	Preservative
Octane	$C_8H_{18}$ (n-octane)	Component of petrol
Camphor	$C_{10}H_{16}O$ (1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one)	Fragrance
Formaldehyde	$CH_2O$ , (Formaldehyde)	Preservatives of corpses.
Alpha-Propylene Glycol	$C_3H_8O_2$ ( Propane-1,2-diol)	Moisturizing Skin
Triethanolamine	$C_6H_{15}NO_3$ (2-[bis(2-hydroxyethyl)amino ethanol)	Lotion, shaving foams, shampoo, etc.
Acetone	$C_3H_6O$ ( Propanone)	Removal of residues, glue, stains & paint.
Plaster of Paris	$CaSO_4 \cdot 1/2H_2O$ (Calcium Sulphate hemihydrates)	Plastering fractured bones
Blue Vitriol	$CuSO_4 \cdot 5H_2O$ (Copper Sulphate)	Colourant
Chloroform	$CHCl_3$ (Trichloro Methane)	Anesthetic.
Chalk (Marble)	$CaCO_3$ (Calcium Carbonate)	Architecture, sculpture.
Caustic Potash	KOH (Potassium Hydroxide)	Cleaner, fertilizer,etc
Dry Ice	$CO_2$ (Solid Carbon dioxide)	Preserving degradable items
Gypsum	$CaSO_4$ (Calcium Sulphate)	Fertiliser & Constituent of plaster, blackboard chalk and wallboard.
Heavy Water	$D_2O$ (Deuterium Oxide)	Moderator in nuclear reactor
Slaked Lime	$Ca(OH)_2$ (Calcium Hydroxide)	pH-regulating agent and acid neutralizer in soil and water.
Potash Alum	$K_2Al(SO_4)_3$ (Potassium Aluminium Sulphate)	Water purification
Quick Lime	$CaO$ (Calcium Oxide)	Whitewash
Mohr's Salt	$FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$ (Ammonium Ferrous Sulphate)	Analytical reagent in laboratory
White Vitriol	$ZnSO_4 \cdot 7H_2O$ ( Zinc Sulphate)	Medicine
Magnesia	$MgO$ ( Magnesium oxide)	Soil and ground water treatment
Vermelium	HgS ( Mercuric Sulphide)	Pigment
T.N.T.	$C_7H_5N_3O_6$ , (Trinitrotoluene)	Explosive
Sand	$SiO_2$	Manufacturing glass, etc.
Calcium Sulphate	$CaSO_4 \cdot 2H_2O$	Cement industry
Borax	$Na_2B_4O_7 \cdot 10 H_2O$ (sodium tetraborate decahydrate)	Washing
Brimstone	S (Sulphur)	In industry
Cream of tartar	$KHC_4H_4O_6$ (Potassium hydrogen tartrate)	Baking to stabilize eggs and creams, as well
Epsom salt	$MgSO_4 \cdot 7 H_2O$ (Magnesium sulphate heptahydrate)	Food additives as salt.
Freon	$CF_2Cl_2$ (Dichlorodifluoromethane)	Refrigerant & aerosol propellants
Galena	PbS (Lead sulphide)	Lead-acid batteries

Grain alcohol	$C_2H_5OH$ (Ethanol)	Alcoholic drinks, fuel & solvent
Hypo	$Na_2S_2O_3$ (Sodium thiosulphate)	Film photographic paper processing
Milk of magnesia	$Mg(OH)_2$ (Magnesium hydroxide)	Antacid
Muriatic acid	HCl (Hydrochloric acid)	Industrial substance
Gammexene	$C_6H_6Cl_6$ (1,2,3,4,5,6-hexachlorocyclohexane)	Insecticide
Potash	$K_2CO_3$ (Potassium carbonate)	Fertilizer
Iron pyrites (Fool's gold)	$FeS_2$ ( Iron disulphide)	Source of sulphur and Iron
Quartz	$SiO_2$ (Silicon –di-oxide)	Silicon dioxide
Quicksilver	Hg (mercury)	Thermometers
Rubbing alcohol	$(CH_3)_2CHOH$ ( isopropyl alcohol or Propan-2-ol)	Antiseptic
Sal ammoniac	$NH_4Cl$ (ammonium chloride)	Crisping agent for food and spice
Salt substitute	KCl (potassium chloride)	Treating low blood levels of potassium (hypokalemia)
Saltpeter	$KNO_3$ (potassium nitrate)	Food preservatives & fireworks
TSP( Trisodium phosphate)	$Na_3PO_4$ (Sodium phosphate)	Emulsifiers (in cheese), thickening agents, & leavening agents for baked goods.
Wood alcohol	$CH_3OH$ (Methanol)	Antifreezing, solvent, fuel, denaturant for ethanol
Phenol	$C_6H_5OH$ (Phenol)	Antiseptic
Tincture of iodine	A solution of iodine along with potassium iodide or sodium iodide in water and ethanol mixture	Disinfectant
MSG or Chinese salt	$C_5H_8NNaO_4$ (Mono-sodium glutamate)	Food-additive
Silica	$SiO_4$ (Silicon-di-oxide)	Dehydrating agent
Vitamin C	$C_6H_8O_6$ (Ascorbic acid )	Vitamin
Smelling Salt	$(NH_4)_2CO_3 \cdot H_2O$ (Ammonium Carbonate)	Substance to revive fainted man
Chrome Green	$Cr_2O_3$ (Chromium trioxide)	Green pigment
Oil of Clove	$CH_2CH_2CH_2C_6H_3(OCH_3)OH$ (Eugenol)	Relieving pain in teeth
Talc	$Mg_3Si_4O_{10}(OH)_2$ (Magnesium Silicate)	Talcum powder
Carborundum	SiC(Silicon Carbide)	Abrasive material
Permanganate of potash or Condy's crystals,	$KMnO_4$ (Potassium Permanganate)	Disinfectant
Gobar Gas(Bio gas)	Mixture of methane ( $CH_4$ ) and carbon dioxide ( $CO_2$ ) and small amounts of hydrogen sulfide ( $H_2S$ ), moisture and siloxanes	Fuel in cooking
T.N.T	$C_6H_2CH_3(NO_2)_3$ (Tri nitro toluene)	Explosive material
Tear gas	$CCl_3NO_2$ (2-Chlorobenzalmalononitrile)	Controlling riots,etc.
Aqua-regia	Conc. $H_2SO_4$ +Conc.HCl	Laboratory reagent
Urea	$NH_2CONH_2$	Fertilizer
Westron	$CHCl_2-CHCl_2$ (1,1,2,2-tetrachloroethane)	Solvents for paints and varnishes
Pyrene	$CCl_4$ (Carbon tetra-chloride)	Fire-extinguisher

# MATTER AND ITS COMPOSITION

The universe is made up of matter and energy.

**Matter:** Matter describes the physical things around us: the earth, the air we breathe, the pencil with which we write, etc.

**Energy:** It is the ability to cause change or do work. Some forms of energy include light, heat, chemical, nuclear, electrical and mechanical energy.

The matter can be classified in two different ways;

- According to its physical state
- According to its chemical composition

### Handy Facts

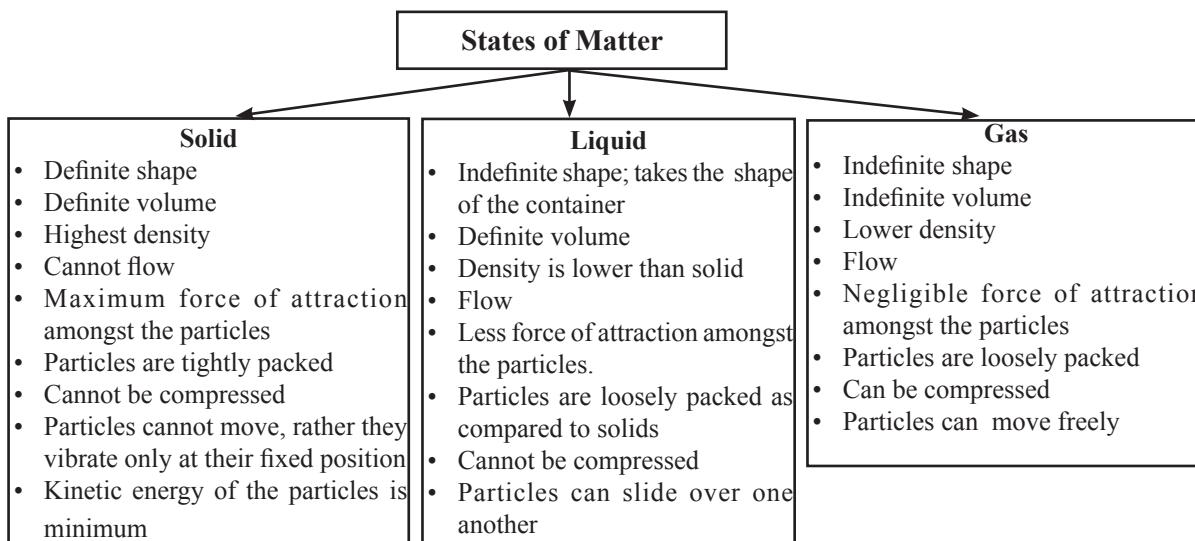
Most of the evidences for the existence of particles in matter come from the experiments on the phenomena **Diffusion** and **Brownian motion**. **Diffusion is the process in which particles constituting a matter move from a higher concentration to a lower concentration.** This process happens at random. Diffusion can happen in a gas or liquid but cannot take place in a solid object. **Particles in both liquids and gases (collectively called fluids) move randomly. This is called Brownian motion.** Brownian motion is named after the botanist **Robert Brown**,

## The Physical States of Matter

Matter is found in three physical states, i.e. Solid,

Liquid and Gas. These states are also known as *phases of matter*. *The difference in the physical states of matter is due to the arrangement of the particles of which the matter is made of.*

Almost all chemical substances can exist in more than one physical state (phase) depending on external pressure and temperature.

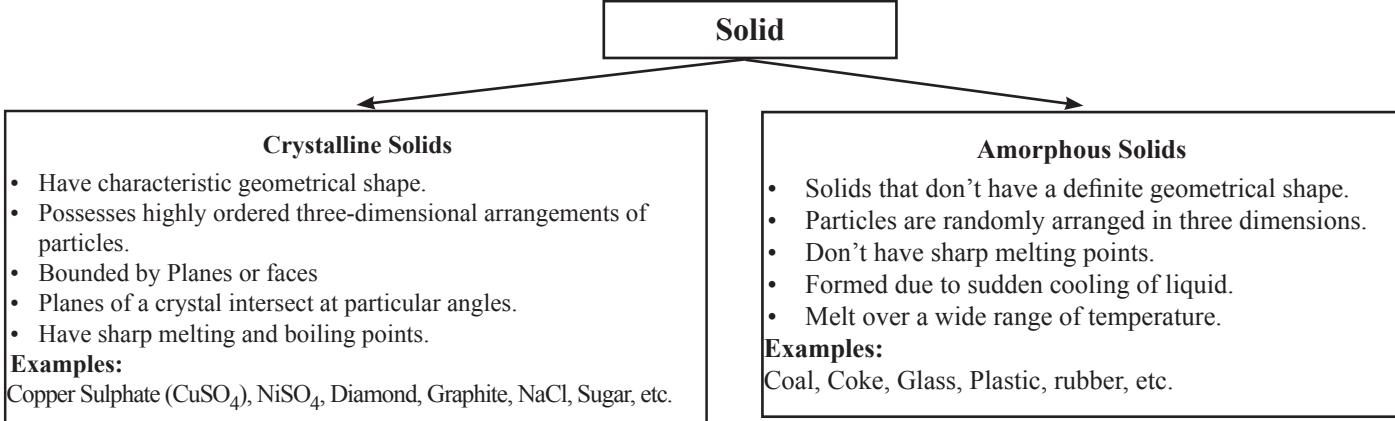


### Handy Facts

Two other forms of matter are Plasma and Bose-Einstein condensate. Plasma consists of highly charged particles with extremely high kinetic energy. The noble gases (helium, neon, argon, krypton, xenon and radon) are often used to make glowing signs by using electricity to ionize them to the plasma state.

### Solid

Solids can be divided into two distinct classes.



## Liquid

Like solids, the volume of a liquid is slightly altered by variations in temperature and pressure.

Liquids have three typical physical properties:

- **Vapour pressure:** A Liquid when kept in a closed container vaporizes into the free space above it. The process of vaporization will continue till the equilibrium is reached between liquid and vapor. *The pressure at which the liquid and vapour can co-exist is called the vapour pressure of the liquid at a given temperature.*
- **Surface tension:** The surface of a liquid is always in a state of tension because a molecule at the surface is attracted towards the bulk by a force much greater than that drawing it toward the vapor where the attracting molecules are more widely spread. The spherical shape of **liquid bubble** and **capillary** movement can be explained with the help of surface tension.
  - **Viscosity:** It determines the flow of the liquid. *It is the internal friction between layers of the liquid.*

## Gases

Gas is the third state of the matter. Gases have three characteristic properties:

- they are easy to compress
- they expand to fill their containers, and
- they occupy far more space than the liquids or solids from which they form.

## EFFECT OF TEMPERATURE AND PRESSURE ON STATES OF MATTER

Physical change of matter from one phase to another phase occurs on adding energy to matter. For example:

- adding thermal energy, i.e. heat to liquid **water** causes it to become **steam** or **vapour**, i.e. a gas.
- taking away energy also causes physical change, such as when liquid **water** becomes ice, i.e., a **solid**, when heat is removed.

Physical change also can be caused by motion and pressure.

Physical processes undergone by matter leading to changes in the phases of the system are:

## Melting and freezing

*The melting point (or, also sometimes called liquefaction point) of a solid is the temperature at which it changes state from solid to liquid at atmospheric pressure.*

- At the *melting point* the solid and liquid phases exist in equilibrium. If we continue to apply heat to the sample, the temperature will not rise above the melting point until the entire sample has been liquefied.
- The heat energy, **called latent heat of fusion**, is being used to convert the solid into the liquid form.

### Science in Action

- A solid mixture, such as a metal alloy, can often be separated into its constituent parts by heating the mixture and extracting the liquids as they reach their different melting points.

*The freezing point is the temperature at which a liquid changes to a solid. As the liquid is cooled, particle motion slows.*

### Handy Facts

Most liquids contract as they freeze. One of the important characteristics of water is that it expands when it freezes, so ice floats.

Adding dissolved substances, or solutes, to a liquid will depress the freezing point.

## Super Cooled liquid

Liquids can be cooled to temperatures well below their melting point before they begin to solidify. Such liquids are said to be “**super cooled**” and often require the presence of a dust particle or “**seed crystal**” to start the process of crystallization.

### Science in Action

The freezing point of pure water is 0°C, but that melting point can be decreased by adding freezing or salt. The use of ordinary salt (sodium chloride, i.e. NaCl) on icy roads in the winter helps to melt the ice from the roads by lowering the melting point of the ice.

## Sublimation

*Sublimation is a chemical process where a solid turns into a gas without going through the liquid phase.*

## Examples of substance which sublime

- The best known of these substances is  $CO_2$  or “**dry ice**” which sublime to gas.
- Other common substances which sublime are *ammonium nitrate, camphor, anthracene, iodine and naphthalene*.

## Vapourisation

*Vapourisation is the conversion of a liquid to a gas.*

Evaporation	Boiling
• Evaporation takes place at all temperatures,	• boiling occurs at a particular temperature.
• Evaporation takes place from the surface,	• Boiling is a bulk phenomenon.

*The temperature at which a liquid boils is called boiling point.*

- Boiling point is dependent upon the pressure the substance is subjected to.
- A liquid under higher pressure will require more heat before vapour bubbles can form within it.

### Science in Action

Food takes longer time to get cooked at high altitude. At high altitudes, the atmospheric pressure is lower than that at sea level, so the boiling point at high altitudes is quite low, which means water boils very fast at low temperatures. The food inside it does not get enough heat to get cooked and thus food is difficult to be cooked at high altitudes. Using a pressure cooker at such conditions helps **increase the boiling time** as the pressure inside the pressure cooker increases due to the vapour produced inside it.

## Condensation and Deposition

*Condensation is the change of the physical state of matter from gas phase into liquid phase.*

Condensation is the opposite of evaporation.

*When the gas transforms directly into a solid, without going*

through the liquid phase, it is called deposition or de-sublimation.

**Example:** Conversion of water vapour in the atmosphere into frost or ice at subfreezing temperatures. Frost tends to outline solid blades of grass and twigs because the air touching these solids cools faster than air that is not touching a solid surface.

## ELEMENT, MIXTURE AND COMPOUNDS

According to chemical composition, matter can be classified as

- **Pure substances** (or simply known as substance) are those matter that has distinct properties and a composition that does not vary from sample to sample. Water and ordinary table salt are examples of pure substances
- **Mixtures** are combinations of two or more substances in which each substance retains its own chemical identity. The substances making up a mixture are called components of the mixture.

## ELEMENTS

Elements are the simplest form of chemical substances that cannot be broken down by ordinary chemical means. Examples are hydrogen (H), sulphur (S) or gold (Au), etc.

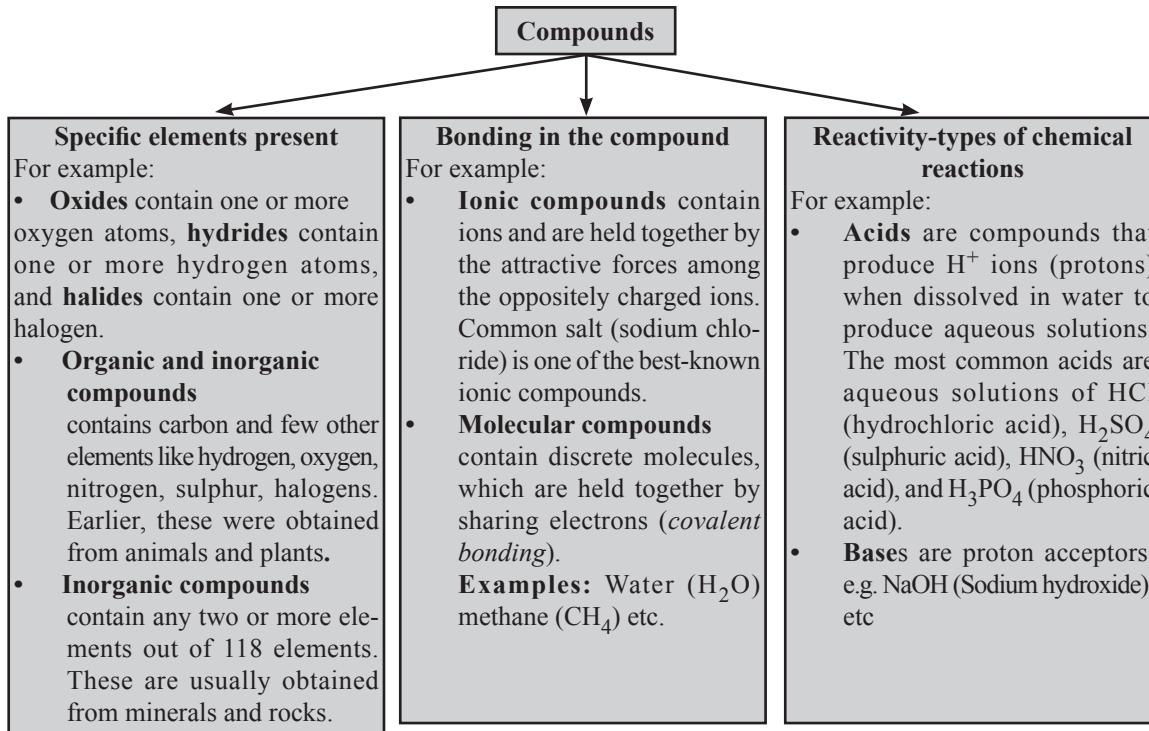
The building blocks of the Universe are the elements. The term *element* was first used by *Robert Boyle*.

### Handy Facts

Most of the elements are *solids*, while *eleven* of them are *gases* and only *two* are *liquids*. Of the two liquids, *mercury* is a *metal* and *bromine* is non-metal. However, two other metals can also exist in the liquid state at around 30°C. These two are *gallium* and *caesium*.

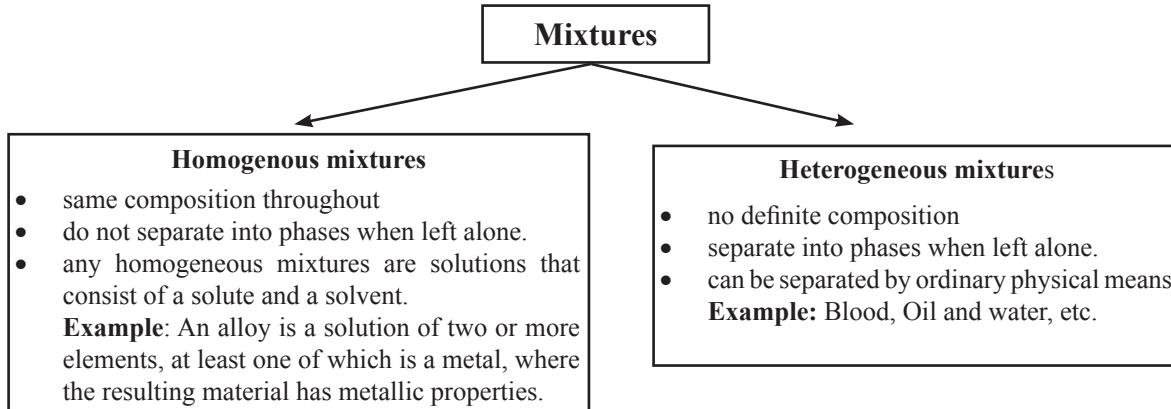
## COMPOUNDS

A compound is a substance composed of two or more elements which are chemically combined. Examples of compounds are water, sugar and salt, etc.



## MIXTURES

Mixtures are all around us. For example, a salad is a mixture of vegetables, a glass of soda is a mixture of water,



## Methods of Separation of the Components of Mixtures

To separate different components of a mixture, varieties of physical techniques are available. *Based on difference in the physical properties of the components present in the mixture.*

### Separation by Using Separating Funnels

A separating funnel is used for the separation of components of a mixture between two immiscible liquid phases. One phase is the aqueous phase and the other phase is an organic solvent. This separation is based on the differences in the densities of the liquids.

### Separation by Evaporation

The separation of liquid (solvent) and solid (solute) from a solution is done by removing the liquid (solvent) by heating or by solar evaporation. By evaporation we can recover the solute component only in solid or powder form.

### Separation by Filtration

Filtration is a better method for separating solids from liquids in heterogeneous mixtures. In filtration the solid material is collected as a residue on filter paper and the liquid phase is obtained as filtrate.

**Applications:** Salt (water soluble) and sand(water insoluble) using water as solvent

Sulphur (soluble in CS<sub>2</sub>) and glass powder (insoluble in CS<sub>2</sub>) using CS<sub>2</sub> as solvent.

### Centrifugation

Sometimes the solid particles in a liquid are very small and can pass through a filter paper. For such particles, the filtration

technique cannot be used for separation. Such mixtures are separated by centrifugation. So, *centrifugation is the process of separation of insoluble materials from a liquid where normal filtration does not work well.*

*During centrifugation the denser particles are forced to the bottom and the lighter particles stay at the top when spun rapidly.*

**Applications:** Used in

- Diagnostic laboratories for blood and urine tests.
- Dairies and home to separate butter from cream.
- Washing machines to squeeze water from wet clothes.

### Simple Distillation

*Simple distillation is a method used for the separation of components of a mixture containing two miscible liquids that boil without decomposition and have sufficient difference in their boiling points.*

**Applications:**

- Separation of acetone and water.
- Distillation of alcohol.

### Fractional Distillation

*Fractional distillation is used for the separation of a mixture of two or more miscible liquids for which the difference in boiling points is less than 25K.*

**Applications:** Separation of

- Different fractions from crude oil.
- A mixture of methanol and ethanol.
- Different gases from liquid air.

Name of the fraction (% in crude oil)	No. of C-atoms	Boiling range	Use
Fuel Gas, LPG, refinery gas (1-2%)	1 to 4 (mainly propane & butane which can be liquified)	25°C	Bottled gas
Petrol	5 to 7	25 to 75°C	Fuel for cars
Naptha (20-40%)	6 to 10	75 to 190°C	Making chemical
Paraffin, kerosene (10-15%)	10 to 16	190 to 250°C	Aircraft fuel
Diesel (15-20%)	14 to 20	250 to 350°	Fuel for cars, lorries, buses
Fuel oil, lubricating oils, waxes and bitumen (40-50%)	over 20 to several hundred	high boiling liquids or low melting solids that boil over 350°C	Fuel oil is used as fuel for ships, power stations. Bitumen is used for roads and roofs.

### Chromatography

**Chromatography** involves passing a mixture of different dissolved substances in a "mobile phase" through another material called a *stationary phase*, which separates the analyte to be measured from other molecules in the mixture and allows it to be isolated.

The mobile phase may be a gas or liquid. The mobile phase is then passed through stationary phase. The stationary phase may be a solid packed in a glass plate or a piece of chromatography paper.

The various chromatographic techniques are:

- Column Chromatography,
- Thin Layer Chromatography (TLC)

- Paper Chromatography
- Gas chromatography.

**Paper chromatography** is one of the important chromatographic methods.

**Applications:** To separate

- Colours in a dye.
- Pigments from natural colors.
- Drugs from blood.

### SOLUTION

A **solution** (a homogeneous mixture) is formed when one or more substances (the **solute**) are completely dissolved in another substance (the **solvent**). Depending on the nature of the solvent and solute we can have following kinds of solutions.

Different kinds of solution			
Solute	Solvent	State of Resulting Solution	Example
Gas	Gas	Gas	Air
Gas	Liquid	Liquid	Soda water ( $\text{CO}_2$ in water)
Gas	Solid	Solid	$\text{H}_2$ gas in palladium
Liquid	Liquid	Liquid	Ethanol in water
Solid	Liquid	Liquid	$\text{NaCl}$ in water
Solid	Solid	Solid	Brass (Cu/Zn), solder (Sn/Pb)

When a substance dissolves in a solvent it is said that the particular solute is **soluble** in that particular solvent. If it does not dissolve then it is **insoluble**.

### Water as a solvent

Water is a commonly used solvent as it dissolves a large number of substances. Because of this property water is called a **universal solvent**.

### Strengths of Solution

Quantitative study of a solution requires its *concentration*, that is, the amount of solute present in a given amount of solution.

The three most common units of concentration are **percent by mass, molarity, and molality**.

**Percent by Mass:** The *percent by mass* (also called the *percent by weight* or the *weight percent*).

$$\% \text{ By Mass} = \left( \frac{\text{Mass of solute}}{\text{Mass of solvent}} \right) \times 100$$

The percent by mass has no units because it is a ratio of two similar quantities.

**Molarity (M):** It is the number of moles of solute dissolved in one liter of the solution.

Thus, molarity has the units of mole per liter (mol/L).

**Molality (m):** Molality is the number of moles of solute dissolved in 1 kg (1000 g) of solvent.

Molality = moles of solute (mass of solvent)/1kg

- On the other hand, **molality is independent of temperature**.

### Colligative Properties of Solutions

Several important properties of solutions depend on the number of solute particles in solution and not on the nature of the solute particles. These properties are called **colligative properties** (or collective properties) because they are bound together by a common origin; The colligative properties are:

- Vapour-pressure lowering
- Boiling-point elevation
- Freezing-point depression
- Osmotic pressure

### Osmotic Pressure

not to solute is called a semi permeable membrane. *Osmotic pressure may be defined as the external pressure applied to the solution in order to stop the osmosis of solvent into solution separated by a semi permeable membrane.*

#### Science in Action

*Reverse osmosis* is one of the processes that makes desalination (or removing salt from seawater) possible. It is the process of osmosis in reverse. Where osmosis occurs naturally without energy required, to reverse the process of osmosis, energy is required to be applied to the more saline solution.

### SUSPENSION AND COLLOID

Depending on the size of the particles suspended, or dispersed in the surrounding medium, heterogeneous mixtures can be divided into the followings:

- Suspension:** Materials of smaller particle size, insoluble in a solvent but visible to naked eyes, form suspension. The size of particles in suspension is over 1000 nanometers (nm).
- Colloid:** A colloid contains smaller particles ranging in size from 1 to 1000 nanometers (nm). In case of true solutions the size of the particles are less than 1 nm.

The following table summarizes the major properties and points of distinction between each type of solution with respect to different properties.

### Properties of colloids, true solutions and suspension

Property	True Solution	Colloidal Solutions	Suspension
Size of the particles	< 1nm	1– 1000nm	>1000nm
Nature	Homogeneous	Heterogeneous	Heterogeneous
Filterability(Diffusion through parchment paper)	Particles of true Solution diffuse rapidly through filter paper as well as parchment paper.	Colloidal particles pass through filter paper but not through parchment paper.	Suspension particles do not pass through filter paper and parchment paper.
Visibility	Particles of True Solution are not visible to naked eye.	Colloidal particles are not seen to naked eye but can be studied through ultra microscope.	Suspension particles are big enough to be seen by naked eye.
Tyndal effect	True Solution does not show Tyndall effect.	Colloids show Tyndall effect.	Suspension may or may not show Tyndall effect.
Appearance	Transparent	Translucent	Opaque

## Classification of Colloids

Colloids are also called colloidal dispersions because the substances remain dispersed and do not settle to the bottom of the container.

- The substance being dispersed is referred to as being in the *dispersed phase*,
- The substance in which it is dispersed is in the continuous phase is called *dispersion phase*.

### Different Kinds of Colloids

Dispersed Phase	Dispersion Medium	Type of Colloid	Example
Solid	Solid	Solid sol	Ruby glass, Gem stone
Liquid	Solid	Solid emulsion/gel	Pearl, cheese
Gas	Solid	Solid foam	Lava, pumice
Solid	Liquid	Sol	Paints, cell fluids
Liquid	Liquid	Emulsion	Milk, oil in water
Gas	Liquid	Foam	Soap suds, whipped cream
Solid	Gas	Aerosol	Smoke
Liquid	Gas	Aerosol	Fog, mist

Gases cannot form a colloidal solution between themselves, because they form homogenous mixtures.

## Determination of a Colloid

Following two methods can be used to determine whether a mixture is colloid or not.

- Tyndall Effect:** When light is shined through a *true solution*, the light passes cleanly through the solution, however when light is passed through a *colloidal solution*, the substance in the dispersed phases scatters the light in all directions, making it readily seen. An example of this is shining a flashlight into fog. The beam of light can be easily seen because the fog is a colloid. *Blue colour of the sky and sea water, twinkling of stars, etc.* are also examples of tyndall effect.
- Dialysis:** The substance is allowed to pass through a semi permeable membrane. The larger dispersed particles in a colloid would be unable to pass through the membrane; while the surrounding liquid molecules can. This process is known as dialysis.

### Science in Action

Kidney Dialysis, also known as *hemodialysis*, is a medical method to remove waste materials from the blood of patients suffering from kidney malfunction.

## Applications of suspensions and colloids

- Suspensions** have many applications in medical sciences.

For example Barium sulfate in suspension is frequently used medically as a radio contrast agent for x-ray imaging and other diagnostic procedures. **Colloids** are also very important in the medical field because they can be used to manipulate blood conditions. To be specific, colloids are often used to regulate colloidal osmotic pressure, a pressure applied by proteins in the blood to pull water in the vascular system.

## PHYSICAL AND CHEMICAL CHANGES

To understand the difference between a pure substance and a mixture, let us understand the difference between a physical and a chemical change.

### Physical Change

During physical changes a substance changes its physical appearance, but not its composition. All changes of state (for example, from liquid to gas or from liquid to solid) are physical changes.

### Characteristics of Physical Changes

- It is a temporary change.
- No new substances are formed.
- No change in mass takes place.
- Can be reversed by reversing the conditions.
- Change in physical state, size and appearance.

## Some Examples Involving Physical Changes

Physical changes	Observation	Change on physical property
• Switching of an electric bulb.	The bulb glows and gives out heat and light energy.	The physical appearance of the bulb changes.
• Rubbing a permanent magnet on a steel rod.	The steel rod gets magnetised. If it is brought near iron nails, they get attracted.	The steel rod acquires the property of attracting pieces of iron.
• Action of heat on iodine	The brownish grey crystals of iodine change to form violet vapours. On cooling the vapours condenses to form crystals.	Change in state and colour.
• Dissolving of common salt in water.	The white crystalline salt disappears in water. However, the water tastes exactly like common salt. Moreover, common salt can be recovered by evaporation.	Change of state.

### Chemical Change

A chemical change is one in which the identity of the original substance is changed and a new substance or new substances are formed.

e.g. souring of milk, burning of paper, burning of candle, etc.

In the burning of candle, the wax of a candle burns into ash and smoke.

### Characteristics of a Chemical Change

- A chemical change is permanent change and cannot be reversed to give back the original substance.
- One or more new substances (called products) are formed.
- Change in mass of a substance takes place.
- The composition of the product is different from that of the starting substance.
- A chemical change is always accompanied by the change in energy.

### Some Examples Involving Chemical Changes :

Chemical change	Observation	Chemical equation
• Burning of magnesium in air	When a magnesium ribbon is heated in a flame of Bunsen burner, it catches fire and burns with dazzling white flame to form white ash.	Magnesium + Oxygen $\longrightarrow$ Magnesium oxide
• Rusting of iron	When iron (silver grey) is left exposed to moist air for a few days, reddish brown powdery mass (rust) is found on its surface.	(from air) $\longrightarrow$ Iron + Oxygen + Water vapours $\longrightarrow$ Rust
• Burning of LPG	When LPG (liquefied petroleum gas) is burnt, it burns with a pale blue flame and liberates colourless gas carbon dioxide along with steam.	Butane (LPG) + Oxygen $\longrightarrow$ Carbon dioxide + Water

#### Handy Facts

Chemical weathering is the process by which rocks are broken down by chemical reactions. Rocks look different from each other because of chemical weathering. Different types of chemical weatherings are :

- Hydrolysis - chemical reaction when combined with water
- Oxidation - It is a reaction with oxygen
- Carbonation - It is mixing of water with  $\text{CO}_2$  to make carbonic acid. This type of weathering is important in the formation of caves
- Dissolution (also called leaching) : it is the process by which rocks are dissolved when exposed to rainwater.

### Some interesting information about elements

- (a) The most abundant element in the universe – *Hydrogen(H)*
- (b) The most abundant element in the earth's crust – *Oxygen(O)*
- (c) The most abundant metallic element in the earth's crust-*Aluminum(Al)*
- (d) The most abundant element in the earth's atmosphere -*Nitrogen(N)*
- (e) The element having the highest density at room temperature – *Osmium(Os)*
- (f) The lightest metal at room temperature-*Lithium (Li)*
- (g) The metal having the highest melting point and boiling point – *Tungsten(W)*
- (h) The element with the highest melting point – *Carbon (C)*
- (i) The element having lowest melting point and boiling point-*Helium(He)*
- (j) The metal having the lowest melting point and boiling point – *Mercury(Hg)*
- (k) The most ductile metal – *Silver(Au)*
- (l) The element having highest number of isotopes- *Silver(Ag)*

# EXERCISE

- 1.** Who among the following is called 'The father of modern chemistry?  
 (a) Michael Faraday    (b) Lavoisier  
 (c) Proust               (d) Linus Pauling
- 2.** Match the following  
 A Azidothymidine      1 Antibiotic  
 B cis-Platin and taxol   2 Drugs for AIDS patient  
 C Streptomycin           3 Drugs for treating cancer patients  
 D Paracetamol           4 Antipyretic  
 (a) A - 2, B - 3, C - 1, D - 4  
 (b) A - 1, B - 2, C - 4, D - 3  
 (c) A - 4, B - 2, C - 3, D - 1  
 (d) A - 1, B - 2, C - 3, D - 4
- 3.** The chemical technique applied to find out age of fossils is known as  
 (a) Carbon dating       (b) Nuclear fusion  
 (c) Photosynthesis      (d) Fermentation
- 4.** The chemical formula for 'laughing gas' is  
 (a)  $N_2O$ (Nitrous oxide)  
 (b) NO (Nitric oxide)  
 (c)  $NO_2$  (Nitrogen dioxide)  
 (d)  $N_2O_5$  (Nitrogen pentoxide)
- 5.** The compound used as 'artificial sweetener' is  
 (a) Saccharine           (b) Tartaric acid  
 (c) citric acid          (d) octane
- 6.** The chemical name of 'Marsh gas' is  
 (a) Ethene               (b) Methane  
 (c) Propane             (d) Hexane
- 7.** Wooden pencil used for writing contains  
 (a) Graphite            (b) Lead  
 (c) Salt                  (d) Cane sugar
- 8.** The chemical formula of Borax is  
 (a)  $Na_2B_4O_7$           (b)  $CaOCl_2$   
 (c)  $BaSO_4$              (d)  $Ca(SO_4)_2$
- 9.** The chemical formula of plaster of paris is  
 (a)  $CaSO_4 \cdot 5H_2O$     (b)  $2CaSO_4 \cdot H_2O$   
 (c)  $(CaSO_4) \cdot 2H_2O$    (d) COSO<sub>4</sub>. MGO
- 10.** The chemical name of lime stone is  
 (a) Calcium chloride  
 (b) Calcium oxide  
 (c) Calcium carbonate  
 (d) Calcium
- 11.** Blue vitriol is  
 (a) Copper sulphate  
 (b) Calcium sulphate  
 (c) Iron sulphate  
 (d) Sodium sulphate
- 12.** The main component of Gobar gas is?  
 (a) Chlorine            (b) Hydrogen  
 (c) Ethylene           (d) Methene
- 13.** The main component of Biogas is  
 (a) Methane           (b) Ethane  
 (c) Propane           (d) Butane
- 14.** Which chemical was an important symbol in our freedom struggle ? [CDS]  
 (a) Glucose            (b) Fertilizer  
 (c) Medicine          (d) Sodium chloride
- 15.** Match the following columns ? [NDA]
- | <b>Column I</b><br><b>(Fuel Gas)</b> | <b>Column II</b><br><b>(Major constituent)</b> |
|--------------------------------------|--|
| A. CNG                               | 1. Carbon monoxide, hydrogen                   |
| B. Coal gas                          | 2. Butane, propene                             |
| C. LPG                               | 3. Methane, ethane                             |
| D. Water gas                         | 4. Hydrogen, methane, carbon monoxide          |
- (a) A - 2, B - 1, C - 3, D - 4  
 (b) A - 2, B - 4, C - 3, D - 1  
 (c) A - 3, B - 4, C - 2, D - 1  
 (d) A - 3, B - 1, C - 2, D - 4
- 16.** The phenomenon of radioactivity was invented by  
 (a) Maril Curie       (b) Pierre Curie  
 (c) Henry Bacquerel   (d) J.J Thompson
- 17.** Which one of the following is used in the preparation of antiseptic solution? [CDS]  
 (a) Potassium nitrate  
 (b) Iodine  
 (c) Iodine chloride  
 (d) Potassium chloride
- 18.** Aqua-regia used by alchemists to separate silver and gold is a mixture of [CDS]  
 (a) hydrochloric acid (concentrated) and nitric acid (concentrated)  
 (b) hydrochloric acid (concentrated) and sulphuric acid (concentrated)  
 (c) nitric acid (concentrated) and sulphuric acid (concentrated)  
 (d) hydrochloric acid (dilute) and sulphuric acid (dilute)
- 19.** Nail polish remover contains [CDS]  
 (a) acetone            (b) benzene  
 (c) formaldehyde    (d) acetic acid
- 20.** Which one among the following is a sin smelling agent added to LPG cylinder to help the detection of gas leakage? [CDS]  
 (a) Ethanol           (b) Thioethanol  
 (c) Methane          (d) Chloroform
- 21.** Vermicompost is an/a [CDS]  
 (a) inorganic fertilizer  
 (b) toxic substance  
 (c) organic bio fertilizer  
 (d) synthetic fertilizer
- 22.** Which of the following is a good lubricant ? [CDS]  
 (a) Diamond powder  
 (b) Graphite powder  
 (c) Molten carbon  
 (d) Alloy of carbon and iron
- 23.** The main constituent of vinegar is [NDA]  
 (a) Acetic acid       (b) Ascorbic acid  
 (c) Citric acid       (d) Tartaric acid

24. To weld metals together, high temperature is required. Such a high temperature is obtained by burning [NDA]

  - Acetylene in oxygen
  - LPG in oxygen
  - Methane in oxygen
  - Acetylene in nitrogen

25. Which one is a sublime substance?

  - Table salt
  - Sugar
  - Iodine
  - Potassium Iodide

26. What happens when a fixed amount of oxygen gas is taken in a cylinder and compressed at constant temperature?

  - Number of collisions of oxygen molecules at per unit area of the wall of the cylinder increase.
  - Oxygen ( $O_2$ ) gets converted into ozone ( $O_3$ ).
  - Kinetic energy of the molecules of oxygen gas increases.
  - A and C
  - B and C
  - C only
  - A only

27. A gas can be compressed to a fraction of its volume. The same volume of a gas can be spread all over a room. The reason for this is that

  - the volume occupied by molecules of a gas is negligible as compared to the total volume of the gas.
  - gases consists of molecules which are in a state of random motion
  - gases consist of molecules having very large inter-molecular space which can be reduced or increased under ordinary conditions
  - None of these

28. Select the correct order of evaporation for water, alcohol, petrol and kerosene oil

  - water > alcohol > kerosene oil > petrol
  - alcohol > petrol > water > kerosene oil
  - petrol > alcohol > water > kerosene oil
  - petrol > alcohol > kerosene oil > water

29. Non-reacting gases have a tendency to mix with each other. This phenomenon is known as

  - chemical reaction
  - diffusion
  - effusion
  - explosion

30. Boyle's law states that the

  - pressure of a gas is directly proportional to the temperature at constant volume
  - pressure of a gas is inversely proportional the volume at constant temperature
  - volume is directly proportional to the temperature at constant pressure
  - None of the above

31. The boiling point of alcohol is  $78^{\circ}\text{C}$ . What is this temperature in Kelvin scale

  - 373 K
  - 351 K
  - 375 K
  - 78 K

32. At higher altitudes

  - boiling point of a liquid increases
  - boiling point of a liquid decreases
  - no change in boiling point
  - melting point of solid increases

33. When we put some crystals of potassium permanganate in a beaker containing water, we observe that after sometime whole water has turned pink. This is due to

  - boiling
  - melting of potassium permanganate crystals
  - sublimation of crystals
  - diffusion

34. Which of the following processes is known as fusion?

  - change of liquid to solid
  - change of solid to liquid
  - change of liquid to vapour
  - change of gaseous state to solid state

35. When a gas is compressed keeping temperature constant, it results in

  - increase in speed of gaseous molecules
  - increase in collision among gaseous molecules
  - decrease in speed of gaseous molecules
  - decrease in collision among gaseous molecules.

36. A pungent smell often present near the urinals is due to

  - sulphur-di-oxide
  - chlorine
  - ammonia
  - urea

37. Kerosene is a mixture of

  - aromatic hydrocarbons
  - aliphatic hydrocarbons
  - saturated hydrocarbons
  - acyclic hydrocarbons

38. The oxide of which of the following elements is used as a coolant?

  - Silicon
  - Nitrogen
  - Carbon
  - Phosphorus

39. Which one of the following is not a mixture? [NDA]

  - Air
  - Mercury
  - Milk
  - Cement

40. Which one among the following statements regarding the properties of mixtures and compounds is not correct? [NDA]

  - A mixture shows the properties of its constituents but the properties of a compound are entirely different from its constituents
  - A mixture may be homogeneous or heterogeneous but a compound is a homogeneous substance
  - The constituents of a mixture can be separated by physical methods but those of a compound cannot be separated by physical methods
  - Energy is either absorbed or evolved during the preparation of a mixture but not in the preparation of a compound

41. Which one among the following is *not* a mixture?

  - Graphite
  - Glass
  - Brass
  - Steel

42. The latest discovered state of matter is [NDA]

  - solid
  - Bose-Einstein condensation
  - plasma
  - liquid

43. Which one of the following is not a mixture?

  - Tootpaste
  - Toilet soap
  - Baking soda
  - Vinegar

44. Iodised salt is a [CDS] (a) mixture of potassium iodide and common salt  
(b) mixture of molecular iodide and common salt  
(c) compound formed by combination of potassium iodide and common salt  
(d) compound formed by molecular iodine and common salt
45. What type of mixture is smoke? [CDS] (a) Solid mixed with a gas  
(b) Gas mixed with a gas  
(c) Liquid mixed with a gas  
(d) Gas mixed with a liquid and a solid
46. Iron sheet kept in moist air covered with rust. Rust is [CDS] (a) an element  
(b) a compound  
(c) a mixture of iron and dust  
(d) a mixture of iron, oxygen and water
47. What is the term used to denote the critical temperature at which the air becomes saturated with vapour and below which the condensation is likely to begin? [NDA] (a) Condensation point  
(b) Evaporation point  
(c) Dew point  
(d) Point of critical temperature
48. Tails of comets are visible due to (a) Tyndall Effect (b) Reflection  
(c) Brownian movement  
(d) None of these
49. The process used to separate oil and water is (a) distillation (b) sublimation  
(c) separating funnel (d) chromatography
50. Amalgam is a solution of (a) solid in solid (b) solid in liquid  
(c) liquid in solid (d) liquid in liquid
51. Which one of the following is correct? Butter is [CDS] (a) a supercooled oil (b) an emulsion  
(c) a molecular solid (d) None of these
52. Which one of the following petroleum refinery products has the lowest boiling point? [CDS] (a) Kerosene (b) Diesel  
(c) Gasoline (d) Lubricating oil
53. Which one of the following is not a mixture? [CDS] (a) Tootpaste (b) Toilet soap  
(c) Baking soda (d) Vinegar
54. Iodised salt is a [CDS] (a) mixture of potassium iodide and common salt  
(b) mixture of molecular iodide and common salt  
(c) compound formed by combination of potassium iodide and common salt  
(d) compound formed by molecular iodine and common salt
55. At NTP, the least volume will be occupied by 15 g of which one of the following? [NDA] (a)  $\text{NH}_3$  (b)  $\text{O}_2$   
(c)  $\text{N}_2$  (d)  $\text{Ne}$
56. What is the weight of one atom of Hydrogen in grams? [NDA] (a)  $6.023 \times 10^{-23}$  (b)  $1.66 \times 10^{-24}$   
(c)  $6.62 \times 10^{-24}$  (d) None of these
57. Which one of the following elements shows variable equivalent mass? [NDA] (a) Zinc (b) Silver  
(c) Calcium (d) Iron
58. The atomic weights are expressed in terms of atomic mass unit. Which one of the following is used as a standard? [NDA] (a)  ${}^1\text{H}_1$  (b)  ${}^{12}\text{C}_6$   
(c)  ${}^{16}\text{O}_8$  (d)  ${}^{35}\text{Cl}_{17}$
59. Which one of the following mixtures is homogeneous? [NDA] (a) Starch and sugar  
(b) Methanol and water  
(c) Graphite and charcoal  
(d) Calcium carbonate and calcium bicarbonate
60. In which one of the following situations a chemical reaction does not occur? [NDA] (a) Common salt is exposed to air  
(b) Coal is burnt in air  
(c) Sodium is placed in water  
(d) Iron is kept in moist air
61. Which of the following is the best example of the law of conservation of mass? [NDA] (a) When 12 gm of carbon is heated in vacuum, there is no change in mass  
(b) Weight of platinum wire is the same before and after heating  
(c) A sample of air increases in volume when heated at constant pressure but mass remains unchanged  
(d) 12 gm of carbon combines with 32 gm of oxygen to give 44 gm of carbondioxide.

## ANSWER KEY

1	(b)	2	(a)	3	(a)	4	(a)	5	(a)	6	(b)	7	(a)	8	(a)
9	(c)	10	(c)	11	(a)	12	(d)	13	(a)	14	(b)	15	(c)	16	(c)
17	(b)	18	(a)	19	(a)	20	(b)	21	(c)	22	(b)	23	(a)	24	(a)
25	(c)	26	(d)	27	(c)	28	(d)	29	(b)	30	(b)	31	(b)	32	(b)
33	(d)	34	(b)	35	(d)	36	(c)	37	(b)	38	(c)	39	(b)	40	(d)
41	(a)	42	(c)	43	(c)	44	(c)	45	(d)	46	(b)	47	(c)	48	(a)
49	(c)	50	(c)	51	(d)	52	(c)	53	(c)	54	(c)	55	(c)	56	(b)
57	(d)	58	(b)	59	(b)	60	(a)	61	(a)						

# Chapter 2

# ATOMS, MOLECULES & NUCLEAR CHEMISTRY

## ATOMS AND MOLECULES

The combination of different elements to form compounds is governed by some basic rules. These rules, collectively called 'laws of chemical combination'.

### LAW OF CHEMICAL COMBINATIONS

#### Law of Conservation Mass:

Lavoisier, who is widely regarded as the father of modern chemistry, gave the law of conservation of mass. *This law states that in any chemical reaction, the mass of the substances that react equals the mass of the products that are formed.*

#### Law of Definite Proportions:

This law was given by Joseph Proust, a French chemist, in 1799. Proust's law of definite proportions states that *different samples of the same compound always contain its constituent elements in the same proportion by mass.*

#### Law of Multiple Proportions :

In 1803 Dalton gave this law. *As per this law if two elements combine to form more compounds, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.*

#### The Law of Gaseous Volume:

When gases react, the volumes consumed and produced, measured at the same temperature and pressure, are in ratios of small whole numbers. This is also known as Gay-Lussac's Law.

### Dalton's Atomic Theory

The hypotheses about the nature of matter on which Dalton's atomic theory is based can be summarized as:

- Matter consists of indivisible atoms.
- All the atoms of a given chemical element are identical in mass and in all other properties.
- Different chemical elements have different kinds of atoms and in particular such atoms have different masses.
- Atoms are indestructible and retain their identity in chemical reactions.

### Laws of Chemical Combination and Dalton's Theory

- Dalton's fourth postulate explains the law of conservation of mass.
- The fifth postulate is an attempt to explain the law of definite proportions.

## ATOMS

Atoms are building blocks of all matter. On the basis of Dalton's atomic theory, we can define an atom as *the basic unit of an element that can enter into chemical combination.*

The size of an atom is extremely small and not visible to eye. The comparative idea regarding the size of atom can be had from the following:

Relative sizes	
Radius (in meter)	Example
$10^{-10}$	Atoms of hydrogen
$10^{-4}$	Grain of sand
$10^{-1}$	Water melon
$0.2 \times 10^{-1}$	Cricket ball

### Atomic Symbols

*It was Jon Jacob Berzelius who devised the modern convenient system of using letters of the alphabet to represent elements.* The systems of naming the elements are enumerated below:

- The symbols of the most common elements, mainly nonmetals, use the first letter of their English name. Examples: H (hydrogen), B (Boron), C (Carbon), N (nitrogen), O (Oxygen), F(Flourine), P (Phosphorous), S (Sulphur), I (iodine), etc.
- If the name of the element has the same initial letter as another element, then the symbol uses the first and second letters of their English name. Examples: He(Helium), Li(Lithium), Be(Beryllium), Ne(Neon), Al(Aluminum)

### Atomic Number, Mass Number and Isotopes

The subatomic particles present in atom are *neutron, proton and electron*. All atoms can be identified by the number of protons and neutrons they contain.

#### Atomic number

*The number of protons in the nucleus of an atom decides which element it is. This very important number is called the atomic number (Z).* In a neutral atom the number of protons is equal to the number of electrons, so the atomic number also indicates the number of electrons present in the atom. The chemical identity of an atom can be determined solely by its atomic number.

#### Mass number

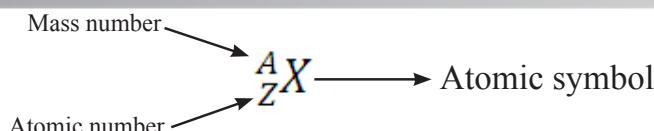
*The mass number (A) is the total number of neutrons and protons present in the nucleus of an atom of an element.*

$$\text{Mass number} = \text{number of protons} + \text{number of neutrons}$$
$$= \text{atomic number} + \text{number of neutrons}$$

The number of neutrons in an atom is equal to the difference between the mass number and the atomic number, or  $(A - Z)$ .

### ISOTOPES

*Atoms that have the same atomic number but different mass numbers are called isotopes.*



The first isotope of uranium is used in nuclear reactors and atomic bombs, whereas the second isotope lacks the properties necessary for these applications.

#### **Handy Facts**

The chemical properties of an element are determined primarily by the protons and electrons in its atoms; neutrons do not take part in chemical changes under normal conditions. Therefore, isotopes of the same element have similar chemistry, forming the same types of compounds and displaying similar relativities.

#### **Isobars**

Thus, elements atoms of different elements having same mass number ( $A$ ) but different atomic number( $z$ ) are termed as isobars.

Examples :  $^{14}_{7}\text{N}$  and  $^{14}_{6}\text{C}$   
 $^{24}_{11}\text{Na}$  and  $^{24}_{12}\text{Mg}$

#### **Isotones**

The atoms of an element which have *atomic numbers and mass number both different but the number of neutrons in atomic nuclei are same* called isotones.

#### **Atomic Mass**

A property closely related to an atom's mass number is its **atomic mass**. The mass of an atom depends on the number of electrons, protons, and neutrons it contains.

- A value is assigned to the mass of one atom of a given element so that it can be used as standard. By international agreement, **atomic mass** (sometimes called *atomic weight*) is *the mass of the atom in atomic mass units (amu)*.
- One **atomic mass unit** (also called one Dalton) is defined as *a mass exactly equal to one-twelfth the mass of one carbon-12 atom*.

Carbon-12 is the carbon isotope that has six protons and six neutrons. Setting the atomic mass of carbon-12 at 12 amu provides the standard for measuring the atomic mass of the other elements.

#### **MOLECULE**

**Amedeo Avogadro**, an Italian chemist, first coined the term molecule in 1801 in order to explain the Gay-Lussac's law.

*Molecule may be defined as a combination of two or more than two atoms of the same or different elements in a definite arrangement.* These atoms are held together by chemical forces or *chemical bonds*.

#### **Difference between Atoms and Molecules**

- An atom is the smallest particle of a substance which cannot exist freely whereas molecules can be considered as the smallest particle of an element or of a compound which can exist alone or freely under ordinary conditions.
- A molecule of a substance shows all chemical properties of that substance.

#### **Representing a Molecule Chemically**

The chemical composition of a molecule can be expressed with the help of symbols of elements and formulae.

- Oxygen molecule is made of two atoms of oxygen and therefore it is a *diatomic molecule* (represented by  $\text{O}_2$ ), hydrogen,

nitrogen, fluorine, chlorine, bromine and iodine are other examples of diatomic molecules and are represented as  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{F}_2$ ,  $\text{Cl}_2$ ,  $\text{Br}_2$  and  $\text{I}_2$  respectively.

- Some other elements exist as more complex molecules. Phosphorus molecule consists of four atoms (denoted by  $\text{P}_4$ ) whereas sulphur exists as eight atom molecule ( $\text{S}_8$ ).
- Normally, molecules consisting of more than three or four atoms are considered under the category of **polyatomic molecules**.

#### **Handy Facts**

*Buckminsterfullerene* is a soccer ball-shaped molecule.

#### **Molecular Formula**

Formulae are combinations of symbols that represent a compound. A formula indicates:

- The elements involved in the molecule.
- The number of atoms of each element contained in the molecule. In writing formulae, we use subscripts, coefficients, and parentheses in addition to the symbols of the elements.
- **Subscripts** indicate the number of atoms of an element, as in  $\text{H}_2$  where two is the subscript meaning two hydrogen atoms. If there is no subscript with a symbol, it is assumed there is only one atom of that element.
- **Coefficients** are numbers in front of the formula; indicate the number of molecules of compound, as in  $4\text{HCl}$  where four is the coefficient indicating four molecules of HCl.
- **Parentheses** are used to separate a radical from the rest of the formula when it would be confusing not to do so.

#### **Steps in Formula Writing**

In writing formulae for compounds, there are four steps that should be followed:

- Determine the symbols for the elements in a compound.
- Determine the valence of each of the atoms or radicals.
- Write the positive element's symbol first, followed by that of the negative element.
- Make the compound electrically neutral by using subscripts.

For example, the formula for calcium chloride may be written as follows:

- Symbols of Calcium = Ca and Chloride = Cl.
- Ca valence is +2, Cl valence is -1.
- $\text{Ca}^{+2} 2\text{Cl}^{-1}$ . If we add the charges, we find that this compound is not neutral ( $+2 - 1 = +1$ ). Therefore, we must proceed to step (4).
- To have two negative charges to balance the two positive charges, we must have two  $\text{Cl}^{-1}$  ions ( $-1 \times 2 = -2$ ). Thus, the formula would be  $\text{CaCl}_2$ .

#### **Empirical Formula**

The **empirical formula** of a compound is the simplest formula which expresses its percentage composition. It is the ratio of the different elements present in a chemical compound. Empirical formula does not show the exact number of elements present.

For example, molecular formula of Benzene is  $\text{C}_6\text{H}_6$ .

#### **Structural Formula**

**Structural formula** of a molecule represents the structure of the molecule. Structural formula shows how the atoms are bonded to each other.

#### **Molecular Mass**

Molecular formula of a compound is normally used for determining the molecular mass of that compound.

- The **molecular mass** is the sum of atomic masses of all the atoms present in that molecule.

For example:

The molecular mass of  $\text{CO}_2$  is obtained as:

$$\text{C} = 1 \times 12.0 \text{ u} = 12.0 \text{ u}$$

$$\text{For two O} = 2 \times 16.0 \text{ u} = 32.0 \text{ u}$$

$$\text{Mass of } \text{CO}_2 = 44.0 \text{ u}$$

$$\text{Hence, we write molecular mass of } \text{CO}_2 = 44.0 \text{ u.}$$

### Equivalent Mass

The formula to calculate the equivalent mass of an element is given by :

$$\text{Equivalent mass} = \frac{\text{Atomic Mass}}{\text{Valency}}$$

### IONS

An ion is an atom or a group of atoms that has a net positive or negative charge.

- The number of positively charged protons in the nucleus of an atom remains the same during ordinary chemical changes (called chemical reactions), but negatively charged electrons may be lost or gained.
- The loss of one or more electrons from a neutral atom results in a **cation**, an ion with a net positive charge. For example, a sodium atom ( $\text{Na}$ ) can readily lose an electron to become a sodium cation.
- On the other hand, an **anion** is an ion whose net charge is negative due to an increase in the number of electrons. A bromine atom ( $\text{Br}$ ), for instance, can gain an electron to become the bromide ion  $\text{Br}^-$ .

### AVOGADRO'S LAW (AVOGADRO'S THEORY; AVOGADRO'S HYPOTHESIS):

This law states that equal volumes of gases at the same temperature and pressure contain the same number of molecules regardless of their chemical nature and physical properties. Avogadro's number is  $6.022 \times 10^{23}$ . It is the number of molecules of any gas present in a volume of 22.4 L and is the same for the lightest gas (hydrogen) as for a heavy gas such as carbon dioxide or bromine. Avogadro's law provides a method to determine molecular weights of gaseous elements.

### Avogadro's Number and Molar mass of an element

Chemists measure atoms and molecules (or any particle like ions, radicals, etc) in moles. Mole is chemist's counting unit and is central to all of quantitative chemistry.

In the SI system the mole (mol) is the amount of a substance that contains as many elementary entities (atoms, molecules, or other particles) as there are atoms in exactly 12 g (or 0.012 kg) of the carbon-12 isotope. The actual number of atoms in 12 g of carbon-12 is determined experimentally. This number is called **Avogadro's number ( $N_A$ )**, in honor of Amedeo Avogadro.

The currently accepted value is,  $N_A = 6.0221415 \times 10^{23}$  Generally, Avogadro's number is rounded to  $6.022 \times 10^{23}$ . This mass of carbon-12 is its molar mass ( $M$ ), defined as the mass (in grams or kilograms) of 1 mole of units (such as atoms or molecules) of a substance.

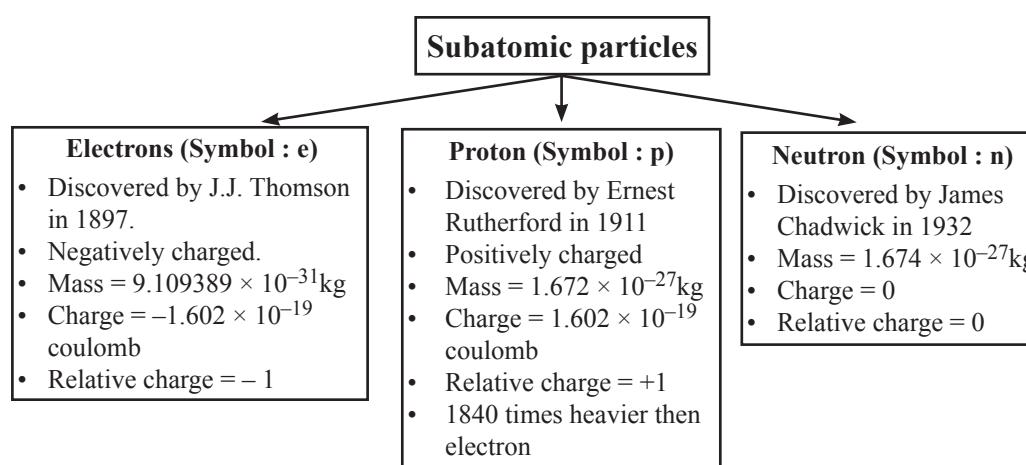
## ATOMIC STRUCTURE AND NUCLEAR CHEMISTRY

Matter is made up of atoms, and therefore an understanding of the structure of atom is very important.

- In 1879, Sir William Crooks discovered cathode rays. Cathode rays are produced in vacuum tubes equipped with two electrodes.
- Using a cathode ray tube in 1897, J.J. Thomson determined that all matter, whatever its source, contains particles of the same kind that are much less massive than the atoms of which they form a part.
- Thomson originally called these as **corpuscles** which later came to be known as **electrons**.

### FUNDAMENTAL PARTICLES OF ATOM

Electrons, Protons and neutrons are called fundamental particles. Characteristics of the fundamental particles are given below:



The discovery of the sub-atomic particles led to the enunciation of different models of the atoms which tried to explain the internal structure of the atom.

### MODELS OF ATOM

#### Thomson Model

- J.J. Thomson proposed that atoms can be considered as a large positively charged body with a number of small nega-

tively charged electrons scattered throughout it. This model was called as *Plum pudding* model of the atom.

- The electrons represent the plums in the pudding made of positive charge.
- Thomson model was discarded because it could not explain certain experimental observations like alpha particle scattering experiment by thin metal foils conducted by Ernest Rutherford.

## Rutherford's Model

In 1909, Rutherford discovered proton in his famous *gold foil experiment*. In this experiment, Rutherford bombarded a beam of alpha particles on an ultrathin gold foil and then detected the scattered alpha particles in zinc sulfide (ZnS) screen.

### Results

- Most of the particles pass through the foil without any deflection.
- Some of the alpha particles deflect at small angle.
- Very few even bounce back (1 in 20,000).

### Conclusion

Based on his observations, Rutherford proposed the following structural feature of an atom:

- Most of the atom's mass and its entire positive charge are confined in a small core, called *nucleus*. The positively charged particle is called *proton*.
- Most of the volume of an atom is empty space.
- The number of negatively charged electrons dispersed outside the nucleus is same as number of positively charged particles in the nucleus. It explains the overall electrical neutrality of an atom.

## Bohr's Model

The assumptions of Bohr's Theory are as follows:

- Electrons revolve round the nucleus in definite orbits called stationary states.

- Each stationary state is associated with a definite energy, which is called an energy level.
- As long as electrons revolve in the *stationary states*, they don't lose or gain energy.
- Electrons may jump from one orbit to another, in which case energy is absorbed or emitted in fixed quantities only (known as 'quanta').

## Modern Atomic Model

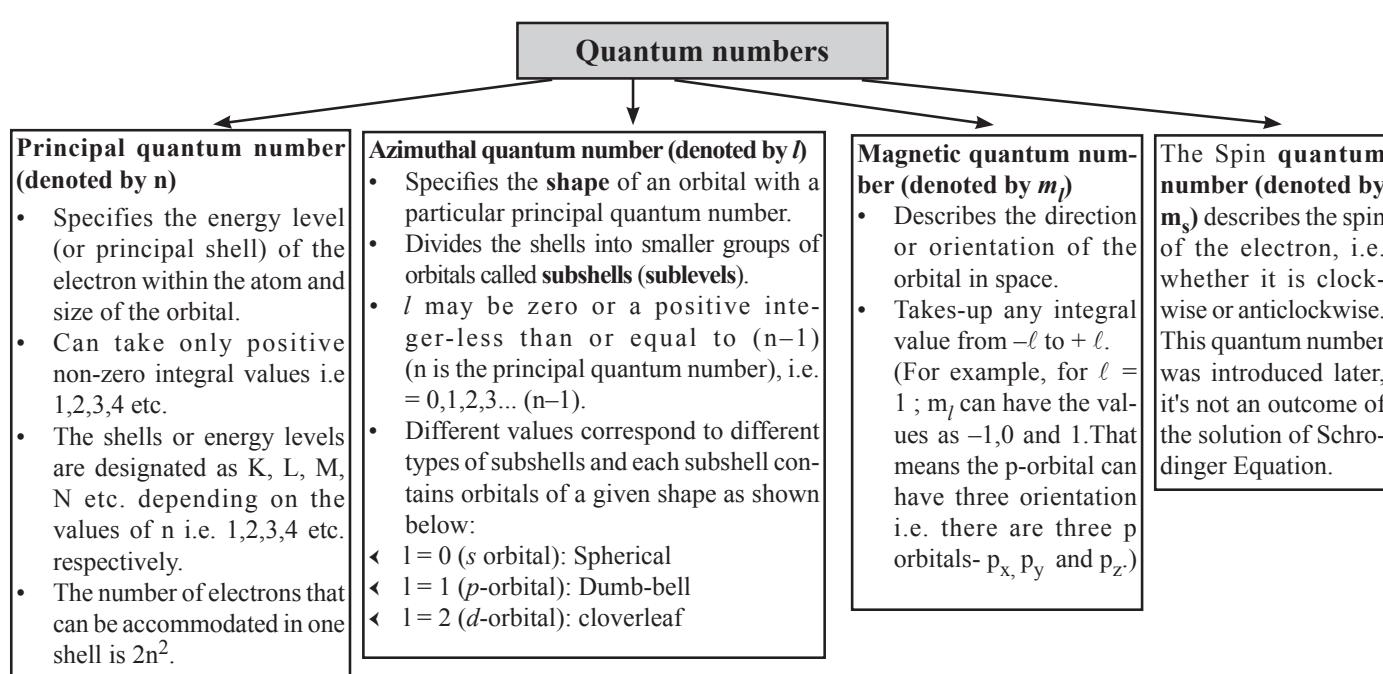
The present accepted model of atom, called **quantum mechanical or wave-mechanical concept of atom**, is basically mathematical in nature. This was proposed by Erwin Schrödinger- an Austrian physicist in 1926.

### Handy Facts

#### Heisenberg's Uncertainty Principle

An important consequence of the wave-particle duality of matter and radiation was discovered by Werner Heisenberg in 1927 and is called the **Uncertainty Principle**. According to this principle, it is not possible to simultaneously measure both the position and momentum (or velocity) of an electron accurately.

The characteristics of each of the quantum numbers are given below:



## ARRANGEMENT OF ELECTRONS IN AN ATOM

- Each electron in an atom is described by four different **quantum numbers**. The first three ( $n, l, m_l$ ) specify the particular orbital of interest, and the fourth ( $m_s$ ) specifies how many electrons can occupy that orbital.

**Table of Allowed Quantum Numbers**

<b>n</b>	<b>l</b>	<b><math>m_l</math></b>	<b>Number of orbitals</b>	<b>Orbital Name</b>	<b>Number of electrons</b>
1	0	0	1	1s	2
2	0	0	1	2s	2

	1	-1, 0, +1	3	2p	6
3	0	0	1	3s	2
	1	-1, 0, +1	3	3p	6
	2	-2, -1, 0, +1, +2	5	3d	10
4	0	0	1	4s	2
	1	-1, 0, +1	3	4p	6
	2	-2, -1, 0, +1, +2	5	4d	10
	3	-3, -2, -1, 0, +1, +2, +3	7	4f	14

- The *Pauli Exclusion Principle* (Wolfgang Pauli, Nobel Prize in 1945) states that *no two electrons in the same atom can have identical values for all four of their quantum numbers.*
- The distribution of electrons among the orbitals of an atom is called the *electronic configuration*. The electrons are filled in according to a scheme known as the *Aufbau principle* ("building-up"), which corresponds to increasing energy of the subshells as below:

$1s \rightarrow 2s \rightarrow 2p \rightarrow 3s \rightarrow 3p \rightarrow 4s \rightarrow 3d \rightarrow 4p \rightarrow 5s \rightarrow 6s \rightarrow 4f \rightarrow 5d \rightarrow 6p \rightarrow 7s \rightarrow 5s$

### Handy Facts

Because an electron spins, it creates a magnetic field, which can be oriented in one of two directions. For two electrons in the same orbital, the spins must be opposite to each other; the spins are said to be **paired**. These substances are not attracted to magnets and are said to be **diamagnetic**. Atoms with more electrons that spin in one direction than another contain **unpaired** electrons. These substances are weakly attracted to magnets and are said to be **paramagnetic**.

## NUCLEAR CHEMISTRY

In 1896, a French physicist named Henri Baequerel discovered that uranium-containing crystals emitted rays that could expose and fog photographic plates. He called these rays-*uranic rays*. Marie curie, later discovered two other elements-polonium and radium emitting *uranic rays*. She renamed uranic rays as radioactivity (or radioactive decay).

*Radioactivity may be defined as disintegration or decay of unstable atoms accompanied by emission of radiation*

Radioactivity can be of two types-Natural and artificial or induced radioactivity.

### Nature of Radiations

The invisible radioactive radiations are of three types:

- Alpha ( $\alpha$ ) particle:** a helium nucleus ( ${}^4_2\alpha$  or  ${}^4_2He$ ) without electrons. These are positively charged and largest particle emitted by radioactive nuclei. Also has the highest charge.
- Beta ( $\beta$ ) particle:** a beta particle ( ${}^0_{-1}\beta$  or  ${}^0_{-1}e$ ) is an electron emitted from an atomic nucleus.
- Positron:** the antiparticle of an electron/beta particle,  ${}^0_1\beta$  or  ${}^0_1e$ . The same size as an electron but with a positive charge.
- Gamma ( $\gamma$ ) rays:** high-energy rays (like X-rays).

### Comparison of the Properties of Alpha, Beta, and Gamma Rays

Property	$\alpha$ ray	$\beta$ ray	$\gamma$ ray
Nature	Helium nuclei, ${}^4_2He$	Fast electrons	Electro-magnetic radiation
Velocity	One-tenth of the velocity of light	Velocity of light	Velocity of light
Penetrating power	Low	moderate	high
Stopped by	Paper of 0.01 mm thick	1 cm of aluminum	Several cm thick lead/concrete layer

### Nuclear Reactions

A nuclear reaction is that which proceeds with a change in the composition of the nucleus resulting in the formation of an atom of a new element.

Therefore, the process in which the artificial transmutation of a stable nuclide leads to the formation of radioactive isotope is called *artificial radioactivity* or *induced radioactivity*.

### Difference Between Nuclear Reactions and Chemical Reactions

Following are some of the important points, given in table, which differentiate a nuclear reaction from ordinary chemical reaction.

### Nuclear Fusion

*Nuclear fusion* refers to a nuclear reaction in which two light nuclei fuse together to form heavy nucleus with release of large amount of energy.

### Nuclear Fission

Nuclear fission is a nuclear reaction in which a heavy atomic nucleus (such as that of uranium) disintegrates into two nearly equal fragments with release of large amount of energy.

### Application of Nuclear Fusion For The Benefit Of Mankind (Nuclear Reactor)

It has been possible to control fission of U-235 so that energy is released slowly at a usable rate. *Controlled fission is carried out in*

*a specially designed plant called a nuclear power reactor or simply nuclear reactor.* The chief components of a nuclear reactor are:

- U-235 fuel rods** constitute the 'fuel core'. The fission of U-235 produces heat energy and neutrons that start the chain reaction.
- Moderator** slows down or moderates the neutrons. The most commonly used moderator is ordinary water. Graphite rods are sometimes used. Neutrons slow down by losing energy due to collisions with atoms/molecules of the moderator.
- Control rods** control the rate of fission of U-235. These are made of boron-10 or cadmium that absorbs some of the slowed neutrons. Thus the chain reaction is prevented from going too fast.
- Coolant** cools the fuel core by removing heat produced by fission. Water used in the reactor serves both as moderator and coolant. Heavy water ( $D_2O$ ) is even more efficient than light water.
- Concrete shield** which protects the operating personnel and environment from destruction in case of leakage of radiation.

Nuclear power is a major source of energy for electrical generation worldwide.

### Hydrogen Bomb or H-Bomb

*This destructive device makes use of the nuclear fusion of the isotopes of hydrogen.* It consists of a small plutonium fission bomb with a container of isotopes of hydrogen.



## Uses for Radioactive Substances and Radiation

Radioactive substance and radiation have been used for the benefit of people also.

### Medicine

Radionuclides are used to directly treat illnesses. For example radioactive iodine is used, which is taken up almost exclusively by the thyroid, to treat cancer or hyperthyroidism. Radioactive tracers and dyes are also used to accurately map a specific area or system, such as in a cardiac stress test, which may use a radioactive isotope like Technetium-99 to identify areas of the heart and surrounding arteries with diminished blood flow. Cobalt-60 is also used to treat cancer patients. In Positron emission tomography (PET), a computer imaging diagnostic technique, radioactivity of some substances is utilized.

### Smoke Detectors

Some smoke detectors also use radioactive elements as part of their detection mechanism, usually americium-241. The ionizing radiation of the alpha particles is used to cause and then measure changes in the ionization of the air immediately around the detector. A change due to smoke in the air will cause the alarm to sound.

### Radiography

Essentially high-powered versions of the types of X-Ray machines used in medicine, industrial radiography cameras use

X-rays or even gamma sources (such as Iridium-192, Cobalt-60, or Cesium-137) to examine hard to reach or hard to see places. This is frequently used to examine welds for defects or irregularities, or examining other materials to locate structural anomalies or internal components.

### Food Safety

Food irradiation is the process of using radioactive sources to sterilize foodstuffs. The radiation works by killing bacteria and viruses, or eliminating their ability to reproduce by severely damaging their DNA or RNA.

### Archaeology

One important contribution that nuclear science has made in this area is the ability to determine the age of ancient artifacts. There are several techniques for doing this, but the most common process for dating objects of up to about 50,000 years is called *radiocarbon dating*.

### Tracer

Unstable nuclei have also been used as *radioactive tracers* in scientific research. *A tracer is a radioactive element whose pathway through a chemical reaction can be followed.* For example, scientists have used carbon-14 to study many aspects of photosynthesis. Likewise, phosphorus-32 atoms can be used to trace phosphorus-containing chemicals as they move from the soil into plants.

## EXERCISE

1. 1 u or 1 amu means
  - (a) 1/12th mass of C-12 atoms
  - (b) Mass of C-12 atom
  - (c) Mass of O-16 atom
  - (d) Mass of Hydrogen molecule
2. Which is the symbol of the element tungsten? [NDA]
  - (a) Ta
  - (b) Tc
  - (c) W
  - (d) V
3. What is the mass (in grams) of 3 moles of N?
  - (a) 14
  - (b) 28
  - (c) 42
  - (d) 56
4. The number of molecules in one mole of a gas is
  - (a)  $6.023 \times 10^{23}$
  - (b)  $6.023 \times 10^{22}$
  - (c)  $6.023 \times 10^{21}$
  - (d)  $6.023 \times 10^{20}$
5. Valency of Cr in CrPO<sub>4</sub> is
  - (a) 4
  - (b) 3
  - (c) 2
  - (d) 1
6. Which of the following are the constituents of matter?
 

A. Atoms	B. Molecules
C. Solid	
(a) A and B only	(b) A and C only
(c) B and C only	(d) A, B and C
7. The number value  $6.022 \times 10^{23}$  is also called
  - (a) Dalton Number
  - (b) Avagadro's number
  - (c) Atomic Number
  - (d) Mass Number
8. The molecular formula P<sub>2</sub>O<sub>5</sub> means that
  - (a) a molecule contains 2 atoms of P and 5 atoms of O
  - (b) the ratio of the mass of P to the mass of O in the molecule is 2:5
9. What mass of hydrogen and oxygen will be produced on complete electrolysis of 18g of water?
  - (a) 2g hydrogen and 32g oxygen
  - (b) 2g hydrogen and 16g oxygen
  - (c) 4g hydrogen and 32g oxygen
  - (d) 4g hydrogen and 14g oxygen
10. Which of the following statements is /are correct?  
According to Dalton's theory
  - A. An atom is the smallest particle of matter
  - B. An atom is the smallest particle of an element
  - C. An atom is the smallest indivisible particle of an element that can take part in a chemical change
  - D. An atom is the radioactive emission
  - (a) A, B and C
  - (b) B, C and D
  - (c) A, C and D
  - (d) A and D
11. Which one among the following statements about an atom is not correct? [CDS]
  - (a) Atoms always combine to form molecules
  - (b) Atoms are the basic units from which molecules and ions are formed
  - (c) Atoms are always neutral in nature
  - (d) Atoms aggregate in large numbers to form the matter that we can see, feel and touch

12. Which one among the following is correct regarding  $^{20}\text{Ne}$ ,  $^{23}\text{Na}^+$ ,  $^{19}\text{F}^-$  and  $^{24}\text{Mg}^{2+}$ ? [CDS]
- They are isomers of each other
  - They are isotopes of each other
  - They are isoelectronic with each other
  - All of the above
13. Which of the following pairs is/are correctly matched?
- Isotopes** : Atoms with same atomic number but different atomic mass
  - Isobars** : Atoms with same number of neutrons but different atomic number
  - Isotones** : Atoms with same mass number but different atomic number
- Select the correct answer using the code given below :
- [NDA]
- Code :**
- |                  |            |
|------------------|------------|
| (a) 1, 2 and 3   | (b) 1 only |
| (c) 1 and 2 only | (d) 2 only |
14. The nucleus of a singly ionized carbon atom contains [NDA]
- |  |
|--|
| (a) 6 protons and 6 neutrons               |
| (b) 5 protons and 6 neutrons               |
| (c) 6 protons, 6 neutrons and 6 electrons  |
| (d) 12 protons, 6 neutrons and 6 electrons |
15. The following questions consist of two statements, one labelled as the Assertion (A) and the other as 'Reason (R), You are to examine these two statements carefully and select the answers to these items using the codes given below:
- Assertion (A)** : Atomic weights of most of the elements are not whole numbers.
- Reason (R)** : Atoms of most of the elements contain mixture of isotopes having different atomic weights. [NDA]
- |  |
|--|
| (a) Both A and R are individually true and R is the correct explanation of A     |
| (b) Both A and R are individually true but R is NOT the correct explanation of A |
| (c) A is true but R is false   |
| (d) A is false but R is true   |
16. An oxide of nitrogen has molecular weight 30. What is the number of electrons in one molecule of the compound? [NDA]
- |        |        |
|--------|--------|
| (a) 14 | (b) 15 |
| (c) 22 | (d) 23 |
17. What is the weight of one atom of Hydrogen in grams?
- |                             |                            |
|-----------------------------|----------------------------|
| (a) $6.023 \times 10^{-23}$ | (b) $1.66 \times 10^{-24}$ |
| (b) $6.62 \times 10^{-24}$  | (d) None of these [NDA]    |
18. The atomic weights are expressed in terms of atomic mass unit. Which one of the following is used as a standard? [NDA]
- |                       |                           |
|-----------------------|---------------------------|
| (a) $^1\text{H}_1$    | (b) $^{12}\text{C}_6$     |
| (c) $^{16}\text{O}_8$ | (d) $^{35}\text{Cl}_{17}$ |
19. What is the number of water molecules present in a tiny drop of water ( volume 0.0018 ml ) at room temperature? [NDA]
- |                            |                            |
|----------------------------|----------------------------|
| (a) $4.84 \times 10^{17}$  | (b) $4.184 \times 10^{18}$ |
| (c) $6.023 \times 10^{19}$ | (d) $6.023 \times 10^{23}$ |
20. The number of neutrons in  $^7\text{Al}^{27}$  is [NDA]
- |        |        |
|--------|--------|
| (a) 40 | (b) 27 |
| (c) 14 | (d) 13 |
21. The nucleus of a singly ionized carbon atom contains [NDA]
- |  |
|--|
| (a) 6 protons and 6 neutrons               |
| (b) 5 protons and 6 neutrons               |
| (c) 6 protons, 6 neutrons and 6 electrons  |
| (d) 12 protons, 6 neutrons and 6 electrons |
22. An atom of carbon has 6 protons. Its mass number is 12. How many neutrons are present in an atom of carbon? [NDA]
- |        |        |
|--------|--------|
| (a) 12 | (b) 6  |
| (c) 10 | (d) 14 |
23. What is the number of mole(s) of  $\text{H}_2(\text{g})$  required to saturate one mole benzene? [NDA]
- |       |       |
|-------|-------|
| (a) 1 | (b) 2 |
| (c) 3 | (d) 4 |
24. How many moles of hydrogen atom are present in one mole of Aluminium hydroxide ? [NDA]
- |                 |                |
|-----------------|----------------|
| (a) one mole    | (b) Two moles  |
| (c) Three moles | (d) Four moles |
25. Protons and neutrons are bound in a nucleus by the [NDA]
- |  |
|--|
| (a) short range 'weak interaction'           |
| (b) short range 'strong interaction'         |
| (c) long range 'electromagnetic interaction' |
| (d) long range 'gravitational interaction'   |
26. Which one among the following most correctly determines the atomic number of an element? [NDA]
- |                                     |
|-------------------------------------|
| (a) Number of protons               |
| (b) Number of protons and electrons |
| (c) Number of ions                  |
| (d) Number of nucleons              |
27. The number of protons in a negatively charged atom (anion) is [NDA]
- |   |
|---|
| (a) more than the atomic number of the element    |
| (b) less than the atomic number of the element    |
| (c) more than the number of electrons in the atom |
| (d) less than the number of electrons in the atom |
28. Which one among the following is correct regarding  $^{20}\text{Ne}$ ,  $^{23}\text{Na}^+$ ,  $^{19}\text{F}^-$  and  $^{24}\text{Mg}^{2+}$ ? [NDA]
- |  |
|--|
| (a) They are isomers of each other         |
| (b) They are isotopes of each other        |
| (c) They are isoelectronic with each other |
| (d) All of the above                       |
29. Which of the following pairs is/are correctly matched? [NDA]
- Isotopes** : Atoms with same atomic number but different atomic mass
  - Isobars** : Atoms with same number of neutrons but different atomic number
  - Isotones** : Atoms with same mass number but different atomic number
- Select the correct answer using the code given below :
- Code :**
- |                  |            |
|------------------|------------|
| (a) 1, 2 and 3   | (b) 1 only |
| (c) 1 and 2 only | (d) 2 only |

- 30.** Which one among the following transitions of electron of hydrogen atom emits radiation of the shortest wavelength? [NDA]  
 (a)  $n = 2$  to  $n = 1$       (b)  $n = 3$  to  $n = 2$   
 (c)  $n = 4$  to  $n = 3$       (d)  $n = 5$  to  $n = 4$

**31.** Match List I with List II and select the correct answer using the code given below the Lists : [NDA]

<b>List I</b>	<b>List II</b>
(Scientist)	(Discovery)
A. Goldstein	1. Atomic theory
B. Chadwick	2. Proton
C. JJ Thomson	3. Neutron
D. John Dalton	4. Electron

**Code :**

A	B	C	D
(a) 2	3	4	1
(b) 2	4	3	1
(c) 1	4	3	2
(d) 1	3	4	2

**32.** Which formula gives the maximum number of electrons in a shell?  
 (a)  $n^2$       (b)  $2n^2$   
 (c)  $3n^2$       (d)  $4n^2$

**33.** In which one of the following is the valence electronic configuration,  $ns^2np^3$  found ? [NDA]  
 (a) Carbon      (b) Oxygen  
 (c) Nitrogen      (d) Argon

**34.** Which of the following isotopes of carbon is/are used in carbon dating? [CDS]  
 (a)  ${}^6C^{12}$  only      (b)  ${}^6C^{13}$  only  
 (c)  ${}^6C^{14}$  only      (d)  ${}^6C^{12}$  and  ${}^6C^{14}$

**35.** An  $\alpha$ -particle consists of which of the following? [CDS]  
 (a) 2 protons and 2 neutrons  
 (b) 1 proton and 1 electron  
 (c) 2 protons and 4 neutrons  
 (d) 1 proton and 1 neutron

**36.** Which one of the following is heavy water used in nuclear reactor? [CDS]  
 (a) Water having molecular weight 18 u  
 (b) Water having molecular weight 20 u  
 (c) Water at  $4^\circ C$  but having molecular weight 19 u  
 (d) Water below the ice in a frozen sea

**37.** Which one of the following is not needed in a nuclear fission reactor? [CDS]  
 (a) Moderator      (b) Coolant  
 (c) Accelerator      (d) Control device

**38.** Heavy water implies [CDS]  
 (a) water which is used in heavy industries such as thermal power plants  
 (b) water which contains  $SO_4^{2-}$  and  $Cl^-$  of calcium and magnesium  
 (c) deuterated water  
 (d) water which has maximum density

**39.** Age of fossil may be found out by determining the ratio of two isotopes of carbon. The isotopes are [CDS]  
 (a) C-12 and C-13      (b) C-13 and C-14  
 (c) C-12 and C-14      (d) C-12 and carbon black

**40.** Which one of the following reactions is the main cause of the energy radiation from the Sun? [CDS]  
 (a) Fusion reaction      (b) Fission reaction  
 (c) Chemical reaction      (d) Diffusion reaction

---

**ANSWER KEY**

1	(a)	2	(c)	3	(c)	4	(a)	5	(b)	6	(a)	7	(b)	8	(a)	9	(b)	10	(a)
11	(d)	12	(c)	13	(b)	14	(a)	15	(a)	16	(c)	17	(b)	18	(b)	19	(c)	20	(c)
21	(a)	22	(b)	23	(c)	24	(c)	25	(b)	26	(a)	27	(d)	28	(c)	29	(b)	30	(a)
31	(a)	32	(b)	33	(c)	34	(c)	35	(a)	36	(b)	37	(c)	38	(c)	39	(c)	40	(a)

# Chapter 3

# ELEMENTS CLASSIFICATION & CHEMICAL BONDING

# **CLASSIFICATION OF ELEMENTS**

Four major attempts made for classification of the elements are follows:

- Dobereiner's Triads
  - Newlands' Law of Octaves
  - Mendeleev's Periodic Law & Periodic Tables
  - Modern Periodic Table

# Dobereiner's Triads

In 1829, J.W. Dobereiner, a German chemist made groups of three elements each and called them triads.

- All three elements of a triad were similar in their physical and chemical properties. He proposed a law known as *Dobereiner's law of triads*.
  - According to this law, when elements are arranged in order of increasing atomic mass, the atomic mass of the middle element was nearly equal to the arithmetic mean of the other two and its properties were intermediate between those of the other two.

## Newlands' Law of Octaves

John Alexander Reina Newlands in 1863–64 noted that every eighth element showed similar physical and chemical properties, when the elements are placed in the increasing order of their atomic masses. **This was called the Newlands law of octaves.**

*The law states that when elements are placed in the increasing order of atomic masses, the properties of the eighth elements are repeated.*

# Mendeleev's Periodic Law and Periodic Table

On arranging the elements in the increasing order of atomic masses, it was observed that the elements with similar properties repeat periodically.

In 1869, Mendeleev stated his observation in the form of the following statement which is known as the **Mendeleev's Periodic Law**  
*The chemical and physical properties of elements are periodic function of their atomic masses.*

Mendeleev arranged the elements in the form of a table which is known as the **Mendeleev's Periodic Table** as below:

- Elements were arranged in increasing order of their atomic masses in horizontal rows till element whose properties were similar to those of the first element was came across.

## **Salient Features of Mendeleev's Periodic Table**

The following are the main features of this periodic table:

- The elements are arranged in rows and columns in the periodic table.
  - The horizontal rows are called **periods**. There are six periods in the periodic table. These are numbered from 1 to 6 (Arabic numerals). Each one of the 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> periods have two series of elements.
  - All the elements present in a particular group are chemically similar in nature. They also show a regular gradation in their physical and chemical properties from top to bottom.

# **Modern Periodic Law and Periodic Table**

*The Modern Periodic Law states that the chemical and physical properties of elements are periodic functions of their atomic numbers, i.e. if elements are arranged in the order of their increasing atomic number, the elements with similar properties are repeated after certain regular intervals.*

The periodic table based on the modern periodic law is called the Modern Periodic Table. Presently, the accepted modern periodic table is the *Long Form of Periodic Table*:

Modern Periodic table is divided into seven horizontal rows of elements. Each row of elements is called "PERIOD". It has 18 vertical columns called groups. These groups are numbered 1 to 18 from the left, using Arabic numerals.

The electron arrangements of atoms are linked to position in the periodic table.

- Elements in the same group have the same number of electrons in their outer shell.
- For the main group elements, the number of group is the number of electrons in the outer shell.
- The number of period shows the shells of electrons the atoms have.

## CLASSIFICATION OF THE ELEMENTS

The elements in the periodic table may be broadly classified as follows:

### Main Group Elements

The elements present in groups 1 and 2 on left side and groups 13 to 17 on the right side of the periodic table are called **representative or main group** elements. Their outermost shells have less than eight electrons and hence are incomplete.

### Noble Gases

Group 18 on the extreme right side of the periodic table contains noble gases. Their outermost shells contain 8 electrons except He which contains only 2 electrons.

Their main properties are:

- Possesses 8 electrons in their outermost shell (except He which has 2 electrons).

### Transition Elements

The middle block of periodic table (groups 3 to 12) contains transition elements. Their two outermost shells are incomplete. Since these elements represent a transition (change) from the most electropositive element to the most electronegative element, they are named as transition elements.

Their important properties are as follows:

- All these elements are metals having high melting and boiling points.

- These elements are good conductors of heat and electricity.

### Inner Transition Elements

These elements, also called *rare-earth elements*, are shown separately below the main periodic table. These are two series of 14 elements each. The first series called **lanthanides** consists of elements having atomic number 58 to 71 (Ce to Lu). The second series of 14 rare-earth elements ia called actinoids.

In all rare-earths (lanthanoids and actinoids), three outermost shells are incomplete. They are therefore called **inner transition elements**.

### Handy Facts

It may be noted that the element *lanthanum* (atomic no. 57) is not a lanthanoid and the element *actinium* (atomic no. 89) is not an actinoid.

### Metals

Metals are present in the left hand portion of the periodic table. The strong metallic elements; alkali metals (Li, Na, K, Rb, Cs, Fr) and alkaline earth metals (Be, Mg, Ca, Sr, Ba, Ra) occupy groups 1 and 2 respectively.

### Non-metals

Non-metals occupy the right hand portion of the periodic table. Strong non-metallic elements i.e. halogens (F, Cl, Br, I, At) and chalcogens (O, S, Se, Te, Po) occupy group 17 and 16 respectively.

### Metalloids

Metalloids are located along the staircase separating the metals from the nonmetals on the periodic table. Boron, silicon, germanium, arsenic, antimony, and tellurium all have metal and nonmetal properties.

### Trends in a Periodic Table (Periodic Properties)

*Definite trends of certain properties of the elements are observed in the periodic table. These properties are called periodic properties.* The following table depicts and describes the important periodic property and their variations:

Periodic property	Definition	Variation	
		Along a period	Down a group
Atomic Radius	Half of the distance between the centers of two atoms of that element that are just touching each other	Decreases	Increases
Ionization Energy	Energy required to completely remove an electron from a gaseous atom or ion.	Increases	Decreases
Electron Affinity	Energy change that occurs when an electron is added to a gaseous atom	Increases (except for Noble Gas whose Electron Affinity is near Zero)	
Electronegativity	Measure of the attraction of an atom for the electrons in a chemical bond.	Increase	Decreases
Metallic Character	Used to define the chemical properties that metallic elements present.	Decreases	Increases

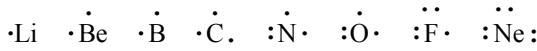
## CHEMICAL BONDING AND REACTIONS

*Chemical Bond may be defined as a force that acts between two or more atoms to hold them together as a stable molecule.*

- Bonds can be formed between atoms of the same element, or between atoms of different elements.

### LEWIS DOT STRUCTURE

*A Lewis dot symbol consists of the symbol of an element and one dot for each valence electron in an atom of the element. The Lewis dot structure of few elements are given below:*



### OCTET RULE

Noble gases namely helium, neon, argon, krypton, xenon and radon do not react with other elements to form compounds i.e. they are non-reactive.

#### Electronic configuration of Noble gases

Name	Symbol	Atomic No.	Electronic Configuration	No. of electrons in the outermost cell
Helium	He	2	2	2
Neon	Ne	10	2,8	8
Argon	Ar	18	2,8,8	8
Krypton	Kr	36	2,8,8,8	8
Xenon	Xe	54	2,8,18,18,8,8	8
Radon	Rn	86	2,8,18,32,18,8	8

It has been concluded that

- Atoms having 8 electrons in their outermost shell are very stable and they don't form compounds.
- Other atoms such as hydrogen, sodium, chlorine, etc. which do not have 8 electrons in their outermost shell undergo chemical reactions. They can stabilize by combining with each other and attain the above configurations of noble gases, i.e. 8 electrons (or 2 electrons in case of helium) in their outermost shells.
- Thus, atoms tend to attain a configuration in which they have 8 electrons in their outermost shells. This is the basic cause of chemical bonding.

*This attainment of eight electrons for stable structure is called the octet rule.* The octet rule explains the chemical bonding in many compounds.

### TYPES OF BONDING

#### Ionic Bonding

*The chemical bond formed by transfer of electron from a metal to a non-metal is known as **ionic** or **electrovalent bond**.*

##### Example:

When sodium metal and chlorine gas are brought into contact, they react violently and we obtain sodium chloride. This reaction is shown below:



#### Properties of Ionic Compounds

Ionic compounds contain ions (cations and anions) which are held together by the strong electrostatic forces of attraction. They show the following general characteristic properties:

**High melting and boiling points:** Ionic bonds are very strong. A lot of energy is needed to break them. So ionic compounds have high melting and boiling points.

**Conductive when liquid:** Ionic compounds can only conduct electricity if their ions are free to move. Ionic compounds do not conduct electricity when they are solid. But these compounds conduct electricity when dissolved in water or melted.

#### Handy Facts

Ionic compounds have high melting and boiling points. The melting point of sodium chloride is 1074 K (801°C) and its boiling point is 1686K (1413°C). The melting and boiling points of ionic compounds are high because of the strong electrostatic forces of attraction present between the ions.

### Covalent Bond

The term "covalent bond" came into use in 1939 first given by Langmuir:

*A covalent bond is a chemical link between two atoms or ions where the electron pairs are shared between them. A covalent bond may also be termed as molecular bond.*

#### Properties of covalent molecular compounds

- Low melting points and boiling points:** A relatively small amount of energy is required to overcome the weak attractions between covalent molecules, so these compounds melt and boil at much lower temperatures than metallic and ionic compounds do.
- Low enthalpies of fusion and vapourisation:** These properties are usually smaller than they are for ionic compounds.
- Soft or brittle solid forms:** The weak intermolecular forces make the solid form of covalent molecular compounds easy to distort or break.
- Poor electrical and thermal conductivity:** Covalent molecular compounds do not conduct electricity well.

#### Handy Facts

Because of the weak forces of attraction present between discrete molecules, called *intermolecular forces*, the covalent compounds exist as a gas or a liquid or a solid. For example O<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub> are gases; water and CCl<sub>4</sub> are liquids and iodine is a solid.

The melting points and boiling points of covalent compounds are lower than those of ionic compounds. For example, melting point of naphthalene which is a covalent compound is 353 K (80°C). Similarly, the boiling point of carbon tetrachloride which is another covalent liquid compound is 350 K (77°C).

#### Types of covalent bonds

- Nonpolar covalent bond:** A bond between two nonmetal atoms that have the same electronegativity and therefore have equal sharing of the bonding electron pair.
- Polar covalent bond:** A bond between two nonmetal atoms that have different electronegativities and therefore have unequal sharing of the bonding electron pair.

**Polar Molecule:** A molecule in which the bond dipoles present do not cancel each other out and thus results in a *molecular dipole*.

## Co-ordinate Covalent Bond

Boron reacts with the halogens to form a class of compounds having the general formula  $\text{BX}_3$ , where X is a halogen atom. **These are examples of compounds having incomplete octets.**

*This type of bond is called a coordinate covalent bond (also referred to as dative bond), defined as a covalent bond in which one of the atoms donates both electrons.*

## Exceptions to Octet Rule

The octet rule applies mainly to the second-period elements. However there are certain exceptions to the octet rules. That is there are certain compounds in which the octet rule is not satisfied. Exceptions to the octet rule fall into three categories:

### An odd number of electrons

There are some molecules containing an *odd* number of electrons. For example, nitric oxide ( $\text{NO}$ ) and nitrogen dioxide ( $\text{NO}_2$ ). As we need an even number of electrons for complete pairing (to reach eight), the octet rule clearly cannot be satisfied for all the atoms in any of these molecules. Odd-electron molecules are sometimes called *radicals*.

### More than eight electrons around the central atom

Atoms of the second-period elements cannot have more than eight valence electrons around the central atom, but atoms of elements in and beyond the third period of the periodic table form some compounds in which more than eight electrons surround the central atom. That is the central atom has expanded octet. One example of such a compound is  $\text{SF}_6$ .

## Metallic Bonding

*The structures formed by metals are held together by metallic bond.*

- Metals form giant structures in which electrons in the outer shells of the metal atoms are free to move.
- The metallic bond is the force of attraction between these free electrons and positive metal ions.

### Handy Facts

Metals are good conductors of electricity and heat, because the free electrons carry a charge or heat energy through the metal. The free electrons allow metal atoms to slide over each other, so metals are malleable and ductile

## Intermolecular Forces Between Molecules

A **hydrogen bond** is the attractive force between the hydrogen attached to an electronegative atom of one molecule and an electronegative atom of a different molecule.

**Van der Wall's forces** are forces of attraction which exist between all atoms and molecules. These forces result from weak electrostatic attraction between temporary dipoles and induced dipoles caused by movement of electrons in atoms and molecules.

## CHEMICAL REACTIONS AND CHEMICAL EQUATIONS

Chemical changes result from chemical reactions taking place between different substances. It is a process in which a substance (or substances) is changed into one or more new substances.

In chemical reaction, the substance which undergoes a chemical change is called the **reactant** and the substance which is formed as a result of a chemical change is called the **product**.

## Balancing Chemical Equations

According to Law of *conservation of mass*, the mass and the number of atoms present in the reactant(s) should be equal to the mass and number of atoms present in product(s).

The Equation can be balanced by placing the appropriate coefficient (2 in this case) in front of  $\text{H}_2$  and  $\text{H}_2\text{O}$ :



This *balanced chemical equation* shows that “two hydrogen molecules can combine or react with one oxygen molecule to form two water molecules”.

### Handy Facts

STP in chemistry is the abbreviation for standard temperature and pressure. STP is most commonly used when performing calculation on gases, such as gas density. The standard temperature is 273K (0° celsius or 32° Fahrenheit) and the standard pressure is 1 atmospheric (atm.) pressure.

## Types of Chemical Reactions

The types of Chemical Reaction are discussed below with examples.

### • Combination reactions

In combination reactions, as the name indicates, *two or more substances (elements or compounds) simply combine to form a new substance*. For example, when a substance burns it combines with oxygen present in the air.

### • Decomposition reactions

*A decomposition reaction is the one in which a compound decomposes into two or more than two substances (elements or compounds).* For example, lime stone when heated gives lime and carbon dioxide.

### • Displacement reaction

*The displacement reaction is one in which one element displaces another element from its compounds.*

### • Double displacement reaction

The reactions in which mutual exchange of radicals takes place are known as double decomposition reactions. As a result of double decomposition reactions two new substances are formed.

## Oxidation and reduction reaction

*When a substance gains oxygen during a reaction, it is said to be oxidized and when a substance loses oxygen during a reaction, it is said to be reduced.*

Thus in this reaction, during the reaction process, one reactant gets oxidized while the other gets reduced. Such reactions are called **oxidation reduction reaction or Redox Reactions**.

*There is no oxidation without reduction and there is no reduction without oxidation, i.e oxidation and reduction take place simultaneously.*

As per modern concept, oxidation and reduction is explained in terms of loss and gain of electrons not in terms of gain and loss of oxygen and hydrogen.

- Oxidation is loss of electrons.*
- Reduction is gain of electrons.*

## OXIDATION NUMBER

Oxidation Number shows the total number of electrons which have been removed from an element (a positive oxidation state)

# **Elements Classification & Chemical Bonding**

or added to an element (a negative oxidation state) to get to its present state.

By knowing how the oxidation number of an element changes during a reaction, we can tell whether it is being oxidised or reduced.

- Increase in oxidation number is oxidation
  - Decrease in oxidation number is reduction.

# Rules to Calculate Oxidation Numbers

- The oxidation number for an atom of any free (uncombined) element is ZERO.

**Examples:** Na, Mg have zero oxidation number.

- The oxidation number of an element in self-combination is always ZERO.

**Examples:** H<sub>2</sub>, Cl<sub>2</sub>, P<sub>4</sub> have zero oxidation number.

- In most hydrogen containing compounds, oxidation number of hydrogen is +1. (Exception is when H combines with alkali metals or alkaline earth to form hydrides of metals such as: NaH, LiH, CaH<sub>2</sub>. Then, the oxidation number of H is -1).
  - In compounds involving the alkali metals, the elements are assigned oxidation number of +1.
  - In combinations of non-metals **not** involving hydrogen and oxygen, the nonmetal that is more electronegative is considered negative.

# **REDOX REACTION IN DAY-TO-DAY LIFE**

Redox reactions are very important in our lives. Two very common phenomena- corrosion and rancidity are results of redox reactions. These are discussed below:

## **Corrosion:**

For most of us, Corrosion is the degradation of metals and is often called rust. Chemically we can define it as an irreversible interfacial reaction of a material (metal, ceramic, polymer) with its environment which results in consumption of the material.

Most metals corrode on contact with water (and moisture in the air), acids, bases, salts, oils, aggressive metal polishes, and other solid and liquid chemicals. Metals will also corrode when exposed to gaseous materials like acid vapors, formaldehyde gas, ammonia gas, and sulphur containing gases. *Corrosion specifically refers to any process involving the deterioration or degradation of metal components.* The best known case is

that of the rusting of steel. Corrosion processes are usually electrochemical in nature.

# **Factors Influencing Corrosion**

Following factors influence the corrosion. These are the

- Reactivity of metals
  - Presence of moisture and atmospheric gases like  $\text{CO}_2$ ,  $\text{SO}_2$  etc.
  - Presence of impurities.
  - Strains in the metal
  - Presence of electrolyte.

### **Methods to Prevent Corrosions :**

- To minimize corrosion, protective coatings are applied to prevent the direct contact of moisture and oxygen with the metal. This process is called *galvanising*. It involves coating of Zn metal on iron surface.
  - Electrochemical principles can also be applied to inhibit corrosion. This is known as *cathodic protection*.
  - Another way to protect iron and other metals from oxidation is to coat them with a corrosion-resistant metal, such as chromium, platinum or gold. This process of coating one metal with another by electrolysis is called *electroplating*.

## Rancidity

What we perceive is an unpleasant change in the flavor and odour of a food, called rancidity. Unsaturated fats are more susceptible to oxidation than are saturated fats. Factors which accelerate fat oxidation include trace metals (iron, zinc, etc.), salt, light, water, bacteria, and molds. Fat oxidation can be retarded by use of antioxidants (Antioxidants are compounds that inhibit chemical reactions with oxygen such as BHT, BHA, vitamin E, and vitamin C), by use of spices such as sage and rosemary, and by use of light and/or air tight wrapping.

# **ENERGY CHANGES IN CHEMICAL REACTIONS**

When chemical reactions take place they are often accompanied by **heat changes**.

- Exothermic reactions give out energy to the surroundings.
  - Endothermic reactions take energy from the surroundings.

# EXERCISE

1. The early attempt to classify elements as metals and non-metals was made by  
(a) Mendeleev      (b) Lothar Meyer  
(c) Lavoisier      (d) Henry Moseley

2. The long form of periodic table consists of  
(a) seven periods and eight groups  
(b) seven periods and eighteen groups  
(c) eight periods and eighteen groups  
(d) eighteen periods and eight groups

3. Which one of the following is most electropositive element?  
(a) Sodium      (b) Calcium  
(c) Aluminium      (d) Silicon

4. Which of the following is not isoelectronic with  $O^{2-}$ ?  
(a)  $N^{3-}$       (b)  $Na^+$   
(c)  $F^-$       (d)  $Ti^+$

5. On the basis of following features identify correct option  
A. Gaps were left for undiscovered elements  
B. No correct position of hydrogen  
C. The isotopes of same element will be given different position  
(a) Mendeleev's periodic table  
(b) Modern periodic table  
(c) Newland's arrangement of elements  
(d) Both (a) and (b)

6. According to Newland's law of octaves, which element is the repetition of the first element in the periodic table?  
(a) Oxygen      (b) Nitrogen  
(c) Chlorine      (d) Sulphur

7. Which one of the following is a diagonally related pair?  
(a) H, Be      (b) Na, Mg  
(c) B, Si      (d) K, Ca



**ANSWER KEY**

# Chapter

# 4

# ACIDS, BASES, SALTS & METALS

## ACIDS, BASES AND SALTS

Some naturally occurring substances that contain acids are given in the following table:

Substances	Acid present
Orange, lemon	Citric acid, ascorbic acid (vitamin c)
Apple	Malic acid
Tamarind	Tartaric acid
Vinegar	Acetic acid
Curd	Lactic acid
Tomato	Oxalic acid
Gastric juice	Hydrochloric acid
Tea	Tannic acid
Red ants	Formic acid

- Robert Boyle was the first scientist to term substances as acid and base based on different characteristics of substances.

Swedish scientist Svante Arrhenius in the late nineteenth century first attempted to explain the behaviour of acids and bases from their chemical structure.

## CONCEPTS OF ACIDS AND BASES

### Arrhenius Concept

According to Arrhenius, *an acid is a compound that releases  $H^+$  ions in water; and a base is a compound that releases  $OH^-$  ions in water.*

### Bronsted-Lowry Concept

In 1923 J.N. Bronsted and J.M. Lowry independently proposed a broader concept of acids and bases. According to this concept,

- An acid is any molecule or ion that can donate a proton ( $H^+$ )
- A base is any molecule or ion that can accept a proton
- An acid is a proton donor while a base is a proton acceptor.
- Water that accepts a proton is a Bronsted base.

### Conjugate Acid-Base pairs

An important concept that emanates from Bronsted-Lowry concept is **conjugate acid-base pairs**. In an acid-base reaction the acid ( $HA$ ) gives up its proton ( $H^+$ ) and produces a new base ( $A^-$ ).

- The new base that is related to the original acid is called a **conjugate (meaning related) base**.
- Similarly the original base ( $B^-$ ) after accepting a proton ( $H^+$ ) gives a new acid ( $HB$ ) which is called a **conjugate acid**.

### Classes of Bronsted Acids and Bases

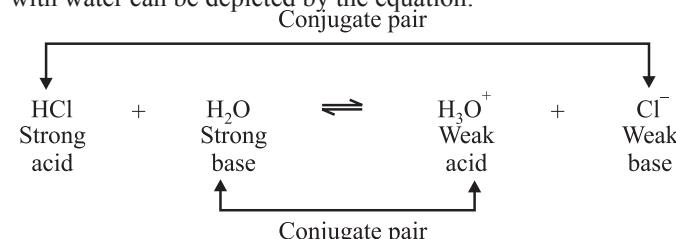
Bronsted acids can be classified as per its capacity to furnish protons as follows:

- Monoprotic acids** are capable of donating one proton only,
- Polyprotic acids** are capable of donating two or more protons, e.g.  $H_2SO_4$ ,  $H_3PO_4$ , carbonic acid ( $H_2CO_3$ ), hydrochloric acid, etc.
- Monoprotic bases** can accept one proton.
- Polyprotic bases** can accept two or more protons, e.g. anions of diprotic and tripototic acids.

### Strength of Bronsted Acids and Bases

*The strength of a Bronsted acid depends upon its tendency to donate a proton. The strength of a Bronsted base depends on its ability to accept a proton.*

For example, HCl is nearly 100% ionised in water. Its reaction with water can be depicted by the equation:



The above reaction has proceeded almost completely to the right; that indicates that HCl has a strong tendency to lose a proton. Also, the base  $H_2O$  has a strong ability to accept a proton. The overall situation is that the acid and base on the left are each stronger than the conjugate acid and conjugate base on the right. That is why the equilibrium is displaced to the right. Thus it may be stated that:

- a strong acid has a weak conjugate base
- a strong base has a weak conjugate acid

**Strong Acids:** HCl, HBr, HI,  $HNO_3$ ,  $H_2SO_4$ ,  $HClO_3$ ,  $HClO_4$

**Strong Bases:** Alkali metal hydroxides,  $Ba(OH)_2$ ,  $Sr(OH)_2$ ,  $Ca(OH)_2$ ,  $Mg(OH)_2$

### Lewis Concept of Acids and Bases

In the early 1930s, G.N. Lewis gave an even a more general model of acids and bases. According to Lewis theory:

- an acid is an electron-pair acceptor
- a base is an electron-pair donor

Lewis visualized an acid and base as sharing the electron pair provided by the base. As a result a covalent bond (or coordinate bond) between the **Lewis acid** and the **Lewis base** is formed. The resulting combination is called a **Complex**.

### pH SCALE-THE MEASURE OF ACIDITY

The concentrations of  $H^+$  and  $OH^-$  ions in aqueous solutions are frequently very small and hence not convenient to work with.

## Acids, Bases, Salts & Metals

- It was Danish chemist Soren Sorensen who in 1909 proposed a more useful quantity called pH. The pH of a solution is defined as the negative logarithm of the hydrogen ion concentration (in mol/L):
 
$$\text{pH} = -\log[\text{H}_3\text{O}^+] \quad \text{or} \quad \text{pH} = -\log [\text{H}^+]$$
- The above equation gives a convenient numbers to work with. The negative logarithm gives a positive number for pH, which otherwise would be negative due to the small value of  $[\text{H}^+]$ . The pH of a solution is a dimensionless quantity.
- pH is simply a way to express hydrogen ion concentration, acidic and basic solutions at  $25^\circ\text{C}$  can be distinguished by their pH values, as follows:
- A pOH scale analogous to the pH scale can be devised using the negative logarithm of the hydroxide ion concentration of a solution. Thus, we define pOH as:
 
$$\text{pOH} = -\log [\text{OH}^-]$$
- In general, from the definitions it follows that
 
$$\text{pH} + \text{pOH} = 14.00$$
- The pH scale ranges from 0 to 14 on this scale. pH 7 is considered neutral, below 7 acidic and above 7 basic. Farther from 7, more acidic or basic the solution is.

### pH in Humans and Animals

Most of the biochemical reactions taking place in our body are in a narrow pH range of 7.0 to 7.8. Even a small change in pH hampers the processes. Any condition in which blood pH drops below 7.35 is known as *acidosis*, if pH rises above 7.45-then it is called *alkalosis*.

### Acid Rain

When the pH of rain water goes below 5.6, it is called **acid rain**. Acid rain is a major environmental disaster.

### pH in Plants

Soils need to be of optimum pH for plants to have an adequate growth .It should be neither highly alkaline nor highly acidic.

### In digestive system

pH plays an important part in the digestion of food. Our stomach produces hydrochloric acid (formic acid) which helps in digestion of food. When we eat spicy food, stomach produces too much of acid which causes ‘acidity’ i.e. irritation and sometimes pain too. In order to get cured from this we use ‘antacids’ which are bases like ‘milk of magnesia’ (suspension of magnesium hydroxide in water).

### Self-defence of Animals and Plants

Bee sting causes severe pain and burning sensation. It is due to the presence of *methanoic acid* (formic acid) in it. Use of a mild base like baking soda can provides relief from pain. Some plants like ‘nettle plant’ have fine stinging hair which inject *methanoic acid* into the body of any animal or human being that comes in its contact.

## BUFFER SOLUTIONS

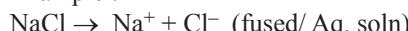
Generally pH of an aqueous solution decreases on addition of a small amount of HCl because of the increase in the concentration of  $\text{H}^+$  ions. On the other hand, if a small amount of NaOH is added, the pH of the solution increases. However, there are some solutions which resist the change in pH on addition of small amount of strong acid or alkali. Such solutions are called *buffer solutions*. For example, solution of ammonium acetate, blood, a equimolar mixture of  $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$ ,  $\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$ , etc.

### Types of Buffer Solution

- Acidic buffer :** Acidic buffer solution contains equimolar quantities of a weak acid and its salt with strong base. For example, acetic acid ( $\text{CH}_3\text{COOH}$ ) and sodium acetate ( $\text{CH}_3\text{COONa}$ ). A solution containing equimolar quantities of acetic acid and sodium acetate maintains its pH value around 4.74.
- Basic buffer :** Basic buffer solution contains equimolar quantities of a weak base and its salt with a strong acid. For example, ammonium hydroxide ( $\text{NH}_4\text{OH}$ ) and ammonium chloride ( $\text{NH}_4\text{Cl}$ ).
- SALTS**

A salt is an ionic compound which dissociates to yield a positive ion other than hydrogen ion  $[\text{H}^+]$  and a negative ion other than hydroxide ion  $[\text{OH}^-]$

Example :



### Classification of Salts

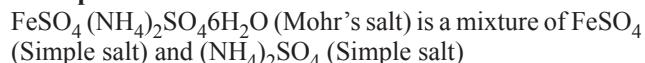
- Acidic Salt :** If a polybasic acid (Example,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{H}_2\text{SO}_3$  etc.) is neutralised partly by a base, the salt formed is acidic.
- Normal Salt :** In case the acid and base neutralise completely the salt formed is a normal salt.
- Basic Salts :** This type of salts are formed by incomplete neutralization of a base with an acid or by partial replacement of hydroxy radicals of a diacids or triacidic base with an acid radical.

**Examples :**



- Double Salt** - Such a salt is formed by mixing saturated solution of two simple salts followed by crystallisation of the saturated solution.

**Example:**



- Mixed Salts** - There is no general method for the formation of this type of salt.
- Examples:** Sodium potassium sulphate  $\text{NaKSO}_4$  (two basic radicals,  $\text{Na}^+$ ,  $\text{K}^+$ )
- Complex salt** - Such a salt is formed by mixing saturated solution of simple salts followed by crystallisation of the solution similar to double salts.

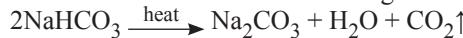
## SOME COMMON USEFUL SALTS

A large number of salts are useful for our homes and industry for various purposes. Some are discussed below:

### Baking Soda

Chemically baking soda is sodium hydrogen carbonate;  $\text{NaHCO}_3$ .

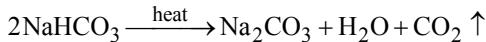
- It is an important part of food.
- Baking soda is manufactured by Solvay’s process.
- It is mainly used for manufacturing washing soda but baking soda is obtained as an intermediate.
- On heating, sodium hydrogen carbonate is converted into sodium carbonate and carbon dioxide is given off:



### Uses:

- It is used as a component of baking powder.
- It is used as a *tenderizer* and *leavening agent* in *baking* (In combination with a liquid and acid it releases  $\text{CO}_2$  )

- It is used as deodorizer because of its neutralizing action.
- It is used in laundry work for enhancing the detergents effectiveness because it stabilizes the pH level (acts as a buffer)
- It is used in fire extinguishers.* Baking soda undergoes a chemical reaction that gives off  $\text{CO}_2$  that makes it useful in extinguishing small grease or electrical fires.



- It is used as **abrasive cleaner**.

### Washing Soda

- Washing soda is used for washing of clothes. Chemically, washing soda is sodium carbonate decahydrate,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ .
- Washing soda is manufactured by Solvay's process.

### Uses

- It is used in the manufacture of caustic soda, glass, soap powders, borax and in paper industry.
- For removing permanent hardness of water.
- As a cleansing agent for domestic purpose.

### Plaster of Paris

Also called POP, chemically, it is  $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$  or  $\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$  (calcium sulphate hemi hydrate)

- Gypsum, ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) is used as the raw material to manufacture POP.
- The only difference between gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) and plaster of Paris ( $\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$ ) is the less amount of water of crystallization.

### Uses

- In medicine, used for making plaster casts to hold fractured bones in place while they set. It is also used for making casts in dentistry.
- For making fire proof materials.

### Bleaching Powder

Bleaching is a process of removing colour from a cloth to make it whiter. Bleaching powder has been used for this purpose since long. Chemically, it is calcium oxychloride  $\text{CaOCl}_2$ .

### Uses:

- Used in textile industry for bleaching of clothes.
- In paper industry for bleaching of wood pulp.
- It makes wool unshrinkable.
- Used as disinfectant and germicide for sterilization of drinking water and swimming pool water.
- For the manufacture of chloroform( $\text{CHCl}_3$ )
- Used as an oxidizing agent in chemical industry.

### Sodium Hydroxide

Also known as Caustic Soda, chemically it is  $\text{NaOH}$ . Industrial methods of its production are:

- Causticisation process(Gossage process)
- Castner Kellner cell
- Chlor-Alkali process

### Handy Facts

#### Some properties of $\text{NaOH}$ are:

- $\text{NaOH}$  (Caustic soda) is a white translucent solid available in pellets, flakes and granules as 50% saturated solution.
- Its solution when exposed to air reacts with atmospheric  $\text{CO}_2$  and form a crust of  $\text{Na}_2\text{CO}_3$  at the surface.

### Uses:

- It is used in many industries, mostly as a strong chemical base in the manufacture of pulp and paper, textiles, soaps, dyes, cellulose, detergents etc.
- It is used in petroleum refining.

### Sodium Carbonate

Also called soda ash, its chemical formula is  $\text{Na}_2\text{CO}_3$

It exists in various forms, namely anhydrous sodium carbonate  $\text{Na}_2\text{CO}_3$  (Soda-ash). Monohydrate  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$  (crystal carbonate), heptahydrate  $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$  and decahydrate  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  (washing soda or sal soda)

Sodium carbonate is generally prepared now a days by *ammonia soda* or *Solvay process*. The ingredients of this process are readily available and inexpensive. These are *Salt brine* ( $\text{NaCl}$ ) (from sea), ammonia ( $\text{NH}_3$ ) and *lime stone*  $\text{CaCO}_3$  (from mines). The process consists of many sections,  $\text{CaCl}_2$  is an important by-product obtained.

### Uses:

- It is used for softening of hard water. For this purpose hydrated sodium carbonate,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  known as *washing soda* is used.
- A mixture of sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) and potassium carbonate ( $\text{K}_2\text{CO}_3$ ) is used as fusion mixture.
- It is used in paper, paint and textile industries
- It is used for the manufacture of glass, borax, soap and caustic soda ( $\text{NaOH}$ )

### PROPERTIES, EXTRACTION AND USES OF METALS

Out of 118 chemical elements known till date, 103 has been well characterized in terms of their properties. The systematic classification of these 103 elements shows their numbers as:

- Metals=79
- Non-metals=17
- And metalloids=7

### COMPARISON OF METALS AND NON-METALS

Metals and non-metals differ both in physical and chemical properties.

The characteristic physical properties of metals and non-metals are listed in following table:

Serial No.	Metals	Non-metals
1	Metals have luster. They reflect light from polished or freshly cut surface	Non-metals do not have luster( exceptions – Diamond and Iodine )
2	Metals generally have high density.	Non-metals generally have low density.

3	They are good conductors of heat and electricity.	They are usually bad conductors of heat (exception – carbon in the form of gas carbon and graphite )
4	Metals are malleable and ductile. They can be beaten into thin sheets and drawn into wires.	Non-metals are not malleable and ductile. They can be crushed into powder.
5	They have a three dimensional crystal structure with metallic bonds	They have different types of structures with covalent and van-der-Waals' bonds
6	Metals are generally hard.	Non- metals are generally soft (Exception: Diamond)
7	Metals generally have 1 to 3 electrons in their outermost shell	Non-metals generally have 4 to 8 in their outermost shell of the atom.
8	They show valency 1 to 4.	They show valency 1 to 7.
9	They are electropositive in nature.	They are electronegative in nature.
10	They generally form basic oxides.	They generally form acidic oxides.
11	They act as reducing agents.	They act as oxidizing agents.
12	Active metals react with cold and hot water.	Non-metals usually do not react with cold or hot water.
13	Active metals react with non- oxidizing acids to form their oxides or oxyacids.	Solid non-metals react with oxidizing acids to form hydrogen gas.
14	They react with non-metals under different conditions to form salts.	They react with metals as well as non metals under different conditions to form salts.

## CHEMICAL PROPERTIES OF METAL

The chemical reactions undergone by metals are furnished below:

### Reaction with Oxygen

Most of the metals react with oxygen and form oxides. The reaction may take place without heating as in sodium, calcium or potassium, while some *metals* react with oxygen on heating to form oxides.

- Oxides of metals are *basic* in nature as they react with water and form bases, e.g.  $\text{Na}_2\text{O}$ ,  $\text{CaO}$ ,  $\text{MgO}$ ,  $\text{K}_2\text{O}$ , etc.
- Oxides of aluminium ( $\text{Al}_2\text{O}_3$ ), zinc ( $\text{ZnO}$ ), tin ( $\text{SnO}$ ) and iron ( $\text{Fe}_2\text{O}_3$ ) are *amphoteric* in nature as they react with acids as well as with bases.

### Reaction of Metals with Acids

Metals react with common acids like dilute  $\text{HCl}$  and dilute  $\text{H}_2\text{SO}_4$  with evolution of  $\text{H}_2$ .

### Reaction of Metals with Water

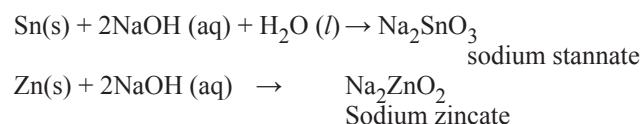
Many metals react with water to form hydroxides. Hydroxides are basic in nature. Sodium and potassium react with cold water.

- Magnesium reacts with hot water  

$$\text{Mg(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$$
- Metals like Al or Fe react on heating with water or with steam. In these conditions metals form metal oxides.

### Reaction of Metals with Common Bases

Some metals like aluminum and zinc react with common bases.



### REACTIVITY SERIES

A metal that can lose electrons more easily in comparison to other metal is more electropositive and would be more active in nature than other metal. Such a metal when dipped in a solution of salt of a less active metal would displace it.

*The arrangement of metals in the decreasing order of their activity is known as activity or reactivity series. It is also known as electrochemical series.*

## EXTRACTION OF METALS-METALLURGY

The process of extraction of metal from its ore is called **metallurgy**.

- Minerals** are naturally occurring compounds of metals.
- Ores** are those minerals from which metals can be economically extracted.

### Examples

- Aluminum is the most common metal in the Earth's crust, occurring in all sorts of minerals. However, it isn't ec onomically worthwhile to extract it from most of these minerals. Instead, the usual ore of aluminum is bauxite - which contains from 50 - 70% of aluminium oxide.

### Examples of Ores

Some important ores and the metals present in these ores are listed in the following table:

Type of ore	Metals
Native Metals (Found in Free State)	Gold (Au), silver (Ag)
Oxide ores	Iron (Haematite, $\text{Fe}_2\text{O}_3$ ); Aluminium (Bauxite, $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ ); Tin(Cassiterite, $\text{SnO}_2$ ); Copper Cuprite, $\text{Cu}_2\text{O}$ ; Zinc (Zincite, $\text{ZnO}$ ); Titanium (Ilmenite, $\text{FeTiO}_3$ , Rutile, $\text{TiO}_2$ )
Sulphide ores	Zinc (Zinc blende, $\text{ZnS}$ ); Lead (Galena, $\text{PbS}$ ); Copper (Copperglance, $\text{Cu}_2\text{S}$ ); Silver (Silver glance or Argentite, $\text{Ag}_2\text{S}$ ); Iron(Ironpyrites, $\text{FeS}_2$ )
Carbonate ores	Iron (Siferite, $\text{FeCO}_3$ ); Zinc (Calamine, $\text{ZnCO}_3$ ), Lead (Cerrusite, $\text{PbCO}_3$ )
Sulphate ores	Lead(Anglesite, $\text{PbSO}_4$ )
Halide ores	Silver (Horn silver, $\text{AgCl}$ ); Sodium (Common salt or Rock salt, $\text{NaCl}$ ); Aluminium(Cryolite, $\text{Na}_3\text{AlF}_6$ )
Silicate ores	Zinc (Hemimorphite, $2\text{ZnO} \cdot \text{SiO}_2 \cdot \text{H}_2\text{O}$ )

The method used to extract metals from the ore in which they are found depends on their reactivity.

### Steps Involved in the Extraction of Metals from Ores

#### Metallurgical Steps

Few steps involved in extracting the metal as shown above are discussed below:

#### Concentrating the Ore

This means getting rid of as much of the unwanted rocky material (called **gangue** or **matrix**) as possible before the ore is converted into the metal.

Some methods are:

**Froth floatation :** The ore is first crushed and then treated with something which will bind to the particles of the metal compound that are required and make those particles hydrophobic. "Hydrophobic" stands for "water fearing".

**Magnetic separation:** Magnetic ores like pyrolusite ( $\text{MnO}_2$ ) and chromite ( $\text{FeO} \cdot \text{Cr}_2\text{O}_3$ ) are enriched by this method by making use of the difference in the magnetic properties of the ore and gangue particles.

#### Conversion of concentrated ore to oxide

It is easier to obtain a metal from its oxide form as compared to its sulphide, carbonate or any other form. Therefore, prior to reduction usually the metal is converted to its oxide form.

Following methods are used to convert the concentrated ore to its oxide form.

**Calcination:** It is a process in which the ore is heated strongly in absence of air. The ore is heated at a temperature well below its melting point.

This method is generally used for carbonate and hydrated ores.

**Roasting:** It is a process wherein the ore is heated either alone or with some other material in excess of air below the fusion point of the ore.

- Usually, this method is used for sulphide ores.

- Ores of metals like zinc, lead, copper and nickel, when roasted in air, are converted to their oxides.
- The purpose of roasting is to convert the ore in a form suitable to reduce. The gaseous product of sulphide roasting, sulphur dioxide is often used to produce sulphuric acid.

The differences between roasting and calcinations are given in the following table:

#### Reducing the metal compound to the metal

##### • Carbon reduction

Carbon (as coke or charcoal) is cheap. It not only acts as a reducing agent, but it also acts as the fuel to provide heat for the process.

##### • Reduction using a more reactive metal

Titanium is produced by reducing titanium chloride using a more reactive metal such as sodium or magnesium. This is the only way of producing high purity metal.

##### • Reduction by electrolysis

This is a common extraction process for the more reactive metals - for example, for aluminum and metals above it in the electrochemical series.

An advantage is that it can produce very pure metals.

#### Refining of metals

Refining of metals is done to obtain metals in very pure form by removing impurities present in it. *Electrolytic refining* is widely used method for this purpose.

### ALLOYS

#### Alloys are metallic materials prepared by mixing two or more molten metals.

These are used for many purposes, such as construction, and are central to the transportation and electrical industries. Composition of some common alloys and their uses are given in the following table.

	Alloy	Composition	Uses
1.	Brass	Cu = 80%, Zn = 20%	For making utensils and cartridges.
2.	Bronze	Cu = 90%, Sn = 10%	For making statues, medals, ships, coins and machines
3.	Solder	Sn = 50%, Pb = 50%	For joining metals, soldering wire and electronic components etc.
4.	Duraluminum	Al = 95.5%, Cu = 3%, Mn = 1.0%, Mg = 0.5%	Used in bodies of aircrafts, kitchen parts etc. ware and automobile
5.	German Silver	Cu = 60%, Zn = 20%, Ni = 20%	For making utensils and ornaments
6.	Gun metal	Cu = 90%, Sn = 10%	For Gears and castings etc.
7.	Bell metal	Cu = 80%, Sn = 20%	For bells, gangs etc.
8.	Magnalium	Al = 90%, Mg = 10%	For balance beams, light instruments.
9.	Type metal	Pb = 82%, Sb = 15%, Sn = 3%	For casting type
10.	Stainless steel	Fe, Ni, Cr, C	For utensils, cutlery etc.

- In **homogeneous alloys**, atoms of the different elements are distributed uniformly. Examples include brass, bronze, and the coinage alloys.
- Heterogeneous alloys**, such as tin-lead solder and the mercury amalgam sometimes used to fill teeth, consist of a mixture of crystalline phases with different compositions.

An **amalgam** is an alloy of mercury with one or more metals. Most of the metals form amalgams with mercury except iron and platinum. Amalgams of sodium and aluminium are good reducing agents. Amalgam of silver, tin, cadmium and copper have been utilized as *dental fillings*.

## SOME IMPORTANT METALS AND THEIR USES

### Iron(Fe)

Iron is the most abundant metal which occurs in the earth's crust. The most commonly used iron ores are **haematite**,  $\text{Fe}_2\text{O}_3$ , and **magnetite**,  $\text{Fe}_3\text{O}_4$ .

#### Cast Iron:

The molten iron from the bottom of the furnace can be used as **cast iron**. However, it is very impure, containing about 4% of carbon. This carbon makes it very hard, but also very brittle. If you hit it hard, it tends to shatter rather than bend or dent.

**Use:** Cast iron is used for things like manhole covers, cast iron pipes, valves and pump bodies in the water industry, guttering

and drainpipes, cylinder blocks in car engines, Aga-type cookers, and very expensive and very heavy cookware.

### Wrought iron

If all the carbon is removed from the iron to give high purity iron, it is known as wrought iron. Wrought iron is quite soft and easily worked and has little structural strength.

**Use:** It was once used to make decorative gates and railings, but these days mild steel is normally used instead.

### Mild steel

Mild steel is iron containing up to about 0.25% of carbon. The presence of the carbon makes the steel stronger and harder than pure iron. The higher the percentage of carbon, the harder the steel becomes.

**Use:** Mild steel is used for lots of things - nails, wire, car bodies, ship building, girders and bridges amongst others.

### High carbon steel

High carbon steel contains up to about 1.5% of carbon. The presence of the extra carbon makes it very hard, but it also makes it more brittle.

**Use:** Used for cutting tools and masonry nails (nails designed to be driven into concrete blocks or brickwork without bending). It tends to fracture rather than bend if you mistreat it.

### Special steels

These are iron alloyed with other metals. Examples are given in the following table:

Variety	Iron mixed with	Special Properties	Uses
stainless steel	chromium and nickel	resists corrosion	cutlery, cooking utensils, kitchen sinks, industrial equipment for food and drink processing
titanium steel	titanium	withstands high temperatures	gas turbines, spacecraft
manganese steel	manganese	very hard	rock-breaking machinery, some railway track (e.g. points), military helmets

### Handy Facts

The hardness and elasticity of steel can be controlled by heat treatment. The steel is heated to a temperature below redness. It is then cooled slowly. The process is called **tempering of steel**. It is used to bring the steel to a suitable state of hardness and elasticity. Hard steel can be softened by heating it to a high temperature and then allowing it to cool down slowly. This process is called **annealing**.

Steel produced in this way is known as quenched steel and the process of making such steel is known as **quenching or hardening of steel**

### Some important compounds of iron:

**Green Vitriol:** Iron sulphate or ferrous sulphate is the chemical compound with the formula  $(\text{FeSO}_4 \cdot 7\text{H}_2\text{O})$ . It is called Green vitriol.

It is used as:

- A reducing agent, mostly for the reduction of chromate in cement.
- As nutritional supplement to patients suffering from iron deficiency.
- As a colorant.

**Mohr's Salt:** Ammonium iron sulphate, or Mohr's Salt, is a double salt of iron sulphate and ammonium sulphate, with the formula  $[\text{NH}_4]_2[\text{Fe}][\text{SO}_4]_2 \cdot 6\text{H}_2\text{O}$ . It is used in the laboratory.

### Copper(Cu)

Copper is malleable and ductile and is a good conductor of both heat and electricity. The important ores of copper is chalcopyrite,  $\text{CuFeS}_2$  (also known as *copper pyrites*)

Copper has multifarious uses like:

- **Making brass:** Brass is a copper-zinc alloy. Alloying produces a metal harder than either copper or zinc individually. Bronze is another copper alloy - this time with tin.
- **Coinage:** Used for masking coins in its alloy forms.

### Some important compounds of Copper

#### • Blue vitriol

Copper sulphate is the compound with the formula  $\text{CuSO}_4$ . This salt exists as a series of compounds that differ in their degree of hydration. The anhydrous form is a pale green or gray-white powder, whereas the penta hydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ), the most commonly encountered salt, is bright blue.

#### • Black oxide of copper

Copper oxide or cupric oxide ( $\text{CuO}$ ) is the higher oxide of copper. As a mineral, it is known as *tenorite*.

#### Uses:

- Cupric oxide is used as a pigment in ceramics to produce blue, red, and green (and sometimes gray, pink, or black) glazes.
- To produce cuprammonium hydroxide solutions, used to make rayon.
- Occasionally used as a dietary supplement in animals, against copper deficiency.
- Copper oxide has application as a p-type semiconductor, because it has a narrow band gap.

#### • Red oxide of copper

Copper oxide or cuprous oxide is the inorganic compound with the formula-  $\text{Cu}_2\text{O}$ . It is one of the principal oxides of copper.

### Uses

Cuprous oxide is commonly used as a pigment, a fungicide, and an antifouling agent for marine paints.

Rectifier based on this material have been used industrially.

### Aluminium

The usual aluminium ore is *bauxite*. Bauxite is essentially an impure aluminium oxide. The major impurities include iron oxides, silicon dioxide and titanium dioxide. Bauxite actually contains one of a variety of hydrated aluminium oxides some of which can be written as  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ .

**Uses:** Aluminum is used in aircraft making, container vehicle bodies, tube trains, in making saucepans, etc.

#### Science in Action

**Anodizing of Aluminium:** In anodising the aluminium is first etched with sodium hydroxide solution to remove the existing oxide layer, and then making the aluminium article the anode in electrolysis of dilute sulphuric acid. The oxygen given off at the anode reacts with the aluminium surface, and form a film of oxide up to about 0.02 mm thick..

### Zinc (Zn)

It is extracted from ores like zinc blende ( $\text{ZnS}$ ).

- Zinc is an essential trace element, necessary for plants, animals, and microorganisms.
- It is typically the second most abundant transition metal in organisms after iron and it is the only metal which appears in all enzyme classes.
- Zinc is used in galvanizing. *Galvanization* is a metal coating process in which a ferrous part is coated with a thin layer of zinc.

#### Handy Facts

#### Important uses of some other metals are also listed below:

- *Tin* is used for soldering, for preparing foils, for metal coatings to prevent chemical action and corrosion, for panel lighting, etc.
- *Lead* is used in making water pipes, in pigments, batteries, in alloys, etc.
- *Titanium* finds extensive use in aircraft industries.
- Pure metals, which display zero resistance to electrical currents, are called **superconductors**. Mercury ( $\text{Hg}$ ), Niobium ( $\text{Nb}$ ) are examples of superconductors. They become superconductors below a critical temperature of 4.2 K and 9.2 K respectively.

## EXERCISE

1. Plaster of paris is obtained –
  - by adding water to calcium sulphate
  - by adding sulphuric acid to calcium hydroxide
  - by heating gypsum to a very high temperature
  - by heating gypsum to 373 K.
2. Bleaching powder gives smell of chlorine because it –
  - is unstable
  - gives chlorine on exposure to atmosphere
  - is a mixture of chlorine and slaked lime
  - contains excess of chlorine
3. Why bases are kept in glass bottles?
  - Bases produce  $\text{OH}^-$  ions in aqueous solutions
  - Basic solutions are conducting in nature
  - Bases are corrosive in nature
  - Bases have soapy texture
4. Which one of the following salts when dissolved in water makes the solution basic?
  - Sodium chloride
  - Copper sulphate
  - Ferric chloride
  - Sodium acetate

[NDA]
5. Which of the following salts are insoluble in water ?
 

[NDA]

  - Chlorides of Fe and Mn
  - Nitrates of Ag and Pb
  - Carbonates of Pb and Cu
  - Phosphates of Na and  $\text{NH}_4$
6. Two elements gallium and oxygen combine to form a compound  $\text{Ga}_2\text{O}_3$ . Which among the following is the valency of gallium ?  

[NDA]

  - 1
  - 2
  - 3
  - 4
7. Arrange the following bases in increasing order of their, basic strength  

[NDA]

  1. Sodium hydroxide
  2. Magnesium hydroxide
  3. Aluminium hydroxide
  4. Ammonium hydroxide

Select the correct answer using the code given below

**Codes:**

A	B	C	D
(a) 4	2	1	3
(b) 4	1	2	3
(c) 4	3	2	1
(d) 1	2	3	4
8. Which one among the following is not a property of salt?  

[NDA]

  - Salts have ordered packing arrangements called lattices
  - Salts have low melting points but high boiling points
  - Salts are brittle
  - Salts conduct electricity when dissolved in water or even in the molten state
9. Which among the following statements with regard to pH scale is/are correct? [NDA]
  - It is a logarithmic scale.
  - The scale is limited to 0-14 because the ionic product of water is about  $10^{-14}$
  - The lower the value of pH, the greater is the acidity of the solution.

Select the correct answer using the code given below

  - I and II only
  - I, II and III
  - I and III only
  - II only
10. **Statement I :** Metal ions are Lewis acids.  
**Statement II :** Metal ions are electron pair acceptors.  

[NDA]

  - Both the statements individually true and Statement II is the correct explanation of Statement I.
  - Both the statements are individually true but Statement II is not correct explanation of Statement I.
  - Statement I is true but Statement II is false.
  - Statement I is false but Statement II is true.
11. Neutral water with pH about 7 becomes slightly acidic when aerated. This is because  

[NDA]

  - oxygen from air is dissolved in the water which makes the water acidic
  - dirt, which get contaminated with the water during aeration makes the water acidic
  - ultraviolet radiation dissociates water molecules and makes water acidic
  - carbon-dioxide from air is dissolved
12. The concentration of hydrochloric acid in a given solution is  $10^{-8}$  M. What is the value of pH for this solution ?  

[NDA]

  - 7
  - > 7 but not 14
  - < 7
  - 14
13. Human stomach produces acid 'X' which helps in digestion of food. Acid 'X' is  

[NDA]

  - acetic acid
  - methanoic acid
  - hydrochloric acid
  - citric acid
14. Bases turn red litmus blue and acids turn blue litmus red. A student tested a liquid with a red litmus paper and it stayed red with no change. This shows that the liquid  

[NDA]

  - must be pure water
  - must be an acid
  - is not a base
  - is neither a base nor an acid
15. Which of the following statements regarding oxidation and reduction are correct?
  - In oxidation, loss of electron takes place whereas in reduction, gain of electron takes place.
  - In oxidation, gain of electron takes place whereas in reduction, loss of electron takes place.

3. Oxidizing agent decreases the oxidation number but reducing agent increases the oxidation number.  
 4. Oxidizing agent increases the oxidation number but reducing agent reduces the oxidation number.

[NDA]

Select the correct answer using the code given below :

*Code :*

- |             |             |
|-------------|-------------|
| (a) 1 and 3 | (b) 2 and 4 |
| (c) 2 and 3 | (d) 1 and 4 |

16. The following equation is an example of a redox reaction, in which  $\text{Cl}_2$  is the oxidizing agent and  $\text{FeBr}_3$  is the reducing agent :



Which one among the following statements is *incorrect* for this redox reaction? [NDA]

- (a) Oxidizing agents are themselves reduced
- (b) Reducing agents gain or appear to gain electrons
- (c) Reducing agents are themselves oxidized
- (d) Oxidizing agents oxidize other substances

17. Which one among the following is the correct order of strength of acids ? [NDA]

- (a)  $\text{H}_2\text{SO}_4 > \text{H}_3\text{PO}_3 > \text{CH}_3\text{COOH}$
- (b)  $\text{H}_3\text{PO}_3 > \text{H}_2\text{SO}_4 > \text{CH}_3\text{COOH}$
- (c)  $\text{CH}_3\text{COOH} > \text{H}_3\text{PO}_3 > \text{H}_2\text{SO}_4$
- (d)  $\text{CH}_3\text{COOH} > \text{H}_2\text{SO}_4 > \text{H}_3\text{PO}_3$

18. Which one among the following is an electrochemical cell that cannot be charged ? [NDA]

- (a) Electrolytic cell
- (b) Storage cell
- (c) Primary cell
- (d) Fuel cell

19. The pH of fresh milk is 6. When it turns sour, the pH [NDA]

- (a) becomes  $< 6$
- (b) remains the same i.e., 6
- (c) becomes  $> 6$
- (d) becomes neutral, i.e., 7

20. Which one among the following is a double salt ? [NDA]

- (a)  $\text{K}_4[\text{Fe}(\text{CN})_6]$
- (b)  $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
- (c)  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
- (d)  $\text{NaCl}$

21. **Statement I :** Addition of water to an aqueous solution of  $\text{HCl}$  decreases the pH. [CDS]

**Statement II :** Addition of water suppresses the ionisation of  $\text{HCl}$ .

- (a) Both the statements are individually true and Statement II is the correct explanation of Statement I
- (b) Both the statements are individually true but Statement II is not the correct explanation of Statement I
- (c) Statement I is true, but Statement II is false
- (d) Statement I is false, but Statement II is true

22. The pH of fresh ground water slightly decreases upon exposure to air because [CDS]

- (a) carbon dioxide from air is dissolved in the water
- (b) oxygen from air is dissolved in the water

- (c) the dissolved carbon dioxide of the ground water escapes into air
- (d) the dissolved oxygen of the ground water escapes into air

23. On the labels of the bottles, some soft drinks are claimed to be acidity regulators. They regulate acidity using [CDS]

- (a) carbon dioxide
- (b) bicarbonate salts
- (c) Both (a) and (b)
- (d) carbon dioxide and lime

24. Antacids are commonly used to get rid of acidity in the stomach. A commonly used antacid is [CDS]

- (a) sodium hydrogen phthalate
- (b) magnesium hydroxide
- (c) calcium hydroxide
- (d) manganese acetate

25. Which of the following is **not** correct about Baking Soda ? [CDS]

- (a) It is used in soda acid fire extinguisher
- (b) It is added for faster cooking.
- (c) It is a corrosive base
- (d) It neutralizes excess acid in the stomach

26. The acid in gastric juice is [NDA]

- (a) acetic acid
- (b) nitric acid
- (c) hydrochloric acid
- (d) sulphuric acid

27. Removal of impurities from ore is known as –

- (a) crushing and grinding
- (b) concentration of ore
- (c) calcination
- (d) roasting

28. Aluminium is used in thermite welding because –

- (a) aluminium is a light metal
- (b) aluminium has more affinity for oxygen
- (c) aluminium is a strong oxidising agent
- (d) aluminium is a reactive metal

29. Which method is employed for obtaining a pure metal?

- (a) Froth floatation
- (b) Electrolytic refining
- (c) Magnetic separation
- (d) Gravity separation

**Column-I**                                   **Column-II**

- |                                   |                     |
|-----------------------------------|---------------------|
| A. Hardest Non-metal              | P. Graphite         |
| B. Non-metal conducts electricity | Q. Sulphur          |
| C. Non-metal with lustre          | R. Diamond (Carbon) |
| D. Non-metal used as fungicide    | S. Iodine           |

- (a) A – R; B – P; C – S; D – Q

- (b) A – Q; B – P; C – S; D – R

- (c) A – P; B – R; C – S; D – Q

- (d) A – R; B – P; C – Q; D – S

**Column-I (Alloy)**                           **Column-II (Composition of Elements)**

- |              |                 |
|--------------|-----------------|
| A. Steel     | P. Cu and Sn    |
| B. Brass     | Q. Cu and Zn    |
| C. Bronze    | R. Fe, C and Cr |
| D. Magnalium | S. Al and Mg    |

- (a) A – Q; B – R; C – P; D – S

- (b) A – R; B – Q; C – P; D – S

- (c) A – Q; B – R; C – S; D – P

- (d) A – R; B – Q; C – S; D – P

32. **Column-I (Product)**
- A. Aircrafts
  - B. Utensils
  - C. Medals
  - D. Balance beam
  - (a) A – S; B – P; C – Q; D – R
  - (b) A–P; B–S; C–Q; D–R
  - (c) A – S; B – P; C – R; D – Q
  - (d) A – P; B – S; C – R; D – Q
33. What is anode mud ?
- (a) Fan of anode
  - (b) Metal of anode
  - (c) Impurities collected at anode in electrolysis during purification of metals
  - (d) All of these
34. Food cans are coated with tin and not with zinc because [CDS]
- (a) zinc is costlier than tin.
  - (b) zinc has a higher melting point than tin.
  - (c) zinc is more reactive than tin.
  - (d) zinc is less reactive than tin.
35. **Column-I**
- A. Titanium
  - B. Palladium
  - C. Uranium
  - D. Platinum
- Column-II**
- P Coinage metal
  - Q Fuel
  - R Catalyst
  - S Strategic metal
- (a) A – S; B – R; C – Q; D – P
  - (b) A – P; B – R; C – Q; D – S
  - (c) A – R; B – S; C – Q; D – P
  - (d) A – S; B – Q; C – R; D – P
36. ‘Yellow cake’, an item of smuggling across border is [IAS Prelim]
- (a) a crude form of heroin
  - (b) a crude form of cocaine
  - (c) uranium oxide
  - (d) unrefined gold
37. Which one of the following materials is very hard and very ductile? [IAS Prelim]
- (a) Carborundum
  - (b) Tungsten
  - (c) Cast iron
  - (d) Nichrome
38. Match List I with List II and select the correct answer using the codes given below the lists: [IAS Prelim]
- List- I**
- A. Blue vitriol
  - B. Epsom salt
  - C. Baking soda
  - D. Caustic soda
- List-II**
- 1. Sodium bicarbonate
  - 2. Sodium hydroxide
  - 3. Magnesium sulphate
  - 4. Copper sulphate
- Codes:**
- (a) A-3; B-4; C-2; D-1
  - (b) A-4; B-3; C-2; D-1
  - (c) A-3; B-4; C-1; D-2
  - (d) A-4; B-3; C-1; D-2
39. Match List-I with List-II and select the correct answer using the codes given below the lists: [IAS Prelim]
- List-I**
- A. Potassium bromide
  - B. Potassium nitrate
  - C. Potassium sulphate
  - D. Monopotassium
- List-II**
- 1. Fertiliser
  - 2. Photography
  - 3. Bakery
  - 4. Gun powder tartarate
- Codes :**
- (a) A-2; B-4; C-1; D-3
  - (b) A-2; B-3; C-1; D-4
  - (c) A-4; B-2; C-3; D-1
  - (d) A-4; B-2; C-1; D-3
40. [CDS]
- | <b>List I</b>    | <b>List II</b>                           |                           |  |  |
|------------------|--|---------------------------|--|--|
| <b>(Mineral)</b> | <b>Industries in which largely used)</b> |                           |  |  |
| A. Limestone     | 1  | Cement                    |  |  |
| B. Copper        | 2  | Electrical goods          |  |  |
| C. Bauxite       | 3  | Manufacture of aeroplanes |  |  |
| D. Manganese     | 4  | Steel                     |  |  |
- Codes**
- | <b>A</b> | <b>B</b> | <b>C</b> | <b>D</b> |
|----------|----------|----------|----------|
| (a) 3    | 4        | 1        | 2        |
| (b) 1    | 2        | 3        | 4        |
| (c) 3    | 2        | 1        | 4        |
| (d) 1    | 4        | 3        | 2        |

## ANSWER KEY

1	(d)	2	(b)	3	(c)	4	(d)	5	(c)	6	(c)	7	(c)	8	(b)
9	(b)	10	(a)	11	(d)	12	(c)	13	(c)	14	(a)	15	(d)	16	(b)
17	(a)	18	(c)	19	(a)	20	(b)	21	(c)	22	(a)	23	(b)	24	(b)
25	(c)	26	(c)	27	(b)	28	(b)	29	(b)	30	(a)	31	(b)	32	(a)
33	(c)	34	(c)	35	(a)	36	(c)	37	(d)	38	(d)	39	(a)	40	(b)

## Chapter

# 5

# NON - METALS

## NON - METALS

Non-metals occupy the upper right hand corner of the periodic table.

Seventeen elements are generally classified as nonmetals. Their names as per their states in the normal conditions are:

*Gases* : hydrogen, helium, nitrogen, oxygen, fluorine, neon, chlorine, argon, krypton, xenon and radon.

*Liquid* : bromine.

*Solid* : carbon, phosphorus, sulfur, selenium, and iodine.

## PROPERTIES OF NON-METALS

### Physical Properties

- Non-metals are neither malleable nor ductile.
- They are brittle (break easily).
- They do not conduct heat and electricity.
- They are not lustrous (not shiny). They are dull.
- They are generally soft (except diamond which is extremely hard non-metal).
- They may be solid, liquid or gases at the room temperature.
- They have comparatively low melting points and boiling points (except diamond which is a non-metal having a high melting point and boiling point).
- Non-metals have low densities, that is, non-metals are light substances.
- Non-metals are non-soundorous. They do not produce sound when hit with an object.

### Chemical Properties of Non-Metals

Non-metals are more reactive with metals than with other non-metals. Generally non-metals react with each other at a high temperature.

#### Action of Air :

Non-metals do not react with air at room temperature except white phosphorus.

#### Action of water:

Generally, non-metals do not react with water. However, chlorine dissolves in water and form an acidic solution.

#### Displacement of one non-metal by another from salt solution :

Just like metals, non-metals also differ in their reactivities. Among halogen family (*i.e.* Cl, Br, I and F) the most reactive is chlorine (Cl). The order of reactivity is Cl > Br > I. Thus chlorine can displace Br and I from solutions of bromides (NaBr) and Iodides (NaI).

### Reaction with metals :

Non metals with high electronegativity (F, Cl, Br etc.) generally reacts with alkali and alkaline earth metals to form ionic compounds.

#### Handy Facts

Allotropes are different form of the same element. Different bonding arrangements between atoms result in different structures with different chemical and physical properties. For example : The allotropic forms of carbon are white, red and black phosphorous. The term allotropy is referred to element only another term polymorphism is used to mean the ability of solid to exist in more than one term or crystal structure.

## SOME IMPORTANT NON-METALLIC ELEMENTS

### Hydrogen

The discovery of hydrogen is credited to *Henry Cavendish* in 1766, although it had been isolated as early as 1671 by Robert Boyle.

#### Isotopes of Hydrogen

Three isotopes of hydrogen exist and all occur naturally.

- $^1\text{H}$  is sometimes called **Protium**, It is abundant in nature. It is the only hydrogen isotope lacking neutrons.
- The second isotope,  $^2\text{H}$ , is called **deuterium**

#### Handy Facts

D-element bonds are more difficult to break than H-element bonds and this fact allows the mechanisms of many chemical reactions to be examined.  $\text{D}_2\text{O}$  itself is important as a material that slows neutrons in nuclear reactors.

- The third isotope,  $^3\text{H}$ , **Tritium** is radioactive.

#### Properties

- Hydrogen occupies a unique place in the periodic table, and while it usually appears above the alkali metals or the halogens (or both), its properties don't fall well within either group.
- The ionization energy of hydrogen is much higher than any of the alkali metals.
- Hydrogen is a colorless, odorless, tasteless gas at ambient temperature. It has very low boiling and melting points (only helium boils colder). It is poorly soluble in most solvents.

#### Uses

- Over two-thirds of this hydrogen produced is used to prepare ammonia ( $\text{NH}_3$ ) by the Haber process. The large majority of this ammonia is then used in fertilizer production.

## Non - Metals

- Methanol, which is an industrially important compound, is prepared from the reaction of hydrogen with carbon monoxide:

### Group 18 : Noble Gases

- The elements in Group 18 are helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn).
- All Group 18 elements are gases at room temperature.
- They are completely chemically inert with few exceptions.
- The first noble gas compound was prepared in 1962 by scientist Neil Bartlett. Bartlett noticed that the ionization energy of xenon is about the same as that of oxygen.

### Group 17: Halogens

The halogens are fluorine (F), chlorine (Cl), bromine (Br), iodine (I) and astatine (Ats).

- Fluorine typically occurs in nature in minerals such as fluorite (fluorspar,  $\text{CaF}_2$ ). The other halogens are generally isolated from salts dissolved in seawater. They are obtained by oxidation of the halide ion to the halogen in a molten salt, except fluorine which requires special conditions to prevent explosions.
- All halogens have high electronaffinities and ionization energies. .

### Uses of halogenated compounds

- Teflon— non-stick coating, is a polymer made of carbon and fluorine ( $\text{CF}_3(\text{CF}_2)_n(\text{CF}_2-\text{CF}_2-)$ , n is very large).
- The compounds used in air-conditioners (now HCFCs) are compounds made up of carbon, fluorine, hydrogen, and chlorine (e.g. HCFC-22:  $\text{CHF}_2\text{Cl}$ ). These substances are more environment friendly than the Freons. (HCFCs are Freons in which either a chlorine or fluorine atom has been replaced by a hydrogen atom to allow easier environmental degradation to occur.)
- Many plastics, organic solvents, pesticides, fungicides, and bactericides contain chlorine atoms. Chlorinated compounds are also used as disinfectants and bleaching agents.

### Group 16: Chalcogens

- The elements of the Group 16 of the periodic table are Oxygen (O), Sulphur(S), Selenium (Se), Tellurium (Te) and Polonium (Po) which are also called **chalcogens**.
- Oxygen is the second most abundant element in the Earth's crust and in hydrosphere.
- Two *allotropes* of oxygen are;  $\text{O}_2$ : Oxygen and  $\text{O}_3$ : Ozone. Both occur naturally. Oxygen has a high electron affinity, electronegativity, and ionization energy. It tends to form compounds in the -2 oxidation state, although compounds with -1,  $-\frac{1}{2}$ , and +2 oxidation states also exist (in  $\text{H}_2\text{O}_2$ ,  $\text{KO}_2$ , and  $\text{OF}_2$  respectively).
- $\text{O}_2$  is an odourless, colorless, and tasteless gas at room temperature. It is quite reactive and form oxide ions or strong covalent single bonds to other elements. Oxygen is obtained by the fractional distillation of air.
- Ozone* is a pale blue gas with an irritating odor. It is a significantly stronger oxidant than Dioxygen( $\text{O}_2$ ) because of its structure. Small amounts of ozone are generated by lightning

striking the earth. We can even smell this ozone also. *Internal combustion engines* (cars, trucks, etc.) produce large quantities of *ozone* that frequently affect air quality in cities.

### Handy Facts

The word oxygen comes from the Greek meaning ‘acid former,’ while ozone comes from the Greek meaning ‘to smell.’

### Water ( $\text{H}_2\text{O}$ ) :

Water is the most abundant molecule on the earth. Approximately 70% of the Earth's surface is water. Water is also the only substance on Earth which naturally occurs in a solid, liquid and gas form. Water is also medium for many chemical reactions. That is why it is called “universal solvent”.

### Hardness of Water

Hardness of water is due to dissolved sulphate, chloride or carbonate salt of calcium and magnesium. There are two kinds of hardness of water.

- Temporary
- Permanent

**Temporary hardness** is due to dissolved bicarbonate salt of calcium and magnesium. Temporary hardness can be removed by boiling. Boiling causes formation of carbonate from the bicarbonate.

**Permanent hardness** is caused by chlorides and sulphate of calcium and magnesium. Permanent hard water can not be softened by boiling.

Though hard water is not considered harmful for drinking, it may cause other harms. Hard water can leave the clothes rough and worn out. More soap is required for washing clothes.

### Properties of Water

- It is attracted to other polar molecules. This is also called adhesion. Adhesion leads to occurrence of capillary action.
- Water has high specific heat and high heat of vapourisation because of this water is used as coolant in motor vehicles
- It has high heat of evaporation. This property is responsible for its ability to resist evaporation in moderate temperature.
- Ice has lower density compared to water. This low density allows icebergs to float and is also the reason that only top part of the lakes are frozen.
- Water has high polarity. This makes water a powerful solvent as it attracts other less polar molecules.

### Group 15: Nitrogen

- Nitrogen is rare in the hydrosphere and lithosphere, though abundant in the atmosphere. Only  $\text{NaNO}_3$  and  $\text{KNO}_3$  are found in significant amounts as mineral deposits.
- Compounds of nitrogen occur in all oxidation states from -3 to +5. In this property, nitrogen differs from all other second-row elements except carbon which have very limited numbers of accessible oxidation states.
- Diamond consists of an infinite array of tetrahedral carbon atoms. It is the hardest naturally occurring substance and pure diamond is a colourless crystalline material. It is a very soft, black material that is quite slippery and is a good electrical conductor.

## Group 14: Carbon

- Carbon has been known since pre-historic times. Carbon ranks only 17<sup>th</sup> amongst all elements (between sulfur and zirconium) in abundance in the Earth's crust.
- Carbon is one of the elements which shows allotropy.

### Carbon-monoxide (CO)

- Carbon monoxide (CO) is a colorless, odorless, tasteless gas with a relatively low boiling point.
- It forms when carbon or hydrocarbons burn in a deficiency of oxygen.
- It is toxic in either high doses or prolonged (hours) exposure to low doses. Its toxicity arises because it binds to hemoglobin much like oxygen does, but more strongly

#### Uses:

- Industrially, carbon monoxide is sometimes used as a fuel because it burns to carbon dioxide.
- It also is a valuable reducing agent. When reacted with hydrogen it generates methanol, an important organic solvent and basic reagent.

### Carbon-dioxide(CO<sub>2</sub>)

- Like carbon monoxide, carbon dioxide (CO<sub>2</sub>) is colourless, odourless, and tasteless.
- It is much less toxic than CO, but will induce unconsciousness and death at very high concentrations even if it is not inhaled.
- Carbon dioxide is absorbed by plants in the presence of sunlight and chlorophyll (green colouring matter) to form glucose and higher carbohydrates. This process is known as **photosynthesis**.

**Uses:** The two major uses of carbon dioxide are as a refrigerant and for carbonating soft drinks.

### Carbonic Acid and Carbonates

- When CO<sub>2</sub> dissolves in water, the weak acid, i.e. carbonic acid (H<sub>2</sub>CO<sub>3</sub>) forms.

- Carbonate minerals are plentiful in nature and include aragonite (CaCO<sub>3</sub>), calcite (CaCO<sub>3</sub>), dolomite (CaMgCO<sub>3</sub>), gaylussite (Na<sub>2</sub>Ca(CO<sub>3</sub>)<sub>2</sub>), lanthanite ((La,Ce)<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>), magnesite (MgCO<sub>3</sub>), and witherite (BaCO<sub>3</sub>). Of the minerals, the calcium and magnesium containing varieties are most important.
- In particular, the stalactites and stalagmites in caves are composed of calcium carbonate are coral reefs.

### Science in Action

*Elemental silicon* is a semiconductor and very pure material (99.9999%). It is used in the production of computer chips.

## Glass

- Glass is simply quartz to which one or more other substances have been added. Because of this added substance, the temperature at which the quartz melts is lowered. This is important because quartz melts near 1000°C and getting flames that hot is very difficult.
- Common glass* (also soft glass or soda-lime glass) is prepared by adding calcium carbonate and sodium carbonate to molten quartz. The heat drives carbon dioxide off, leaving calcium oxide and sodium oxide behind.
- Lead crystal* results from adding lead oxide to quartz. The extra mass of the lead gives high quality crystal its heavier feel and the high refractive index that gives crystal its special look.
- Pyrex* is obtained by adding boron oxide, B<sub>2</sub>O<sub>3</sub>, to quartz. This causes its coefficient of thermal expansion to decrease. Baking dish made of pyrex glass when moved from freezer to the oven do not crack. Also, stovetop cookware is possible with borosilicate glass, because it won't crack or melt under normal kitchen conditions.
- Coloured glass results from the addition of transition metal ions to the glass. The metal usually exists as an oxide in the structure. Examples are:

Colour	Metal used	Colour	Metal used
blue-violet	cobalt	green	chromium
canary	uranium	pale pink	tellurium
peacock blue	copper	violet	manganese
cranberry	gold		
photochromatic	AgCl/AgBr (changes color as surrounding lighting changes)		

### Science in Action

#### Uses of some other non-metals are given below:

- Sulphur* is used in making compounds like sulpha drugs, sulphuric acid, in matches, in gun powder, for vulcanization of rubber, etc.
- Boron*, in the form of compound borax, is used in making skin ointments.
- Phosphorus* is used in making crackers.
- Chlorine*, in the form of bleaching powder, is used for purification of water.
- Carbon* is used as a fuel, as electrodes (graphite), as a reducing agent in metallurgy.
- Oxygen, hydrogen and nitrogen* are used by all living things; they are the 'building blocks' of life.
- Iodine* is used to prevent thyroid problems.
- Bromine* is used in the preparation of dyes.
- Some compounds of *fluorine* (such as sodium fluoride, stannous fluoride) are added to toothpastes to prevent dental decays or formation of cavities.

# **EXERCISE**



## **ANSWER KEY**

1	(b)	2	(b)	3	(c)	4	(b)	5	(a)	6	(a)	7	(c)	8	(d)
9	(b)	10	(a)	11	(b)	12	(c)	13	(a)	14	(c)	15	(c)	16	(b)
17	(d)	18	(a)	19	(c)	20	(c)	21	(c)	22	(c)	23	(c)	24	(a)

## Chapter

# 6

# ORGANIC CHEMISTRY

## ORGANIC CHEMISTRY

Organic chemistry is the study of carbon containing compounds and their properties. This includes the great majority of chemical compounds on the planet, but **some substances** such as **carbonates** and **oxides of carbon** are considered to be **inorganic** substances even though they contain carbon. There exists a large number of organic compounds.

### Differences Between Organic and Inorganic Compounds

Following table compares the properties of the organic and inorganic compounds:

Organic Compounds	Inorganic Compounds
Use mostly covalent bonding	Mostly ionic bonding
Are gases, liquids or solids with low melting points	Are generally solids with high melting points
Mostly insoluble in water	Many are water soluble
Many are soluble in organic solvents such as petroleum, benzene and hexane	Most are not soluble in organic solvents

Solution in water generally do not conduct electricity	When dissolved in water conducts electrical current
Almost all burn	Most not combustible
Slow to react with other chemicals	Often undergo fast chemical reactions

### CATENATION IN CARBON

Majority of organic compounds contain chains or rings of carbon atoms that contain other elements such as O, N, P, S, Cl, Br and I. The compounds of carbon are far more numerous than the known compounds of all the other elements put together. *This is because that carbon has the power to combine with other carbon atoms to form long chains; this property is not shown to such an extent by any other element. This property of carbon is known as catenation.*

### FUNCTIONAL GROUPS

Classes of organic compounds can be distinguished according to functional groups they contain. *A functional group is a group of atoms that is largely responsible for the chemical behavior of the parent molecule.*

### Important Functional Groups and the Corresponding Classes of Organic Compounds :

S.No.	Functional Group	Class of compounds
	Formula	Name
1.	$-X$ ( $-F$ , $Cl$ , $-Br$ , $-I$ )	Halo (fluoro, chloro, bromo, iodo)
2.	$-OH$	Hydroxy
3.	$-OR$	Alkoxy
4.	$-SH$	Mercapto
5.	$-SR$	Thioethers or sulphides
6.	$-CHO$	Aldehydic
7.	$-CO-$	Ketonic
8.	$-COOH$	Carboxyl
9.	$-COOR$	Ester
10.	$-COX$ ( $X = Cl$ , $Br$ or $I$ )	Acyl halide
11.	$-CONH_2$	Amide
12.	$-COO.CO-$	Anhydride
13.	$-NH_2$	Amino
14.	$-NH-$	Imino
15.	$-C \equiv N$	Cyano
		Cyanides or Nitriles

16.	$-N \equiv C$	Isocyano	Isocyanides or Isonitriles
17.	$-NO_2$	Nitro	Nitro compounds
18.	$-N = O$	Nitroso	Nitroso compounds
19.	$-N = N-$	Azo	Azo compounds
20.	$-SO_2 - OH$	Sulphonic acid	Sulphonic acids

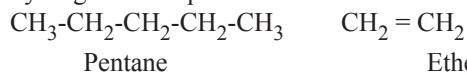
## HYDROCARBONS

The simplest organic compounds are the hydrocarbons, which are composed solely of carbon and hydrogen.

Hydrocarbons can be classified in two general groups *aliphatic* and *aromatic*. These compounds are the starting point for all organic compounds.

### Aliphatic Hydrocarbons

Aliphatic hydrocarbons consist of straight or branched chains of carbon atoms with the other valence electrons involved in bonds with hydrogen. Examples are:



Aliphatic hydrocarbons can be subdivided into two groups based on the types of carbon-carbon bonds the compounds contain.

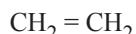
#### Saturated aliphatic hydrocarbons

Saturated aliphatic hydrocarbons are hydrocarbons in which all of the carbon-carbon bonds are single bonds. These compounds are also referred to as *alkanes*, as mentioned for single bonds earlier. The simplest alkane is methane,  $\text{CH}_4$ .

- All other alkanes are formed by adding  $\text{CH}_2$ s to the formula. Hence the general formula for the alkanes is  $\text{C}_n\text{H}_{2n+2}$ .
- Alkanes are not very reactive chemically and are insoluble in water. They burn to form carbon dioxide and water (*combustion reaction*).
- Alkanes also undergo reactions induced by UV light.* Examples include the slow breakdown of plastics in the sun, and halogenations reactions (reactions where halogen atoms such as Cl, Br, or I replace H in the molecule).

#### Unsaturated aliphatic hydrocarbons

Unsaturated hydrocarbons are those hydrocarbons, which contain at least one double or triple bond (that is, they are alkenes or alkynes) between two carbon atoms. Simplest of alkene (General formula of alkenes are:  $\text{C}_n\text{H}_{2n-2}$ ) is ethene which consists of two double-bonded carbon atoms and four hydrogen atoms.



- The general formula of alkyne is  $\text{C}_n\text{H}_{2n}$  and the simplest of alkyne is acetylene  $\text{CH}=\text{CH}$

### Aromatic Hydrocarbons:

- The second major group of the hydrocarbons is the aromatic hydrocarbons, which are hydrocarbons that contain a benzene ring as part of their structure.
- Benzene has the formula  $\text{C}_6\text{H}_6$  and consists of six carbon atoms in a ring with three alternating double bonds.
- Aromatic compounds show completely different behavior to aliphatic compounds, and hence it is not difficult to deduce that they have a special chemical structure.

### Representations of Benzene

There are two accepted ways of representing the structure of benzene. The first is the Kekulé structure that is written as shown below. Two structures-called resonating structures- are required, as one structure cannot fully represent the molecule. The molecule is said to alternate very rapidly between the two structures.

### Properties of benzene

Benzene is totally insoluble in water, it is a volatile liquid at room temperature. The properties of other aromatics are reflective of benzene but vary according to the substituent added to the ring in place of one of the hydrogen atoms.

#### Handy Facts

The term “aromatic” has its origin in the fact that certain aromatic substances (for example: oil of bitter almonds, vanilla, and oil of wintergreen) contain the benzene ring. The possession of an odor is not characteristic, however, of all aromatic substances. Aromatic compounds containing benzene ring are known as benzenoids and those not containing benzene ring are known as non-benzenoids.

Aromatic hydrocarbons are the starting point for many medicinally important compounds.

### ALCOHOL (ALKANOL)

- Alcohols are hydroxyl (-OH) derivatives of hydrocarbons formed by replacing a hydrogen with the hydroxyl radical and are of the general form R-OH where R represents the hydrocarbon.
- There are three categories of alcohols: primary, secondary, and tertiary.

#### Handy Facts

Methanol is very poisonous; consumption of less than two teaspoons can cause blindness. Of all the alcohols, methanol is produced in the greatest quantities in industry. Many people die due to consumption of spurious alcohol contaminated with methanol.

- Ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) has been prepared since antiquity by fermentation of sugars and starches, catalyzed by yeast. Sugars for fermentation come from a variety of sources, including grains, grape juice, various vegetables and agricultural wastes.
- Yeast secretes two enzymes called invertase and zymase. These enzymes act as catalyst for converting sugar to ethanol.

### Properties of Alcohols

The low-molecular-weight alcohols are volatile liquids, and the high-molecular-weight alcohols (more than 13 carbons) are solids. The first three alcohols ( $\text{C}_1$  to  $\text{C}_3$ ) are completely miscible (mix in any proportion) with water.

## Uses of Alcohols

- Alcohols are most commonly used as solvents in the pharmacy.
- They are also used as disinfectants and antiseptics.

## ETHERS

Ethers are a class of organic compounds that contain an ether group—an oxygen atom connected to two alkyl or aryl groups—of general formula: R—O—R'. When the two alkyl groups are similar, then its *Symmetrical ether* otherwise we call it *Unsymmetrical ether*.

## Properties of Ethers

Ether molecules cannot form hydrogen bonds with each other since they do not have a hydrogen atom attached directly to an oxygen atom. Therefore, they have about the same boiling points and melting points as alkanes of similar molecular weights.

## Uses of Ethers

Ethers are used as general anaesthetics in medicine. They also find use as solvents. Some important ethers include diethyl ether (which has been traditionally known as ether) that was used as a general anaesthetic, and methyl phenyl ether (commonly called anisole) which is used extensively in the perfume industry.

## AMINES

- Amines result from the replacement of one or more of the hydrogen atoms of ammonia with hydrocarbons and have the general formula R-NH<sub>2</sub>.
- Amines are derivatives of ammonia that has three hydrogen.
- Amines are classified according to the number of hydrogen that are replaced by alkyl or phenyl groups in ammonia (NH<sub>3</sub>)
- Whenever one of the hydrocarbon groups connected to the nitrogen atom contains a benzene ring, the compound is referred to as an aromatic amine.

## Properties of Amines

The low-molecular-weight amines are all volatile liquids, and those having up to five carbons are soluble in water. The element nitrogen is in the same period of the periodic table as oxygen and has some similar properties—the most significant being the ability to form hydrogen bonds. The formation of hydrogen bonds between amines, and between amines and water, accounts for their higher boiling points (than alkanes) and their water solubility.

### Science in Action

Amines react with inorganic acids to form salts. (Amines react with organic acids to form amides, a class of organic compounds.) This reaction results in a hydrochloride salt of the amine and is a very important reaction in pharmacy. Many drugs contain an amine functional group, and if they contain many carbon atoms, they are not very soluble in water. The salts formed from amines, however, are very soluble in water. Therefore, if we wish to use a water solution of an amine drug that is insoluble, we can make it soluble by forming the salt of the amine.

## Use of Amines

Amines are very important biological compounds and are responsible for most of the fishy odours that we detect in nature. They are also found in decomposing tissues (such as off meat). Amines are building blocks of many natural and synthetic materials—proteins, textiles, plastics, adhesives, and pharmaceuticals.

## ALKANOIC ACID (CARBOXYLIC ACIDS)

Carboxylic acids are compounds which contain a -COOH group.

- Most of the simpler saturated carboxylic acids are found in nature.

**For example** ethanoic acid (also referred to as acetic acid) is commonly found in vinegar and wine. Its structural formula is CH<sub>3</sub>COOH. Butanoic acid (C<sub>4</sub>H<sub>9</sub>COOH) is found in cheeses, rancid butter, and under armpits of human; whilst hexanoic acid (C<sub>6</sub>H<sub>13</sub>COOH) is the odour associated with goats and goat cheeses. Ethanoic acid is an important industrial chemical.

- Alkanoic acids (Carboxylic acids) are produced in major quantities by the combustion of coal and wood. Long chain carboxylic acids have also been found in the atmosphere, the major source of the compounds being pollens and other plant products.

## Properties of Carboxylic Acids

Carboxylic acids are very polar compounds due to the two oxygen atoms and can form two hydrogen bonds between themselves.

A carboxylic acid has a higher melting point than a different type of organic compound with a similar molecular weight. Consequently, they are all solids under normal conditions.

**Uses of Carboxylic Acids :** Many carboxylic acids have use in food industry.

- benzoic acid** – a common preservative used in beverages.
- citric acid** – used to provide a sour taste in fruit and vegetables.
- sorbic acid** – used as an acidic anti-microbial agent.
- lactic acid** – commonly found in cultured dairy products.
- malic acid** – commonly found in fruits.
- tartaric acid** – used extensively in cooking processes (it is also called cream of tartar)

## ALDEHYDE (ALKANOLS)

Aldehydes and Ketones are characterised by the presence of carbonyl group >C = O in their molecules. Aldehydes contain

$\begin{matrix} \text{H} & & \text{R} \\ & > & \\ \text{R} & > & \text{C} = \text{O} \end{matrix}$

- Aldehydes have lower boiling points than corresponding alcohols or acids as they cannot form hydrogen bonds between themselves.
- The lower-molecular-weight aldehydes (up to five carbons) are soluble in water. Aldehydes are neutral in pH and undergo both oxidation and reduction reactions.
- They are easily oxidized to acids and reduced to alcohols.

**Use**

- Some aldehydes, such as vanillin and benzaldehyde, are frequently used in the pharmacy as flavouring agents. Others, such as formaldehyde, are often used as disinfectants.
- Both aldehyde (and ketones) occurs in natural and man-made products very frequently.
- All naturally occurring plant sugars (such as glucose) are aldehydes, ketones, or their products.

**Handy Facts**

Aldehydes are also produced in the atmosphere from hydrocarbons as a result of a complicated process called *photo-oxidation*. These aldehydes contribute to smog; ethanal is the aldehyde most commonly identified in smog. Methanal is almost present in all air samples tested. Aldehydes produced by plants such as 2-hexenal has been found in forested atmospheres, in addition to methanal and ethanal.

**KETONES (ALKANONE)**

Ketones result from the oxidation of a secondary alcohol and have the general structural formula O where R and R' can be the same or different hydrocarbon groups.



- Ketones are similar to aldehydes in their boiling points, which are lower than those of corresponding alcohols and carboxylic acids.
- Ketones are neutral compounds, being neither acids nor bases.

**Science in Action**

Ketones are also often responsible for the smell component of many natural body substances. e.g. the strange smelling breath of a diabetic is due to the presence of propanone.

**ESTERS**

Esters are formed from the reaction of a carboxylic acid with an alcohol and have the general structural formula  $\text{RCOOR}'$  where R and R' can be the same or different hydrocarbon groups.

- The simplest esters are liquids and have fragrant odours. An example is ethyl acetate,  $\text{CH}_3\text{-CH}_2\text{-OOC-CH}_3$ , which has the odour of pineapple.
- Esters have boiling points similar to alkanes of similar molecular weight as they cannot form hydrogen bonds between themselves.
- They can form hydrogen bonds with water. Therefore, esters that contain less than five carbon atoms are soluble in water.

**Uses of Esters**

- The sweet and pleasant odours and tastes of many foods are due to complex mixtures of organic compounds, of which esters are generally the most prevalent component. Some examples of esters that are used as flavouring agents and the corresponding flavours are:
  - methyl butanoate : apple
  - ethyl butanoate : strawberry
  - butyl butanoate : pineapple
  - pentyl ethanoate : banana
  - methyl 2-phenylethanoate: jasmine

**EXERCISE**

- The enzyme involved in the oxidation of ethanol to form vinegar is
 

(a) zymase	(b) oxidase
(c) acetobacter	(d) invertase
- The main constituent of Vinegar is: [NDA]
 

(a) Acetic acid	(b) Ascorbic acid
(c) Citric acid	(d) Tartaric acid
- Soaps are sodium salts of fatty acids. Which of the following fatty acid does not form soap?
 

(a) Butyric acid	(b) Oleic acid
(c) Palmitic acid	(d) Stearic acid
- Identify the enzyme which converts glucose to ethyl alcohol.
 

(a) Zymase	(b) Invertase
(c) Maltase	(d) Diastase
- Mineral acids are stronger acids than carboxylic acids because
  - mineral acids are completely ionised
  - carboxylic acids are completely ionised
  - mineral acids are partially ionised
  - carboxylic acids are partially ionised

(a) A and D	(b) B and C
(c) A and B	(d) C and D
- 'Drinking alcohol' is very harmful and it ruins the health. 'Drinking alcohol' stands for:
 

(a) drinking methyl alcohol	(b) drinking ethyl alcohol
-----------------------------	----------------------------
- (c) drinking propyl alcohol  
(d) drinking isopropyl alcohol
- Which of the following has shortest carbon-carbon bond length?
 

(a) $\text{C}_2\text{H}_2$	(b) $\text{C}_2\text{H}_4$
(c) $\text{C}_2\text{H}_6$	(d) $\text{C}_6\text{H}_6$
- Which of the following can be used distinguish between ethane and ethene?
 

(a) A lighted splinter	(b) Aqueous bromine
(c) Litmus solution	(d) Lime water
- Column-I**                   **Column-II**  

A. Carbon black	P. Water filters.
B. Diamond	Q. Fuel
C. Coke	R. Jewellery
D. Charcoal	S. Filler in automobiles

  - A-Q; B-R; C-S; D-P
  - A-P; B-Q; C-Q; D-S
  - A-S; B-R; C-P; D-Q
  - A-S; B-R; C-Q; D-P
- Column-I**                   **Column-II**  

A. Polyethylene	P. wood glue
B. Cellulose acetate	Q. Soft drinks
C. Polyvinyl acetate	R. Descaling agents
D. Dil Acetic acid	S. Photographic film.

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**ANSWER KEY**

1.	(c)	2	(a)	3	(a)	4	(a)	5	(a)	6	(b)	7	(a)	8	(b)
9	(d)	10	(a)	11	(c)	12	(a)	13	(c)	14	(b)	15	(d)	16	(d)
17	(b)	18	(b)	19	(a)	20	(a)	21	(d)	22	(d)				

# Chapter

# 7

# ENVIRONMENTAL CHEMISTRY

## CHEMISTRY AND MANKIND

- Living systems are made of a number of complex organic compounds which are called bio-molecules. The various biomolecules are carbohydrates, amino acids, proteins, enzymes, lipids, hormones; etc. We may call these molecules of life also.

## SOME IMPORTANT MOLECULES OF LIFE

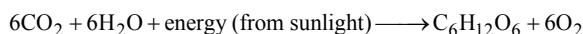
### Carbohydrate

The chemicals used by the body may be divided into two categories;

- Macronutrients:** those substances that we need to eat regularly in fairly large quantities.
- Micronutrients:** those substances that we need only in small quantities.

Carbohydrates are the main energy sources for the human body. Chemically, carbohydrates are organic molecules in which carbon, hydrogen, and oxygen bond together in the ratio :  $C_X(H_2O)_Y$ , where X and Y are whole numbers.

Animals obtain carbohydrates by eating foods like potatoes, rice, breads, and so on. These carbohydrates are manufactured by plants during the process of photosynthesis. Plants harvest energy from sunlight to run the reaction just described in reverse :



There are two types of carbohydrates, the simple sugars and those that are made of long chains of sugars - the complex carbohydrates.

### Simple Sugars

All carbohydrates are made up of units of sugar (also called saccharide units). Carbohydrates that contain only one sugar unit (monosaccharides) or two sugar units (disaccharides) are referred to as simple sugars. Simple sugars are sweet in taste and are broken down quickly in the body to release energy. Two of the most common monosaccharides are glucose and fructose. Glucose is the primary form of sugar stored in the human body for energy. Fructose is the main sugar found in most fruits. Both glucose and fructose have the same chemical formula ( $C_6H_{12}O_6$ ); however, they have different structures. Disaccharides have two sugar units bonded together. For example, common table sugar is sucrose, a disaccharide that consists of a glucose unit bonded to a fructose unit.

#### Sweetening power of common sugars :

Fructose > Invert sugar > Sucrose > Glucose > Maltose > Lactose

### Complex Carbohydrates

Complex carbohydrates are polymers of the simple sugars. In other words, the complex carbohydrates are long chains of simple sugar units bonded together. Therefore the complex carbohydrates can also be referred to as polysaccharides. Starch is an example of complex carbohydrate.

#### Handy Facts

Both starch and glycogen are polymers of glucose; however, starch is a long, straight chain of glucose units, whereas glycogen is a branched chain of glucose units. Another important polysaccharide is **cellulose**. Cellulose is yet a third polymer of the monosaccharide glucose. Cellulose differs from starch and glycogen in terms of extra stability. Cellulose, also known as plant fiber, cannot be digested by human beings, therefore cellulose passes through the digestive tract without being absorbed into the body. Cellulose fiber is essential in the diet because it helps exercise the digestive track and keep it clean and healthy.

## AMINO ACIDS AND PROTEINS

### Amino Acids

Amino acids play central roles both as building blocks of proteins and as intermediate in metabolism. There twenty amino acids which are present in the protein. Humans can produce 10 of the 20 amino acids. The others must be supplied by food.

### Structure of Amino Acids

- Structure :** The amino acid is an organic acid in which one or more hydrogen atoms are replaced by  $NH_2$  group.

### Proteins

**Proteins** (also known as **polypeptide**) are *organic compounds* made of *amino acids* arranged in a linear chain and folded into a globular form. The amino acids in a *polymer* are joined together by the *peptide bonds* between the *carboxyl* and *amino* groups of adjacent amino acid *residues*.

Like other biological macromolecules such as polysaccharides and nucleic acids, proteins are essential parts of organisms and participate in virtually every process within cells. Many proteins are enzymes that catalyze biochemical reactions and are vital to metabolism. Proteins also have structural or mechanical functions, such as actin and myosin in muscle and the proteins in the cytoskeleton, which form a system of scaffolding that maintains cell shape. Other proteins are important in cell signaling, immune responses, cell adhesion, and the cell cycle. Proteins are

also necessary in animals diets, since animals cannot synthesize all the amino acids they need and must obtain essential amino acids from food. Through the process of digestion, animals break down ingested protein into free amino acids that are then used in metabolism.

- Insulin is a globular protein and myosin is a fibrous protein.
- Globular proteins on heating or on treatment with mineral acids undergo coagulation to give fibrous protein that is insoluble in water called denaturation of protein.
- Haemoglobin is a globular protein found in red blood cells.

### Peptides

Peptides are short polymers formed from the linking in a defined order, of an amino acid residue and the next is called an amide bond or a peptide bond.

Peptides play a crucial role in fundamental physiological and biochemical functions of life. For decades now, peptide research is a continuously growing field of science.

Peptide is a molecule formed by joining two or more amino acids. When the number of amino acids is less than about 50, these molecules formed by peptides while larger sequences are referred to as proteins.

The amino acids are coupled by a peptide bond, a special linkage in which the nitrogen atom of one amino acid binds to the carboxyl carbon atom of another.

Peptides (proteins) are present in every living cell and possess a variety of biochemical activities. They appear as enzymes, hormones, antibiotics, receptors, etc.

#### **Handy Facts**

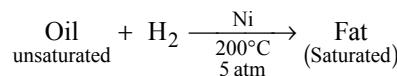
When proteins are heated above body temperature or when they are subjected to unusual acid or base conditions or treated with special reagents called denaturants, they lose some or all of their tertiary and secondary structure. Proteins in this state no longer exhibit normal biological activities and are called denatured proteins.

## OIL AND FATS

Fats consist of a wide group of compounds that are generally soluble in organic solvents and largely insoluble in water. Chemically, fats are generally triesters of glycerol and fatty acids. Fats may be either solid or liquid at room temperature, depending on their structure and composition.

### Hydrogenation of Oils

Unsaturated vegetable fats and oils can be transformed through partial or complete hydrogenation into fats and oils of higher melting point. The hydrogenation process involves “sparging” the oil at high temperature and pressure with hydrogen in the presence of a catalyst, typically a powdered nickel compound. As each double-bond is broken, two hydrogen atoms each form single bonds with the two carbon atoms. The elimination of double-bonds by adding hydrogen atoms is called saturation; as the degree of saturation increases, the oil progresses towards being fully hydrogenated. An oil may be hydrogenated to increase resistance to rancidity (oxidation) or to change its physical characteristics. As the degree of saturation increases, the oil's viscosity and melting point increase.



## HORMONES

Hormones are the substances produced by ductless or endocrine glands and poured directly into the blood stream.

### Effects of Hormone

Hormones have the following effects on the body :

- stimulation or inhibition of growth
- mood swings
- activation or inhibition of the immune system
- regulation of metabolism
- preparation of the body for mating, fighting, and other activity
- preparation of the body for a new phase of life, such as puberty, parenting, and menopause
- control of the reproductive cycle

A hormone may also regulate the production and release of other hormones. Hormone signals control the internal environment of the body through homeostasis.

## Enzyme

Enzymes are the biocatalysts of life. *They are defined as biocatalysts synthesized by living cells. They are simple or conjugate protein and specific in action.* At present about 300 enzymes are recognized and classified into six classes by International Union of Biochemistry (IUB). They are: Oxidoreductases, Transferases, Hydrolases, Lyases, Isomerases and Ligases.

### Functions of Enzymes

- Enzymes control several metabolic pathways and are highly specific in their action.
- Enzymes like invertase, zymase and maltase are used in manufacture of alcoholic drinks.
- Some enzymes are used as therapeutic agents. e.g., streptokinase is used to dissolve blood clots. Asparaginase is used for treatment of leukemia.

#### **Science in Action**

Deficiency of some enzymes causes diseases like albinism in individuals. Albinism is caused due to the deficiency of enzyme tyrosinase. Phenyl ketonuria is caused due to the deficiency of enzyme phenyl alanine hydroxylase.

## Vitamins

Vitamins are organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health of the organism. Vitamins are designated by alphabets A,B,C,D, etc., some of them are further named as sub-groups, e.g, B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, B<sub>12</sub>, etc.

### Vitamins are classified into two groups:

- Fat soluble vitamins : These are vitamins A, D, E and K.
- Water soluble vitamins : B group vitamin and vitamin C are soluble in water so that they are grouped together. Water soluble vitamins must be regularly supplied in diet because they are readily excreted in urine and cannot be stored.

Some important vitamins, their sources and diseases caused by their deficiency are listed in the following table :

Sr. No.	Name of Vitamins	Source	Deficiency Diseases
1	Vitamin A (Retinol)	Cod, liver oil, carrots, egg, butter and milk	Xerophthalmia (hardening of cornea of eye) Night blindness
2	Vitamin B1 (Thiamine)	Seeds, whole grains, Pulses, nuts	Beri beri (loss of appetite, retarded growth)
3	Vitamin B2 (Riboflavin)	Milk, egg white, liver, Kidney	Cheilosis (fissuring at corners of mouth and lips), digestive disorders and burning sensation of the skin
4	Vitamin B5 (Nicotinamid)	Barley, liver maize, wheat	Pellagra (skin pigmentation) degeneration of spinal cord)
5	Vitamin B6 (Pyridoxine)	Yeast, milk, egg yolk, rice, cereals and grams	Anaemia
6	Vitamin B12 (Cyanocobal-amine)	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemoglobin)
7	Vitamin C (Ascorbic acid)	Citrus fruits, amla and green leafy vegetables	Scurvy (bleeding gums)
8	Vitamin D (Calciferol)	Exposure to sunlight, fish and egg yolk	Rickets (bone deformities in children) and osteomalacia (soft bones and joint pain in adults)
9	Vitamin E (Tocoferol)	Vegetable oils like wheat germ oil, cotton seed oil, sunflower oil, etc	Increased fragility of RBCs and muscular weakness, Antifertility
10	Vitamin K (phyllo-quinone)	Green leafy vegetables	Increased blood clotting time

## MAN-MADE MOLECULES

### Polymers

A polymer may be defined as a high molecular weight compound formed by the combination of a large number of one or more types of small molecules of low molecular weight. The small unit (or units) of which the polymer is made is known as *monomer* (or monomers). Many polymeric substances occur in nature such as cellulose, starch, rubber, proteins, and resins.

The synthetic polymers are manufactured generally from the small units by the process known as polymerisation. **Polymerisation** may be defined as a chemical combination of a number of similar or different molecules to form a single large molecule.

Some Common Examples of Addition and Condensation Polymers and their uses :

Addition Polymers	Repeating Unit	Common Uses
Polyethylene (PE)	$\cdots \text{C} \begin{array}{c}   \\ \text{H} \end{array} \text{---} \begin{array}{c}   \\ \text{H} \end{array} \text{C} \cdots$	Plastic bags, bottles
Polypropylene (PP)	$\cdots \text{C} \begin{array}{c}   \\ \text{H} \end{array} \text{---} \begin{array}{c}   \\ \text{CH}_3 \end{array} \text{C} \cdots$	Indoor-outdoor carpets
Polystyrene (PS)	$\cdots \text{C} \begin{array}{c}   \\ \text{H} \end{array} = \text{C} \begin{array}{c}   \\ \text{H} \end{array} \text{---} \text{C}_6\text{H}_5 \cdots$	Plastic utensils, insulation
Polyvinyl chloride (PVC)	$\cdots \text{C} \begin{array}{c}   \\ \text{H} \end{array} = \text{C} \begin{array}{c}   \\ \text{Cl} \end{array} \cdots$	Shower curtains, tubing

### Addition Polymerisation

This involves the self-addition of n-unsaturated molecules of one or two monomers without loss of any small molecule to form a single giant molecule, e.g., propylene polymerises to polypropylene.

Some of the polymers are obtained only from one type of monomer, whereas the others are obtained from two different types of monomers, the former polymers are known as *homopolymers* whereas the latter are known as *copolymers*. Polypropylene, polyethylene, polyisoprene, etc. are the examples of homopolymers; on the other hand, dacron, nylon, certain vinyl polymers, etc. constitute the examples of *copolymers*.

Polyvinylidene chloride (Saran)	$\cdots \text{C}(\text{H})=\text{C}(\text{Cl})\cdots$	Plastic wrap
Polytetrafluoroethylene (Teflon)	$\cdots \text{C}(\text{F})=\text{C}(\text{F})\cdots$	Nonstick coating
Polyacrylonitrile (Orion)	$\cdots \text{C}(\text{H})=\text{C}(\text{H})\equiv\text{N}\cdots$	Yarn, paints
Polymethyl methacrylate (Lucite, Plexiglas)	$\cdots \text{C}(\text{H})=\text{C}(\text{H})\equiv\text{N}\cdots$	Windows, bowling balls
Polyvinyl acetate (PVA)	$\cdots \text{C}(\text{H})=\text{C}(\text{H})\cdots$ II      O   C—CH <sub>3</sub> 	Adhesives, chewing gum
Nylon	$\cdots \text{C}(\text{O})-(\text{CH}_2)_4-\text{C}(=\text{O})\text{N}-\text{(CH}_2\text{CH}_2)_3-\text{N}'\cdots$                    H   H	Carpeting, clothing
Polyethylene terephthalate	$\cdots \text{C}(=\text{O})-\text{C}_6\text{H}_4-\text{C}(=\text{O})\text{O}-\text{CH}_2\text{CH}_3-\text{O}'\cdots$	Clothing, plastic bottles
Melamine-formaldehyde resin (Melmac, Formica)	$\text{C}_3\text{N}_3\text{H}_3\text{O}_3\text{C}_\text{M}$	Dishes, countertops

### Polymers may be divided into two categories

- **Natural polymers** - They are obtained from natural sources e.g. **polysaccharides** (starch, cellulose), **Proteins** (polymers of amino acids), gums, resins (cross linked polymers formed by compounds containing double or triple bonds slowly oxidised by atmospheric oxygen). **natural rubber** (polymer of isoprene), **Nucleic acids** (polymers of nucleotides) silk and wool (polymers of amino acids).
- **Synthetic polymers** - Polymers prepared by synthesis (man made), are known as synthetic polymers eg. polystyrene, nylon, PVC, etc.  
Rayon was originally called artificial silk but now a days it is a name given to artificial fibres derived from cellulose. Rayon can absorb over 90% of its own mass of water and it was not stick to wound.  
Natural silk contains nitrogen while artificial silk may not have nitrogen.

**Science in Action**

Rubber a well-known organic polymer and the **only true hydrocarbon polymer found in nature**. It is formed by the radical addition of the monomer **isoprene**. Polymerization can result in either poly-*cis*-isoprene or poly-*trans* isoprene—or a mixture of both, depending on reaction conditions. Natural rubber is poly-*cis*-isoprene, which is extracted from the tree *Hevea brasiliensis*.

In 1839, the American chemist Charles Goodyear discovered that natural rubber could be cross-linked with sulfur (using zinc oxide as the catalyst) to maintain its elasticity even under external pressure. His process, known as *vulcanization*, paved the way for many practical and commercial uses of rubber, such as in automobile tires and dentures.

Most synthetic rubbers (called *elastomers*) are made from petroleum products such as ethylene, propene, and butadiene. For example, chloroprene molecules polymerize readily to form polychloroprene, commonly known as **neoprene**, which has properties that are comparable or even superior to those of natural rubber.

**Dye**

A dye can generally be described as a colored substance that has an affinity to the substrate to which it is being applied. The dye is generally applied in an aqueous solution, and may require a mordant to improve the fastness of the dye on the fiber.

The dyes were obtained from animal, vegetable or mineral origin, with no or very little processing.

**Classification of dye**

Dyes may be classified as discussed below :

**Acid dyes** : These are water-soluble anionic dyes that are applied to fibres such as silk, wool, nylon and modified acrylic fibres using neutral to acid dyebaths.

**Basic dyes** : These are water-soluble cationic dyes that are mainly applied to acrylic fibers, but find some use for wool and silk. Usually acetic acid is added to the dyebath to help the uptake of the dye onto the fiber. Basic dyes are also used in the coloration of paper.

**Direct or substantive dyes** : These kind of dyes are obtained when dyeing is normally carried out in a neutral or slightly alkaline dyebath, at or near boiling point, with the addition of either sodium chloride ( $\text{NaCl}$ ) or sodium sulfate ( $\text{Na}_2\text{SO}_4$ ). Direct dyes are used on cotton, paper, leather, wool, silk and nylon. They are also used as pH indicators and as biological stains.

**Mordant dyes** : These require a mordant, which improves the fastness of the dye against water, light and perspiration.

**Science in Action**

The most important mordant dyes are the synthetic mordant dyes, or chrome dyes, used for wool; these comprise some 30% of dyes used for wool, and are especially useful for black and navy shades. The mordants, potassium dichromate, is applied as an after treatment.

**Vat dyes** : These are essentially insoluble in water and incapable of dyeing fibres directly.

**Reactive dyes** : These utilize a chromophore attached to a substituent that is capable of directly reacting with the fibre substrate. Reactive dyes are by far the best choice for dyeing cotton and other cellulose fibers at home or in the art studio.

**Disperse dyes** : These were originally developed for the dyeing of cellulose acetate, and are water insoluble. The dyes are finely ground in the presence of a dispersing agent and sold as a paste, or spray-dried and sold as a powder. Their main use is to dye polyester but they can also be used to dye nylon, cellulose triacetate, and acrylic fibres.

**Pigments**

**Pigments** are various organic and inorganic insoluble substances, which are widely used as surface coatings. They are also employed in the ink, plastic, rubber, ceramic, paper and linoleum industries to impart colour. The pigment industry is usually regarded as associated with paints, but in fact it is a separate industry.

Pigments are broadly classified into two types:

- White Pigments e.g. white lead, zinc oxide, etc.
- Coloured Pigments.e.g.ultramarine blue.

**Paints**

Paints are stable mechanical mixtures of one or more pigments. The main function of the pigments is to impart the desired colour and to protect the paint film from penetrating radiation, such as U.V. rays.

- The pigments and the extenders are suspended in drying oils called **vehicle**. The vehicle or drying oil is a film forming material, to which other ingredients are added in varying amounts. The paint is applied on a metal or wood surface to give it a protective coating.
- **Driers** promote the process of film formation and hardening.
- **Thinner**s maintain the uniformity of the film by reducing viscosity of the blend.

The important varieties of paints are emulsion paints, latex paints, metallic paints, epoxide resin paints, oil paints, water paints or distempers, etc.

- **Varnishes** differ from paints in that they have no pigments and in varnishes a part or whole of the oil is substituted by resin.

**Drugs and Medicines**

Chemical substances administered to a human body or to an animal, either for treatment of diseases or reduce suffering from pain are called medicines or drugs. The various types of medicinal compounds according to the purpose for which they are used are:

**Antiseptics**

The chemicals which prevent or check the sepsis of wounds. Examples are : *dettol* (chloroxylenol + terpeneol), *Bithional* (added to soaps). *Salol*, *Acriflavin*, *Savlon*, *Gention violet*, *Mercuro Chrome*, *Salicylic acid*, *picric acid*, *resorcinol*, *phenol*, *iodoform*, *boric acid*, *iodine*, *methylene blue*, *potassium permanganate*.

**Disinfectants**

The chemical substances which completely destroy the micro organisms or stop their growth but are harmful to human tissues are called disinfectants. Examples are : *1.0% phenol*,  *$\text{SO}_2$*  etc. They are used to disinfect floors, clothes, utensils etc.

**Antipyretics**

They lower the body temperature i.e. fever reducing. Examples are : *aspirin*, *para-cetamol*, *phenacetin*, *analgin*.

### **Analgesics**

They are pain relieving. Examples are : *Aspirin* and *analgin*, both are antipyretic and analgesics. *Novalgin* is most widely used analgesic.

Certain narcotics like *Codeine*, *morphene*, *pethidine hydrochloride*, *methadone* and *heroin* etc. are also used as analgesics.

### **Tranquilizers**

Also called psycho-therapeutic drugs, reduce anxiety, induce sleep, and cure mental diseases. Examples are : *Barbituric acid* and its derivatives, *seconal*, *luminal*, *Methyldopa* and *Hydralazine*, *Equanil*.

### **Sedatives and Hypnotics**

They are central nervous system depressants reduce restlessness, emotional tension and induce sleep. Examples are : *Phenobarbital*, *Glute thimide*, *Valium* etc.

### **Antianxiety Agents**

Examples are : *Meprobamate* and *Diazepam*.

*Tranquilizers*, *Sedatives & Hypnotics* and *Antianxiety agents* are central nervous system stimulants.

### **Anaesthetics**

The chemical substances which produce insensibility to the vital functions of all types of cell especially of nervous system temporarily are called anaesthetics. Examples are, *General anaesthetics* - *Chloroform*, *Fluothane*, *Local anaesthetics* - *Cocaine*,  $\alpha$ -*Eucaine*,  $\beta$ -*Eucaine*.

### **Narcotics**

The chemical substances which act as depressant and analgesic.

Examples : *Heroin*, *Opium* and *Pethidine*.

### **Antibiotics**

The chemical substances produced by micro-organisms that inhibit the growth of bacteria or even destroy them are called antibiotics. Examples : Penicillin is the first antibiotic discovered by Alexander Fleming. It is effective against pneumonia, bronchitis and sore throat etc.

### **Antimalarials**

These are the drugs which cure malaria. Examples are : *Plasmoquin* (*Plasmochin*), *Atebrin* (*Mepacrine*), *Chloroquine*.

### **Antacids**

Antacids are the drugs which neutralize excess acid in the gastric Juices and give relief from acid indigestion. They remove the excess acid and raise the pH to appropriate level in stomach. There are mainly weak bases.

Examples–  $\text{Mg(OH)}_2$ ,  $\text{KHCO}_3$

### **Fertilizer**

A chemical fertilizer is defined as any inorganic material of wholly or partially synthetic origin that is added to the soil to sustain plant growth.

### **Classification of Fertilizers**

Based on the availability of nutrients in them chemical fertilizers are divided into four groups:

- **Nitrogenous fertilizers** :  $\text{NH}_3$  is the feed stock of all nitrogenous fertilizers such as anhydrous ammonium nitrate ( $\text{NH}_4\text{NO}_3$ ) and urea ( $\text{CO}(\text{NH}_2)_2$ ).  $\text{NH}_3$  is obtained by **Born Haber process**.

- **Phosphatic fertilizers** : e.g. superphosphate of lime,  $\text{Ca}(\text{H}_2\text{PO}_4)_2$ .
- **Potassic fertilizers** : Potash is a mixture of potassium minerals used to make potassium fertilizers.
- **Complex fertilizers** : Compound fertilizers, which contain N, P, and K, can often be produced by mixing straight fertilizers.

### **Science in Action**

Long term use of chemical fertilizer causes harms to the ecosystem. Some fertilizers are highly acidic, which in turn often increases the acidity of the soil, thereby reducing beneficial organisms and stunting plant growth. By upsetting this natural ecosystem, long-term use of synthetic fertilizer can eventually lead to a chemical imbalance in the recipient plants. Hence chemical fertilizer needs to be applied in moderation, as too much can easily “burn” the plants and sometimes even kill them.

### **Pesticides**

*Pesticides are a class of synthetic chemicals used to control the pests of crops.* Pests can be an insect, disease or weed or sometimes non - insect pest like rats.

### **Some important pesticides commonly used in agriculture are:**

- **Organochlorine chemicals**: They are highly dangerous pesticides having the ability to persist in plant bodies and soil for long period to cause innumerable ecological and health hazards later. Examples: DDT, BHC, endosulfan, heptachlor and chlordane.
- **Organophosphorous chemicals**: They are also dangerous pesticides with ability to kill many useful bacteria besides killing the pests. They act as a source of pollution of agricultural land and ground water. Examples: Phorate, methyl parathion.
- **Carbonates**: They are used as insecticides, acaricides or nematicides to kill insects, mites and nematodes respectively. They can kill many aerobic and anaerobic bacteria in soil. They migrate into the underground water- when excess dosage is used.Examples: Carbofuran, aldicarb and carbaryl.
- **Ethylene Di Bromide (EDB)**: They are volatile liquids used to produce gaseous poisons to kill stored grain pests. They can leave traces of dangerous chemicals on grains and cause food pollution.

### **Handy Facts**

Pesticides can cause large scale pollution - as less than 5% of applied pesticide reaches the actual pests and balance 95% enters the eco-system. The pesticides may remain in plant bodies and may accumulate in edible part of crops or pesticides and may persist in soils to cause serious damage to biological balance in the soil. Pesticides can also enter ground water and may act as source of water pollution.

### **Cement**

Portland cement is the basic ingredient of concrete. Concrete is formed when portland cement creates a paste with water (called hydration) that binds with sand and rock to harden. Bricklayer Joseph Aspdin of Leeds, England first made portland cement early in the 19th century by burning powdered limestone and clay.

### Manufacture of Portland Cement

Portland cement is manufactured by crushing, milling and proportioning the following materials:

- Lime or calcium oxide,  $\text{CaO}$ (70%): from limestone, chalk, shells, shale or calcareous rock
- Silica,  $\text{SiO}_2$ (20%): from sand, old bottles, clay or argillaceous rock
- Alumina,  $\text{Al}_2\text{O}_3$ (5%): from bauxite, recycled aluminum, clay
- Iron,  $\text{Fe}_2\text{O}_3$ (3%): from clay, iron ore, scrap iron and fly ash
- Gypsum,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (2%): found along with limestone

The most common way to manufacture portland cement is through a **dry method**:

70% of the cement produced in the world is Portland cement.

- Picric acid
- T.N.T(Tri-nitro toluene)
- PETN (Pentaerythritol nitrate)
- RDX (Research Department Explosive)

#### Handy Facts

Nitroglycerine was first made in 1847. It is hazardous to make, use and transport. In 1866, Alfred Nobel found that nitroglycerine soaks into diatomaceous earth to give a pasty mixture that can be molded into sticks that don't detonate so easily. These were called dynamite and Nobel started the company Dynamite Nobel to manufacture dynamite. He made lots of money through dynamite business and later funded the Nobel prizes.

### Safety Matches

The credit for developing friction matches that are presently still in use has been attributed to English chemist, John Walker, in 1826.

- Charles Sauria, a French chemist, invented the first phosphorus-based match, by replacing the antimony sulfide in Walker's matches with white phosphorus in 1830. But white phosphorus is toxic and was eventually banned. Subsequently red phosphorus was used in the place of white phosphorus which are allotropic forms of one another.
- The red phosphorus is located on the striking surface on the side of the box, mixed with an abrasive substance such as powdered glass.
- A small amount of the red phosphorus on the striking surface is converted into white phosphorus when match is struck. The white phosphorous then ignites.

### Ink

Ink is a colloidal system of fine pigment particles dispersed in a solvent. The pigment may or may not be coloured, and the solvent may be aqueous or organic. We can have two types of inks: Writing inks and Printing inks

- In **Writing inks** which are used in fountain pens, a fluid water-based dye system is applied. In ballpoint pens, pastelike oil-based dye systems are used. The thickness of the ink allows to flow consistently through capillary action. The ink does not spread unevenly, and dries easily compared to water-based systems.

#### Handy Facts

Dyes tend to be preferred over pigments for writing inks because pigments can't be dispersed minutely enough and tend to clog the pen tip. And water-based dye or pigment systems are still used for markers, highlighters, and roller ball pens.

- **Printing inks** may be of two varieties: ink for conventional printing and ink for digital nonimpact printing, which includes ink-jet and laser (electrophotographic) technologies. In **printing inks** colour is imparted by pigments rather than the dyes used in writing inks. Pigments are insoluble, whereas dyes are soluble. Ink pigments are both inorganic and organic.

### Gun-powder

Gunpowder is a mixture of three different components:

- Potassium nitrate,  $\text{KNO}_3$  (also called salt petre) (75% by weight)
- Charcoal (15% by weight), and sulphur (10% by weight).
  - Nitroglycerine

### Soaps and Detergents

Soaps are water-soluble sodium or potassium salts of fatty acids.

- Soaps are made from fats and oils, or their fatty acids, by treating them chemically with a strong alkali. The fats and oils used in soap making come from animal or plant sources.
- Fatty acids are the components of fats and oils that are used in making soap. They are weak acids composed of two parts:
- A carboxylic acid group (-COOH), plus a hydrocarbon chain attached to the carboxylic acid group. Generally, it is made up of a long straight chain of carbon (C) atoms each carrying two hydrogen (H) atoms.

The common alkalis used in soap making are sodium hydroxide ( $\text{NaOH}$ ), also called caustic soda; and potassium hydroxide ( $\text{KOH}$ ), also called caustic potash.

**Saponification** of fats and oils is the most widely used soap making process. Saponification involves heating fats and oils and reacting them with a liquid alkali to produce soap and water (neat soap) plus glycerine.

#### Cleaning action of soaps and detergents:

Water alone will not remove grease or oil from clothes because oil and grease present in soil repel the water molecules. Both soaps and detergents share a critical chemical property - they are surface-active agents, or surfactants. In other words, they reduce the surface tension of water. Because of reduction of surface tension, water soaks more easily in clothes and removes stains faster.

The carboxylate end of the soap molecule is attracted to water. It is called the hydrophilic (water-loving) end. The hydrocarbon chain is attracted to oil and grease and repelled by water. It is known as the hydrophobic (water-hating) end.

The water-hating end is repelled by water but attracted to the oil in the soil. At the same time, the water-loving end is attracted to the water molecules. These opposing forces loosen the soil and suspend it in the water. Warm or hot water helps dissolve grease and oil in soil. Washing machine agitation or hand rubbing helps pull the soil free.

### Fuels

A fuel is a substance that releases energy. Some fuels (for example uranium) release energy from nuclear reactions.

- This energy is captured in chemical bonds through processes such as photosynthesis and respiration. Energy is released during oxidation.

- The most common form of oxidation is the direct reaction of a fuel with oxygen through combustion. Wood, gasoline, **coal**, and any number of other fuels have energy-rich chemical bonds created using the energy from the **Sun**, which is released when the fuel is burned (i.e., the release of chemical energy).
- Fossil fuels are principally hydrocarbons with minor impurities. They are so named because they originate from the decayed and fossilized remains of plants and animals that lived millions of years ago.

### Types of Fossil Fuels

Fossil fuels can be separated into three categories:

- Petroleum** : The first is **petroleum** or **crude oil**. This is a mixture of light, simple hydrocarbons dominated by the fractions with 6 to 12 carbons but also containing some light hydrocarbons (e.g., methane and ethane).
- Coal** : The second most prominent and naturally most abundant fossil fuel is **coal**. Coal also was produced from decayed vegetative material buried years ago through a process that is slightly different, being less oxidizing. Coal is found as a solid not a liquid.
- Natural gas** : The third major fossil fuel is **natural gas**. This is a general term for the light hydrocarbon fractions found associated with most oil deposits. Natural gas is mostly methane with small quantities of ethane and other gases mixed in. It is hydrogen rich, since methane has a carbon to hydrogen ratio of 1:4. It is also an excellent fuel, burning with a high heat output and little in the way of unwanted pollution. Natural gas is also easy to transport through pressurized pipelines.

### Factors to consider when choosing a fuel

**Energy Value** : Energy Value is the heat of combustion of a fuel given per gram of fuel. The higher the energy value, the more energy is released, the better the fuel.

**Ignition Temperature** : Ignition Temperature is the minimum temperature to which the fuel-oxidizer mixture (or a portion of it) must be heated in order for the combustion reaction to occur.

## CHEMISTRY AND THE ENVIRONMENT

The environment consists of various segments such as **atmosphere, hydrosphere, lithosphere and biosphere**.

**Atmosphere**: The atmosphere is the protective layer of gases which is surrounding the earth. Its main functions are:

- Absorbs IR radiations emitted by the sun and reemitted from the earth and thus controls the temperature of the earth.
- Filters tissue damaging UV radiation of the sun.
- It acts as a source for  $\text{CO}_2$  for plant photosynthesis and  $\text{O}_2$  for respiration
- It acts as a source for nitrogen for nitrogen fixing bacteria and ammonia producing plants.
- The atmosphere transports water from ocean to land.

**Hydrosphere**: Hydrosphere is the part of earth on which all types of water resources exist, viz., oceans, seas, rivers, lakes, glaciers, ice caps, ground water, etc.

**Lithosphere**: Lithosphere is the part of the earth where all types of minerals, metals, organic matters, rocks, soils, etc. exist. Soil is a part of lithosphere.

**Biosphere**: The biosphere refers to the sphere of living organisms and their interactions with the environment (viz. atmosphere, hydrosphere and lithosphere). The biosphere is very large and complex and is divided into smaller units called *ecosystems*.

### DAMAGE TO ENVIRONMENT

Environment may get damaged due to several reasons. The damage may be in the small area or may affect a much larger area and its ill-effects may be felt all over the globe. The environmental damages may be broadly classified as:

#### Regional Environmental Damage

Those environmental damages which affect the living and non-living things locally over a small area are termed as *regional environmental damages*.

Examples are:

#### Acid rain

Acid rain, or acid deposition, is a broad term that includes any form of precipitation with acidic components, such as sulphuric or nitric acid that fall to the ground from the atmosphere in wet or dry forms. This may include rain, snow, fog, hail or even dust that is acidic. Acid rain results when sulphur dioxide ( $\text{SO}_2$ ) and nitrogen oxides ( $\text{NO}_X$ ) are emitted into the atmosphere and transported by wind and air currents. The  $\text{SO}_2$  and  $\text{NO}_X$  react with water, oxygen and other chemicals to form sulphuric and nitric acids. These then mix with water and other material before falling to the ground. The major sources of  $\text{SO}_2$  and  $\text{NO}_X$  in the atmosphere are:

- Burning of fossil fuels to generate electricity. Two thirds of  $\text{SO}_2$  and one fourth of  $\text{NO}_X$  in the atmosphere come from electric power generators.
- Vehicles and heavy equipments.
- Manufacturing, oil refineries and other industries.

The environmental effects of acid rain include:

- Washes away of nutrients from soil and
- Degradation of basic material such as limestone and marble. Acid rain affects building and structures, particularly. Those made of metal or stone.

#### Handy Facts

*The Taj Mahal which is made of marble ( $\text{CaCO}_3$ ) has been seriously affected by acid rain. To protect Taj Mahal, Govt. of India has notified 'Taj Trapezium' – an area surrounding it. In this area all industries have been asked to switch to LPG or natural gas in the place of coal or oil.*

#### Global Environmental Damage

The environmental damages which affect the living and non-living things globally or wider part of the earth are called global environmental damages.

Examples are:

#### Ozone layer depletion

Chlorofluorocarbons (CFCs) are chemicals used in refrigerants, and various kinds of sprays or sols (e.g. perfumes, air freshener, etc.). CFCs cause ozone holes in the ozone layer. Ozone hole refer to depletion of ozone layer due to the reaction of CFCs and ozone molecule. The ozone layer resides in the stratosphere and

surrounds the entire Earth. UV radiation (280 to 315 nanometer wavelength) which comes from the Sun is partially absorbed in this layer. As a result, the amount of UV-radiation reaching the Earth's surface is greatly reduced. Due to depletion of ozone layer, human exposure to UV-radiation increases the risk of skin cancer, cataracts, and a suppressed immune system. UV-radiation exposure can also damage terrestrial plant life, single cell organisms, and aquatic ecosystems.

### Green House effect

More ultraviolet radiations reach the earth through the ozone holes and the reflected radiations from the earth are absorbed by CO<sub>2</sub>, water vapour, etc. The trapped radiations release more and more heat resulting in the phenomenon of Global Warming. This effect is also known as Green House Effect. Green house effect may lead to the rising of water level in the seas, changes in rainfall, increased frequency of extreme natural events, melting of the ice-caps or glaciers etc.

## POLLUTION

**Pollution** refers to deterioration or unclean objectionable conditions in the quality of natural resources such as air, water and soil because of the action or presence of unwanted substances beyond a certain limit. Pollutants are the substances or effect introduced into the environment in significant amounts in solid, semi solid, liquid, gas or sub molecular particle form which has a detrimental effect on the environment. Pollutants can be natural or man-made (anthropogenic).

Some examples of **natural pollutants** are:

- Fires in forests may be caused when lightning strikes the trees. Burning of tree produces a lot of CO<sub>2</sub> which is released to the atmosphere.
- Soil erosion increases suspended particulate matter and dust in air. These may even enter water bodies as they are washed down by rain or natural water falls.
- Volcanic eruptions also add pollutants like SO<sub>2</sub> and solid particles to the environment.
- Volatile organic compounds from leaves, trees and dead animals naturally enter the atmosphere.
- Natural radioactivity and the other natural pollutants have been entering the environment since ages.

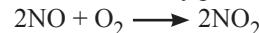
**Anthropogenic pollutants** are of two types:

**Primary pollutants:** Primary pollutants are added directly in a harmful form to the atmosphere.

e.g. CO<sub>2</sub> and CO from burning of fossil fuel; SO<sub>2</sub> and oxides of nitrogen from vehicular combustion, thermal power stations, etc.

**Secondary Pollutants:** Secondary pollutants are the products of reaction between the primary pollutants and normal environmental constituents.

Nitric oxide, a primary pollutant reacts with oxygen to give nitrogen-di-oxide which is a secondary pollutant.



The sources of anthropogenic pollutants can be of two types: Industrial and Domestic sources.

### Major pollutants of air

Pollutants	Primary sources	Significant Effects
SO <sub>2</sub>	Vehicular combustion, fossil burning	Acid rain, irritation in eyes, premature falling of leaves
CO and CO <sub>2</sub>	Vehicular combustion, burning of fuels and hydrocarbons	Global warming, green house effect, CO has great affinity for hydrocarbons, haemoglobin and forms carboxy haemoglobin
Smoke, fly ash and soot	Thermal power stations	Respiratory diseases.
Lead and mercury	Autoexhaust from gasoline (petrol), paints, storage batteries. Fossil fuel like coal burning.	Affects the nervous system and circulatory system causing nerve fuel burning and brain damage
CFCs (Chloro fluoro Carbon)	Refridgerants and aerosol	Kidney damage and ozone depletion.

### Major pollutants of water

Pollutants	Primary sources	Significant Effects
Pesticides and insecticides	Improper use in agriculture like DDT, BHC, mosquito repellants	Toxic to fishes, predatory birds and mammals
Plastics	Homes and industries	Kills fishes and animals. Persists in the environment because of non-biodegradability.
Chlorine compounds	Water disinfection with chlorine, paper industries and bleaching powder	Fatal for plankton (organisms floating on the surface of water), foul taste and odour, can cause Cancer in humans.
Lead paints	Leaded gasoline	Toxic to organisms
Mercury	Natural evaporation and dissolved industrial wastes, fungicides	Highly toxic to humans
Acids Mine drainage, industrial wastes	Mine drainage, industrial wastes	Kills organisms
Sediments	Natural erosion, run off from factories mining and construction activities, fertilizer and other	Reduces ability of water to assimilate oxygen.

## Radioactive Pollution

*Radioactive Pollution can be defined as the release of radioactive substances or high-energy particles into the air, water, or earth as a result of human activity, either by accident or by design.*

The sources of such waste include: (1) nuclear weapon testing or detonation; (2) the nuclear fuel cycle, including the mining, separation, and production of nuclear materials for use in nuclear power plants or nuclear bombs; (3) accidental release of radioactive material from nuclear power plants.

### Some worst environmental disasters

Name of the disaster	Reason for occurrence	Effect of the disaster
Bhopal Gas Leak(1983)	Toxic gases (Methyl iso-cyanide-CH <sub>3</sub> NC) leaked from the Union Carbide (now Dow Chemical) pesticide plant in Bhopal, India	The harmful fumes spread into the sleeping city and people woke with burning eyes and lungs. Thousands died within days. Years later also, pollutants seeping out of the plant site into groundwater have caused cancer, growth retardation and dizziness.
Tokaimura Nuclear Plant (1999)	Japan's worst nuclear accident happened in a facility northeast of Tokyo.	Two ended up dying, and hundreds were exposed to various levels of radiation.
Minamata disease (1956)	Industrial poisoning of Minamata Bay in Japan. Large amounts of mercury and other heavy metals were released into the waste water.	Large amounts of mercury and other heavy metals found their way into the fish and shellfish that comprised a large part of the local diet. Thousands of residents of the Minamata have slowly suffered over the decades and died from a disease-termed as Minamata disease.
The Great Smog of (1952 in London)	A smog covered London for 5 days in 1952. Cold weather, combined with windless conditions collected airborne pollutants from the use of coal to form a thick layer of smog over the city.	Thousands died and a hundred thousand fell ill because of a blanket of smog. An estimated 12,000 premature deaths have been attributed to this smog.
Baia Mare Cyanide Spill(2000)	Cyanide-contaminated water leaked out from a dam, leaking out 100 tonnes of cyanide in to Baia Mare lake in Romania. It has been considered as the second fatal environmental next to Chernobyl in Russia which has been discussed already.	An incredible amount of fish and aquatic plants were killed and up to 100 people were hospitalized after eating contaminated fish.

### Handy Facts

*Dioxin* is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8-tetrachlorodibenz-p-dioxin or TCDD. Dioxin and furan are some of the most toxic compounds.

atmosphere to which a healthy industrial worker can be exposed during an eight-hour day without any adverse effect.

### Smog

The word smog is derived from smoke and fog. There are two types of smog: classical and photochemical smog. Classical smog occurs in cool humid climate. It is a mixture of smoke, fog and sulphur dioxide. It is also called reducing smog. Whereas photochemical smog occurs in warm and dry sunny climate. It has high concentration of oxidizing agents and therefore, it is also called as oxidizing smog.

### Biomagnification

This refers to increase in concentration of the toxicant at successive trophic levels. This happens because a toxic substance accumulated by an organism can not be metabolised or excreted, and is thus passed on to the next higher trophic level. Biomagnification happens in the aquatic food chain. This is well known for mercury and DDT.

### Eutrophication

The process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of oxygen and results in subsequent loss of biodiversity, is known as Eutrophication.

### Science in Action

Photochemical smog mainly contains ozone, nitric oxide, acrolein, formaldehyde and peroxyacetyl nitrate (PAN). These cause serious health problems. In order to stop photochemical smog, catalytic converter are used now-a-days in cars so that release of NO<sub>2</sub> and hydrocarbons are controlled.

### Dissolved Oxygen (DO)

Oxygen dissolved in water is vital for aquatic life. The optimum value for dissolved oxygen in good quality water is 4-8mg/L. It is consumed by oxidation of organic matter/ reducing agent etc. present in water. Water which has DO value less than 4 mg/L is termed as polluted and is unfit for human or aquatic animal consumptions.

### Chemical Oxygen Demand (COD)

It is an index of the organic content of water, since the most common substance oxidized by the dissolved oxygen in water is organic matter, from a biological origin, such as dead plants etc.

### Biological Oxygen Demand (BOD)

The capacity of the organic matter in the sample of natural water to consume oxygen is called its BOD. It is determined experimentally by determining the dissolved oxygen (DO) at the beginning and at the end of a 5-day period in a sealed sample. The BOD gives the measure of oxygen utilized or consumed in the period as a result of oxidation of dissolved organic matter present in the water sample.

### Threshold Limit Value (TLV)

This value indicates the permissible level of a toxic pollutant in

# **EXERCISE**

23. Consider the following chemicals: [IAS Prelim]
- Benzene
  - Carbon tetrachloride
  - Sodium carbonate
  - Trichloroethylene
- Which of the above/is are used as dry cleaning chemical?
- 1 only
  - 2 only
  - 1, 2 and 4 only
  - 1, 2, 3 and 4
24. Which one of the following is another name of RDX? [IAS Prelim]
- Cyanohydrin
  - Dextran
  - Cyclohexane
  - Cyclonite
25. Which one of the following is used as an explosive? [IAS Prelim]
- Phosphorus trichloride
  - Mercuric oxide
  - Graphite
  - Nitroglycerine
26. It is said, the Tajmahal may be destroyed due to –
- flood in Yamuna river
  - decomposition of marble as a result of high temperature
  - air pollutants released from oil refinery of Mathura
  - all the above
27.  $\text{CO}_2$  absorbs some of the ..... that radiates from the surface of Earth to space –
- ozone
  - heat
  - ultraviolet light
  - smog
28. Which of the following is a measure of organic pollution of water –
- DO
  - BOD
  - COD
  - All of these
29. Which of the following gas causes pollution –
- CO
  - $\text{SO}_2$
  - Both (a) and (b)
  - None of the above
30. DDT is a –
- non-biodegradable pollutant
  - biodegradable pollutant
  - antibiotics
  - none of the above
31. Ozone layer in upper atmosphere (stratosphere) is destroyed by –
- hydrochloric acid
  - photochemical smog
  - chlorofluoro carbon (CFC)
  - sulphur dioxide
32. Chipko movement is concerned with –
- plant conservation
  - project tiger
  - plant breeding
  - animal breeding
33. The layer which reflects radio signals back to earth is –
- Ozone layer
  - Troposphere
  - Ionosphere
  - Stratosphere
34. Which of the following is the major cause of global warming?
- (a) re-radiation of U.V. rays by  $\text{CO}_2$  and  $\text{H}_2\text{O}$   
 (b) re-radiation of I.R. rays by  $\text{CO}_2$  and  $\text{H}_2\text{O}$   
 (c) re-radiation of I.R. rays by  $\text{O}_2$  and  $\text{N}_2$   
 (d) re-radiation of U.V. rays by  $\text{O}_2$  and  $\text{N}_2$
35. A green house
- is an enclosure of glass in which plants are kept to protect them from cold air outside
  - is that “body” which allows the short wavelength incoming solar radiation to enter in, but does not allow long wavelength outgoing infra-red radiations to escape out
  - both the above
  - none of the above
36. Minimata disease is a pollution-related disease, which results from –
- release of human organic waste into drinking water
  - release of industrial waste mercury into fishing water
  - accumulation of arsenic into atmosphere
  - oil spills into sea
37. Which of the following best describes “jet streams”?
- Wind system with seas and reversal of direction.
  - Wind blowing from sub tropical high pressure belts towards the tropical low pressure belts.
  - Narrow meandering bands of winds which blow in mid latitude near the tropopause and encircle the globe.
  - Winds blowing from the tropical high pressure belts towards the equatorial low pressure belts.
38. Which one of the following is associated with the formation of brown air in traffic congested cities? [CDS]
- Sulphur dioxide
  - Nitrogen oxide
  - Carbon dioxide
  - Carbon monoxide
39. Some statements about the benefits of organic farming are given below. Indicate whether they are true or false using the codes given below the statements : [CDS]
- It reduces  $\text{CO}_2$  emission.
  - It does not lead to toxic effect.
  - It improves the water-retention capacity of the soil.
- Codes**
- |     |       |       |       |
|-----|-------|-------|-------|
| (a) | 1     | 2     | 3     |
|     | False | True  | False |
| (b) | 1     | 2     | 3     |
|     | True  | False | False |
| (c) | 1     | 2     | 3     |
|     | False | True  | True  |
| (d) | 1     | 2     | 3     |
|     | False | True  | True  |
40. From which one among the following water sources, the water is likely to be contaminated with fluoride? [CDS]
- Ground water
  - River water
  - Pond water
  - Rain water

**ANSWER KEY**

1	(a)	2	(d)	3	(c)	4	(c)	5	(d)	6	(c)	7	(c)	8	(a)
9	(d)	10	(d)	11	(b)	12	(b)	13	(c)	14	(a)	15	(a)	16	(a)
17	(c)	18	(c)	19	(b)	20	(b)	21	(c)	22	(a)	23	(c)	24	(d)
25	(d)	26	(c)	27	(b)	28	(d)	29	(c)	30	(a)	31	(c)	32	(a)
33	(c)	34	(b)	35	(c)	36	(b)	37	(c)	38	(b)	39	(c)	40	(b)

# Chapter 1

# BIOLOGICAL CLASSIFICATION/ CELL & ITS DIVISION

## BIOLOGICAL CLASSIFICATION

Biological classification is the scientific procedure of arranging organisms into groups and subgroups on the basis of their similarities and dissimilarities and placing the groups in a hierarchy of categories. The purpose of biological classification is to organize the vast number of known plants and animals into groups that could be named, remembered and studied.

### NEED FOR THE BIOLOGICAL CLASSIFICATION

#### Classification is Needed to

- help in establishing relationship between different organisms and to know about their evolution.
- help in the identification of organisms.
- study one or two organisms of one particular group and give the sufficient information of that group. It gives an idea of whole range of diversity found in organisms.
- it gives an idea of the evolution of various groups of organisms.

#### Systematics

Systematics is the study of the units of biodiversity. It is the study of the diversification of organisms and their relationship among living things through time. It includes the following parts:

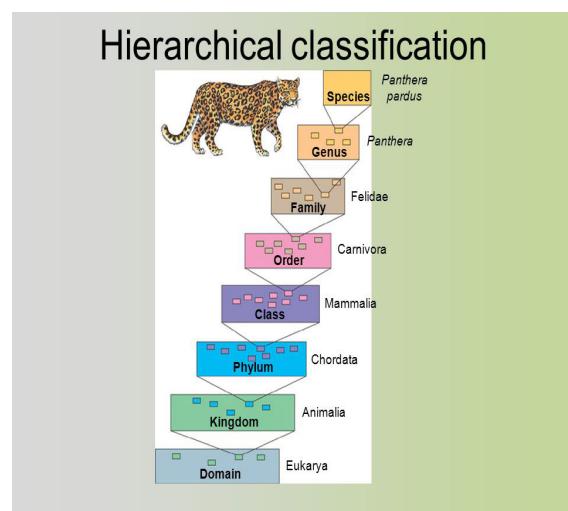
- *Identification*: It is a process of finding the correct name and place of an organism in a system of classification.
- *Classification*: It is the arrangement of an organism in a particular group on the basis of their similarities and dissimilarities.
- *Nomenclature*: It is a system of providing proper and distinct name to one particular organism which helps in recognizing that organism.
- *Taxonomy*: It is a science dealing with the description, identification, naming and classification of organism.

#### Classification of Organisms

It is the arrangement of organisms into taxonomic group according to their similarities and dissimilarities. System of classification is an attempt to organize different organisms into different categories that we can use to study.

#### Hierarchy in Classification

Hierarchy in classification involves many steps. Each step represents a rank or category. All categories or steps together constitute the taxonomic hierarchy.



#### Species

The smallest taxon is species. At the species level organisms look alike and are able to breed with one another.

#### Genus

The next largest taxon is genus. At the genus level, there is a group of similar species that are closely related.

#### Family

A group of two or more genera with common characteristics make a family. For example, lion (*Panthera leo*), tiger (*Panthera tigris*) and the domestic cat (*Felis domesticus*) make the family **Felidae**.

#### Order

A group of related families make an order. For example the family of cat (Felidae) and the family of dogs, foxes, etc. (Canidae) is grouped under the Carnivora.

#### Class

Related orders make a class. For example several orders like those of the tigers, cats, dogs, monkey, bats and human belong to class **Mammalia**.

#### Phylum

A phylum is the largest category with related classes grouped together. For example the classes of mammals, birds, reptiles, amphibians and fishes together constitute the phylum **Chordata**. In plants, the corresponding category is named division.

## Kingdom

Kingdom is the largest group of organisms differentiated on very general similarities. For example, plant and animal kingdom. The plant kingdom comprises all kinds of plants while animal kingdom comprises all kinds of animals.

### Handy Facts

- *Ashoka* was the first ruler in recorded history to order the establishment of wildlife sanctuaries.
- *Carolus Linnaeus* was a Swedish naturalist also known as the father of Taxonomy as he developed a way to name and organize species that we still use today. He wrote a book named '*Systema Naturae*' in which he describes the system of classification of nature. Two most important contribution of Linnaeus are:
  - (i) Hierarchical Classification System
  - (ii). System of Binomial Classification
- *Aristotle*, also known as father of zoology classified animals on the basis of habitat into aquatic, terrestrial and aerial animals.
- *Theophrastus*, also known as father of botany divided plants on the basis of form texture and habitat into four types as trees, shrubs, undershrubs and herbs. He wrote a book named '*Historia Plantarum*'.

## BINOMIAL SYSTEM OF CLASSIFICATION

Biologists have devised a technique for identification naming and grouping of various organisms.

There is a need to standardize the naming of living organisms such as particular organism. *Carl Von Linnaeus* devised a binomial system of nomenclature in which an organism is given two names.

- A *Generic name* which it shares with other closely related organisms which has features similar enough to place them in the same group.
- A *specific name* which distinguishes the organism from all other species. No other organism can have the same combination of genus and species.

## FIVE KINGDOM CLASSIFICATION

This type of classification was proposed by R.H. Whittaker. The five kingdom proposed by Whittaker are *Monera*, *Protista*, *Fungi*, *Plantae*, *Animalia*.

## Kingdom Monera

- Monerans are single cell which may or may not move. It consists of primitive type of organism which includes *bacteria*, *cyanobacteria*, *archaeabacteria* and *mycoplasma*. They can live in both living and non living environment.
- They can also survive in harsh and extreme climatic conditions like in hot springs, acidic soils etc.
- These are classified in 4 groups :– *cyanobacteria*, *Archaeabacteria*, *Bacteria* and *Mycoplasma*.
- These are detected on the basis of Gram staining. Gram (+) thick Peptidoglycan cell wall. Gram (-) no cell wall/thin cell wall.

## Economic importance of bacteria

- *Saprophytic* bacteria causes decay and decomposition of organic matter (dead plants and animals) clean the environment and release minerals in the soil.
- *Antibiotics* are the chemicals released by the bacteria which render the growth of other microorganisms.

- Some bacteria are also involved in gobar gas plant and manure formation. In gobar gas plant bacteria are used to convert animal dung and other organic wastes into manure along with the fuel gas. Biogas consists of methane (50-75%), CO<sub>2</sub> (25-50%), H<sub>2</sub>S (0-3%), N<sub>2</sub> (0-10%) and O<sub>2</sub> (0-0.5%).

### Handy Facts

- |                                  |  |
|----------------------------------|--|
| Streptomycin                     | — <i>Streptomyces griseus</i>            |
| Chloramphenicol                  | — <i>S. venezuelae</i>                   |
| Tetracyclines                    | — <i>S. aureofaciens</i>                 |
| Terramycin                       | — <i>S. ramosus</i>                      |
| Erythromycin                     | — <i>S. erythreus</i>                    |
| Bacitracin                       | — <i>Bacillus Licheniformis Vitamins</i> |
| Riboflavin                       | — <i>Clostridium butylicum</i>           |
| Cobalamin (Vit B <sub>12</sub> ) | — <i>Bacillus megatherium</i>            |
| Vitamin C                        | — <i>Escherichia coli</i>                |

- *Nitrogen Fixation*: Some bacteria are free living which are able to pick nitrogen from the air and soil and convert it into organic nitrogen in the form of amino acid. E.g., *Azotobacter*, *Beijerinckia*, *Clostridium*, etc. On the other part some are symbiotic which forms nodules in the root of the plant. e.g., *Rhizobium*.

## Kingdom Protista

Protista are considered as a diverse group of eukaryotic organism. Protists can be unicellular or multicellular and also exists in colonial form. They do not have specialized tissue organization. Protists live in water, in moist terrestrial habitats, and as parasites and other symbionts in the bodies of multicellular eukaryotes.

These are classified into 3 groups –: protistan algal, slime molds, protozoan protists.

### Handy Facts

#### Protozoan diseases

##### Causative agent Diseases

- |                                  |                                   |
|----------------------------------|-----------------------------------|
| • <i>Trypanosoma gambiense</i> – | Central african sleeping sickness |
| • <i>Giardia Lambia</i> –        | Giardiasis                        |
| • <i>Leishmania donovani</i> –   | Kala-Zar                          |
| • <i>Dermal leishmaniasis</i> –  | Leishmania tropica                |
| • <i>Plasmodium vivax</i> –      | Malaria                           |
| • <i>Entamoeba histolytica</i> – | Amoebic dysentery                 |
| • <i>Entamoeba gingivalis</i> –  | Pyorrhoea                         |

## Economic Importance of Diatoms

- Diatoms are important sources of food to aquatic animals.
- The oils extracted from some fishes and whales are actually produced by diatoms.
- Diatoms are employed as a cleaning agent in tooth pastes and metal polishes, added to paints for enhancing night visibility, are also employed as insulation material in refrigerators, boilers and furnaces.
- Diatomaceous earth is used to make sound proof rooms.

## Kingdom Fungi

Fungi are basically multi-cellular. *Yeast* is an exception in being unicellular. The cell wall is generally composed of chitin (a nitrogen containing carbohydrate). They do not contain chlorophyll and hence are heterotrophic. Most of them are

decomposers, hence fungi are also known as kingdom of multicellular decomposers. They may be saprophytic (depend on dead or decaying organic matter for their food) or may be parasitic (depend on living organisms for their food). Kingdom is classified on the basis of Morphology of reproductive structures, which exhibits more variation.

These are classified into 4 groups . Deuteromycetes, Oomycetes, Zygomycetes, Ascomycetes and Basidiomycetes.

#### Handy Facts

*Lichens* are dual organisms that are formed by permanent symbiotic association between an algae and a fungus. They co-exist for mutual benefit. This type of relationship is known as *symbiosis*. The alga manufactures food for itself and for the fungus. Fungus provides protection to alga and helps in fixation and absorption of water and minerals.

#### Economic Importance of Lichen

- Lichens grows in a dry naked rocks, mountain, barren earth. It makes the way for growth of grasses and mosses.
- These are used as a food in tundra for reindeer, caribou, musk, etc., and also used as food article in iceland, sweden and Norway.
- These are used as dyes or biological stain obtained from *Roccella tinctoria*.
- These are used as perfumes obtained from species *Ramalina* and *Evernia*.

**Algal**  
Red, Green,  
Brown

**Bryophyta**  
Liverwort  
Hornwort

#### Handy Facts

Mycorrhizae are the type of symbiotic association between fungus with the root of higher plants, in which both the organism are mutually benefited, these fungus secretes antimicrobial substances, that protects the plant root from harmful pathogens, fungus helps plants to absorb water and important nutrients from the soil. Fungus also derives nutrient from the roots.

Eg. pinus, birch, etc.

#### Disease caused by fungi in Humans

Allergies	– <i>Alternaria, phoma, Trichoderma, Aspergillus, etc.</i>
Ear infection	– <i>Aspergillus flavus</i>
Valley fever	– <i>Colcidiodomycosis</i>
Neurites	– <i>Mucor pusillus</i>
Candidiasis	– <i>Candida albicans</i>

#### Kingdom Plantae

They are multicellular eukaryotes. All plants contain plastids. Plastids are double membrane organelle that possesses photosynthetic pigments. They are called *chloroplast*. They are usually *autotrophic*. Chloroplast contains a green colour pigment called *chlorophyll* and prepares own food by the process of photosynthesis. Cells have cell wall made up of cellulose.

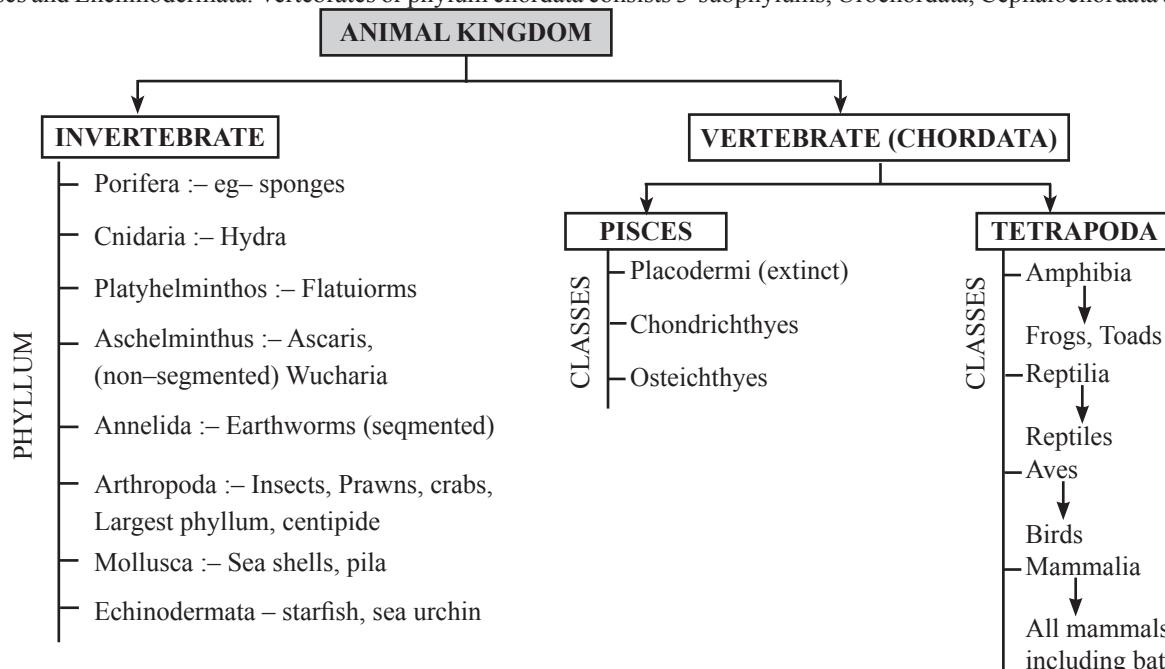
*Kingdom plantae shows a lot of diversity, because of which, it has been divided into four divisions: Algae, Bryophyta, Pteridophyta, and Spermatophyta (Gymnosperms and Angiosperms).*

These are classified into 4 groups :-

Pteridophyta	Spermatophyta
Equisetum	Gymno
selaginella	angio sperms.

#### Kingdom Animalia

There are diverse group of animals in the whole world they lives in different habitats. All animals are multicellular except protozoa, these are eukaryotic, lacks cell wall, heterotrophic, have power of locomotion and shows increased sensitivity through the nervous system. On the basis of presence and absence of vertebrate column. Animal Kingdom are broadly divided into vertebrates and invertebrates. Invertebrates consists 8-phylums named Porifera, Cnidaria, Platyhelminths, Aschelminths, Annelida, Arthropoda, Molluscs and Echinodermata. Vertebrates or phylum chordata consists 3-subphylums, Urochordata, Cephalochordata and Vertebrata.



# CELL : FUNDAMENTAL UNIT OF LIFE

Cell is a structural and functional unit of life. In 1665, *Robert Hooke*, an English scientist, saw cells for the first time in a thin slice of cork with its microscope. He observed and described the cells as “*Honey comb*” like structures. He named the box-like compartments as *cellulae* or *cells*. The term “cell” is derived from a Latin word *cella* which means little room or hollow space.

In 1674, *Van Leeuwenhoek*, a Dutch Scientist, studied living cells for the first time with the help of an improved microscope.

## CELL THEORY

- In 1838, two biologists, *J.M Schleiden and T.Schwann* proposed the “**Cell Theory**”.
- In 1855, *Rudolf Virchow*, a German pathologist proposed that all cells arise from pre-existing cells. He stated this in Latin as “*Omnis cellula-e- cellula*”.
- Smaller Organisms, like bacteria are unicellular and larger organisms are made up of many cells, and are called multicellular organism.

*Cells theory, therefore, states that*

- i. All living organisms are composed of one or more cells
- ii. The cell is the basic unit of life.
- iii. Cells develop from pre-existing cells. *Virus is an exception to cell theory.*

	<b>Prokaryotic cell</b>	<b>Eukaryotic cell</b>
1.	The size cell is small ( $0.1\text{-}5.0\mu\text{m}$ ).	Cell Size is larger ( $5\text{-}100\mu\text{m}$ ).
2.	It consists one envelope organisation.	It consists two envelope organisation.
3.	Unorganized nucleus is present. Hereditary material lies freely in cytoplasm.	Well developed organized nucleus is present. Hereditary are embedded in nucleus covered by nuclear membrane .
4.	Membrane bound organelles like ribosomes, nucleus, endoplasmic-reticulum, golgi body, mitochondria, lysosomes, vacuoles etc are absent.	Membrane bound organelles are present.
5.	DNA is naked.	DNA is associated by histone proteins.
6.	Site of translation and transcription is cytoplasm ex- Bacteria, Cyanobacteria, etc.	Site of Translation is cytoplasm and Transcription is nucleus ex-plants, animals, fungi.
7	Endocytosis and exocytosis does not takes place.	Endocytosis and exocytosis takes place in protists and animal cell.

## CELL STRUCTURE

### Cell Wall

Bacterial cell wall is made up of peptidoglycans. The archean cell wall is made up glycoproteins and polysaccharides. The plant cell wall is mainly composed of cellulose hemi-cellulose glycoproteins, pectins and lignin. Animal cell lacks cell wall.

### Plant Cell Wall

Plant cell walls are primarily made up of cellulose which is the most abundant micro molecule on the earth. Plant cell wall consists of three layers, the *primary cell wall*, *secondary cell wall* and *middle lamella*.

#### The middle lamella:

- It is a first, thin, amorphous sticky layer, which get deposited during cytokinesis.
- This layer is present in two adjacent cells, which are rich in Pectin.
- It consists calcium and magnesium pectates, these pectic compounds are partially solubilised to make the ripen fruits soft.

#### Primary cell wall ( $0.1\text{-}3 \mu\text{m}$ )

- It is formed inner to the middle lamella and are thin, flexible and extensive. ex-cells of cortex, pith, etc. It contains cellulose microfibril.

- Microfibril embedded in primary cell wall provides high tensile strength to the wall.

#### Secondary cell wall ( $3\text{-}19 \mu\text{m}$ )

- It is formed between the plasma - membrane and primary wall. Lignin, suberin, cutin, etc are deposited in the wall.
- These layers are thicker and provides mechanical strength to the cell. Xylan is present in this layer.

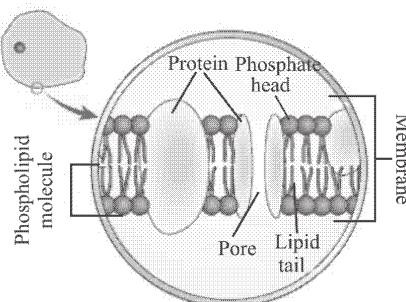
#### Handy facts

- The smallest cell found is a mycoplasma cell, which is about 0.1 micron in diameter.
- The longest cells are the nerve cells, measuring about a metre in length.
- The largest cells are represented by eggs of Ostrich, which is about 170-135 mm.

### Cell Membrane/Plasma Membrane

- Plasma membrane is a living, selectively permeable membrane. It allows some selected materials to move in and out of the cell, and prevents the entry and exit of the other substances.

The plasma membrane is made up of a bilayer of lipids and proteins. Small carbohydrates are attached at places to outer surface of lipids and proteins.

**Fig. Plasma membrane**

- The *Fluid Mosaic Model* proposed by *Singer and Nicholson* is widely accepted.  
*According to this model:*
- The cell membrane is composed of lipid bilayer of phospholipid molecules into which variety of globular proteins are embedded.
- Each phospholipid molecule has two ends- an *outer head hydrophilic* (water attracting) and the *inner tail hydrophobic* (water repelling).

Plant-cell	Animal-cell
Larger	Smaller
cell wall present	Cell wall absent
Plastids present	Plastids absent
Large one vacuole	Small vacuoles
Golgi body is present in the form of dictyosomes.	Golgi body is well developed
Nucleus lies in the peripheral cytoplasm.	Nucleus lies in centre
Centrosome and centrioles are absent	Centrosome with centrioles are present.
Cannot change shape	Can change shape
Lysosome absent	Lysosomes Present
Chloroplast present	Chloroplast absent
Ribosomes present	Ribosomes present
ER present	ER present
Cell wall and plasma membrane both are present	Only plasma membrane present
Microtubules or microfilaments are Present	Present
Cytoplasm present	Present

### Function of cell membrane

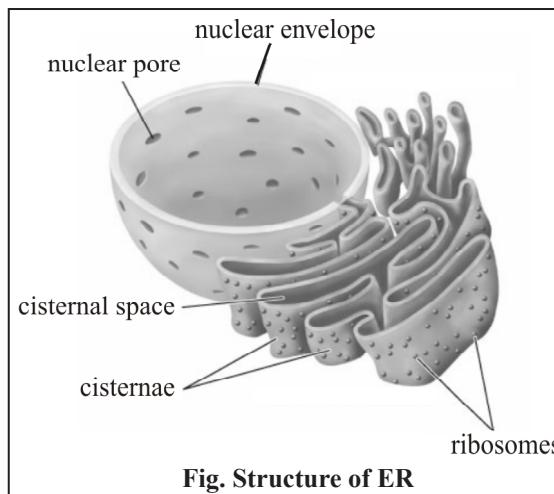
- It provides definite shape to the cell and acts as a mechanical barrier between external and internal environment of the cells.
- It regulates the movement of molecules in and out of cell.
- The flexibility of membrane helps the cell to engulf food and other substances from its external environment by endocytosis.

### CYTOPLASM

It is living portion or protoplasm of cell that comprises gelly like substance called *cytosol* and organelles with nucleus. It is present in both plant and animal cell. It includes, ER, Golgi bodies, plastids, lysosomes, peroxisomes, ribosomes, Mitochondria, and Centrosomes.

### Endoplasmic Reticulum

*Endoplasmic reticulum* is a complex network of membrane bound structure which runs through the cytoplasm. Cisternae are spaces within the folds of the ER membranes. It is connected to both the outer nuclear membrane as well as cell membrane. The membrane has the same structure as the plasma membrane but ribosomes do not have membranes.

**Fig. Structure of ER**

- Depending on presence or absence of ribosome on the surface of ER, it is divided into two types:
  - Rough Endoplasmic reticulum (RER):* It is lined with ribosomes and is rough in appearance, hence, named as rough endoplasmic reticulum. It is the site of protein synthesis.
  - Smooth Endoplasmic reticulum (SER):* It contains no ribosomes and hence is smooth in appearance. It helps in lipid and steroid synthesis.

### Functions of endoplasmic reticulum:

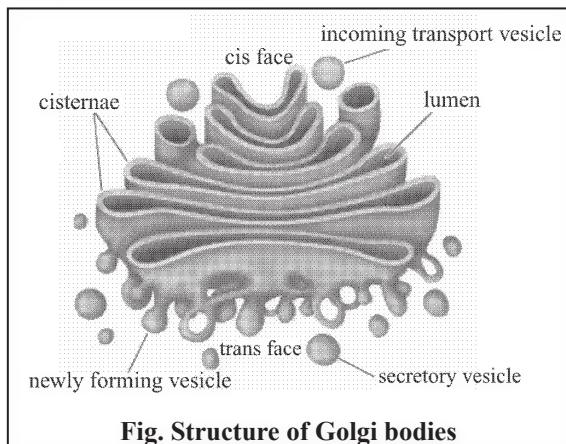
- Endoplasmic reticulum helps in intracellular and intercellular transport of materials. It is the “*transport system*” of the cell. It transports chemicals between cells and within cells.
- RER is the site of protein synthesis. and enzyme synthesis. It conjugates with golgi body and helps in the formation of lysosomes.
- SER helps in lipid synthesis and detoxifying many drugs and poisons.
- Proteins and lipids synthesized on ER are used for making cell membrane. The process is known as membrane biogenesis.

### Golgi Bodies

*Golgi body* consists of smooth, flattened, membrane bound, sac-like structures called cisternae. The cisternae are stacked together; placed one above another in parallel rows. It is *Golgi body is a single complex in animal cells while in plant cells, it is formed of separate units called dictyosomes*. Membranes of Golgi body may develop connections with membranes of ER to form complex called extramembrane system.

### Functions of golgi body

- It is involved in the synthesis, repair of cell membrane, formation of lysosomes and peroxisomes.
- Secretion is the major function of Golgi apparatus. All types of substances that are secreted and excreted are packed in vesicles by Golgi bodies for passage to the outside. It is the *secretory organelle* of the cell.
- It also takes part in storage, modification and packaging of various biochemical products produced by different components of the cell.



**Fig. Structure of Golgi bodies**

### Lysosomes (Lysis = Breaking down; Soma = Body):

Lysosomes are small, spherical vesicle covered by a single membrane. It is scattered all over the cytoplasm. It contains powerful digestive enzymes (about 40 in number) that are capable of breaking down the organic material. Thus, lysosome serves as an intracellular digestive system, and is called *digestive bags*. These are also known as suicidal bags.

### Functions of lysosomes:

- Lysosome helps in intracellular digestion of food particles as they are rich in various digestive enzymes.
- They help in destruction of foreign particles, as in white blood cell, and also help in cleaning up the cell by digesting damaged materials of the cell. They are therefore called cellular scavengers.
- They digest the cell's own damaged and dead cells. Hence, they provide energy during cell starvation by digesting cell's own parts.

### Vacuoles

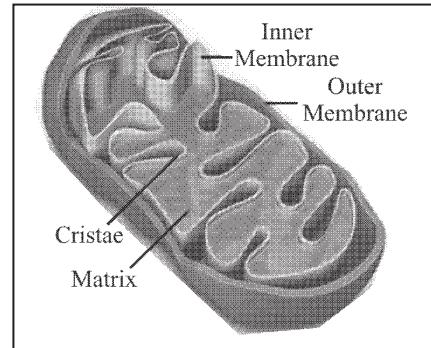
Vacuoles are membrane bound fluid-filled cavities or sacs present in the cytoplasm. They are surrounded by a membrane called tonoplast. The vacuole is filled with a liquid called "*cell sap*" that contains dissolved salts and sugars.

### Functions of vacuoles

- In plant cells Vacuoles help to provide turgidity and rigidity to the cell.
- It acts as a store house of pigments and waste products. It also stores useful minerals and salts.

### Mitochondria

Mitochondria are rod shaped cell organelles surrounded by a double membrane. The outer membrane is smooth and porous while the inner membrane is folded into large number of finger like structures called cristae. *Cristae* increase the surface area of the inner membrane, which provides more surface area for the metabolic reactions to take place. The fluid inside the mitochondria is called the *matrix*.



**Fig. Structure of Mitochondrion**

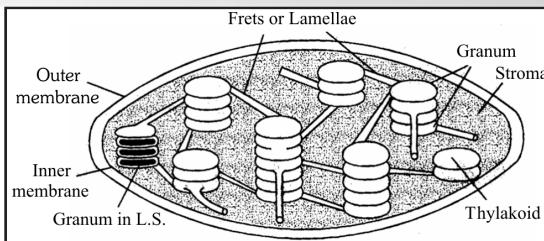
Mitochondria are commonly known as "*Powerhouse of the cell*". They contain enzymes necessary for the total oxidation of food and for the release of large amount of energy in the form of ATP molecules. The energy stored in this ATP is used for synthesis of new products and other metabolic process.

### Function of Mitochondria

- It also stores calcium when required during cell signaling, generation of heat, mediation of cell growth and death.

### Plastids

- Plastids are semi-autonomous organelles having DNA, RNA, ribosomes and double membrane envelope. These are largest cell organelles in plant cell.
- Leucoplasts : They are colourless plastids which generally occur near the nucleus in non-green cells and possess internal lamellae. They mainly store food materials and occur in the cells not exposed to sunlight, e.g., seeds, underground stems, roots, tubers, rhizomes etc.
- These are of three types
  - Amyloplast* : Synthesize and store starch grains.
  - Elaeoplast (Lipidoplast, Oleoplast)* : They store lipids and oils.
  - Aleuroplast (Proteinoplast)* : Store proteins.
- Chromoplasts* : Coloured plastids other than green are known as chromoplasts. These plastids are red, orange, yellow etc. coloured due to the presence at carotenoid. These are present in petals and fruits.
- Chloroplast*: Chloroplasts are green coloured plastids due to the presence of chlorophyll. They occur abundantly in green leaves and green parts of the shoot. They trap the solar energy which is used for manufacturing food. So, they are the *sites of photosynthesis*.
- It is double membrane structure. Both membranes are smooth. The inner membrane is less permeable than outer but rich in proteins especially carrier proteins.



- The inter-membrane space is called the *periplastidial space*. Inner to membranes, matrix is present, which is divided into two parts—

*Grana* : Inner plastidial membrane of the chloroplast is invaginated to form a series of parallel membranous sheets, called *lamellae*, which form a number of oval - shaped closed sacs, called *thylakoids*.

*Stroma* : It is transparent, proteinaceous and watery substance. Dark reaction of photosynthesis occurs in this portions.

### Functions of Plastids

- It is the site of photosynthesis, (light and dark reactions).
- Photolysis of water, reduction of NADP to NADPH<sub>2</sub> take place in grana.
- Photophosphorylation through cytochrome *b*<sub>6</sub>*f*plastocyanin and plastoquinone etc.
- They store starch or factory of synthesis of sugars.

### Ribosomes

- The ribosomes are smallest known electron microscopic without membrane, ribonucleo-protein particles attached either on RER or floating freely in the cytoplasm and are the sites of protein synthesis.
- It has two subunits, one is small and another is large. Small submit reads RNA and large subunits joins amino acids to form a long polypeptide chain through which protein synthesis takes place. 70S ribosomes are found in prokaryotes, mitochondria and plastids of eukaryotes while 80S ribosomes are found in cytoplasm of eukaryotes.

### Functions of ribosomes

- Ribosomes are also called protein factories of the cell.
- Enzyme peptidyl transferase occurs in large subunit of ribosome which helps in protein synthesis.

### Cytoskeleton

In eukaryotic cell, a framework of fibrous protein elements became necessary to support the extensive system of membranes. These elements collectively form cytoskeleton of the cell. There are of three types- Microtubules, Microfilaments and intermediate filaments.

### Microtubules

The microtubules are electron-microscopic structures found only in the eukaryotic cellular structures like cilia, flagella, centriole, basal-body, astral fibres, spindle fibres. These are mainly formed of tubulin protein.

### Functions of microtubules

- These form a part of cytoskeleton and help in cell-shape and mechanical support.
- The microtubules of cilia and flagella help in locomotion and feeding.

### Microfilaments

These are microscopic, long, narrow, cylindrical, non-contractile and proteins structures found only in the eukaryotic cytoplasm. These are present in the microvilli, muscle fibres (called myofilaments) etc. But these are absent in prokaryotes. These are mainly formed of actin-protein (contractile).

### Functions microfilaments

- The microfilaments forms a part of cytoskeleton and change the cell shape during development, motility and division.
- The microfilaments bring about directed movements of particles and organelles along them in the cell.

### Intermediate Filaments

They are supportive elements in the cytoplasm of the eukaryotic cells. They are missing in mammalian RBCs. The IFs are somewhat larger than the microfilaments and are about 10nm thick. They are solid, unbranched and composed of nonmotile structural proteins, such as keratin, desmin, vimentin.

### Functions of intermediate filaments

- They form a part of cytoskeleton that supports the fluid cytosol.
  - It maintains the shape of the cell.
  - They provide support to myofibrils, which is essential for their *contraction*.
- Cilia* (sing.: cilium) and *flagella* (sing.: flagellum) – (9+2) Pattern are hair-like outgrowths of the cell membrane.

### Functions

- They help in locomotion, respiration, cleaning, circulation, feeding, etc.
- They show sensitivity to changes in light, temperature and contact.

## CILIA AND FLAGELLA

### Centrosome and Centriole

Centrosome is an organelle usually containing *two cylindrical structures* called *centrioles*. They are surrounded by amorphous pericentriolar materials. Both the centrioles in a centrosome lie perpendicular to each other in which each has an organisation like the cartwheel. They are made up of nine evenly spaced peripheral fibrils of tubulin.

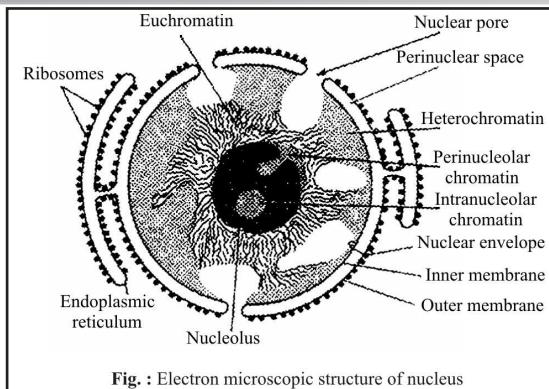
### Functions of centrosome

- The centrioles help in organising the spindle fibres and astral rays during cell division.
- They provide basal bodies which give rise to cilia and flagella.

### Nucleus

Nucleus is the prominent, spherical structure found at the center of the cell. It is the largest organelle present in cell. Basically, nucleus is the controlling centre of all cell activities and hence, it has been described as the *brain of the cell*.

In *plant cell*, nucleus lies towards the periphery due to the presence of large central vacuole while in *animal cell*, nucleus lies in the central position.



### Nuclear envelope or membrane

Nuclear membrane or nuclear envelope, consists of two parallel membranes inner and outer with a space between 10 to 50 nm called the *perinuclear space*, forms a barrier between the materials present inside the nucleus and that of the cytoplasm. The outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.

#### Functions :

- It allows the passage of inorganic ions, small organic molecules, ribosomal subunits, RNAs and proteins through nuclear pores.
- It maintains the shape of the nucleus.

### The nucleolus

Nucleolus is a conspicuous, darkly stained spherical body found in nucleoplasm. It is composed of large amount of ribosomal proteins and ribosomal RNA. It is generally associated with nucleolar organizer region (NOR) of the nucleolar chromosomes.

#### Functions of nucleolus

- It is seat of biogenesis of rRNA and also stores rRNA.
- It plays important role in spindle formation during cell division.

### Nucleoplasm:

- It is transparent, homogenous, semifluid, colloidal, ground substance present inside the nuclear membrane.
- Function the nucleoplasm helps in maintaining the shape of nucleus formation of spindle protein of NAD, ATP, DNA, RNAs and ribosomal subunits.

### Nuclear matrix:

- It is a fine network of proteinaceous fibrils that traverses the whole nucleus.

### Function of nuclear matrix

- It helps in maintaining shape of nucleus.
- It provides anchorage to chromatin.

### Chromosomes

- These are thread like structures which uniformly distributed in the nucleoplasm. They are observed only in the “interphase stage”. Chromatin contains DNA and some basic proteins called histones, some non-histone proteins and also RNA.

### Functions of Chromatin

- Chromatin stores genetic information and forms chromosomes for equitable distribution of genetic information during cell division and reproduction.
- They are DNA-protein hereditary structures which are formed by condensation of chromatin fibres for equitable distribution during cell division and reproduction.

#### Handy Facts

##### Giant Chromosome

It was discovered by E.G. Balbiani in 1881. These are Commonly present in salivary glands of insect, hence known as salivary chromosomes. Its length is 2000 $\mu$ m.

##### Lamp brush chromosome

It was discovered by Flemming in 1882. It is larger in compared to giant chromosome. These are visible in diplotene stage of most animal oocytes, spermatocysts. and giant nucleus of unicellular algae i.e Acetabularia.

### Microbodies

- Many membrane bound minute vesicles called microbodies that contain various enzymes, are present in both plant and animal cells.

### Peroxisomes (Uricosomes)

- These were called peroxisomes because these contain peroxide producing enzymes (oxidases) and peroxide destroying enzymes (catalases).
- These are found in photosynthetic cells of plants. In animals peroxisomes are found in vertebrates (cells of liver, kidney), brain, small intestine, testis and adrenal cortex), invertebrates and protozoans, e.g., *Paramecium*.
- Their membrane is permeable to amino acids, uric acids, etc. They contain four enzymes of  $H_2O_2$  metabolism. The enzymes *urate oxidase*, *d-amino oxidase*,  *$\alpha$ -hydroxy acid oxidase* produce  $H_2O_2$  whereas the *catalases* plays a significant protective role by degrading  $H_2O_2$  because  $H_2O_2$  is toxic for cells.

### Glyoxysomes

- These are found in fungi, some protists and germinating fatty seeds where insoluble lipid food reserves must be turned into soluble sugars. These are absent in animal cell.
- They contain enzymes of metabolism of glycolic acid via glyoxylate cycle and bounded by a unit membrane. These also contain enzymes for  $\beta$ -oxidation of fatty acids, produce acetyl CoA. It is metabolised in glyoxylate cycle to produced carbohydrates.

## CELL DIVISION

- Rudolf Virchow (1855) observed that new cells always develop from pre-existing cells. He also produced *cell lineage theory or law of cell lineage* and *doctrine of genetic continuity*.
- In *unicellular organisms*, cell division is the means of reproduction by which the mother cell produces two or more new cells. In *multicellular organisms* also, new individual develop from a single cell.

## CELL CYCLE

- Cell division is a biological process in all living organisms in which mother cell divides into two daughter nuclei.
  - Although cell growth (in terms of cytoplasmic increase) is a continuous process, DNA synthesis occurs only during one specific stage in the cell cycle. The replicated chromosomes (DNA) are then distributed to daughter nuclei by a complex series of events during cell division. These events are themselves under genetic control.
  - The sequence of events which occur during cell growth and cell division are collectively called *cell cycle*.
- It was introduced by Howard and pole in 1953.

### Phases of Cell Cycle

The period required to complete one cell cycle (from beginning of one cell division to the beginning of next) is called generation time. It is 24 hours in human cells and 90 minutes in yeast. Cell cycle is simpler in prokaryotes and more complex in eukaryotes.

#### The cell cycle is divided into two basic phases :

- Interphase
- M Phase (Mitosis phase)/Dividing phase

#### Interphase

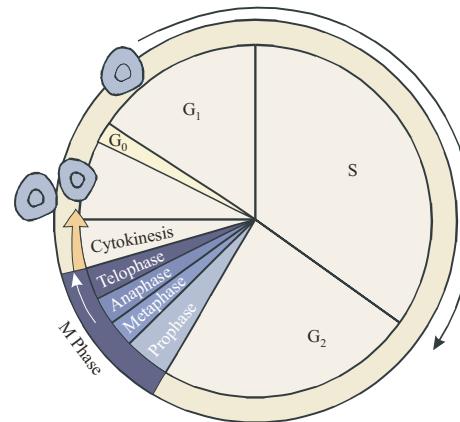
- It is the period between the end of one cell division to the beginning of next cell division.
- It is highly metabolically active phase, in which cell prepares itself for next cell division.

#### Interphase is Completed into Three Successive Stages

- G<sub>1</sub> phase/Post mitotic/Pre-DNA synthetic phase/gap-I* :
- G<sub>1</sub>* phase corresponds to the interval between mitosis and initiation of DNA replication.

*Following events take place during this phase*

- Intensive cellular synthesis.
- Synthesis of rRNA, mRNA ribosomes and proteins.
- Metabolic rate is high.
- Cell size increases.
- Synthesis of enzymes, amino acids, nucleotides etc. but there is no change in DNA amount.



**Fig : A diagrammatic view of Cell Cycle**

#### S-phase/Synthetic phase

S or synthesis phase marks the period during which DNA synthesis or replication takes place.

*Following events take place during this phase*

- DNA replicates and its amount becomes double. If the initial amount of DNA is denoted as 2C then it increases to 4C.
  - Synthesis of histone proteins and NHC (non-histone chromosomal proteins).
  - Duplication of centriole in the cytoplasm.
  - G<sub>2</sub>-phase/Pre mitotic/Post synthetic phase/Gap-II*
- Following events take place during this phase*
- Mitotic spindle protein (tubulin) synthesis begins.
  - Chromosome condensation factor appears.
  - Synthesis of 3 types of RNA, NHC proteins, and ATP molecule.
  - Repair of damaged DNA occurs.
- The cells that do not divide further exit G<sub>1</sub> phase to enter an inactive stage called *quiescent stage (G<sub>0</sub>)* of the cell cycle. Cells in this stage remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism.

Cell division		
Amitosis	Mitosis	Meiosis
<ul style="list-style-type: none"> <li>Amitosis is also called as direct cell division.</li> <li>In this division there is no differentiation of chromosomes and spindle. The nuclear envelope does not degenerate. The nucleus elongates and constricts in the middle to form two daughter nuclei. This is followed by a centripetal constriction of the cytoplasm to form two daughter cells.</li> </ul> <p>Examples: Prokaryotes, protozoans, yeasts, foetal membrane of mammals, cartilage of mammals etc.</p>	<ul style="list-style-type: none"> <li>Mitosis is also called indirect cell division or somatic cell division or equational division.</li> <li>In this, mature somatic cell divides in such a way that chromosomes number is kept constant in daughter cells equal to those in parent cell.</li> <li>The growing regions of plants have meristematic cells (e.g. these cells are found in apical portion of root and stem and in the expanding leaf) in which mitosis takes place.</li> </ul>	<ul style="list-style-type: none"> <li>It is a division that occurs in a mature diploid reproductive cell (2x) in which nucleus divides twice but chromosome (DNA) replicates only once to form four haploid cells, each having half the number of chromosomes present in the parent cell. As it causes reduction in the number of chromosomes, it is known as <i>reduction division</i>.</li> </ul>

## MITOSIS

### Prophase

It is the longest phase of karyokinesis.

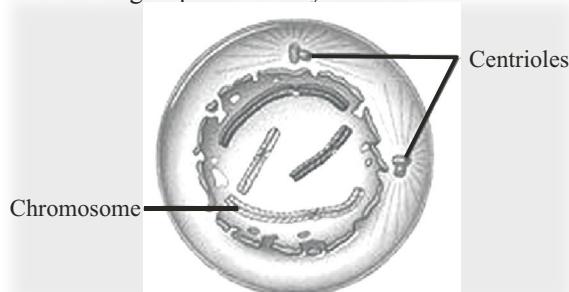


Fig. : Prophase

- Chromatin fibres thicken and shorten to form chromosomes which may overlap each other and appears like a ball of wool.
- Each chromosome divides longitudinally into 2 chromatids which remain attached to centromere.
- Nuclear membrane starts disintegrating except in dinoflagellates.
- Nucleolus starts disintegrating.
- Spindle formation begins.

### Prometaphase

- The degeneration of nuclear envelop and membrane vesicles are formed.
- Emergence of kinetochores starts and spindle reaches to the chromosomes and get attached to the kinetochore.

### Metaphase

- Chromosomes become maximally distinct i.e., size can be measured.

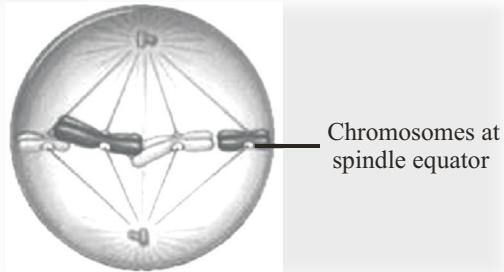


Fig. : Metaphase

- Chromosomes move towards equatorial plane of spindles called congression and become arranged with their arms directed towards pole and centromere towards equator.
- Spindle fibres attach to kinetochores.
- Metaphase is the best stage for studying chromosome morphology (structure, size, number) and cancer studies.

### Anaphase

- Centromere splits from the middle and two chromatids gets separated.

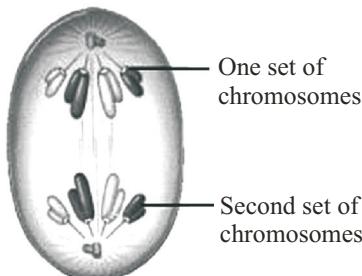


Fig. : Anaphase

- Both the chromatids move towards opposite poles due to repulsive force called anaphasic movement.
- The centromere faces towards equator.
- Shape of chromosome is best studied at anaphase.

### Telophase

- Chromosomes reached on poles by the spindle fibers and form two groups.
- Chromosomes begin to uncoil and form chromatin net.
- The nuclear membrane and nucleolus reappear.

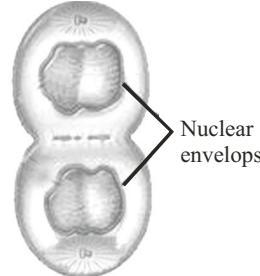


Fig. Anaphase

- In animal cells, astral rays and spindle fibres completely disappear in telophase. The two centriole pairs organise themselves into centrosomes.
- Golgi complex and ER etc., reform.

### Cytokinesis

- Cytokinesis is division of cell having undergone karyokinesis to produce two daughter cells each with a daughter nucleus. It begins in mid-anaphase and is generally completed alongwith the completion of telophase.

## ENDOMITOSIS

- *Endomitosis* : Chromosomes and their DNA duplicate but fails to separate which lead to polyploidy e.g., in liver of man, both diploid ( $2n$ ) and polyploid cells have been reported. It is also called endoduplication and endopolyploidy.

S. No.	Animal cell cytokinesis	Plant cell cytokinesis
1.	Centrioles present at spindle poles.	Centrioles lacking at spindle poles.
2.	Asters are formed (amphistastral).	No asters are formed (anastral).
3.	Cytokinesis by furrowing of cytoplasm.	Cytokinesis mostly by cell plate formation.
4.	Furrow extends centripetally.	Cell plate grows centrifugally.
5.	Occurs nearly in all tissues.	Occurs mainly at meristems.
6.	Cell becomes rounded and its cytoplasm more viscous at the time of mitosis.	Cell does not change form or nature at the time of mitosis.

## MEIOSIS

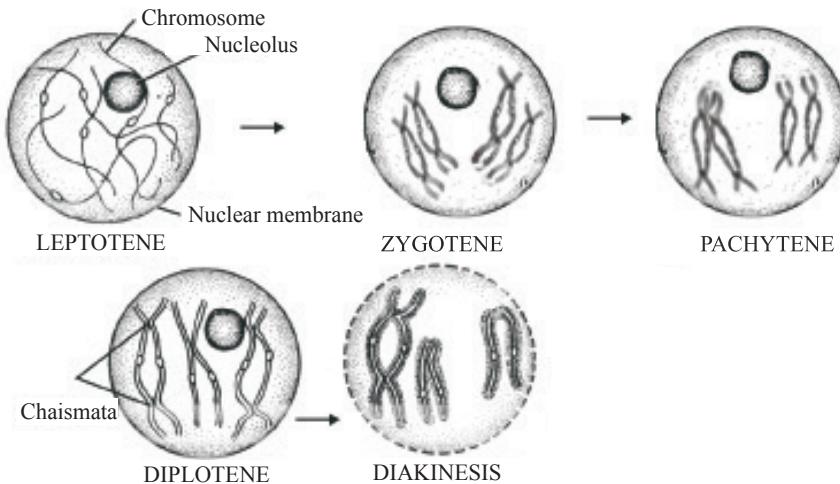
- It is a process in which, a single cell divides twice to produce four daughter cells.
- Occurs in reproductive cells, in which cell have a half number of chromosomes present in parent cell.
- It occurs only in reproductive cells.

### Meiosis I

Meiosis I	Meiosis II
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II

### Meiosis I

It results in the formation of two haploid cells from one diploid cell. The daughter cells are, therefore, haploid but with  $2n$  DNA



Paired chromosomes are called bivalents, which by further molecular packing and spiralization becomes shorter and thicker.

#### (iii) Pachytene/Pachynema

Crossing over It takes place by breakage and reunion of chromatid segments. Breakage called *nicking*, is assisted by an enzyme *endonuclease* and reunion termed *annealing* is added by an enzyme *ligase*.

#### (iv) Diplotene/Diplonema

This stage the paired chromosomes begin to separate (**desynapsis**) terminalisation starts.

is formed at the place of crossing over between non-sister chromatids.

Homologous chromosomes move apart they remain attached to one another at specific points called *chiasmata*.

#### (v) Diakinesis

Terminalization of chiasmata. Occurs Nuclear membrane and nucleolus degenerates. Chromosome recondense and tetrad moves to the metaphase plate. Formation of spindle. When the diakinesis of prophase-I is completed than cell enters into the metaphase-I.

### Metaphase-I

Chromosomes align on the equator. Bivalents arrange themselves in two parallel equatorial or metaphasic plates.

### Anaphase-I

In involves separation of homologous chromosomes which start moving towards opposite poles so each tetrad is divided into two daughter dyads. So anaphase-I involves the reduction of chromosome number, this is called *disjunction*.

content. It is divided into four phases i.e., prophase, metaphase, anaphase, telophase.

**Prophase-I :** It is of longest phase of karyokinesis of meiosis. It is again divisible into five subphases i.e., *leptotene, zygotene, pachytene, diplotene and diakinesis*.

#### (i) Leptonema

Chromosomes are long thread like with chromomeres (i.e. linear series of darkly stained swollen areas) on it. *homologous chromosomes* derived from different parents either paternal or maternal.

#### (ii) Zygotene/Zygonema

**Pairing or “Synapsis”** of homologous chromosomes takes place in this stage.

### Telophase-I

Two daughter nuclei are formed but the chromosome number is half of the chromosome number of mother cell. Nuclear membrane reappears and after telophase I cytokinesis may or may not occur.

### Significance of meiosis-I

- It separates the homologous chromosomes to reduce the chromosome number to the haploid state, a necessity for sexual reproduction.
- It introduces variation by forming new gene combinations through crossing over and random assortment of paternal and maternal chromosomes.

### Meiosis-II

It is also called equational or homotypical division because the number of chromosomes remains same as after meiosis-I. It involves the separation of two chromatids of each chromosome and their movement to separate cells. It is divided in four phases i.e., Prophase-II, Metaphase-II, Anaphase-II and Telophase-II.

### Significance of Meiosis-II

- Constancy of chromosomes number in successive generation is brought by this process.
- It helps in introducing variations and mutations.
- It maintains the amount of genetic material.
- The four daughter cells will have different types of chromatids.

## EXERCISE

1. Who was the first to describe that species is the unit of classification?
  - (a) John Ray (b) Huxley
  - (c) Linnaeus (d) Candolle
2. Plants that grow in the desert are called
  - (a) hydrophytes (b) mesophytes
  - (c) xerophytes (d) epiphytes
3. Basic taxonomic category is
  - (a) population (b) species
  - (c) variety (d) breed
4. An important character of chordata is presence of
  - (a) dorsal notochord
  - (b) dorsal hollow nerve cord
  - (c) post-anal tail
  - (d) all the above
5. Venus fly trap is a
  - (a) Bryophyta (b) Pteridophyta
  - (c) Gymnosperm (d) Angiosperm
6. **Column-I**                   **Column-II**

A. The name of the genus	P. underlined begins with a letter.
B. The name of the species	Q. small begin with a letter.
C. When printed the scientific name is in a letter.	R. italics
D. When written by hand the scientific name is a letter.	S. capitals

  - (a) A-Q; B-R; C-S; D-P
  - (b) A-P; B-Q; C-R; D-S
  - (c) A-S; B-R; C-Q; D-P
  - (d) A-S; B-Q; C-R; D-P
7. Largest group in Animal Kingdom is
  - (a) Mollusca (b) Amphibia
  - (c) Arthropods (d) Reptilia
8. Pollination takes place in
  - (a) Gymnosperms (b) Pteridophyta
  - (c) Both (a) & (b) (d) None of these
9. The generic name of mango is
  - (a) *Mangifera indica*
  - (b) *Helminthosporium oryzae*
  - (c) *Solanum tuberosum*
  - (d) *Lycopersicon esculentum*
10. Mitochondria are absent in
  - (a) green algae
  - (b) brown algae
  - (c) cyanobacteria and bacteria
  - (d) all above
11. Angiosperms have
  - (a) tracheids and vessels
  - (b) tracheids only
12. Which of the followings are correct order of hierarchy?
  - (a) Kingdom, division, phylum, genus and species
  - (b) Phylum, division, genus and class
  - (c) Kingdom, genus, class, phylum and division
  - (d) Phylum, kingdom, genus, species and class
13. Which one of the following is responsible for converting milk into curd? [CDS]
  - (a) Fungi (b) Bacteria
  - (c) Virus (d) None of these
14. Bryophytes are photosynthetic but do not have vascular tissue and true roots. This feature enables them to resemble with which of the following? [CDS]
  - (a) Fungi (b) Algae
  - (c) Pteridophytes (d) Angiosperms
15. Which one of the following is a freeliving bacterium that helps in nitrogen fixation in soil? [CDS]
  - (a) Azotobacter (b) Anabaena
  - (c) Azolla (d) Nostoc
16. Which one among the following groups of animals maintains constant body temperature in changing environmental conditions? [CDS]
  - (a) Birds (b) Fishes
  - (c) Amphibians (d) Reptiles
17. Among the following animals, choose the one having three pairs of legs. [CDS]
  - (a) Spider (b) Scorpion
  - (c) Bug (d) Mite
18. Cyanobacteria are
  - (a) Mosses which attack bacteria
  - (b) Bacteria which attack cyanophyceae
  - (c) Autotrophic organisms with phycocyanin
  - (d) None of these
19. Rough endoplasmic reticulum is concerned with
  - (a) Protein synthesis (b) Fat synthesis
  - (c) Respiration (d) Photosynthesis
20. The most abundant compound in cytoplasm is
  - (a) fat (b) water
  - (c) protein (d) carbohydrates
21. Nucleolus is
  - (a) rounded structure found in cytoplasm near nucleus.
  - (b) rounded structure inside nucleus and having rRNA.
  - (c) rod-shaped structure in cytoplasm near the nucleus.
  - (d) none of the above.
22. Silver nitrate solution is used to study
  - (a) endoplasmic reticulum
  - (b) Golgi apparatus
  - (c) nucleus
  - (d) mitochondria

23. Human cheek cells are commonly stained with  
 (a) methylene blue (b) safranin  
 (c) acetocarmine (d) eosine
24. The chromosome number in humans is  
 (a) 94 (b) 23  
 (c) 46 (d) 22
25. Which of the following statement is incorrect ?  
 (a) Mycoplasma is the smallest cell ( $0.3\text{ }\mu$ ).  
 (b) Bacteria are 3 to 5  $\mu\text{m}$  in size.  
 (c) The largest cell is the egg of an ostrich.  
 (d) Nerve cells are some of the smallest cells.
26. Which of the following group is present in animal cells ? [NDA]  
 (a) Mitochondria, Cell membrane, Cell wall, Cytoplasm  
 (b) Chloroplasts, Cytoplasm, Vacuole, Nucleus  
 (c) Nucleus, Cell membrane, Mitochondria, Cytoplasm  
 (d) Vacuole, Cell membrane, Nucleus, Mitochondria
27. Which organelle in the cell, other than nucleus, contains DNA? [NDA]  
 (a) Endoplasmic reticulum  
 (b) Golgi apparatus  
 (c) Lysosome  
 (d) Mitochondria
28. Which of the following parts are found in both plant and animal cells ? [CDS]  
 (a) Cell membrane, Chloroplast, Vacuole  
 (b) Cell wall, Nucleus, Vacuole  
 (c) Cell membrane, Cytoplasm, Nucleus  
 (d) Cell wall, Chloroplast, Cytoplasm
29. Which one among the following statements is correct ? [CDS]  
 (a) Prokaryotic cells possess nucleus.  
 (b) Cell membrane is present both in plant and animal cells.  
 (c) Mitochondria and chloroplasts are not found in eukaryotic cells.  
 (d) Ribosomes are present in eukaryotic cells only.
30. What part of the cell serves as the intracellular highway?  
 (a) Endoplasmic reticulum  
 (b) Golgi apparatus  
 (c) Cell membrane  
 (d) Mitochondria
31. Which of the following is a part of endomembrane system of eukaryotic cell?  
 (a) Peroxisomes (b) Chloroplasts  
 (c) Mitochondria (d) Golgi complexes
32. Mitochondria supply most of the necessary biological energy by  
 (a) Breaking down of sugar  
 (b) Oxidizing substrates of TCA cycle  
 (c) Reducing NADP  
 (d) Breaking down of protein
33. 70S type of ribosomes is found in  
 (a) Prokaryotic cells  
 (b) Prokaryotic cells, chloroplasts and mitochondria  
 (c) Mitochondria  
 (d) Nucleus, mitochondria
34. Crossing over occurs during  
 (a) leptotene (b) pachytene  
 (c) diplotene (d) diakinesis
35. Recombination involves  
 (a) crossing over  
 (b) chromosome duplication  
 (c) spindle formation  
 (d) cytokinesis
36. Chiasmata are first seen in  
 (a) leptotene (b) zygotene  
 (c) pachytene (d) diplotene
37. Terminalization occurs during  
 (a) mitosis (b) diakinesis  
 (c) meiosis II (d) cytokinesis
38. In cell cycle, DNA replication takes place in  
 (a) G1 phase (b) G2 phase  
 (c) Mitotic metaphase (d) S phase
39. Which phase of cell cycle is known as quiescent stage ?  
 (a) M phase (b) G0 phase  
 (c) G1 phase (d) S phase
40. Which of the following phase follows S and G2 phases of interphase?  
 (a) Prophase (b) Metaphase  
 (c) Anaphase (d) Telophase

**ANSWER KEY**

1.	(a)	2.	(c)	3.	(b)	4.	(d)	5.	(d)	6.	(d)	7.	(c)	8.	(a)	9.	(a)	10.	(c)
11.	(a)	12.	(a)	13.	(b)	14.	(b)	15.	(a)	16.	(a)	17.	(c)	18.	(c)	19.	(a)	20.	(b)
21.	(b)	22.	(b)	23.	(a)	24.	(c)	25.	(d)	26.	(c)	27.	(d)	28.	(c)	29.	(b)	30.	(a)
31.	(d)	32.	(b)	33.	(b)	34.	(b)	35.	(a)	36.	(d)	37.	(b)	38.	(d)	39.	(b)	40.	(a)

# Chapter

# 2

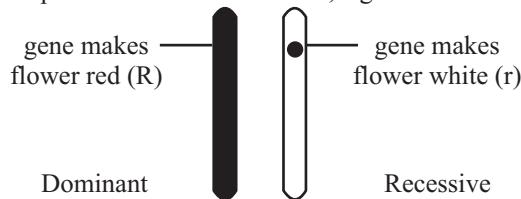
# GENETICS & BIOTECHNOLOGY

## GENETICS

Heredity is the transmission of genetic characters from parent to offsprings. Individuals of same species have some differences, these are called variation.

### MENDEL'S FINDINGS

- Mendel's Law of Dominance and Recessive**
  - Each of the  $F_1$  generation plant shows inheritance of Y allele from one parent and a G allele from the other. When the  $F_1$  plants breed, each has equal chance of passing on either Y or G allele to each offspring.
  - In all the seven traits that Mendel examined, one form appeared dominant over the other i.e., it marked the presence of the other allele, e.g.



### BASIC TERMS USED IN INHERITANCE STUDIES

- Allele:** It is an alternative form of a gene which are located on same position (loci) on the homologous chromosome. Term allele was coined by Bateson.
- Homozygous:** A zygote is formed by fusion of two gametes having identical factors is called homozygote and organism developed from this zygote is called homozygous.  
Ex. TT, RR, tt.
- Heterozygous:** A zygote is formed by fusion of two different types of gamete carrying different factors is called heterozygote ( $Tt$ ,  $Rr$ ) and individual developed from such zygote is called heterozygous.
- Hemizygous:** If individual contains only one gene of a pair then individual is said to be hemizygous. Male individual is always hemizygous for sex linked gene.
- Phenotype:** It is the external and morphological appearances of an organism for a particular character.
- Genotype:** It is the genetic constitution or genetic make-up of an organism for a particular character.
- Back cross:** A back cross is a cross in which  $F_1$  individuals are crossed with any of their parents.
- Test cross:** When  $F_1$  progeny is crossed with recessive parent then it is called test cross.

- Monohybrid test cross:** The progeny obtained from the monohybrid test cross are in equal proportion, means 50% is dominant phenotypes and 50% is recessive phenotypes.  
It can be represented in symbolic forms as follows.  
 $F_1$  progeny (hybrid)  $\times$  Recessive parent

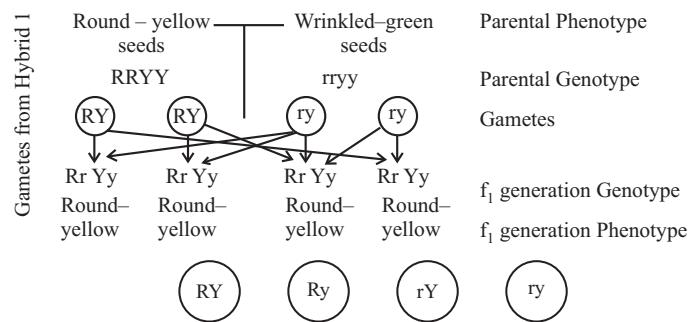


Monohybrid test cross ratio = 1 : 1

- Dihybrid test cross:** The progeny is obtained from dihybrid test cross are of four types and each of them is 25%.

- Law of Segregation:** According to this law, for any particular trait, the pair of alleles of each parent separate and only one allele passes from each parent to an offspring. Allele in a parent's pair of allele is inherited as a matter of chance (we now know segregation of alleles occurs during the process of meiosis).
- Law of Independent Assortment:** This is also known as 'Inheritance law'. According to this law, different pairs of alleles are passed to offspring independently of each other.

#### PARENTAL CROSS



RY	RRYy	RrYY	RrYy
Ry	Rryy	RrYy	Rryy
rY	rrYY	rrYY	rrYy
ry	rrYy	rrYY	rrYy

Punnett Square

## Exceptions of Conclusions of Mendel

Exception of Dominance

There are two exceptions of law of dominance–

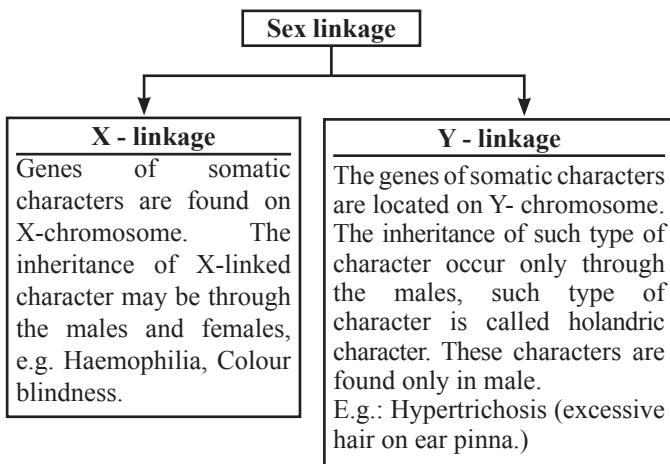
- (i) Incomplete dominance
- (ii) Co-dominance

## LINKAGE

- Linkage is the phenomenon of certain genes staying together during inheritance through generations without any change or separation. This is due to their location on the same chromosomes.
- Linkage was first time seen by *Bateson and Punnett* in *Lathyrus odoratus* and gave coupling and repulsion phenomenon. But they did not explain the phenomenon of linkage.
- Sex linkage was first discovered by Morgan in *Drosophila* and coined the term linkage. He *proposed the theory of linkage*.

## Sex Linkage

When the genes of vegetative/somatic characters are present on sex-chromosome, it is termed as *sex linked gene* and such phenomenon is known as *sex-linkage*.



## GENES

Genes are responsible for the characteristics features (or traits) of organism-plant or animals. The characteristics or traits of parents are transmitted to their progeny (off springs) through genes present on their chromosomes during the process of sexual reproduction.

- Genes are arranged linearly along long chains of DNA sequence, called chromosomes. The DNA of the chromosome is associated with proteins that organise, compact and control the access to the DNA, forming a material called chromatin. In eukaryotes, chromatin is composed of nucleosomes – segments of DNA wound around histone protein. The full set of hereditary material in an organism i.e., the combined DNA sequences of all chromosomes is called genome.

## Lethal Gene

- Gene which causes death of individual in early stage when it comes in homozygous condition is called lethal gene.

- It may be dominant or recessive both, but mostly recessive for lethality. Lethal gene was discovered by L. Cuenot in coat colour of mice.

## MULTIPLE ALLELE

- More than 2 alternative forms of same gene is called as multiple allele. Multiple allele is formed due to mutation and located on same locus of homologous chromosome.

Example of multiple allele

- ABO blood group : ABO blood groups are determined by allele IA, allele IB, allele ID

IA = dominant

IB = dominant

ID = recessive

Possible phenotypes - A, B, AB, O

Blood group	Genotype	Antigen or agglutinogen	Antibody or agglutinin
A	I <sup>A</sup> I <sup>A</sup> , I <sup>A</sup> I <sup>O</sup>	A	b
B	I <sup>B</sup> I <sup>B</sup> , I <sup>B</sup> I <sup>O</sup>	B	a
AB	I <sup>A</sup> I <sup>B</sup>	A & B	None
O	I <sup>O</sup> I <sup>O</sup>	None	a & b

Possible genotype number =  $\frac{3(3-1)}{2} = 6$  genotype.

## SEX DETERMINATION

- Sex determination is a biological system that determines the development of sexual characters in an organism. Most sexual organisms have two sexes: Males and females.
- In a human, the sexual chromosomes complement is 46, 44 of which are autosomes while 2 distinct chromosomes are the sex chromosomes, which determine the sex of an organism and various sex-linked characteristics.
- In humans, sex is predetermined in the sperm gamete. The egg gamete mother cell is said to be homogametic because all its cells possess the XX sex chromosomes, sperm gametes are said to be heterogametic because around half of them contain the X-chromosome and others possess the Y-chromosome to compliment the first X-chromosome.

## Deoxyribose Nucleic Acid (DNA)

- Deoxyribose nucleic acid (DNA) carries the genetic information. It is a constitute of chromosome.
- Structure of DNA was worked out by X-ray diffraction studies. A double helix model by DNA was proposed by Watson and Crick in 1953. They suggested that :
  - (i) Each DNA molecule consists of two polynucleotide chains.
  - (ii) The chains are helically coiled around a common axis.
  - (iii) DNA molecule has a diameter of 20 Å and complete turn of helix is 3.4 Å. So there are 10 bases per turn of helix.
  - (iv) Each DNA chain is complementary chain to the second chain.

- Deoxyribose and a nitrogenous base together form a nucleoside. A nucleoside and a phosphate together form a nucleotide.  
Nucleoside = Deoxyribose + Nitrogenous base  
Nucleotide = Deoxyribose + Nitrogenous base + Phosphate
- Deoxyribose is pentose sugar with five carbon atoms, four of the given carbon atoms plus a single atom of oxygen for a five numbered ring.

## GENETIC DISORDERS

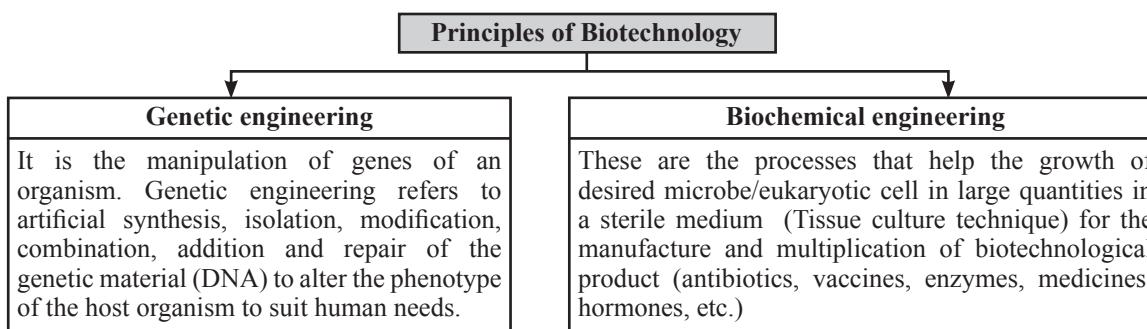
- Genetic disorders** is a disease that is caused by an abnormality in an individual's DNA.
- Genetic disorder may be grouped into two categories- *Mendelian disorders* and *chromosomal disorders*.
- Mendelian disorders* are chiefly determined by alteration or mutation in the single gene. Eg. haemophilia, cystic fibrosis, sickle cell anaemia, thalassemia, colour blindness, phenyl ketonuria, etc.
- (i) *Haemophilia* is an inherited disorder of blood in which essential clotting factor are either partly or completely missing.
- (ii) *In sickle-cell anaemia* glutamic acid (glutamine) is replaced by valine at the sixth position in b chain of haemoglobin. It is a blood disease. Where the red blood blood cells become sickle shaped as compared to normal one.
- The *chromosomal disorders* are caused due to absence or excess or abnormal arrangement of one or more chromosomes. Failure of segre-gation of chromatids

during cell division cycle results in the gain or loss of a chromosome(s), called aneuploidy.

- Types of *chromosomal disorders* are - *Down's Syndrome*, *Klinefelter's Syndrome* and *Turner's Syndrome*. *Down's Syndrome* is caused by the presence of an additional copy of the chromosome number 21 (trisomy of 21). The affected individual is short statured with small round head, furrowed tongue and partially open mouth. Palm is broad with characteristic palm crease. Physical, psychomotor and mental development is retarded.
- Klinefelter's Syndrome* is caused due to the presence of an additional copy of X-chromosome resulting into a karyotype of 47, XXY. Such an individual has overall masculine development , however, the feminine development (development of breast, i.e., Gynaecomastia) is also expressed. Such individuals are sterile.
- Turner's Syndrome* is caused due to the absence of one of the X chromosome, i.e., 45 with XO. Such females are sterile as ovaries are rudimentary besides other features including lack of other secondary sexual characters.

## BIOTECHNOLOGY

The Convention on Biological Diversity (CBD) defines biotechnology as any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.



## RECOMBINANT DNA TECHNOLOGY

**Recombinant DNA technology**, popularly known as '**genetic engineering**' is a stream of biotechnology which deals with the manipulation of genetic material by man in vitro.

*There are two distinct techniques for introducing foreign genetic material into plant cell genome — indirect and direct transfer.*

**The first is indirect transfer through a vector which requires –**

- selection and isolation of the desirable fragment(s) of DNA which contains gene sequence(s) that needs to be cloned known as *insert*;
- Generation of *recombinant DNA* (r DNA) molecule by insertion of these inserts (DNA fragments) into a carrier DNA molecule, termed as *vector* (i.e., the bacterial Agrobacterium tumefaciens, a virus, a plasmid or any other vector) that can replicate within a host cell; Recombinant DNA (r DNA) = Vector + insert
- Introduction of the r DNA molecules into host cells.

**The second, through direct introduction of DNA, involves –**

- Co-cultivation*, i.e., culturing the recipient protoplast with purified DNA
- Electroporation*, i.e., application of electric impulses to change the porosity of protoplasts so that the directly imbibe the purified DNA.
- Micro-injection*, i.e., direct injection of DNA fragments with the help of a micropipette. Other methods of gene transfer are – liposome mediated gene transfer, calcium phosphate precipitation method, transformation by ultrasonification and transformation using pollen or pollen tube.

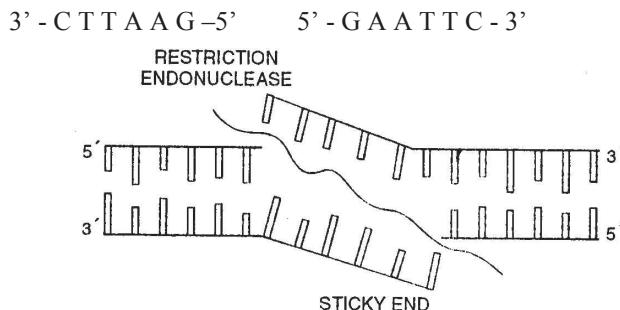
Thus, genetic engineering can be defined as the generation of new combination of heritable material by the insertion of desired genes or DNA of the cell, into any carrier system so as to allow their incorporation into a host organism in which they do not normally occur but in which they are able to perform normal behaviour and propagation.

## Basic Tools of Recombinant DNA Technology

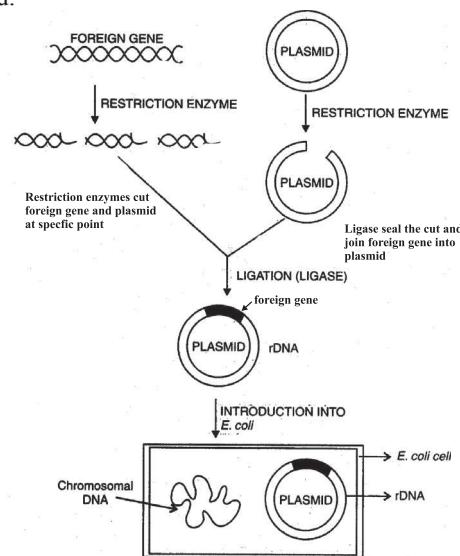
### Enzyme

A number of specific kind of enzymes are employed in genetic engineering. These include lysing enzymes, cleaving enzymes, synthesizing enzyme and joining enzymes.

- **Lysing enzymes** : These are used to open up the cells to get DNA for genetic experiments. It is commonly used to dissolve the bacterial cell wall.
- **Cleaving enzyme** : These are used to break DNA molecule. They are further of 3 kinds—
  - (i) **Exonucleases** – which cut off nucleotides from 5' or '3 ends of DNA molecule;
  - (ii) **Restriction endonucleases** – which cleave DNA duplex at specific points called restriction sites in such a way that single-stranded free ends project from each fragment of DNA duplex. These single-stranded free ends are called 'sticky ends' because they can join similar complementary ends of DNA fragment from some other source. Restriction endonuclease is called molecular scissors or a chemical scalpel.



- **Joining enzyme**: These enzymes help in joining the DNA fragment. For example DNA ligase from *Escherichia coli* is used to join DNA fragments by forming a phosphodiester bond.



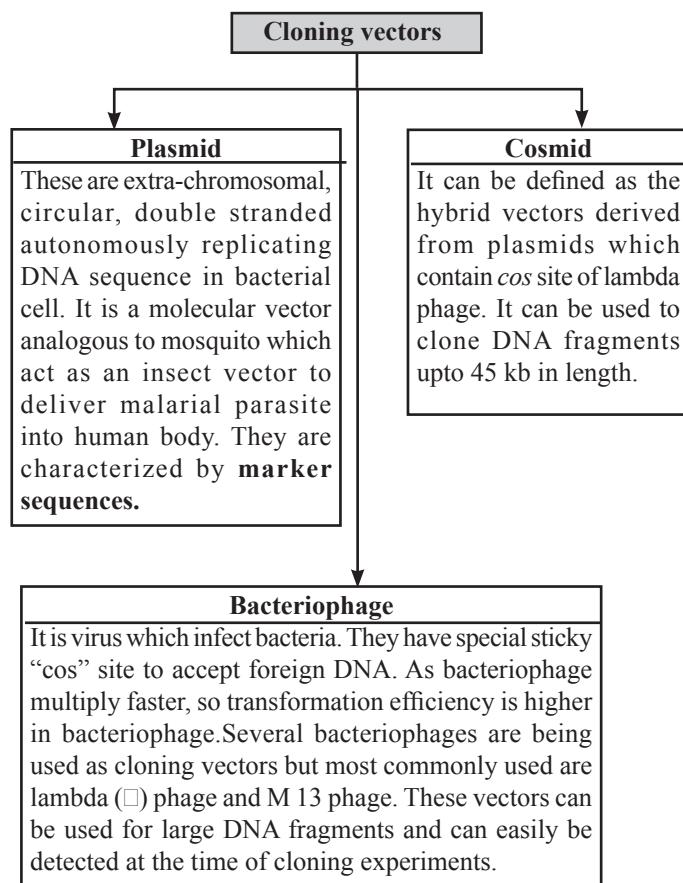
### Vectors

- **Vectors** are cloning vehicles required to transfer DNA of interest from one organism to another.

- *Desirable properties of cloning vector are -*

High copy number, Presence of origin of replication (Ori), Presence of selectable marker, Presence of unique recognition site or cloning site and Ability to sustain in bacterial cell

- *Ori* is sequence where replication starts and any piece of DNA linked here will be replicated. Ori also controls copy number of vector.
- *Selectable marker* allow to select those host cells that contain the vector amongst those which do not. Selectable markers helps in identifying eliminating nontransformants & selectively permitting the growth of transformants.
- *In cloning site*, vector should have single recognition site for restriction enzyme. Presence of more than one recognition site will cut the vector into many fragments.
- **Transformation efficiency** of vector is percentage of competent bacterial host cell receiving desired DNA at specific **recognition sequences** which are palindromic.



### Process of Recombinant Technology

Recombinant DNA (rDNA) is DNA created artificially by combining the DNA from two or more organisms into a single "recombinant" molecule. The term "recombinant DNA technology" also commonly known as 'DNA cloning,' 'molecular cloning' and 'gene cloning', refers to the transfer of a segment of DNA from one organism to another organism (the "host cell") where it reproduces.

## Following are the steps in Recombinant DNA Technology

### Step 1 : Isolation of genetic material

At first required DNA sequence from the donor cell is identified. Later the required DNA is cut by the help of restriction enzymes at specific site, which result is single stranded sequence with "stick ends".

### Step 2: Cutting of DNA of specific locations

Second, cloning vectors from the host cell are identified and removed with the same restrictive enzyme applied to the donor DNA. Cloning vectors are DNA molecules in which another DNA fragment (i.e., foreign DNA) can be integrated and which are capable of independently replicating themselves and the foreign DNA once inserted into the host cell.

### Step 3 : Amplification of Gene of interest using PCR

PCR stands for Polymerase Chain Reaction. It is the process of amplifying a desired gene of interest into a number of copies. In this reaction, multiple copies of the gene (or DNA) of interest is synthesised *in vitro* using two sets of primers (small chemically synthesised oligonucleotides that are complementary to the regions of DNA) and the enzyme DNA polymerase.

### Step 4 : Insertion of Recombinant DNA into the Host Cell/Organism

There are several methods of introducing the ligated DNA into recipient cells. Recipient cells after making them 'competent' to receive, take up DNA present in its surrounding. So, if a recombinant DNA bearing gene for resistance to an antibiotic (e.g. ampicillin) is transferred into *E. coli* cells, the host cells become transformed into ampicillin-resistant cells.

### Step 5 : Obtaining the Foreign Gene Product

After having cloned the gene of interest and having optimised the conditions to induce the expression of the target protein, one has to consider producing it on a large scale. If any protein encoding gene is expressed in a heterologous host, is called a **recombinant protein**.

## APPLICATION OF BIOTECHNOLOGY

### BT COTTON

*Bt* means *Bacillus thuringiensis*. It is a gram positive dwelling bacterium. It produces crystal [Cry] protein. This Cry protein is toxic to larvae of certain insects. Each Cry protein is toxic to a different group of insects. The gene encoding cry protein is called **cry gene**. This Cry protein is isolated and transferred into several crops.

A crop expressing a **cry gene** is usually resistant to the group of insects for which the concerned Cry protein is toxic. There are a number of them, for example, the proteins encoded by the genes *cryIAc* and *cryIAb* control the cotton bollworms, that of *cryIAb* controls corn borer. Some strains of *Bacillus thuringiensis* produce proteins that kill certain insects such as lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes). *B. thuringiensis* forms protein crystals during a particular phase of their growth. These crystals contain a toxic insecticidal protein. The **Bt toxin** protein exist as inactive protoxins but once an insect ingest the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually cause death of the insect.

## Problems related to GM foods are

- The transgene product may toxicity and or produce allergies.
- The enzyme produced by the antibiotic resistance gene could cause allergies, since it is a foreign protein.
- The bacteria present in the alimentary canal of the humans could take up the antibiotic resistance gene that is present in the GM food.

## Application of Biotechnology in Medicine

- The rDNA technology has been used in the production of safe and more effective therapeutic drugs.
- The recombinant therapeutics do not induce unwanted immunological responses, that are commonly observed with similar products isolated from non-human sources.

## Genetically engineered insulin (humulin)

- Human insulin consists of two short polypeptide chains : chain A and chain B, linked by disulphide bridges.
- Insulin is secreted as prohormone which has to be processed before it becomes a mature and functional hormone.

## Transgenic Animals

- Transgenic animals are those animals that have had their DNA manipulated to possess and express a foreign gene.
- Transgenic animals are used in the following ways :
  - (i) Transgenic animals can be specifically designed to allow the study of how genes are regulated and how they affect the normal functions of the body and its development. e.g., Information is obtained about the biological role of insulin like growth factor.
  - (ii) Transgenic animals are designed to increase our understanding of how genes contribute to the development of diseases; they are made to serve as models for human diseases.
  - (iii) Transgenic mice are being developed for use in testing the safety of vaccines. (e.g. polio vaccine).
  - (iv) Transgenic animals with more sensitivity to toxic substances are being developed to test the toxicity of drugs.

## Transgenic Plants

Transgenic Plants (of some species,) are easier to produce because plants have a lot of totipotent tissue (meristem) that can be grown in culture and then induced to develop into a whole plant. One of the most common methods utilizes a natural gene transfer system called the Ti-plasmid of *Agrobacterium tumefaciens* which transfers a piece of DNA called T-DNA into the genome of infected plants.

Table : Transgenic plants

Transgenic plants	Useful application
<i>Bt</i> Cotton	Pest resistance, herbicide tolerance and high yield. It is resistant to boll worm infestation.
<i>Flavr Savr Tomato</i>	Increased shelf-life (delayed ripening) and better nutrient quality.
Golden rice	Vitamin A-rich
Potato	Higher protein content
Corn, Brinjal	Insect resistance
Soyabean, Maize	Herbicide resistance

## Ethical Issues

- Genetic modification of organisms can have unpredictable/undesirable effects when such organisms are introduced into the ecosystem.
  - The modification and use of such organisms for public services has also resulted in problems with the granting of patents.
  - One such organisation is the Genetic Engineering Approval Committee (GEAC).

## Biopiracy

- Basmati rice grown in India is distinct for its unique

flavour and aroma, but an American company got patent rights on Basmati through the US patent and trademark office; the new variety of Basmati has been developed by this company by crossing an Indian variety with the semi-dwarf varieties.

- Now some nations are developing laws to prevent such unauthorised exploitation of their bioresources and traditional knowledge.
  - Some such developed countries use the bioresources and traditional knowledge of the other countries without proper authorisation and/or compensation to the countries concerned (Biopiracy)

# EXERCISE

ANSWER KEY

1.	(b)	2.	(d)	3.	(d)	4.	(a)	5	(b)	6	(c)	7	(b)	8	(d)
9	(d)	10	(d)	11	(a)	12	(d)	13	(d)	14	(b)	15	(b)	16	(a)
17	(a)	18	(c)	19	(a)	20	(a)	21	(a)	22	(d)	23	(d)	24	(c)
25	(a)	26	(b)	27	(d)	28	(c)	29	(d)	30	(c)	31	(a)	32	(b)
33	(d)	34	(c)	35	(a)	36	(d)	37	(c)	38	(c)	39	(a)	40	(c)

## Chapter

# 3

# EVOLUTION AND ECOLOGICAL BIODIVERSITY

## EVOLUTION

The branch of life science for the study of 'origin of life' and evolution of different forms of life on earth was called **bioevolution or evolutionary biology** by Mayer, (1970). The word evolution means to unfold or unroll or to reveal hidden potentialities. Evolution simply means an orderly change from one condition to another. Evolution is slow but continuous process which never stop.

### ORIGIN OF LIFE

- Origin of life is the process by which living organisms developed from inanimate matter which is generally thought to have occurred on Earth between 3800 - 4200 millions years ago. First life evolved 3800-4200 million years back. There are several theories about the origin of life, like big bang theory, theory of special creation, theory of eternity, cosmozoic theory etc.

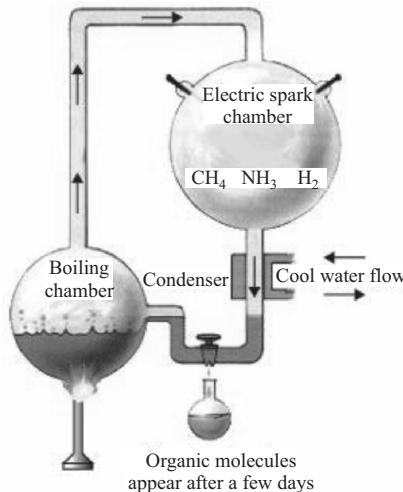
### Chemosynthetic Theory of Origin of Life

The widely accepted theory is the Chemosynthetic theory of origin of life proposed by A.I. Oparin. It states that life has

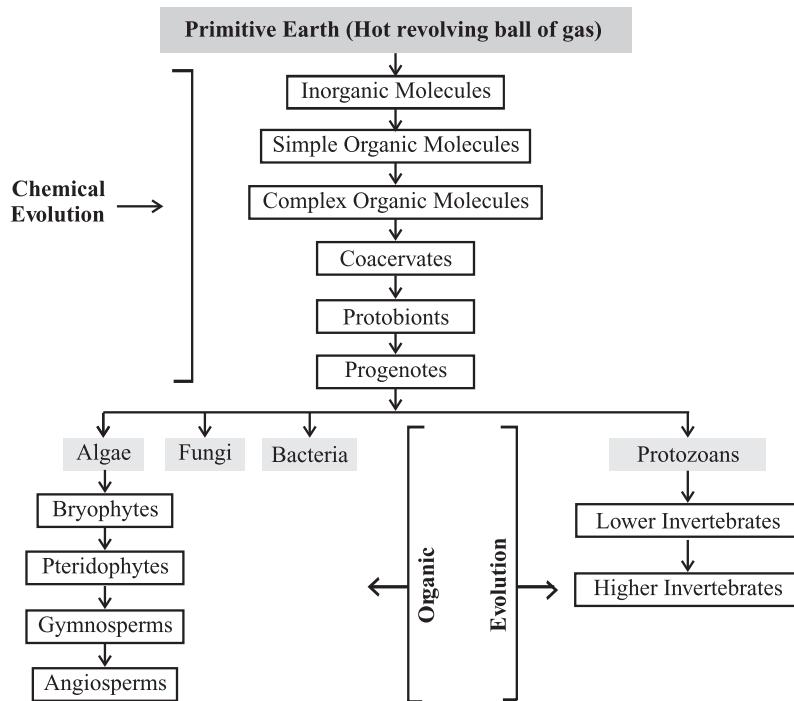
originated on earth through a series of combinations of chemical substances in the distant past. All these processes took place in water.

- The early atmosphere contained ammonia ( $\text{NH}_3$ ), water vapour ( $\text{H}_2\text{O}$ ), hydrogen ( $\text{H}_2$ ), methane ( $\text{CH}_4$ ). At that time there was no free oxygen.

### Miller and Urey Experiment



## CHEMICAL EVOLUTION AND ORGANIC EVOLUTION



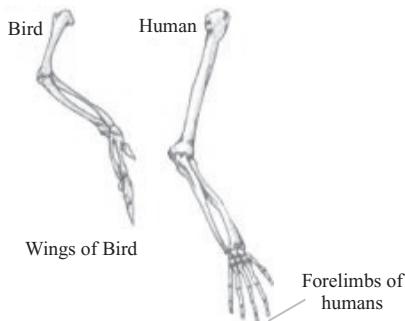
## Comparative Anatomy and Morphology

- Different animals and plants show dissimilarities in their structure but in some characters they show similarity. These similarities provide one of the most concluding evidence of organic evolution.
- Similarities are of two types : **homology** and **analogy**.

Let us discuss some of the important sources that provide evidences for evolution.

- Homologous organs:** Homologous organs are similar in origin (or are embryologically similar) but perform different functions.

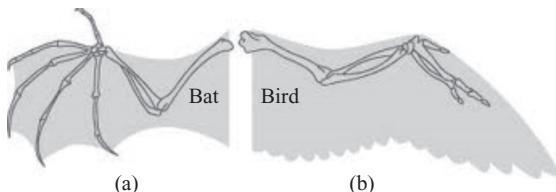
For example, the forelimbs of humans and the wings of birds look different externally but their skeletal structure is similar.



**Homologous Organs:** (a) Wings of bird and  
(b) Forelimbs of humans

- Analogous organs:** Analogous organs have different origin but perform similar functions.

For example, the wings of a bird and a bat are similar in function but this similarity does not mean that these animals are more closely related.



**Analogous Organs:** (a) Wings of bat and  
(b) Wing of a bird

## Vestigial organs

- The organs which are present in reduced form and do not perform any function in the body but correspond to the fully developed functional organs of related animals are called **vestigial organs**.
- Human body possess about **180 vestigial organs**. Some of these are - nictating membrane, muscles of pinna (auricular muscles), vermiform appendix, coccyx, canine teeth, third molars (wisdom teeth), segmental muscles of abdomen, caecum, body hairs, nipples in male and ear pinna.

## Theories of Organic Evolution

- Four main theories to explain theories of evolution are-
  - Lamarckism
  - Darwinism
  - Mutation theory

- Modern concept of evolution (synthetic theory)

## Lamarckism

- Theory of inheritance of acquired characters* is the first theory of organic evolution proposed by *Jean Baptiste de Lamarck* (1744-1829). Lamarck coined the terms
- It states about the internal vital forces, effect of environment and new needs, use and disuse of organs and inheritance of acquired characters. These acquired characters are passed from one generation to another which results in new species.
- Examples in support of Lamarckism are Long neck and high fore limb of Giraffe, Aquatic birds stretched their toes and developed web, Snakes lost their legs, Deers became good runners by the development of strong limbs and streamlined body and retractile claws of carnivorous animals.

## Darwinism

- "Darwinism" or "The theory of Natural Selection" was proposed jointly by *Charles Darwin* and *A.R. Wallace*. This theory was explained by Darwin in his book 'On the origin of species by the means of Natural Selection' (1859).
- Darwin was influenced by two books-
  - "Principles of Population" by Malthus.
  - "Principles of Geology" by Charles Lyell.

## Main features of theory of Natural Selection

- Over production**
  - All organisms have capability to produce enormous number of offspring, organisms multiply in geometric ratio.
  - E.g.
  - (i) Plants produce thousands of seeds.
  - (ii) Insects lay hundreds of eggs.
  - (iii) One pair of elephant gives rise to about six offspring and if all survived in 750 years a single pair would produce about 19 million elephants. Thus, some organisms produce more offspring and others produce fewer offspring. This is called differential reproduction.

## Mutation Theory

- The mutation theory was put forward in 1901 by **Hugo de Vries**.
- The plant on which de Vries had experimented was *Oenothera Lamarckiana*.
- Role of mutations in evolution is genetic variations.
- Mutations are discontinuous variation called **sports** by **Darwin** and **saltatory variation** by **Bateson**.
- Features of mutation theory are-*
  - It forms the raw material for mutation.
  - It appears suddenly and produce their effect immediately.
  - Mutations are markedly different from the parents and there are no intermediate stages between the two.
  - Mutations can appear in all directions.

## HUMAN EVOLUTION

Evolution of man probably took place in *Central Africa*. Human evolution states that humans develop from primates or ape like

## Evolution and Ecological Biodiversity

ancestors. **Anthropology** is the study of human evolution and culture. It deals with the fossils of pre-historic and living man.

**Homo erectus** was the first human to leave Africa and move to Europe and Asia. It had a sloping forehead, flattish face and brain size between 850-1100 ml. These humans exploited more habitats than their ancestors. They were first to use fire.

**Homo nenderthals** were the first humans to have adopted to life in cold climates of Europe and Asia. They had strong physique and large brain. They wore clothes, made a range of tools and used fire to keep warm. They were the first humans to bury their dead.

**Homo sapiens** or the “modern human” first evolved in Africa. They had a large brain, were considerably intelligent and had developed the ability to use language. Modern man took control

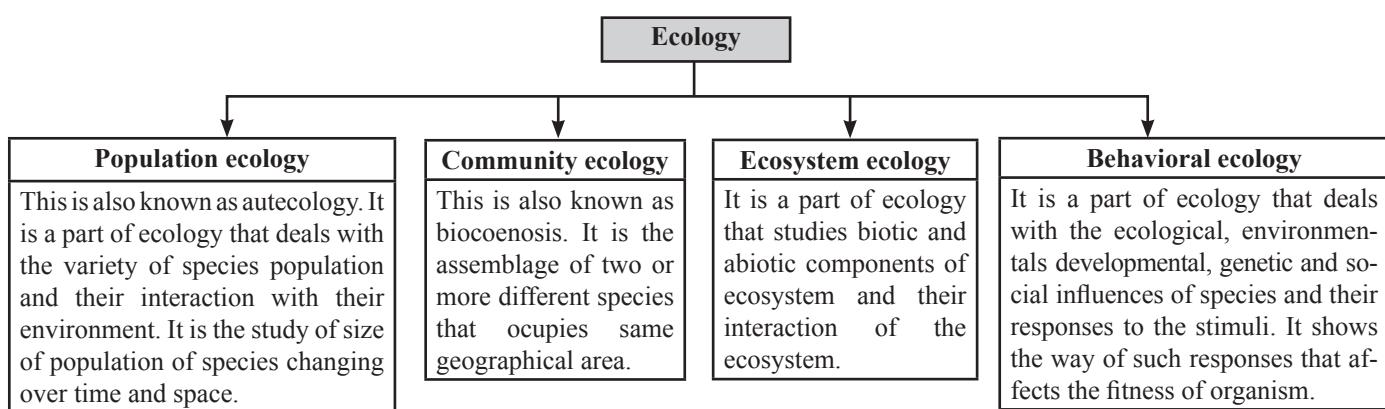
of their surroundings as they developed agriculture, societies and technology.

### Handy Facts

- Carolus Linnaeus gave the term ‘Homo Sapiens’.

## ECOLOGY AND BIODIVERSITY

The term “ecology” was coined in 1866 by German scientist **Ernst Hackel**. It is the study of biota, environment and their interaction. Ecology also provides information about the benefits of ecosystems and how we can use Earth’s resources in ways that leave the environment healthy for future generations. Ecology can be studied in the following heads.

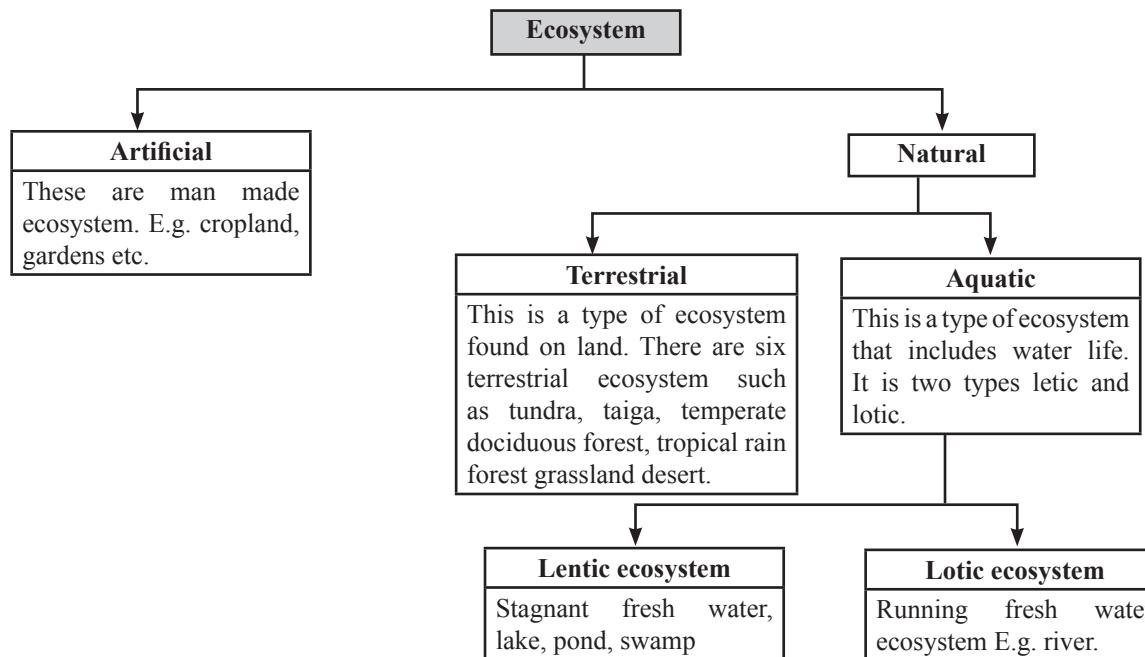


## ECOSYSTEM

- The term ‘ecosystem’ was proposed by a British ecologist **A.G. Tansley (1935)**. It represents the basic fundamental, functional unit of ecology which comprises of the biotic community together with its abiotic

(non-living) environment. Ecosystem simply means ‘ecological systems’. Ecology is the study of ecosystems.

- Ecosystem is the functional unit of nature where living organisms interact with each other and with their environment.



- Ecosystem is normally an **open system** because there is a continuous and variable entry and loss of energy and materials. Ecosystem is known by different terms i.e., biogeocoenosis or geobiocoenosis or microcosm or ecosystem or biosystem etc., the whole earth can be called biosphere or ecosystem.

## Components of Ecosystem

- Ecosystem is composed of a variety of abiotic (non-living) and biotic (living organisms) components that function in an interrelated fashion.

## Structure and Function of Ecosystem

- The structure of an ecosystem can be expressed by the following terms –*
  - Species compositor* : Plant and animal species found in an ecosystem.
  - Stratification* : Vertical layers of plants.
  - Standing crop* : Amount of biomass.
  - Standing state* : Amount of inorganic substances.
- The proper functioning of an ecosystem takes place through the following processes:
  - Productivity*
  - Decomposition*
  - Relationship of producers and consumers*
  - Flow of energy through different trophic levels, and*
  - Cycling of nutrients.*

## Decomposition

- Decomposition* is the breakdown of complex organic compounds of dead bodies of plants and animals into simpler inorganic compounds like  $\text{CO}_2$ , water & various nutrients.
- The organisms carrying out decomposition are called *decomposers*. It includes *micro-organisms* (bacteria and fungi), *detritivores* (earthworm) and some *parasites*.

## Process of Decomposition

- Decomposition is physical as well as chemical in nature and consists of the following processes:*

### (i) Fragmentation

It is the formation of smaller pieces of dead organic matter or detritus by detritivores. Due to fragmentation, the surface area of detritus particles is greatly increased.

### (ii) Catabolism

Chemical conversion of detritus into simpler inorganic substances with the help of bacterial and fungal enzymes is called catabolism.

### (iii) Leaching

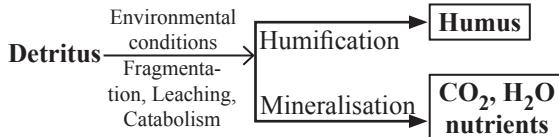
Water soluble substances (formed as a result of decomposition) are leached to deeper layers of soil.

### (iv) Humification

If decomposition leads to the formation of colloidal organic matter (humus), the process is called **humification**. Humus is highly resistant to microbial action and undergoes extremely slow decomposition. It serves as a reservoir of nutrients.

### (v) Mineralisation

Formation of simpler inorganic substances (like  $\text{CO}_2$ , water and minerals) is termed **mineralisation**.



## FOOD CHAIN

- Food chain* is an order or sequence of different organisms which are arranged in a way that the food is passed from one type of organism to other organisms such that the organisms of one order or trophic level are the food of the organisms of next order.

## Types of food chains

The food chains are of two types, namely:

- (i) *Grazing food chain* : This food chain starts from plants, goes through herbivores and ends in carnivores. ex- Plant → Herbivores → Primary Carnivores → Sec. Carnivores. This type of food chain depends on the autotrophs which capture the energy from solar radiation.
- (ii) *Detritus food chain* : It starts from dead organic matter and ends in inorganic compounds. There are certain groups of organisms which feed exclusively on the dead bodies of animals and plants. These organisms are called **detritivores**. The detritivores include algae, bacteria, fungi, protozoans, insects, millipedes, centipedes, crustaceans, mussels, clams, annelid worms, nematodes, ducks, etc.

## FOOD WEB

- Food web* refers to a group of inter-related food chains in a particular community. Under natural conditions, the linear arrangement of food chain hardly occurs & these remain indeed inter-connected with each other through different types of organisms at different trophic level.
- Food webs are very important in maintaining equilibrium (homeostasis) of ecosystem.

**Example :** In a grassland ecosystem

- Grass → Grasshopper → Hawk
- Grass → Grasshopper → Lizard → Hawk
- Grass → Rabbit → Hawk
- Grass → Mouse → Hawk
- Grass → Mouse → Snake → Hawk

## ECOLOGICAL PYRAMIDS

- The pyramidal representation of trophic levels of different organisms based on their ecological position is called Ecological pyramids.
- Three ecological pyramids which are studied are – **pyramid of number**, **pyramid of biomass** and **pyramid of energy**.

## ECOLOGICAL SUCCESSION

- Ecological succession is the successive development of different biotic communities at the same site. The communities develop one after another till the development of a community which is near equilibrium with the environmental conditions. This is called **climax community**.
- Climax community is the stable perpetuating and final biotic community that develops at the end of biotic succession. It has maximum diversity & niche specialization.
- The first biotic community which invades a base area is called **pioneer community**. It is characterized by high growth rate and short life span.
- The transitional communities which develop during the ecological succession or in between the pioneer and climax community are called **seral communities**.

### Types of Succession

- Succession is of *two types* : Primary and Secondary.
- *Primary succession* : It is the ecological succession occurring in an area where no organisms are found, like bare rocks.
- *Secondary succession* : This type of succession takes place in those areas where all the previous biotic communities have been destroyed, e.g.- burned forests, flooded fields.

### Hydrach/Hydrosere Succession

- Hydrosere is a sequence of communities that reflects the developmental stages in a plant succession, which commences on soil, submerged by fresh water.
- *Hydrach succession* takes place in wetter areas like ponds, lakes etc. and the successional series progress from hydric to the mesic conditions.

### Xerarch Succession

- Xerarch succession starts in dry areas & the series progress from xeric to mesic conditions.
- Stages in xerarch occurring on bare rock is called **lithosere**.
- Pioneer of this succession depends on climate. In tropical areas the pioneers are cyanobacteria or blue green algae. In temperate areas, they are crustose lichens.
- The ecological succession on bare rocks includes the development of following communities –  
Crustose lichens → foliose lichens → mosses → grasses → shrubs → trees.

## NUTRIENT CYCLING

- These are the cyclic events by which various nutrients which are essential for the living organisms are transferred from one form to other. During these cycles, the nutrients pass from the biotic components to the abiotic components and vice-versa; hence these are also called *biogeochemical cycles*.
- Two types of nutrient cycles are –
  - (i) *Gaseous cycles* (nitrogen, oxygen, carbon cycles)
  - (ii) *Sedimentary cycles* (phosphorus, sulphur cycles)
- In gaseous cycle, the main reservoirs of chemicals are the atmosphere and ocean.
- In sedimentary cycles, the main reservoirs are soils and rocks.

### Carbon Cycle

- Discovered by Joseph priestley and Antoine Lavoisier
- Carbon is present in carbohydrates, proteins and fats.
- Carbon is taken up by green plants as  $\text{CO}_2$  for photosynthesis.
- Carbon is present as  $\text{CO}_2$  in atmosphere, as graphite and carbonates in rocks and also in fossil fuels (coal, petroleum).
- Ocean are big reservoirs of carbon.
- Carbon is released as  $\text{CO}_2$  in atmosphere during –
  - (i) respiration of plants and animals
  - (ii) burning of fossil fuels
- Carbon is also released in atmosphere as methane by rice fields and marshes.

### Phosphorus Cycle

- Phosphorus is an important element for living beings.
- The cycling of phosphorus between biotic & abiotic com-

- ponents of the environment represent phosphorus cycle.
- Phosphorus is present in biomembranes (as phospholipids), nucleic acids (as phosphoric acid), nucleotides (as AMP, ADP, ATP etc) and bones and teeth (as hydroxyapatite).
- Consumers obtain phosphorus directly or indirectly from plants.
- Phosphorus is also present in phosphatic rocks.
- Phosphorus is released during the decomposition of plant and animal remains.
- The released phosphorus may reach the deeper layers of soil and gets deposited as phosphate rocks.
- Phosphorus containing rocks are mined for manufacture of fertilizers, which provide an additional supply of an organic phosphates to the abiotic environment.

## NITROGEN CYCLE

- *Nitrogen cycle* is a cyclic process that involves conversion of elemental nitrogen of atmosphere into simple molecules that enter living beings forming complex molecules. Then these complex molecules are broken down to release nitrogen back into the atmosphere.
- Earth's atmosphere has about 78% of nitrogen gas. It forms essential constituents of all living organisms and is essential for many biological processes. It is present in all amino acid, nucleic acid and vitamins.

**Broadly, the nitrogen cycle in the biosphere involves five main steps:**

*Atmospheric nitrogen → Nitrogen fixation → Nitrogen assimilation → Ammonification → Nitrification → Denitrification*

- Plants cannot absorb nitrogen from the atmosphere. So, how is atmospheric nitrogen then utilized by plants? It is through nitrogen fixation.
  - (i) *Nitrogen fixation*: It is the process of converting atmospheric nitrogen into usable forms like nitrates. It is of three types:
    - *Biological nitrogen fixation*: Certain bacteria and blue-green algae can fix atmospheric nitrogen directly into ammonia that combines with organic acids to form amino acids.
    - *Atmospheric nitrogen fixation*: During lightning and thunder, the high temperature and pressure in the air convert atmospheric nitrogen into oxides of nitrogen that can dissolve in water to produce nitric and nitrous acids. The nitrogen oxide then dissolve in rain water and pass down as nitrites and nitrates.
  - (ii) *Nitrogen assimilation*: Nitrogen assimilation is carried out by plants. Plants cannot absorb nitrogen in its elemental form. It has to be first converted into nitrates for the use of plants by the process of nitrogen fixation. The atmospheric nitrogen after nitrogen fixation gets converted into nitrates which are then absorbed by plants. Nitrate first changes into ammonium state. Ammonium ions combine with organic acids to form amino acids. Amino acids give rise to proteins and nucleotides, which in turn produce nucleic acids.  
*Animals take organic nitrogen directly or indirectly from plants.*
  - (iii) *Ammonification*: It is the process of conversion of complex organic compounds like proteins into ammonia, in the presence of ammonifying bacteria or putrefying bacteria.

- (iv) **Nitrification:** It is the process of conversion of ammonia into nitrites and nitrates. Nitrification is brought about by nitrifying bacteria such as *Nitrosomonas* and *Nitrobacter*.
- (v) **Denitrification:** It is the process of conversion of nitrate salts present in the soil and water to gaseous nitrogen which escapes into atmosphere. It takes place with the help of bacteria called *Pseudomonas* present in water logged soils. Denitrification reduces soil fertility.

## Water Cycle (Also known as hydrological cycle)

**Water cycle** is the cyclic process of water between various components of biosphere especially evaporation of water from sea, falling on land and then flowing back into sea by rivers. Water is not evenly distributed throughout the surface of the earth. Major percentage of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water (in the form of atmospheric water vapors, ground and soil water). The ice caps and the water deep in the oceans form the reservoir.

## Sulphur Cycle

- Sulphur is the tenth abundant non metallic element, which is brittle, tasteless and odorless. It is a component of litamin, protein and hormones and plays very important role in both climate and ecosystem.
- Its cycle begins with weathering of rocks, due to which sulphur is released in air and converted into sulphate ( $\text{SO}_4^-$ ). Later it is taken up by plants, and microorganisms and converted into organic forms, which is consumed by animals and moves into food chain. Dead and decayed organism after decomposition again releases sulphur in atmosphere.

## BIODIVERSITY

Biodiversity means diversity or heterogeneity at all levels of biological organization, i.e., from macromolecules of the cells to the Biomass. The term Biodiversity was popularized by the sociologist- Edward Wilson.

- The important levels of biodiversity are: *Genetic diversity, Species diversity and Ecological diversity*

## Genetic Diversity

- It is the diversity at genetic level, or at subspecies level, i.e. below species level, in a single species.
- For example there are about 1000 varieties of mango (*Mangifera indica*) and 50,000 strains of rice.
- The genetic diversity helps the population to adapt.
- The low diversity leads to uniformity.
- The genetic variability is therefore, considered to be the raw material for speciation.

## Species Diversity

The measurement of species diversity is its richness, i.e. the number of species per unit area. The greater is the species richness the more will be the species diversity.

## Ecological Diversity

It is the diversity at community level. It can be of 3-types

### Alpha ( $\alpha$ ) diversity

It is the diversity of organisms within the *same community or habitat*.

### Beta ( $\beta$ ) diversity

It is the diversity *between communities or different habitats*. Higher the heterogeneity in the altitude, Humidity and Temperature of a region, the greater will be the dissimilarity between communities, and higher will be the  $\beta$  diversity.

### Gamma ( $\gamma$ ) diversity

It is the diversity of organisms over the *entire geographical area*, covering several ecosystems or habitats and various trophic levels and food webs. Such diversity is most stable and productive.

### Loss of Biodiversity

- There is continuous loss of the earth' treasure of species. For example, the colonization of tropical pacific Islands by human has led to extinction of more than 2000 species of native birds.
- The Red list of IUCN documented the extinction of 784 species in last 500 years. The last 20 years witnessed the disappearance of 27 species.
- Some important examples of recent extinctions are. *Dodo* (Mauritius), *Quagga* (Africa), *Thylacine* (Australia), *Steller Sea-cow* (Russia), and subspecies of Tiger, like *bali, javan* and *caspian*.

### Causes of Loss of Biodiversity

The accelerated rate of species-extinction is largely due to human activities. There are 4-major causes, called '**The Evil Quartet**', for the loss of biodiversity are: Habitat loss and fragmentation, Overexploitation, Invasion of Alien or exotic species and Co-extinctions

### Habitat loss and fragmentation

- The cutting trees, burning of forest, construction of mines, dams, harbors, industries and buildings for human settlement has also affected the biodiversity.
- *The Habitat destruction is the primary and major reason for the loss of biodiversity.*

### Overexploitation

- Many species – extinction, like that of Stellar sea-cow and Passenger pigeon, in last 500 years, are due to overexploitation by humans.
- Ever-increasing need of organism for food and shelter leads to overexploitation.
- It includes as overharvesting, overhunting, overfishing etc.

### Invasion of Alien or exotic species

When alien species are introduced into an explored area, some of the species turn invasive and cause decline or extinction of indigenous species. For example –

- Introduction of *Nile perch* into lake Victoria (E. Africa) led to the extinction of more than 200 species of Cichlid fish in the lake.
- Introduction of weed species, like *Carrot grass (Parthenium)*, *Lantana* and *water hyacinth (Eichornia)* has posed threat to the native species and damage to environment.

### Co-extinctions

- Whenever a plant or animal species becomes extinct, its obligatory-associated species also becomes extinct.

## CONSERVATION OF BIODIVERSITY

Conservation means management of human-use of the biosphere so that it may yield greatest long term (sustainable) benefits for the present generation by maintaining its potential to meet the needs and aspiration of future generations.

The **Conservation of biodiversity** can be *in situ* (on site) or *ex situ* (off site)–

### In Situ Conservation

- In such conservation the endangered species are protected in their natural habitat with entire ecosystem.
- The conservationists, on global basis, have identified certain **Biodiversity Hot Spots** (with high level of species richness and high degree of endemism).
- The hot spots are also the regions of accelerated habitat loss. The number of such hot spots is now 34. These hot spots cover only 1 to 2 percent of earth's land area, but according to one estimate, the strict protection in them can reduce the on-going mass extinction by almost 30%.
- The 3-biodiversity hot spots of India, that cover rich-biodiversity regions, are : Western Ghat, Himalaya and Indo-Burma
- The *in situ* conservation, in India, is done through 15-*Biosphere reserves*, 90-National Parks, more than 450 sanctuaries and several *Sacred Groves* or the tracts of forests.

### Biosphere reserves

They represent natural biomes which contain unique biological communities. They include land as well as coastal environment. Biosphere reserves were created under MAB (Man and Biosphere) programme of UNESCO in 1971. Till May 2000 there were 408 biosphere reserves in 94 countries of the world. In India there are 15 biosphere reserves. There are 3-zones in a biosphere reserve.

- *Core (natural) zone* - It is inner most zone which is legally protected and completely undisturbed from human interference,
- *Buffer zone* - In this zone limited human activity is allowed for research and education purposes.
- *Transition (manipulation) zone* - It is the outermost zone of biosphere reserve in which large number of human activities are permitted, eg. Cultivation, domestication, harvesting of natural product, grazing, forestry, settlement and recreation etc. In this zone the traditional life style of tribals is protected with their live-stock.

### Functions of biosphere reserves

- For conservation of landscape, ecosystem and genetic resources.
- For economic development.
- For scientific research, education and for exchange of information at national and global level.

The list of biosphere reserves of India is given below:

- |                       |                         |
|-----------------------|-------------------------|
| 1. Nilgiri            | 2. Nandadevi            |
| 3. Uttrakhand         | 4. Nokrek (Meghalaya)   |
| 5. Andamans           | 6. Simlipal (Orissa)    |
| 7. Kaziranga (Assam)  | 8. Gulf of Mannar (T.N) |
| 9. Thar Desert        | 10. Sundarbans (W.B.)   |
| 11. Kanha (M.P.)      | 12. Runn of Kutch (Guj) |
| 13. Nicobar           | 14. Manas (Assam)       |
| 15. Namdapha (Ar. P.) |                         |

### National Parks

They are reserved for the betterment of wild life, both *fauna and flora*. In national parks private ownership is not allowed. The grazing, cultivation, forestry etc. is also not permitted. The first national park of the world, Yellow stone, in U.S.A., was founded in 1872.

Important state wise national parks of India are –

<b>Jammu and Kashmir</b>	- Dachigam, Salim Ali
<b>Assam</b>	- Kaziranga, Manas
<b>Meghalaya</b>	- Nokrek
<b>West Bengal</b>	- Sunderbans
<b>Bihar</b>	- Hazaribagh, Palamau
<b>Uttaranchal</b>	- Corbett ( Hailey ), Nanda Devi, Valley of flowers, Rajaji
<b>U. P.</b>	- Dudhwa
<b>Gujrat</b>	- Gir, Marine
<b>Rajasthan</b>	- Sariska, Ranthambore, Desert
<b>Madhya Pradesh</b>	- Kanha, Sanjay, Madhav, Panna, Bandhavgarh, Van Vihar, Fossil
<b>Orissa</b>	- Simlipal
<b>Karnataka</b>	- Bandipur
<b>Kerala</b>	- Silent Valley, Periyar

These national parks are running **Tiger Project** also. (*The maximum national parks are present in Madhya Pradesh*).

### Sanctuaries

In sanctuaries the protection is given to **fauna** only. The important wild life sanctuaries are Chilka wild life sanctuary (*Orissa*), Bharatpur Bird Sanctuary (*Rajasthan*), Sultanpur Bird sanctuary (*Haryana*) and Jalpara sanctuary (*West Bengal*). Maximum sanctuaries belong to Andaman and Nicobar.

The *Project Tiger* was launched in India in year **1973** with the assistance of *WWF* (World Wild life Fund) after the recommendation of *IBWL* (Indian Board of Wild Life).

The sacred groves are found in Khasi and Jaintia hills (Meghalaya), Aravalli hills (Rajasthan), Western ghats (Karnataka and Maharashtra) and Sarguja, Chanda and Bastar areas of Madhya Pradesh.

### Ex situ Conservation

In such type of conservation the threatened animals and plants are taken out of their natural habitat and are protected in special parks or areas like, *Zoological parks*, *Wild life safari parks* and *Botanical gardens\** etc. The ex situ conservation also includes

- *Cryopreservation* of gametes of threatened species in viable and fertile form.
- Fertilization of eggs *in vitro* and propagation of plants through '*Tissue culture methods*'
- Preservation of seeds through *Seed banks*

# EXERCISE

1. Fossils are
  - remains of deadly plants and animals that are extinct
  - remains of plants and animals that are still surviving
  - both (a) & (b)
  - none of the above
2. Speciation is
  - making of independent species
  - macro evolution
  - new environmental ways for existence
  - all of the above
3. The scientific name for the maximum modern man among these is
  - Homosapiens*
  - Human species
  - Neanderthalensis*
  - Homo sapiens*
4. Modern man evolved from
  - Java man
  - Peking man
  - Neanderthal man
  - cro-magnon* man
5. The book 'Origin of Species' was written by
  - Darwin
  - Lamarck
  - Mendel
  - de Vries
6. **Column-I**                   **Column-II**

A. Wing of a bat and P. darwin wing of a bird	B. Dihybrid ratio Q. Mendel
C. Natural selection R. Analogous organ	D. Arm of a man and S. Homologous wing of a bird organs
(a) A -S; B - P; C - Q; D - R	(b) A - R; B - Q; C - P; D - S
(c) A -R; B -Q; C - P; D- S	(d) A - S; B - P; C-P; D-Q
7. Consider the following statements :
  - Life can originate on earth from pre-existing life only.
  - The atmosphere of the primitive earth was reducing.

Which of these statement(s) is/are correct ?

  - A only
  - B only
  - Both A and B
  - Neither A nor B
8. The remains of mummies denote
  - The kind of preservative technique in that era
  - Evolutionary reveal
  - Historical reveals
  - All of the above
9. Vestigial organs are those present in the living beings without functions gives and mark the correct option for vestigial organs in humans
  - Vermifrom appendix
  - mammary glands of male
  - nictitating membrane in eyes
  - all of the above
10. In evolution which animals class is between entirely water living to land
  - fishes and reptile
  - fishes & reptiles
  - reptiles and Amphibion
  - reptiles and birds
11. To which of the following types of animals are Salamanders closely related? [NDA]
  - Dolphins and Whales
  - Frogs and Toads
  - Prawns and Crabs
  - Seals and Walruses
12. In terms of the evolution of organisms, which one among the following is the most advanced? [NDA]
  - Bat
  - Pigeon
  - Shark
  - Vulture
13. Analogous organs are
  - different in origin but perform similar functions.
  - common in origin and perform common functions.
  - common in origin but perform different functions.
  - different in origin and perform different functions.
14. The term 'Survival of Fittest' was used by
  - Charles Darwin
  - Herbert Spencer
  - Jean Baptiste
  - Hugo de Vries
15. **Column-I**                   **Column-II**  
**(Name of the Scientist) (Contributions)**

A. Charles Darwin	I. Mutation theory
B. Lamarck	II. Germ plasm theory
C. Hugo de Vries	III. Philosophie Zoologique
D. Ernst Haeckel	IV. The Origin of species
E. August Weismann	V. Biogenetic law VI. Essay on population
(a) A - IV; B - III; C - I; D - V; E - II	
(b) A - IV; B - III; C - V; D - I; E - VI	
(c) A - IV; B - VI; C - V; D - III; E - I	
(d) A - II; B - III; C - I; D - V; E - II	
16. What was the most significant trend in the evolution of modern man (*Homo sapiens*) from his ancestors?
  - Shortening of jaws
  - Binocular vision
  - Increasing cranial capacity
  - Upright posture.
17. Who proposed that the first form of life come from pre-existing non- living molecules?
  - Oparin and Haldane
  - de Vries and Haldane
  - Darwin and Lamarck
  - Louis Pasteur and Miller
18. A biogeographic region with significant reservoir of biodiversity that is under threat from humans is called as [NDA]
  - bioendangered region
  - biodiversity hotspot
  - biodiversity reservoir
  - environmentally endangered region
19. Which one of the following processes of weathering belongs to both mechanical and chemical weathering? [NDA]
  - Crystallization
  - Exfoliation
  - Hydration
  - Carbonation

21. In the context of ecology and environment, what does the Red Data Book pertain to? [CDS]  
 (a) Details of harmful levels of various pollutants  
 (b) A complete list of all endangered plants and animals  
 (c) A description of the consequences of nuclear holocaust  
 (d) A description of the sociological and psychological consequence of genetically modified plants and animals

22. Which of the following is not a bird? [CDS]  
 (a) Bat (b) Emu  
 (c) Kiwi (d) Ostrich

23. The branches of this tree root themselves like new trees over a large area. The roots then give rise to more trunks and branches. Because of this characteristic and its longevity, this tree is considered immortal and is an integral part of the myths and legends of India. Which tree is this? [CDS]  
 (a) Banyan (b) Neem  
 (c) Tamarind(Imli) (d) Peepal

24. Which one of the following is not a feature of eutrophic lakes? [CDS]  
 (a) Blooms are frequent in eutrophic lakes  
 (b) Plant nutrient flux is high  
 (c) Primary productivity is low  
 (d) Dominated by blue green algae

25. Polar bears are carnivores and prey on many arctic birds and fishes. However, under natural conditions, no one found polar bears predating any penguin. This is because [CDS]  
 (a) penguins have chemical substance in their muscles which is toxic to polar bears  
 (b) penguins are gregarious and always move in groups. Therefore, a polar bear cannot approach them  
 (c) polar bears and penguins never coexist under natural conditions. The former lives in the North Pole while the latter lives in the South Pole  
 (d) None of these

26. **List-I**  
**(Indian wild life species)**

A. Asiatic wild ass  
 B. Barasingha  
 C. Chinkara  
 D. Nilgai

**List-II**  
**(Scientific names)**

1. *Boselaphus tragocamelus*  
 2. *Cervus duvaucelii*  
 3. *Equus hemionus*  
 4. *Gazella gazella*

(a) A – 2; B – 3; C – 1; D – 4  
 (b) A – 3; B – 2; C – 4; D – 1  
 (c) A – 2; B – 3; C – 4; D – 1  
 (d) A – 3; B – 2; C – 1; D – 4 [IAS Prelim]

27. With reference to soil conservation, consider the following practices :  
 1. Crop rotation 2. Sand fences  
 3. Terracing 4. Wind breaks  
 Which of the above are considered appropriate methods for soil conservation in India.  
 (a) 1, 2, and 3 only (b) 2 and 4 only  
 (c) 1, 3 and 4 only (d) 1, 2, 3 and 4 [IAS Prelim]

28. All are ecosystems except  
 (a) Forest (b) Grassland  
 (c) Garden (d) Sun

29. All producers are  
 (a) Food making organisms  
 (b) Make food in the presence of sunlight with chlorophyll  
 (c) All autotrophs  
 (d) All the above

30. Which one of these is not a food chain  
 (a) Trees → Deer → Lion  
 (b) Plants → Man → Anaconda  
 (c) Plants → Insects → Frog → Snake → Kite  
 (d) Small → plants → Crabs → Fish → Swan → bird

31. The last chain of food are  
 (a) Producers (b) Decomposers  
 (c) Parasites (d) None of the above

32. The accumulation of non-biodegradable substances in a food chain in increasing amount at each higher trophic level is known as:  
 (a) Accumulation (b) Eutrophication  
 (c) Pollution (d) Bio magnification

33. Flow of energy in an ecosystem is always  
 (a) Unidirectional  
 (b) Bidirectional  
 (c) Multi directional  
 (d) No specific direction

34. Consider the following statements :  
 A. Earth is kept warm due to green house flux.  
 B. The reproduction and other activities of living organisms are affected by the abiotic components of ecosystem.  
 C. Ecology is the scientific study of the interaction of organisms with each other and the environment.  
 Which of these statement(s) is/are correct ?  
 (a) A and B (b) B and C  
 (c) A, B and C (d) None of these

35. Energy is maximum in ..... trophic level and minimum in the ..... trophic level  
 (a) producer, consumer  
 (b) consumer, decomposer  
 (c) top, Bottom  
 (d) bottom, Top

**ANSWER KEY**

# Chapter

# 4

# TISSUE, PHYSIOLOGY OF PLANTS AND ANIMALS

## TISSUE

Tissue is a group of cells with common origin, structure and function that work together to perform a particular function. For example, Blood, bone, cartilage are some examples of

animal tissues while xylem, phloem, parenchyma etc are different types of tissues found in plants. *The study of tissue is called histology. The term was coined by Meyer.*

### PLANT TISSUES

*On the basis of their ability to divide, plant tissues are divided into two types:*

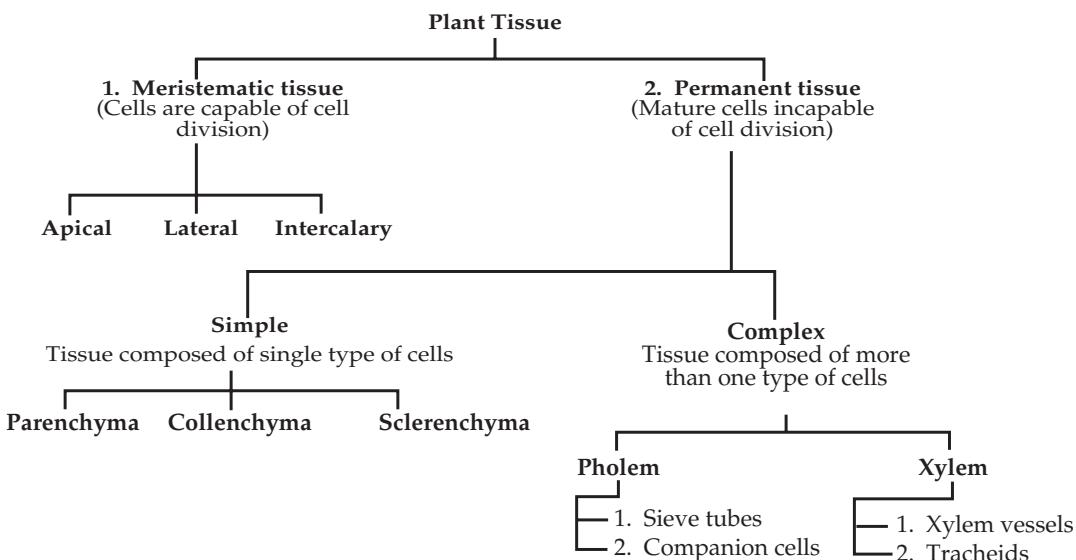
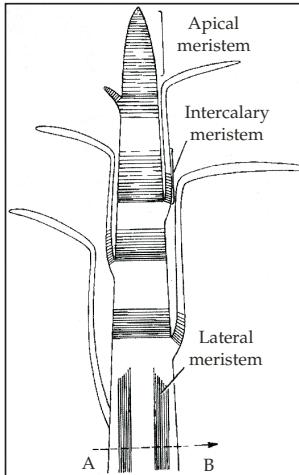


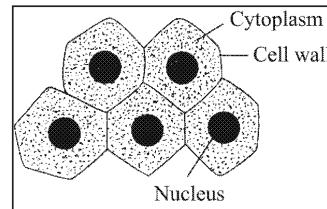
Fig. Classification of plant tissue- at a glance

### Meristematic Tissues

- Meristematic tissues are thin-walled compactly arranged, immature cells that keep on dividing continuously. The new cells produced are initially Meristematic. Slowly, they grow, differentiate and mature into permanent tissues.



- The meristematic cells are spherical, or polygonal in shape and the cells are compactly arranged without intercellular spaces. The cell wall is thin, elastic and is made of cellulose. Each cell has abundant cytoplasm and prominent nuclei. These cells are always living.



## Classification of meristematic tissue

On the basis of origin and development		
Promeristem	Primary meristem	Secondary meristem
<ul style="list-style-type: none"> <li>Represents primary stages of meristematic cells</li> <li>Present at the tip of radicle and plumule</li> </ul>	<ul style="list-style-type: none"> <li>Originate from promeristem that continue to divide to form different tissues.</li> <li>Always in active state of division and give rise to primary permanent tissues for growth in length as well as width e.g., apical meristems, intercalary meristems, lateral meristems (intrafascicular cambium in the vascular bundle of dicot stem).</li> </ul>	<ul style="list-style-type: none"> <li>Developed from primary permanent tissue. They are developed at a later stage by differentiation and acquire power of division. e.g., interfascicular cambium in stem, cambium in roots and also cork cambium (phellogen).</li> </ul>

On the basis of function		
Protoderm	Periblem	Procambium
<ul style="list-style-type: none"> <li>It is the outermost layer meant for producing the single layered epidermis, hairs, velamen, stomata i.e., epidermal tissue system.</li> </ul>	<ul style="list-style-type: none"> <li>It produces hypodermis, cortex and endodermis or ground tissue system.</li> </ul>	<ul style="list-style-type: none"> <li>It is the innermost part of the meristem. It gives rise to the stele which comprises primary vascular tissues and ground tissues like pith, medullary rays and the pericycle.</li> </ul>

## PERMANENT TISSUE

Permanent tissues are tissues that have lost the ability to divide, and have attained a definite form and size. They are actually derived from Meristematic cells. Different type of permanent tissues is formed due to differences in their specialization. Differentiation is the process whereby cells take up a definite shape, size, structure and function. These tissues are divided into simple, Complex and special.

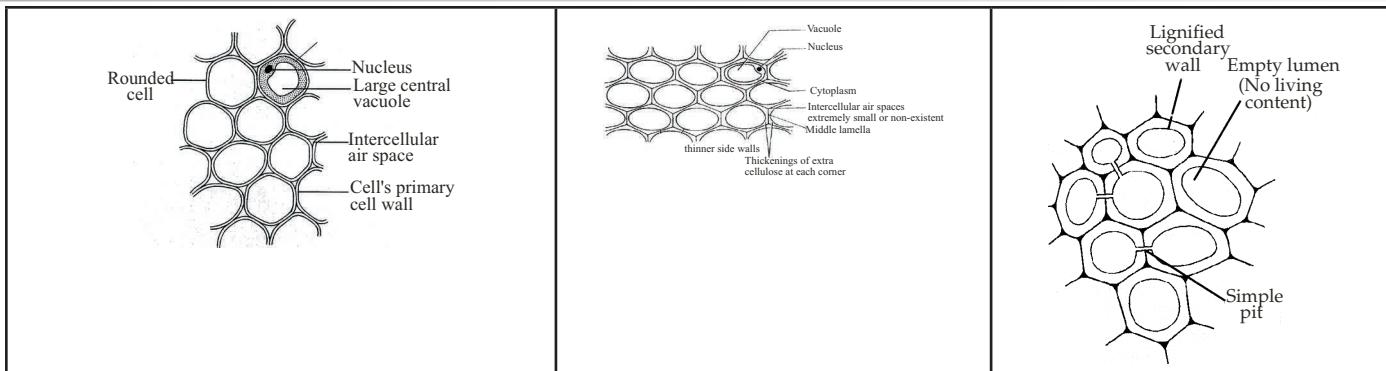
Table : Difference between Meristematic tissue and Permanent tissue

SI No.	Meristematic Tissue	Permanent Tissue
1.	Meristematic tissues are composed of cells that divide continuously.	Permanent tissues are composed of cells that are derived from Meristematic tissue.
2.	Cells are small, undifferentiated and isodiametric in shape.	Cells are large, differentiated with different shapes.
3.	Cell wall is thin and living.	Cell wall may be thin (living) or thick (dead).
4.	Cells are compactly arranged without inter-cellular spaces.	Intercellular spaces are often present.
5.	Nucleus is large and prominent.	Nucleus is less conspicuous.
6.	Cells of Meristematic tissue take part in growth.	Permanent tissue provides protection, support, conduction of substances, storage, photosynthesis etc.

## Simple Tissue

It is made up of only one kind of cells forming a uniform mass. The cells are similar in structure, origin and function. *Simple permanent tissues are of three types: Parenchyma, Collenchyma and Sclerenchyma*

Parenchyma	Collenchyma	Sclerenchyma
<p><b>Parenchyma:</b> Parenchyma is widely distributed in plant body such as stem, roots, leaves and flower.</p> <ul style="list-style-type: none"> <li>They are found in the cortex of root, ground tissue in stems and mesophyll of leaves, cells are isodiametric.</li> <li>It may contain chlorophyll. Parenchyma containing chlorophyll is called <i>chlorenchyma</i>. It is the site of photosynthesis.</li> <li>Parenchyma that encloses large air cavities is known as <i>aerenchyma</i>. Aerenchyma provides buoyancy to aquatic plants.</li> </ul>	<p><b>Collenchyma:</b> Collenchyma is a strong and flexible tissue that provides flexibility to soft aerial parts.</p> <ul style="list-style-type: none"> <li>Collenchyma provides mechanical support, flexibility to soft aerial parts so that they can bend without breaking and may contain chloroplasts and thus take part in photosynthesis.</li> </ul>	<p><b>Sclerenchyma:</b> It is found in and around the vascular tissue, under the skin i.e. the epidermis in dicot stems.</p> <ul style="list-style-type: none"> <li>Cells are long, narrow, thick and lignified usually pointed at both ends. The cell wall is evenly thickened with lignin. Lignin is a water proof material.</li> <li>It gives mechanical support to the plant by giving rigidity, flexibility and elasticity to the plant body.</li> </ul>



## Complex Tissue

Complex tissue is made up of more than one type of cells that work together to perform a particular function. *Complex tissues are of two types: Xylem and Phloem.*

**Table : Difference between xylem and Phloem**

Xylem	Phloem
Xylem helps in conduction of water and minerals.	Phloem helps in conduction of food materials and organic solutes.
The flow of material is mostly unidirectional.	The flow of material is bidirectional.
Xylem consists of tracheids, vessels, xylem parenchyma and xylem fibres.	Phloem consists of sieve tubes, companion cells, phloem parenchyma and phloem fibers.
Conducting elements of xylem are tracheids and vessels.	Conducting element of phloem is sieve tubes.
Out of four element of xylem, only xylem parenchyma is living, rest three are dead.	Out of four elements of phloem, only phloem fibres are dead, rest three are living.

They are scattered throughout the ground tissue of the plant and contain stored organic matter in the form of starch, rubber, tannins, alkaloids, mucilage enzymes, protein, etc.

## TISSUE SYSTEM

In higher plants several tissue work together to form a unit to perform particular function. These tissue have the same origin such tissue form a system which is called tissue system. On the basis of division of labour, tissue categorised by sachs into three different system-epidermal, ground and vascular tissue system.

### Stomata

- Stomata are tiny pores that are found on the epidermis of leaves, stem and some fruits. are absent in roots.
- These Stomata helps in gaseous exchange at the time of respiration and photosynthesis.
- These are composed of two bean-shaped epidermal cell called *guard cells* which encloses stomatal pore.
- In grasses, guard cells are dumb bell shape. In dicot leaves, stomata are scattered whereas in monocots, these are arranged in rows.
- In xerophytes, stomata are of sunken type so as to reduce water loss by transpiration.

### Vascular Bundles

- Xylem and phloem are collectively termed as vascular bundles.
- On the basis of arrangement of different parts, vascular bundle are divided into three categories *radial vascular bundles, conjoint vascular bundles and concentric vascular bundles.*

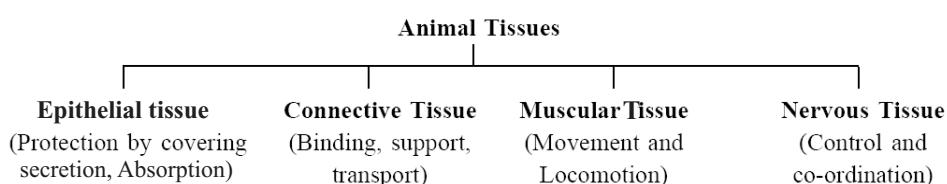
### Secondary Growth

- By the activity of secondary lateral meristems, increase in the circumference/girth of the plant organs due to the formation of secondary tissue in stelar and extra stelar region, is called as secondary growth.
- Normally secondary growth takes place in roots and stem of dicotyledons as Gymnosperms.

## ANIMAL TISSUES

The working of animal body is coordinated by tissues and organs present in their body.

On the basis of structure and function, animal tissues are divided into four types

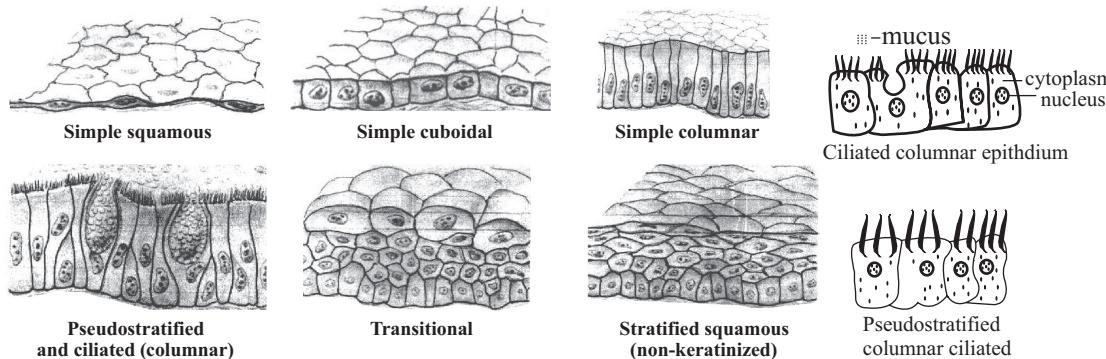


## Epithelial Tissue

- Epithelial Tissue is the simplest animal tissue that forms the continuous sheet of closely packed cells that covers all external and internal surface of the animal body. Thus, it is also known as *covering tissue*.

### Functions :

- It protects the underlying tissues against mechanical injury, dehydration and against infection by micro-organisms.
- Epithelium lining is present in the lung alveoli allows exchange of gases between blood and alveolar air and also present in the uriniferous tubules that helps in ultrafiltration, secretion and reabsorption to produce urine.



### Compound Epithelium

Transitional epithelium	Stratified epithelium
<p>It is 2-6 cells thick. <i>Basement membrane is absent and occurs in the areas where stretching is required eg. Epithelium of Urinary bladder, Ureter and Pelvis.</i></p>	<p>This epithelial layer is more than 6 cells thick Basement membrane is present but single. The name of the epithelium is according to the 'cells' of the top layer. It is of 3-types <b>Stratified Squamous Epithelium</b> is the most common stratified epithelium. The cells of the top layer are squamous. Such epithelium occurs in the region where protection is required, or where there is sufficient wear and tear of the tissue. <i>eg.</i> Buccal cavity (cheek epithelium), skin, pharynx, oesophagus, vaginal epithelium, urethra, conjunctiva and cornea. <b>Stratified Cuboidal Epithelium</b> is present in the ducts of mammary glands and sweat glands. <b>Stratified Columnar Epithelium</b> It mainly occurs in the embryonic tissue and is poorly developed in adults.</p>

## Glandular Epithelium

They are epithelial in origin and therefore, may develop from any of the 3-germ layers.

They can be **Exocrine** or **Endocrine** type ; **Unicellular** (ex. Goblet glands) or **multicellular** type.

## Connective Tissue

It is mesodermal in origin. It binds and supports body parts. The cells are loosely arranged, i.e. the intercellular matrix is well developed and Basement membrane is absent. It is nourished with the blood / lymph.

The study of bones is called **Osteology** and the study of cartilage is called **Chondrology**.

	BONES	CARTILAGE
1.	Outer covering (white fibrous connective tissue) of bones is called periosteum	Outer covering (white fibrous connective tissue) of cartilage is called perichondrium.
2.	Bone forming cells are called osteoblasts	Cartilage forming cells are called chondroblasts.
3.	Bone Protein is 'Ossein'	Cartilage protein is 'Chondrin'. (The sugar in cartilage is chondroitin sulphate)
4.	Osteocytes (bone cells) are solitary	Chondrocytes (cartilage cells) are in groups of 2's or 3's
5.	Osteocytes are arranged on lamellae	Chondrocytes are scattered in matrix.

## BLOOD -

- Study of blood is called Haematology
- Blood is 8% of the body weight ( 4 litre in a person of 50 kg.)
- Osmotic pressure is equivalent to 7-8 atmospheric pressure . pH 7.4 (slightly alkaline)
- Specific Gravity - 1.003 (slightly heavier than water)
- Viscosity - 3-5 times than that of water.

## Muscular Tissue

Muscular tissue is a contractile tissue that occupies more than 40% of total weight of the body.

### Types of Muscle Fibres

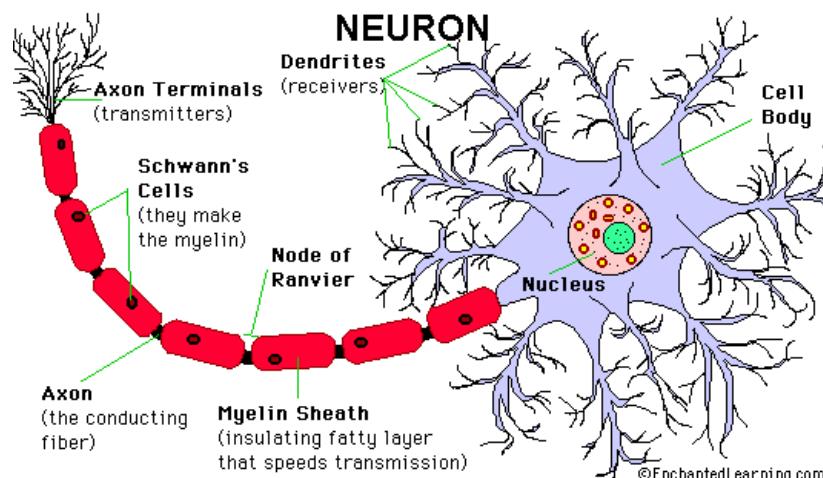
On the basis of their location, structure and function, there are three types of muscle fibres.

Sl No	Striated muscle fibres	Smooth muscle fibres	Cardiac muscle fibres
<b>On the basis of structure</b>			
1.	Cells are long and cylindrical in shape.	Cells are elongated and spindle shaped.	Cells are small and cylindrical
2.	Cells are unbranched.	Cells are unbranched.	Cells are branched.
3.	Fibres have blunt ends.	Fibres have pointed ends.	Fibres have broad ends.
4.	Cells are multinucleated.	Cells are uni-nucleated.	Cells are uni-nucleated.
<b>On the basis of location</b>			
9.	They are found in limbs, hands, feet, tongue, pharynx etc.	They are found in urinogenital tracts, digestive tract, lungs, iris, blood vessel etc.	They are found only in the wall of heart.
<b>On the basis of function</b>			
10.	They are able to perform fast and powerful contractions. Hence, get fatigued soon.	They perform slow but prolonged contractions.	They perform powerful and rhythmic contraction and get fatigued seldom.

## Nervous Tissue

Nervous tissue is specialized to transmit messages in our body. They can receive, integrate and transmit stimuli to various parts of the body. It is devoid of matrix. Its cell is surrounded by a special connective tissue cell. *Nervous tissue contains two types of cells Neuron and neuroglial cells.*

- **Neuron:** It is the functional unit of nervous tissue. It is also known as nerve cells. They are the longest cells of the body reaching upto a metre in length. *Each neuron is made of three parts:*
- **Cell body (Cyton):** is a broader nucleated part of neuron. Its cytoplasm is called Neuroplasm. Neuroplasm contains two special structure called *neurofibrils* and *Nissl granules*. *Neurofibrils* are fine fibrils involved in transmission of impulses.
- *Nissl granules* are ribosome containing structures. They are made up of RNA and protein.
- Axon is a single, long, fibre like process generally arising singly from the cell body of a neuron. It is devoid of Nissl granules. However, it contains neurofibrils.
- Axon is surrounded by a sheath called neurolemma of a special connective tissue called Schwann cells.
- Each such junction is called synapse. Synapse is meant for transmission of impulse from one neuron to another. Axon carries impulses towards the cell body.



# PHYSIOLOGY OF PLANTS

**Morphology** is the branch of biology which deals with the study of form, structure and relative position of different organs.

Physiology is the branch of science that deals with the study of different functions of organs.

- **Plant morphology** refers to the study of external form and structure of plants.

## FLOWERING PLANTS (ANGIOSPERMS)

- These are seed bearing plants in which seeds are always enclosed in a ovary inside the fruits and the sporophylls are organized into flowers.
- These plants have been classified into *monocots* and *dicots*.

**Herbs** : These are the plant, lacking a permanent woody stem and generally dies back at the end of each growing season. E.g., Whean Hen bone, Canna etc.

**Shrubs** : These are the woody plant which is smaller than a tree and has several main stem arising at or near the ground. E.g., Jasmine rose etc.

**Tree** : A woody perennial plant having a single usually elongate main stem generally with few or no branches. E.g., Palm, Pinus, Castuarina, Dalbergia, etc.

**Creepers** : A weak plant that grows along the ground, walls or trees. E.g., grass.

**Climbers** : They have week stem which help plant to climb up trees and other tall object. E.g., Grape vine etc.

**Lianas** : These are the woody climbinig plant that hangs from trees, especially in tropical rain forest. E.g., Hiptage, Phanera, etc.

**Epiphytes** : These are the plant that grow above the ground, supported non parasitically by another plant. E.g., Vanda, etc.

## Root System

### Characteristics

- Root is the descending, nongreen, underground part lacking nodes, internodes, leaves and buds.
- It is responsible for nutrition and support.
- Radicle comes out/arise from the seed coat in the form of soft structure and move toward the soil. It develops and forms *primary root*.

Root	
<b>Tap root</b>	<b>Adventitious root</b>
<p>It develops from radicle which is made up of one main branch and other sub-branches. It also forms lateral branches (called secondary roots) which further divide to form tertiary roots. Tap roots, with the secondary and tertiary roots form tap root system. It is the characteristic of dicot plants.</p>	<p>In some plants after sometime the growth of tap root stops and then roots develops from other part of plant which are branched or unbranched, fibrous or storage, are known as <i>adventitious roots</i>. These are mainly found in monocots and can be grouped into 3 types on the basis of their appearance - roots arising from the base of the stem, e.g. Triticum.</p> <ul style="list-style-type: none"> <li>- roots arising from leaves, e.g. Bryophyllum.</li> <li>- roots developing from nodes and internodes of the stem.</li> </ul>

## Regions

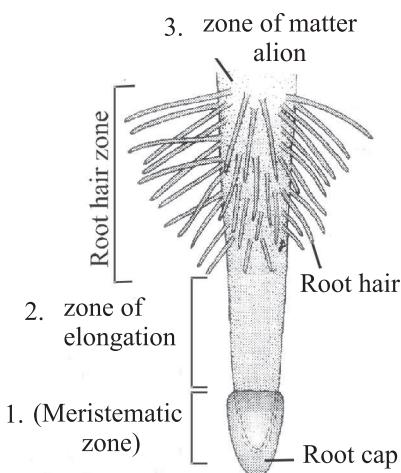


Fig. : Zones or regions of a typical root

### Modification of roots :

Tap and adventitious roots are modified in different forms to perform special functions and called as modified roots.

Modification of Taproot	Modification of adventitious root
<p>Taproot are modified for food storage and respiration</p> <p><b>Fusiform roots:</b> Eg. - Radish.</p> <p><b>Tuberous roots:</b> Eg. <i>Mirabilis</i>.</p> <p><b>Nodulated roots:</b> Eg. Plants of leguminosae family (Papilionaceae) - Pea.</p> <p><b>Modified tap root for respiration are pneumatophores:</b></p> <p>The plants, which grow in this region have some branches of tap root that grow vertically upward and comes on surface of soil. These roots are called <b>pneumatophores</b>. They have minute pores called <b>pneumathodes or lenticels</b> by which air enter inside the plant and get oxygen for respiration. Eg. <i>Rhizophora</i>, Mangrove, <i>Heritiera</i>.</p>	<p>Adventitious roots can be modified on the basis of functions like <b>fleshy</b> for storage (eg moniliform, annulated, tuberous, fasciculated, palmate, nodulose), <b>mechanical support</b> and for <b>vital functions</b>.</p> <p><i>Tuberous adventitious root :</i> Eg. Sweet potato.</p> <p><b>Fasciculated roots :</b> Eg. <i>Asparagus, Dahlia</i>.</p> <p><b>Stilt roots :</b> Eg. Maize, Sugarcane, <i>Pandanus</i> (screwpine).</p> <p><b>Prop root or pillar roots :</b> Eg. Banyan.</p> <p><b>Buttress root :</b> Eg. <i>Terminalia</i>.</p> <p><b>Climbing roots :</b> Eg. Money plant (pothos), <i>Monstera</i> (Betel), Black pepper.</p> <p><b>Respiratory root :</b> Eg. <i>Avicennia, Jussiaea</i>.</p> <p><b>Foliar root or Epiphyllous root :</b> Eg. <i>Bryophyllum, Begonia</i>.</p> <p><b>Sucking or haustorial roots or Parasitic roots :</b> Eg. <i>Dendrophthoe, Cuscuta, Viscum</i>.</p> <p><b>Annulated roots :</b> Eg. <i>Ipecac</i>.</p>

### Functions of Root:

- It helps in the absorption of water and in organic nutrient from the soil.
- It anchors the plant body and support it
- It is a storage of food and nutrients.

### Economic importance

- Sugar beet is edible root, which is an important source of sugar.
- Birth control pills compounds area derived from yam roots.
- Various medicines like ginseng, aconite ipecac, gentian are made from roots

### Stem

#### Characteristics

- It is the ascending part of plant, which develops from the plumule of embryo.
- These are differentiated into nodes and internodes and nodes posses leaves.
- It carries terminal bud for growth in length.
- These are capable of doing photosynthesis.
- When it get matured, it carries flowers and fruits.
- These are positively phototropic, negatively geotropic and negatively hydrotropic.

#### Functions of stem

- It supports plants and holds leaves flower and buds.
- It also connects the passage of roots to leaves and help in transport of water, minerals, sugar, etc to different part of plant.
- Due of modification of stem in thorn, it reduces transpiration

#### Economic importance of stem

- Stems like sugarcane are the source of sugar.
- Stems like asparagus, bamboo, etc. are vegetables, cinnamon used as a spice is derived from the bark of the tree.
- Medicines are obtained like quinine, Camphor, etc.

### Leaf

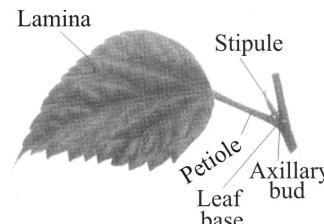
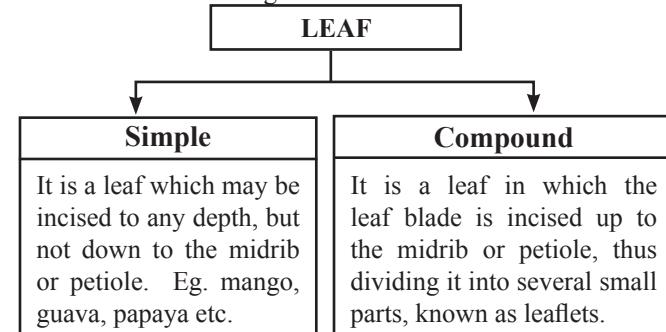


Fig. : Parts of a leaf



#### Modification of leaves

- When leaf is modified in different structure. It is called modification of leaves. Eg – leaf tendrils, leaf spine etc.
- Leaf tendril:** The whole leaf is modified into a wire like structure which is called leaf tendril. Eg. *Lathyrus aphaca* (wild pea).
- Leaf spine:** Leaves or any part of leaflet are modified into pointed spine. (Eg. *Opuntia, Aloe, Argemone*.) either to escape transpiration or for protection.
- Leaf scale:** Leaves become thin, dry and form a membrane or paper like structure and serve to protect axillary buds as in *Ficus* and *Tamarix, Ruscus* or store food and water as in onion.

### FLOWER

Flower is a specialized branch of limited growth which bears floral leaves that carry on sexual reproduction and give rise to seeds and fruits. The study of flower is called *anthology*. The part in a flower, 4 types of floral leaves are found. These are - sepal, petal, stamen and carpel.

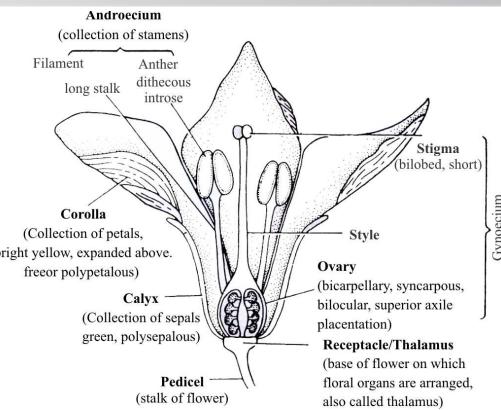


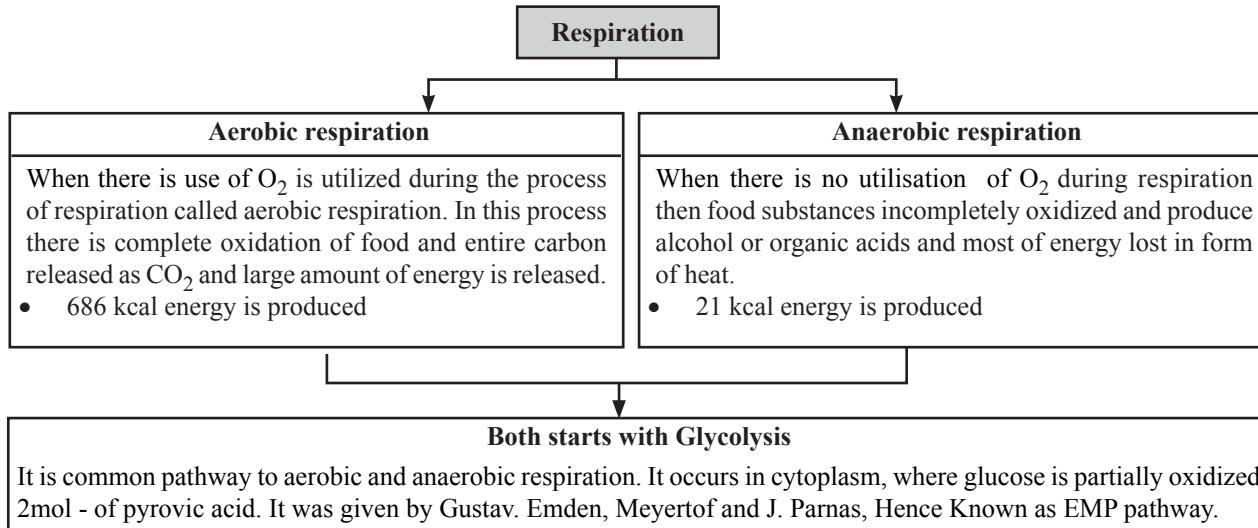
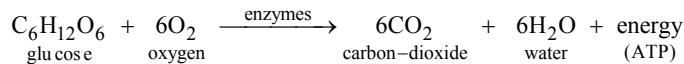
Fig. : Parts of a flower

Flower			
Calyx	Corolla	Androecium	Gynoecium
It is the outermost whorl of flower. each whorl of flower us known as sepal. Sometimes it get modified into spine (Trapa), hairy structure (sunflower), etc.	It is a second whorl of the flower and each members is known as petals. It may be Polypetalous and gamopetalous.	It is a male reproductive part of flower, It consists stamen, which is differentiated into anther and filament.	It is a female reproductive part of flower It comprises stigma, style and ovary.

## RESPIRATION IN PLANTS

### Cellular Respiration

Cellular respiration is an enzyme controlled process of biological oxidation of food materials in a living cell, using molecular  $O_2$ , producing  $CO_2$  and  $H_2O$  and releasing energy in gradual steps and storing it in biologically useful forms, **generally ATP**. So respiration is **catabolic, exothermic and oxidative** process.



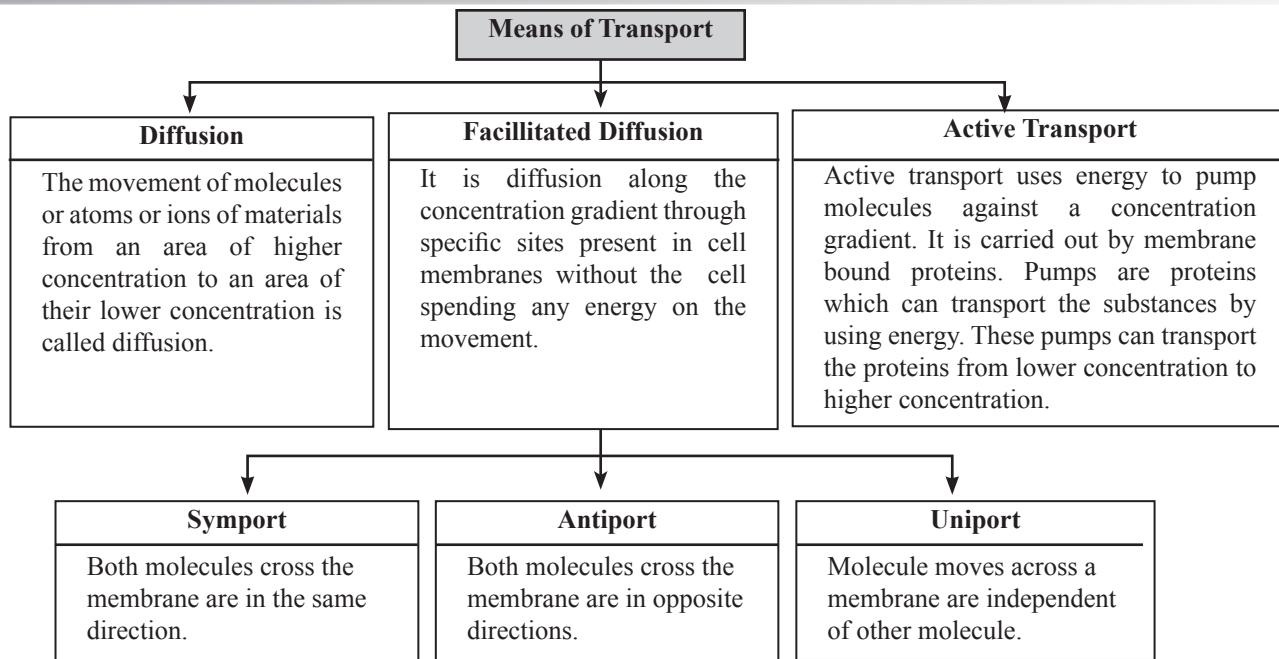
### RESPIRATORY QUOTIENT (R.Q.)

The ratio of the volume of  $CO_2$  released to the volume of  $O_2$  taken in respiration is called Respiratory Quotient (R.Q.)

$$R.Q. = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ absorbed}}$$

### TRANSPORT IN PLANTS

Plants need to move molecules over very long distances, much more than animals do; they also do not have a circulatory system in place. In a flowering plant the substances that are transported includes water, mineral nutrients, organic nutrients and plant growth regulators.



## Plant-water Relations

Water is essential for all physiological activities of plants. It acts as an excellent solvent and help in the uptake and distribution of mineral nutrients and other solutes and also useful for maintaining the turgidity of cells which is essential for cell enlargement, growth & development.

### Osmosis

It is a *type of diffusion* in which water molecules diffuse from the region of *higher chemical potential* (or concentration) to its region of *lower chemical potential* (concentration) *across a permeable membrane*.

### Plasmolysis

The behaviour of the plant cells (or tissues) with regard to water movement depends on the surrounding solution. The shrinkage of the protoplast of a living cell from its cell wall due to exosmosis under the influence of a hypertonic solution is called **plasmolysis**.

Solution		
Isotonic	Hypotonic	Hypertonic
If the solution in which a cell is placed, has equal osmotic concentration to that of cell sap, the outer solution is called isotonic solution.	If the osmotic concentration of outer solution is less than that of the cell sap, the outer solution is called hypotonic solution. If a cell is placed in such solution endosmosis takes place and cell swells up, e.g., swelling of dried grape (Resins).	If the osmotic concentration of a solution is higher than that of the other (cell sap) solution, is known as hypertonic solution.

### Deplasmolysis:

The swelling up of a plasmolysed protoplast due to endosmosis under the influence of a hypotonic solution or water is called **deplasmolysis**.

### Imbibition

It is a special type of diffusion when water is absorbed by solids - colloids - causing them to enormously increase in volume.

- The classical examples are seeds and dry wood.
- The various factors which influencing the rate of imbibitions are *nature of imbibant, surface area of imbibant, temperature, degree of dryness of imbibant, concentration of solutes, pH of imbibant* etc.

### Ascent of sap

- The upward movement of absorbed water against the gravitational force upto top parts of plants is called as *ascent of sap*. Xylem is water conducting tissue in plants. Cohesion and tension theory by Dixon and Joly (1894), etc. is the most accepter theory.

### Transpiration

- Loss of water in vapour form, from the aerial parts(organ) of living plants is known as *transpiration*. The *minimum transpiration* is found in *succulent xerophytes* and *no transpiration* in *submerged hydrophytes*. *Maximum transpiration* is found in *mesophytes*.

### Guttation

- Loss of water from the aerial parts or leaves of the plant in the form of water droplets is called guttation. Normally, guttation process is found in herbaceous plants like Grasses.

## PLANT GROWTH REGULATORS

**Plant hormone** is a chemical substance which may be translocated to another region, for regulating one or more physiological reactions when present in low concentration.

- All phytohormones are growth regulators but **all growth regulators are not phytohormones**.

- Plant growth regulators are **grouped into two categories** based on the nature of their actions :
  - Plant growth promoters**, e.g., auxins, cytokinins, gibberellins. They promote growth activities like cell division, cell enlargement, flowering, fruiting and seed formation, etc.
  - Plant growth inhibitors**, e.g., abscisic acid (ABA) and ethylene. They play an important role in plant response to wounds and stresses of biotic and abiotic origin and are involved in growth inhibiting activities such as dormancy and abscission.

Plant Disease		
Diseases	Causative agent	Symptoms
Branchy top of Banana	<i>Banana Virus- I</i>	Newly formed leaves becomes narrow.
Necrosis (potato)	<i>Potato virus-X(PVX)</i>	Leaves become dwarf and sharp spots are present
Potato mosaic	<i>Potato virus-X</i>	Leaves become dwarf and exhibits dark spots.
Tobacco Mosaic	<i>Tobacco Mosaic Virus (TMV)</i>	Stunted growth of leaves, Mottle appearance and leaves shrinks
Yellow vein Mosaic (Bhindi)	<i>Begmovirus or (YVM)</i>	yellowing of veins leaf become chlorotic
<b>• Fungal</b>		
Early blight	<i>Alternaria solani</i>	Concentric rings are present on leaves and it becomes brown, angular, have necrotic spots on the leaves.
Late blight Potato/Tomato	<i>Phytophthora infestans</i>	appearance of brown lesions on leaves and stem.
Rust of wheat	<i>Puccinia graminis</i>	appearance of red brown rust on stem and leaves.
Loose smut of wheat	<i>Ustilago tritici</i>	Inflorescence is affected and shows early burst of fruits wall.
Red rot (Sugarcane)	<i>Colletotrichum falcatum weat, glomerella cingulata</i>	Leaf dries and exhibits brown or reddish nodal region

#### • Bacterial

Citrus canker	<i>Xanthomonas axonopodis pvcitri, Xanthomonas axonopodis PV aurantifolis</i>	appearance of lesion is leaves, stem and fruit in lemon plant.
Ring disease (witt of potato)	<i>Pseudomonas solanacearum</i>	appearance of share brown ring in xylem of vascular system and collapsing of vascular system occurs.
Bacterial leaf spot	<i>Xanthomonas campestris</i>	appearance of translucent spots lettuce - large brown to black circular area.

## PHYSIOLOGY IN HUMANS

Physiology is a branch of science which deals with normal functions takes place throughout the living system. A living body comprises different system which are separate, but interconnected to each other. It includes Digestion, Respiration, Circulation, Neural and chemical control and co-ordination, excretion and their related disorders. It deals with all metabolic and catabolic processes occurs in the living body. *The process of conversion of complex food substances to simple absorbable forms is called digestion.*

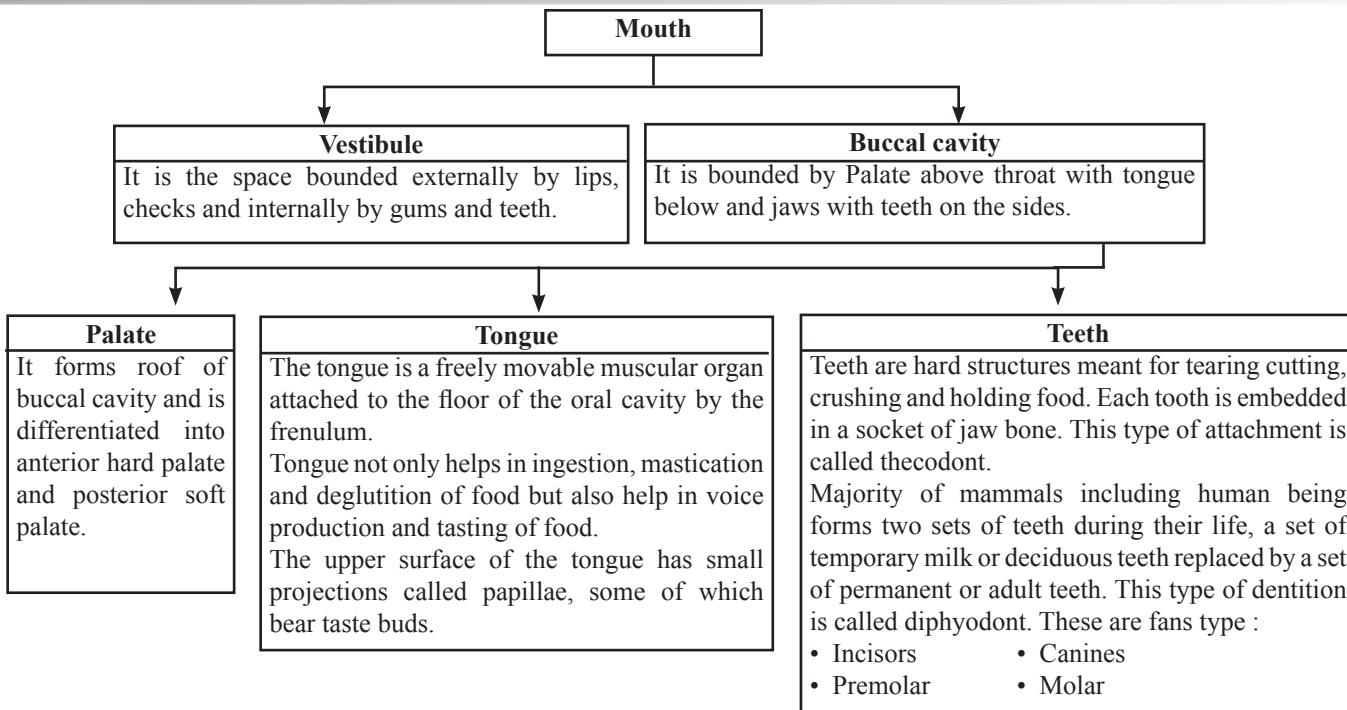
## DIGESTIVE SYSTEM IN HUMANS

The digestion in vertebrates occurs in the digestive tract or alimentary canal. The various parts involved in digestion can be broadly divided in two groups -

- **Digestive tract or alimentary canal**
- **Accessory digestive glands**

### Alimentary Canal

- The alimentary canal is a long coiled tube having muscular wall & glandular epithelium extending from mouth to anus.
- The human digestive system consists of 9 metre long alimentary canal and several digestive glands which pour their secretion into the canal. The alimentary canal is a long tube with muscular wall, glandular epithelial lining and varying diameter.



## Pharynx

It is a 12 cm funnel shaped passage from buccal cavity to esophagus. It is a common passage for both food and air. A flap, epiglottis closes over the trachea when food is swallowed to prevent choking.

## Oesophagus

- The oesophagus is a thin, long tube (25 cm) which extends posteriorly passing through the neck, thorax and diaphragm and leads to a 'J' shaped bag like structure called stomach.
- A muscular sphincter (gastro-oesophageal) regulates the opening of oesophagus into the stomach.

## Stomach

It is differentiated into three main parts, i.e. fundic stomach, body of stomach and pyloric stomach. The fundic as well as body of the stomach are for digestion and contain gastric glands (simple, branched and tubular type).

These glands contain three types of cells.

- (i) *Mucus cells* – They secrete mucus which acts as a lubricant. Mucus also prevents the digestion of stomach by proteolytic enzymes, and injury to stomach, by acid.
- (ii) *Oxyntic (parietal) cells* – They secrete HCl and *Castle's intrinsic factor*.
- (iii) *Peptic/zymogen/chief cells* – They secrete digestive enzymes.

## Functions of HCl-

- It inactivates ptyalin and maintains pH 1-2 (strongly acidic)
- It is germicidal and kills microbes.
- It activates pro-enzymes.

The secretion of HCl is stimulated by histamine, acetylcholine and gastrin.

## Small Intestine

The small intestine is coiled and narrow tube which can be distinctly divided into three regions i.e. Duodenum, Jejunum and Ileum.

### (i) Duodenum :

- It is the proximal part of small intestine.
- It is a U-shaped structure, starts from pyloric end of the stomach and receives the secretion of common duct which brings secretion of liver and pancreas.
- (ii) *Jejunum* : It is 2.4 metre long and bears finger like projections called **villi** which increase the surface area of the inner lining of intestine.
- (iii) *Ileum* : It is 2.4 metre long with **club-shaped villi**. Its lower end forms a **Merkel's diverticulum**. The opening of ileum in caecum (large intestine) called **ileocaecal orifice**.

## Large Intestine

- It is roughly 1.5 meters long with three parts: the **cecum** at the junction of small intestines, the **colon**, and the **rectum**.
- The colon itself has four parts: *ascending colon, transverse colon, descending colon* and the *sigmoid colon*.
- Food products that cannot go through the villi, such as cellulose (dietary fibre), are mixed with other waste products and become hard and concentrated faeces.

## Digestion in Man

- Digestion in man starts from his mouth. In mouth food gets mixed up with saliva secreted by salivary glands. Saliva contains enzymes ptyalin which break starch into single carbohydrates maltose.
- In stomach food is churned by the action of muscles of the stomach. The food gets mixed with the gastric juice which contains dil. HCl and two enzymes namely *renin* and *pepsin*. HCl soften food, kill bacteria present in the food. It provides acidic medium for the enzymes present in the gastric juice to act.
- Renin enzyme present in infants or curdles milk. Pepsin break proteins into proteoses and peptones.
- In duodenum bile juice and pancreatic juice mixed into the churned food. Bile juice emulsified the fat. Pancreatic juice consist of three enzymes.

- (i) *Trypsin* breaks proteins, peptones and peptides into amino acids.
- (ii) *Amylase* breaks starch into sugar.
- (iii) *Lipase* breaks patsineo acids and glycerol.
- From the duodenum food slowly moves towards ileum, where it gets mixed with intestinal juice secreted by intestinal glands. Intestinal juice consists of amylotic, protolytic and lipolytic enzymes.
- Absorption of the digested food occurs through the villi of small intestine.
- The undigested food is collected as faeces in the rectum, rectal wall absorbs water from it and the faecal matter is egested out through anus.

## NUTRITIONAL AND DIGESTIVE DISORDERS

- **Jaundice:** The liver is affected, skin and eyes turn yellow due to the deposit of bile pigments.

- During jaundice or hepatitis the bilirubin (a toxic chemical) is not excreted out and gets deposited in the body tissues.
- *Vomiting* is the ejection of stomach contents through the mouth.
- The abnormal frequency of bowel movement and increased liquidity of the faecal discharge is known as diarrhoea. It reduces the absorption of food.
- **Indigestion** is a condition in which the food is not properly digested leading to a feeling of fullness. The causes of indigestion are inadequate enzyme secretion, anxiety, food poisoning, over eating, and spicy food.

## RESPIRATORY SYSTEM

**Respiration** is an oxidative process occurring within living cells by which the chemical energy of organic molecules is released in a series of metabolic steps involving the consumption of oxygen and liberation of carbon dioxide and water. As the process of respiration takes place inside the cells, it is also known as *cellular respiration*.

- Respiration is of 2-types — aerobic and anaerobic respiration

Respiration	
Aerobic respiration	Anaerobic respiration
<ul style="list-style-type: none"> <li>• It is a process of cellular respiration that uses oxygen in order to break down respiratory substrate which then releases energy.</li> <li>• 38 molecules of ATP are released for every glucose molecule broken down.</li> <li>• It takes place in the cytoplasm (glycolysis) and mitochondria (Krebs and Electron Transport Chain) of the cell.</li> <li>• The equation of aerobic breakdown of glucose is:</li> </ul> $\text{Glucose} \xrightarrow[\text{(6 - C compound)}]{\text{Glycolysis}} \text{Pyruvic Acid} \xrightarrow[\text{(3 - C compound)}]{\text{In cytoplasm}} \text{CO}_2 + \text{H}_2\text{O} + 38\text{ATP}$	<ul style="list-style-type: none"> <li>• It is a process of cellular respiration that takes place in absence of oxygen, there is incomplete breakdown of respiratory substrate and little energy is released.</li> <li>• 2 molecules of ATP are released for break down of every glucose molecule.</li> <li>• It takes place in the cytoplasm of the cell, mitochondria is not involved. The equation is:</li> </ul> $\text{Glucose} \xrightarrow[\text{(6 - C compound)}]{\text{Glycolysis}} \text{Pyruvic Acid} \xrightarrow[\text{(3 - C compound)}]{\substack{\text{In cytoplasm} \\ \text{No oxygen}}} \text{Lactic Acid}$ <p style="text-align: center;">(3 - C compound) + 2ATP</p>

## TYPES OF RESPIRATION AND RESPIRATORY ORGANS OF ANIMALS

### Respiratory System in Human

The primary structure involved in respiratory system are lungs. Which are endodermal in origin. Its components are Nasal passage, pharynx, Larynx trachea, Bronchi, Bronchioles and alveoli.

#### Mechanism of Breathing

The physical movements associated with the gaseous exchange are called breathing. They are controlled by the respiratory centre of medulla oblongata in the human brain. Thus, the breathing movements are involuntary to a large extent. However, we can control the rate of breathing and the extent of breathing but not for a long time. The respiratory centre is stimulated by the carbon dioxide concentration of the blood. There are two types of physical movements associated with the gaseous exchange.

#### Inspiration or Inhalation

Inspiration of air occurs when the volume of the thoracic cavity is increased. When the volume increases, the pressure in the thoracic cavity becomes lower than the outside atmospheric air. Hence atmospheric pressure forces air into the lungs through the nose and trachea.

#### Expiration or Exhalation

When the volume of thoracic cavity is reduced, the pressure of the air inside the thoracic cavity becomes greater than outside atmosphere. Hence, air from inside the lungs expelled through the trachea and nose to the outside to equalize the internal and external pressure.

## DISORDERS OF RESPIRATORY SYSTEM

- Asthma* is an allergic reaction that causes constriction of the bronchiole muscles, thereby reducing the air passage thus the amount of the air that can get to the alveoli.
- Emphysema* it is a situation of short breath in which alveolar walls are damaged due to which respiratory surface is decreased. It is often caused by cigarette smoking.
- Occupational – Respiratory disorders
  - (i) *Asbestosis* – Exposure to the fibrous minerals of asbestos
  - (ii) *Bauxite fibrosis* – Exposure to bauxite fumes that contains aluminum and silica particles.
  - (iii) *Siderosis* – due to the deposition of iron in tissue.
  - (iv) *Byssinosis* – Also known as “brown lung disease” and caused due to exposure to cotton dust in inadequately ventilated environments.

**Bronchitis** : It is caused by the permanent swelling in bronchi. As a result of bronchitis cough is caused and thick mucus with pus cells is spitted out. The patient experiences difficulty in breathing.

**Tuberculosis (TB)** : It is caused by bacteria *Mycobacterium tuberculosis*.

**Lung cancer** : It is believed that by excess smoking, lung cancer (carcinoma of lungs) is caused. The tissue increases limitlessly, which is called malignancy.

## HUMAN CIRCULATORY SYSTEM

- Human circulatory system, also called the blood vascular system, consists of a muscular chambered heart, a network of closed branching blood vessels, blood and the fluid which is circulated. Circulatory system of human is of closed type.

## Heart

- Heart is situated in the thoracic cavity between the lungs with its apex resting on the diaphragm.
- It is measured about 12 cm in length and 9 cm in breadth. Its weight in males (average 300 g) and (average 250 in females). It is enclosed in double walled membranous bag, pericardium, enclosing the pericardial fluid.
- Heart has four chambers, with two anterior auricles and two posterior ventricles.

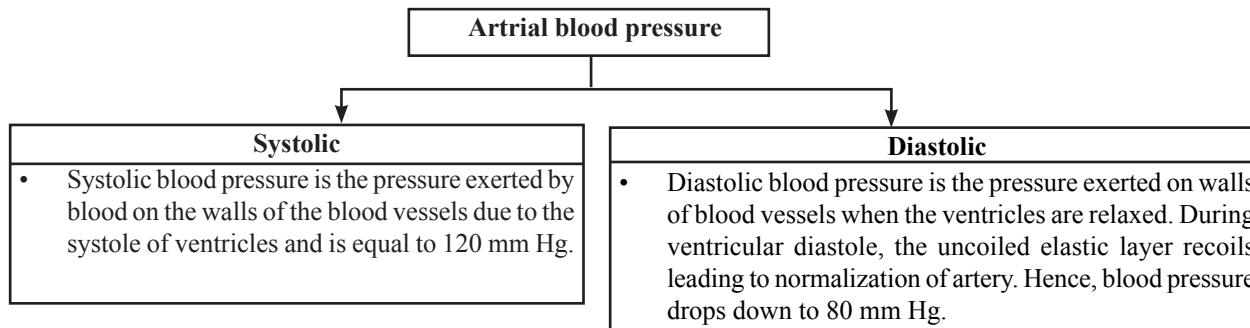
## Rhythmicity of Heart

- Automatic rhythmicity of the heart is the ability to contract spontaneously and at a regular interval of time. A specialized tissue called nodal tissue are distributed throughout the heart. This tissue consists sino-atrial node (SAN) atrio ventricular node (AVN).
- Purkinje branches give rise to minute fibres throughout the ventricular musculature of the respective sides and are called **purkinje fibres**. Purkinje fibres along with right and left bundles are known as **bundle of HIS**.
- The SAN can generate the maximum number of action potentials, i.e., 70-75 min<sup>-1</sup>, and is responsible for initiating and maintaining the rhythmic contractile activity of the heart. Therefore, it is called the **pacemaker**.

## Blood Pressure

The pressure exerted by the blood on the wall of the blood vessels in which it is present is called blood pressure.

- It is usually measured in brachial artery by an instrument called sphygmomanometer.



## ELECTRO CARDIOGRAM (ECG)

- The blood pressure in normal person is systolic/diastolic pressure i.e. 120/80 mm Hg.
- The instrument which records electrical activity of the heart muscles is called Electrocardiograph. The sketch obtained on the graph paper is called **electrocardiogram** (or electrocardiogram).
- The standard symbols used for ECG are PQRST, where P\* represents atrial depolarisation; QRS\* complex represents ventricular depolarisation and T\* represents ventricular repolarisation. (P, R & T are deflection waves).

## EXCRETORY SYSTEM

- Excretion is the essential process in all forms of life. In one

celled organisms waste are discharged through the surface of the cell. The higher plants eliminates gases through the stomata or pores present on the leaf surface. Multicellular animals have special excretory organs.

- Ammonia, urea and uric acid are the major forms of nitrogenous wastes excreted by the animals.
- On the basis of main excretory products, animals can be divided into 3 groups – ammonotelic, ureotelic and uricotelic (described later).

## Human Excretory System

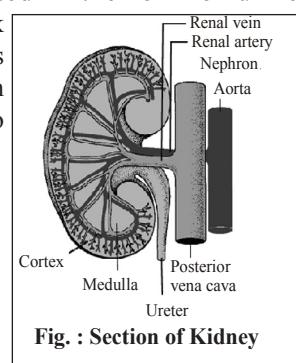
Excretory system consists of a pair of kidneys, one pair of ureters, a urinary bladder and a urethra.

## Kidneys

These are two bean-shaped purplish brown colored structures located in the back of the abdominal cavity. It is the main organ of excretion through which the nitrogenous waste are eliminated in the form of urine about 12 cm long, about 6 cm thick and weighs about 150 gm. Kidneys contain millions of nephron which filter 170 to 200 litres blood to produce 1-1.8 litres of urine daily.

## Renal Arteries

Two renal arteries constantly transport blood to each of the kidneys.



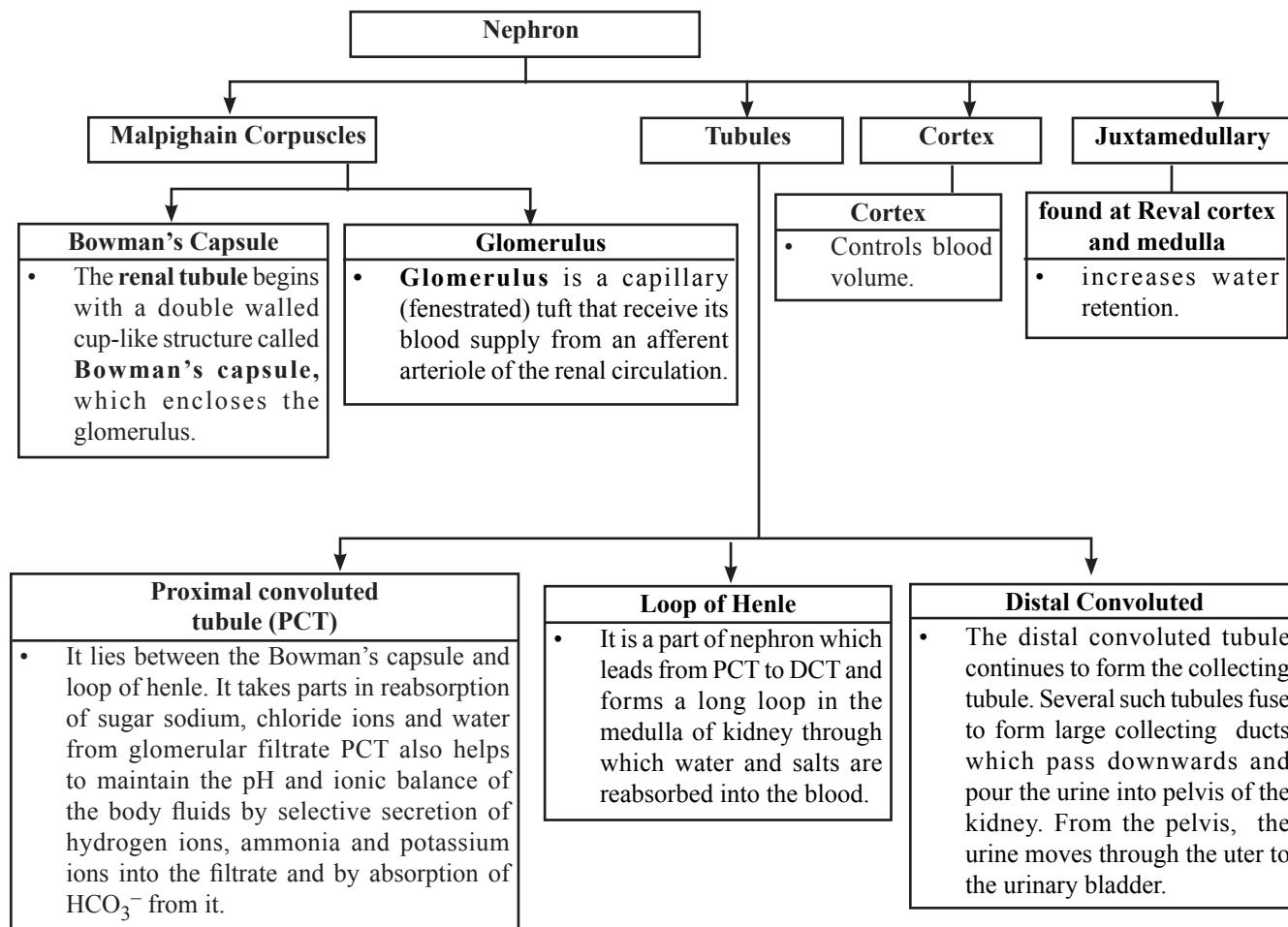
## Renal vein

Two renal veins return useful nutrients back into the blood stream after filtering the unwanted materials in kidneys.

- Internally the kidney is divided into two zones—an outer **cortex** and an inner **medulla**.
- Cortex** - is granular in appearance. Cortex contains Malpighian corpuscles, proximal convoluted tubule and distal convoluted tubule.

## Nephron

- Nephrons are the structural and functional units of kidneys. Nephron eliminates wastes from the body, regulate blood volume and pressure, control levels of electrolytes and metabolites and regulate blood pH.
- There are two types of nephron according to their position in kidney - cortical and juxtaglomerular nephron.*



## Dialysis

Urea is a toxic chemical. When it is not removed from the body, due to kidney disease, it gets accumulated in blood (**Uremia**) and can cause kidney failure. The urea can be removed from the blood by dialysis.

- Peritoneal dialysis-**

It is less costly but risky as there are chances of infection due to the permanent tube in the abdomen. A fluid (dialysate), containing sodium, chloride, bicarbonate and high percentage of glucose, is introduced into the abdominal cavity through a permanent- attached tube. The peritoneum of abdomen acts as a membrane and the exchange of substances occur with the blood. The fluid, containing urea, is removed periodically.

## CONTROL AND COORDINATION IN ANIMALS

- Animals receive a variety of external information through specialised system or organ called **sense organs** or **receptors organ**. There are five sense organs present in the human beings eye, ear, nose tongue and skin.
- The receptors are a nerve cell or group of nerve cells which collect information about changes in the environment, in the form of stimuli.
- The receptors pass information to the brain by a type of nerve cells called sensory neurons.

## DIVISION OF HUMAN NERVOUS SYSTEM

The human nervous system consists of : Central Nervous System (CNS) and Peripheral Nervous System (PNS)

### Central Nervous System

It lies in the mid-dorsal region along the longitudinal axis of the body. It consists of two parts. *Brain and Spinal Cord*.

#### Brain

This is the highest coordinating centre in the body. It is situated in the head region, in the cranial cavity of the skull. It is soft, whitish organ which weighs 1.2 – 1.4 kg. It forms 98% of the weight of the whole CNS. Brain is surrounded by three protective membranes called The space between these meninges is filled with **cerebrospinal fluid** which protects the brain from mechanical shocks. Brain is divisible into three main regions : **Fore brain**, **Mid brain** and **Hind brain**

**(i) Fore brain** forms the greatest part of the brain. It consists of three regions:

**Olfactory lobes** are a pair of club-shaped small structures present below the cerebral hemisphere. Both lobes are widely separated. It is centre of smell.

**Cerebral hemispheres or cerebrum:** It forms the largest part of the brain. It cerebrum has two cerebral hemispheres which lie side by side and are separated by a deep cerebral fissure. The surface of cerebral hemisphere has grooves (sulci) and folds (gyri) to accommodate larger number of nerve cells.

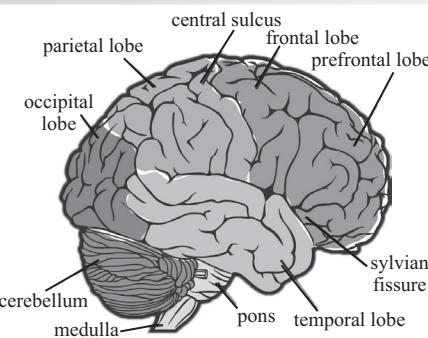


Fig. Human Brain

**Diencephalon:** It is smallest and unpaired part of brain. It lies on the lower side of cerebrum.

- (ii) **Mid brain :** It extends from the pons to the lower portion of the diencephalon. Mid brain is sub divided into Optic Lobes and Crura Cerebri
  - **Optic lobes :** There are four round solid optic lobes called corpora quadrigemina. Anterior optic lobes are centre of vision and posterior lobes are for hearing.
  - **Crura cerebri :** These are two ventral bands of nerves connecting diencephalon and medulla oblongata.
- (iii) **Hind brain** consists of three parts :
  - **Cerebellum** is the second largest part of the brain. It maintains equilibrium posture and tones of muscles.
  - **Pons :** It is located in the centre of brain below the cerebellum.
  - **Medulla oblongata** is the posterior most part of the brain which lies below the cerebellum. It continues posteriorly into the spinal cord.

#### Spinal Cord

It lies in the mid-dorsal region along the longitudinal axis of the body. It is a slender, cylindrical structure, about 45 cm long, originating from medulla oblongata and extending downwards upto the lumbar region. Spinal cord is also covered by three meninges, like the brain, in between which is the cerebrospinal fluid. It acts as a centre for reflex actions, thus, reduces brain's work. It also conducts sensory and motor impulses to and from the brain.

#### Function :-

- It transmits neural signals between the brain and the rest of the body.
- It controls numerous reflexes and central pattern generators.

# EXERCISE

1. Meristematic tissues are found in
  - only stems of the plants
  - both roots and stems
  - in all growing tips of the plant body
  - only roots of the plants
2. The process of formation of blood corpuscles is called
  - haemopoiesis
  - hemolysis
  - heamozoin
  - None of these
3. Largest number of neuron cell is present in human body in
  - retina
  - spinal cord
  - brain
  - tongue
4. Nucleated part of nerve cell is called
  - axon
  - dendrites
  - cyton
  - None of the above
5. The chief function of vessels in the plant body is
  - to translocate food material
  - to conduct water and mineral salts
  - to support living cells
  - all above
6. Which of the following is an epidermal cell
  - Guard cells
  - Root hairs
  - Trichome
  - All of these
7. The muscles in stomach are.
  - voluntary
  - involuntary
  - Cardior
  - None of the above
8. Cavity or lumen is narrow in
  - Sclerenchyma
  - Parenchyma
  - Collenchyma
  - Tracheids
9. Which tissue does lack blood supply and heals slowly ?
  - nervous
  - muscle
  - cartilage
  - bone
10. Nervous tissue is not found in
  - brain
  - spinal cord
  - tendons
  - nerves
11. The dead element present in the phloem is
  - companion cells
  - phloem fibres
  - phloem parenchyma
  - sieve tube
12. Girth of stem increases due to
  - apical meristem
  - lateral meristem
  - intercalary meristem
  - vertical meristem
13. The pH of blood is.
  - acidic
  - Alkaline
  - Slightly alkaline
  - None of the above
14. Which of the following tissues has dead cells?
  - Parenchyma
  - Sclerenchyma
  - Collenchyma
  - Epithelial tissue
15. The muscles in stomach are.
  - voluntary
  - involuntary
  - Cardior
  - None of the above
16. Find the true statement:
  - Meristematic cells are not compactly arranged.
  - Collenchyma is not a simple tissue.
  - the term histology was coined by Meyer
  - None of these
17. The chief function of vessels in the plant body is
  - to translocate food material
  - to conduct water and mineral salts
  - to support living cells
  - all above
18. A tissue is a group of cells which are
  - similar in origin, but dissimilar in form and function.
  - dissimilar in origin, form and function.
  - dissimilar in origin, but similar in form and function.
  - similar in origin, form and function.
19. Various functions like photosynthesis, storage, excretion performed by \_\_\_\_\_.
  - sclerenchyma
  - collenchyma
  - aerenchyma
20. Lignin is the important constituent in the cell wall of
  - phloem
  - parenchyma
  - xylem
  - cambium
21. Main function of lenticel is
  - transpiration
  - guttation
  - gaseous exchange
  - both (a) & (c)
22. Cork is formed from
  - phellogen
  - vascular cambium
  - phloem
  - xylem
23. Which of the following statement(s) is/are correct about the ground tissue system?
  - All tissues except epidermis and vascular bundles constitute the ground tissue.
  - It consists of xylem and phloem.
  - In leaves, it consists of thin – walled chloroplast containing cells called mesophyll.
  - Only (i)
  - Both (i) and (iii)
  - Both (ii) and (iii)
  - All of these
24. Roots develop from parts of the plant other than radicle are called
  - tap roots
  - fibrous roots
  - adventitious roots
  - nodular roots
25. Root hairs develop from
  - region of maturation
  - region of elongation
  - region of meristematic activity
  - root cap
26. Alternate type of phyllotaxy is found in
  - china rose
  - mustard
  - sunflower
  - all of these
27. Which one of the following process releases a carbon dioxide molecule?
  - Glycolysis
  - Lactic acid fermentation
  - Alcohol fermentation
  - Hydrolysis of glycogen
28. Total number of ATP consume during Kreb's cycle is
  - 0
  - 1
  - 2
  - 3
29. Day neutral plants relate to
  - loss of activity during day time.
  - flowering in all possible photoperiods.
  - overactive during day time.
  - no flowering in any photoperiods.

- | <p><b>30.</b></p> <table border="0"> <thead> <tr> <th><b>Column-I</b></th><th><b>Column-II</b></th></tr> </thead> <tbody> <tr> <td>A. Auxin</td><td>I. Fruit ripening</td></tr> <tr> <td>B. Cytokinins</td><td>II. Apical dominance</td></tr> <tr> <td>C. Abscisic acid</td><td>III. Antagonist to GAs</td></tr> <tr> <td>D. Ethylene</td><td>IV. Stomatal opening and closing</td></tr> <tr> <td>(a) A-IV; B-V; C-III; D-I</td><td>V. Growth of lateral buds</td></tr> <tr> <td>(b) A-II; B-IV; C-III, IV; D-I</td><td></td></tr> <tr> <td>(c) A-II; B-V; C-III, IV; D-I</td><td></td></tr> <tr> <td>(d) A-III, IV; B-V; C-II; D-I</td><td></td></tr> </tbody> </table>  | <b>Column-I</b>                                 | <b>Column-II</b>   | A. Auxin    | I. Fruit ripening                         | B. Cytokinins | II. Apical dominance        | C. Abscisic acid | III. Antagonist to GAs                          | D. Ethylene    | IV. Stomatal opening and closing           | (a) A-IV; B-V; C-III; D-I          | V. Growth of lateral buds | (b) A-II; B-IV; C-III, IV; D-I     |  | (c) A-II; B-V; C-III, IV; D-I      |  | (d) A-III, IV; B-V; C-II; D-I      |  | <p><b>37.</b> A surge of which hormone stimulates ovulation in human females? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Luteinizing hormone</li> <li>(b) Estrogen</li> <li>(c) Follicle stimulating hormone</li> <li>(d) Progesterone</li> </ul> <p><b>38.</b> Which one of the following is an enzyme? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Gastrin</li> <li>(b) Keratin</li> <li>(c) Trypsin</li> <li>(d) Vasopressin</li> </ul> <p><b>39.</b> Due to accumulation of which one of the following, joggers experience pain in their leg muscles after running? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Lactic acid</li> <li>(b) Acetic acid</li> <li>(c) Malic acid</li> <li>(d) Citric acid</li> </ul> <p><b>40.</b> A typical human ribcage consists of how many ribs? [NDA]</p> <ul style="list-style-type: none"> <li>(a) 12</li> <li>(b) 14</li> <li>(c) 16</li> <li>(d) 24</li> </ul> <p><b>41.</b> Biological catalysts in living organisms are known as [NDA]</p> <ul style="list-style-type: none"> <li>(a) hormones</li> <li>(b) vitamins</li> <li>(c) steroids</li> <li>(d) enzymes</li> </ul> <p><b>42.</b> Cure to spinal injury is likely to emerge from [NDA]</p> <ul style="list-style-type: none"> <li>(a) gene therapy</li> <li>(b) stem cell therapy</li> <li>(c) xenograft</li> <li>(d) transfusion</li> </ul> <p><b>43.</b> Which one among the following statements about stomach is not correct? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Stomach acts as a temporary reservoir</li> <li>(b) Stomach mixes food with gastric juice</li> <li>(c) Stomach secretes lipase and amylase in gastric juice</li> <li>(d) Rate of stomach emptying depends on the type of food</li> </ul> <p><b>44.</b> Which one among the following statements is correct? [NDA]</p> <ul style="list-style-type: none"> <li>(a) All arteries carry oxygenated blood</li> <li>(b) All veins carry oxygenated blood</li> <li>(c) Except the pulmonary artery, all other arteries carry oxygenated blood</li> <li>(d) Except the pulmonary vein, all other veins carry oxygenated blood</li> </ul> <p><b>45.</b> Which one among the following is the hardest part of our body? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Skull bones of head</li> <li>(b) Thumb nails</li> <li>(c) Enamel of teeth</li> <li>(d) Spinal vertebra</li> </ul> |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
|---|---|--------------------|-------------|---|---------------|-----------------------------|------------------|---|----------------|--|------------------------------------|---------------------------|------------------------------------|--|------------------------------------|--|------------------------------------|--|---|----------------|----------|----------|---------|---------|---------|---------|-----------|----------|-------------------------|--|------------------------|--|------------------------|--|------------------------|--|--|
| <b>Column-I</b>   | <b>Column-II</b>                                |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| A. Auxin  | I. Fruit ripening                               |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| B. Cytokinins   | II. Apical dominance                            |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| C. Abscisic acid  | III. Antagonist to GAs                          |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| D. Ethylene   | IV. Stomatal opening and closing                |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (a) A-IV; B-V; C-III; D-I   | V. Growth of lateral buds                       |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (b) A-II; B-IV; C-III, IV; D-I  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (c) A-II; B-V; C-III, IV; D-I   |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (d) A-III, IV; B-V; C-II; D-I   |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| <p><b>31.</b></p> <table border="0"> <thead> <tr> <th><b>Column - I</b></th><th><b>Column - II</b></th></tr> </thead> <tbody> <tr> <td>A. Isotonic</td><td>I. External solution is more concentrated</td></tr> <tr> <td>B. Hypotonic</td><td>II. Shrinkage of protoplasm</td></tr> <tr> <td>C. Hypertonic</td><td>III. Solution is more dilute than the cytoplasm</td></tr> <tr> <td>D. Plasmolysis</td><td>IV. Two solutions have the same osmolarity</td></tr> <tr> <td>(a) A – II; B – I; C – IV; D – III</td><td></td></tr> <tr> <td>(b) A – IV; B – III; C – I; D – II</td><td></td></tr> <tr> <td>(c) A – III; B – I; C – IV; D – II</td><td></td></tr> <tr> <td>(d) A – II; B – III; C – IV; D – I</td><td></td></tr> </tbody> </table> <p><b>32.</b> Cloves, used as a spice, are derived from which of the following plant parts? [CDS]</p> <ul style="list-style-type: none"> <li>(a) Seeds</li> <li>(b) Fruits</li> <li>(c) Flower buds</li> <li>(d) Young leaves</li> </ul> <p><b>33.</b></p> <table border="0"> <thead> <tr> <th><b>List-I</b></th><th><b>List-II</b></th></tr> </thead> <tbody> <tr> <td>A. Fruit</td><td>1. Ovule</td></tr> <tr> <td>B. Seed</td><td>2. Leaf</td></tr> <tr> <td>C. Wood</td><td>3. Stem</td></tr> <tr> <td>D. Starch</td><td>4. Ovary</td></tr> <tr> <td>(a) A-2; B-1; C-3; D- 4</td><td></td></tr> <tr> <td>(b) A-4; B-1; C-3; D-2</td><td></td></tr> <tr> <td>(c) A-2; B-3; C-1; D-4</td><td></td></tr> <tr> <td>(d) A-4; B-3; C-1; D-2</td><td></td></tr> </tbody> </table> <p><b>34.</b> The involvement of which one of the following is essential in the control of blood sugar? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Adrenal</li> <li>(b) Pancreas</li> <li>(c) Parathyroid</li> <li>(d) Spleen</li> </ul> <p><b>35.</b> Which one of the following pairs is not correctly matched: [NDA]</p> <ul style="list-style-type: none"> <li>(a) Loop of Henle : Kidney</li> <li>(b) Fallopian tube : Female reproductive system</li> <li>(c) Epididymis : Male reproductive system</li> <li>(d) Cowper's gland : Intestine</li> </ul> <p><b>36.</b> Which one of the following glands produces insulin in human body? [NDA]</p> <ul style="list-style-type: none"> <li>(a) Liver</li> <li>(b) Pancreas</li> <li>(c) Spleen</li> <li>(d) Pituitary</li> </ul> | <b>Column - I</b>                               | <b>Column - II</b> | A. Isotonic | I. External solution is more concentrated | B. Hypotonic  | II. Shrinkage of protoplasm | C. Hypertonic    | III. Solution is more dilute than the cytoplasm | D. Plasmolysis | IV. Two solutions have the same osmolarity | (a) A – II; B – I; C – IV; D – III |                           | (b) A – IV; B – III; C – I; D – II |  | (c) A – III; B – I; C – IV; D – II |  | (d) A – II; B – III; C – IV; D – I |  | <b>List-I</b>   | <b>List-II</b> | A. Fruit | 1. Ovule | B. Seed | 2. Leaf | C. Wood | 3. Stem | D. Starch | 4. Ovary | (a) A-2; B-1; C-3; D- 4 |  | (b) A-4; B-1; C-3; D-2 |  | (c) A-2; B-3; C-1; D-4 |  | (d) A-4; B-3; C-1; D-2 |  |  |
| <b>Column - I</b>   | <b>Column - II</b>                              |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| A. Isotonic   | I. External solution is more concentrated       |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| B. Hypotonic  | II. Shrinkage of protoplasm                     |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| C. Hypertonic   | III. Solution is more dilute than the cytoplasm |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| D. Plasmolysis  | IV. Two solutions have the same osmolarity      |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (a) A – II; B – I; C – IV; D – III  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (b) A – IV; B – III; C – I; D – II  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (c) A – III; B – I; C – IV; D – II  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (d) A – II; B – III; C – IV; D – I  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| <b>List-I</b>   | <b>List-II</b>                                  |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| A. Fruit  | 1. Ovule  |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| B. Seed   | 2. Leaf   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| C. Wood   | 3. Stem   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| D. Starch   | 4. Ovary  |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (a) A-2; B-1; C-3; D- 4   |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (b) A-4; B-1; C-3; D-2  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (c) A-2; B-3; C-1; D-4  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |
| (d) A-4; B-3; C-1; D-2  |   |                    |             |   |               |                             |                  |   |                |  |                                    |                           |                                    |  |                                    |  |                                    |  |   |                |          |          |         |         |         |         |           |          |                         |  |                        |  |                        |  |                        |  |  |

---

**ANSWER KEY**

## Chapter

# 5

# REPRODUCTION

## REPRODUCTION

Reproduction is the process by which all living organism give rise to new organisms similar to themselves. It is essential for the survival of the species since all the living beings have a similar life span. Organism reproduces by two modes asexual and sexual reproduction.

### Asexual Reproduction

Asexual reproduction produces offspring that are genetically identical to the parent because the offspring are all clones. The main process of asexual reproduction is mitosis. This type of reproduction is common among same single cell organisms for example, amoeba, etc. Many plants also reproduce asexually.

### Sexual Reproduction

Sexual reproduction is a biological process that creates a new organism by combining the genetic material of two organisms in a process that starts with meiosis, a specialized type of cell division.

### Difference between asexual and sexual reproduction

	Asexual reproduction	Sexual reproduction
1.	It occurs only in invertebrates and lower chordates.	It occurs almost in all types of animals.
2.	It is always uniparental.	It is usually biparental.
3.	Gametes are not formed.	Two types of gametes are formed.
4.	It involves only mitosis.	It involves both meiosis and mitosis.
5.	Daughter organisms are genetically identical to the parent.	Daughter organisms genetically differ from their parents.
6.	Since there is no variation, so it does not contribute to evolution of the species.	Because of variations, it contributes to the evolution of species.
7.	Occurs by fission, budding or fragmentation.	Occurs by the formation of haploid gametes which fuse to form a diploid zygote.
8.	It is a quick method of multiplication.	It is a slower method of multiplication.

## REPRODUCTION IN PLANTS

In plants, asexual reproduction is of 3 types – *agamospermy, spore formation and vegetative reproduction.*

### Vegetative Propagation

Vegetative propagation or vegetative reproduction is the process of multiplication in which a portion of fragment of the plant body functions as propagules and develop into a new individual.

#### Artificial Vegetative Propagation

- Cutting - e.g – sugarcane
- Grafting - e.g – grafted mango, roses, orange, seedless grapes guava, apple and pear.

#### Underground stem

- Rhizome – Ginger, banana, turmeric, Lotus, Musa, etc.
- Corm – Gladiolus, colocasia, crocus, Alocasia, etc.
- Bulbs – Onion, garlic and lilies.
- Tubers – Potato, Helianthus tuberosus etc
- Suckers – Mint and chrysanthemum.

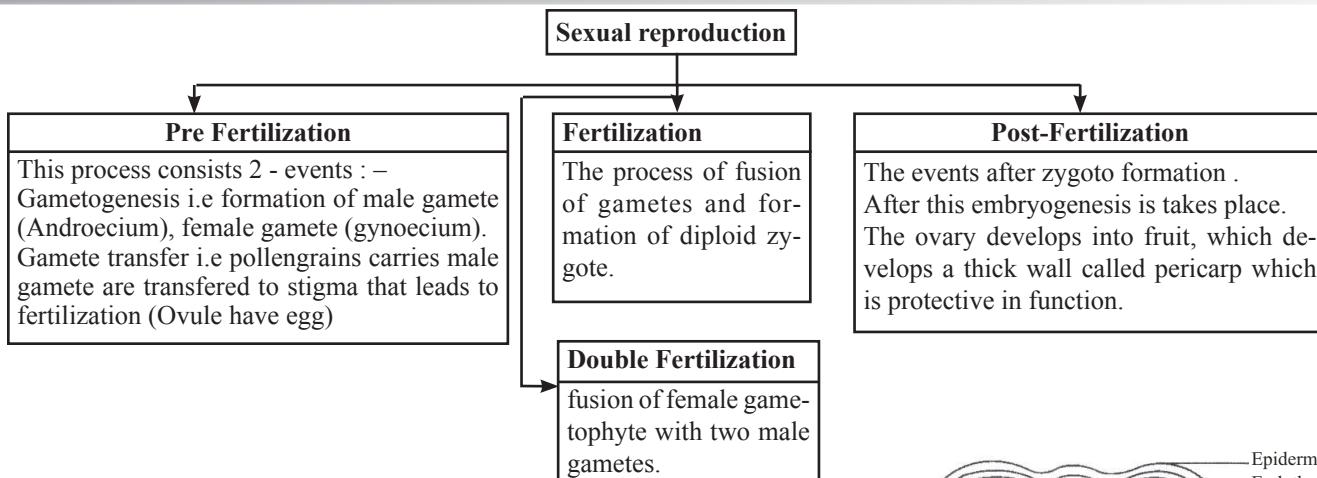
#### Creeper stem

- Runners – Cydonia, oxalis and centella
- Stolon – Fragaria, vallisneria
- offset – Pistia, Eichornia, etc
- Aerial stem - Opuntia.

Leaves – ex – Bryophyllum, Begonia, streptocarpus, saint paulia

## SEXUAL REPRODUCTION IN FLOWERING PLANT

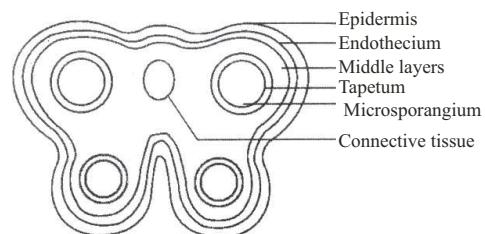
Sexual reproduction is the process of development of new organisms through the formation and fusion of gametes. In flowering plants, stamens are male reproductive organs while carpels are female reproductive organs. Sexual reproduction can be summarised as :



## Male Reproduction Unit

It includes

- Stamen – unit of male gamete, consists anther, connective and filament.
- Microsporangium – sporangium containing micropores.
- Microsporogenesis – Formation of micropores or pollen grains
- Pollen-grains – it consists male reproductive bodies of flower.

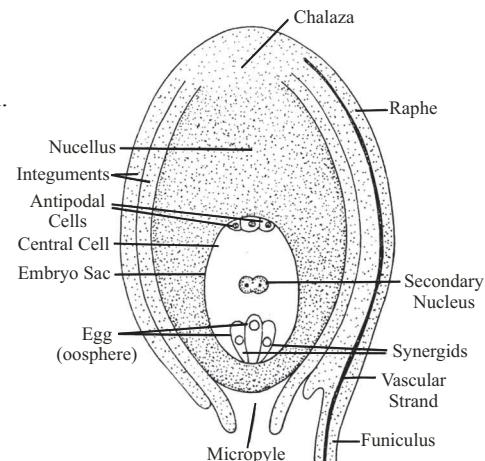


T. S. of young anther

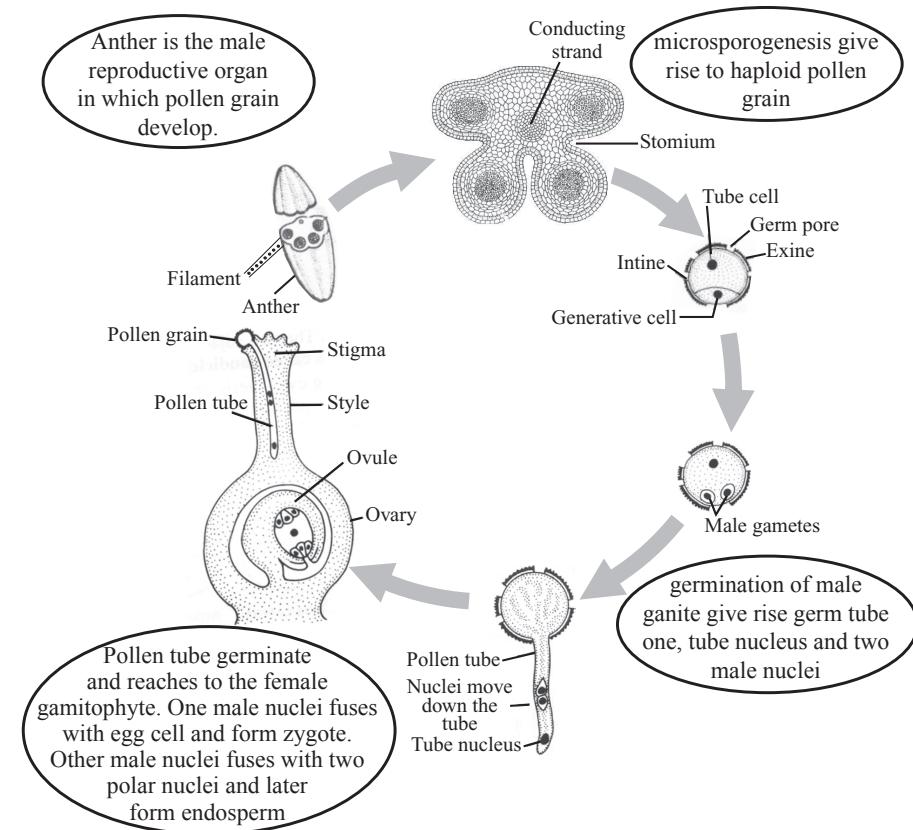
## Female Reproduction Unit

It includes

- Gynoecium/Pistil –Female reproductive part and carpel is a unit of gynoecium.  
Carpel consists three parts–stigma, style and ovary.
- Megasporangium (Ovule) – The integumented nucellus or megasporangium
- Megasporogenesis – The process of formation of megaspore mother cell.
- Embryo sac – Female gametophyte



## Sexual Reproduction Cycle



Structure of a typical ovule  
(anatropous ovule) prior to fertilization

## POLLINATION

The process of transfer of pollengrains form an anther to the stigma of the some flower or different flower is called *pollination*.

### Pollination

(Transfer of pollen grains from anther to the stigma)

Divided into two types

#### Self Pollination

Transfer of pollen grains from anthers to the stigma of the same flower or another flower borne by the same plant

Two types

#### Autogamy

Transfer of pollen grains from anthers to stigma of same flower.

#### Geitonogamy

Transfer of pollen grains in different flowers of same plant.

#### Cross Pollination

- Transfer of pollen grains from anther to stigma of different flowers on different plants
- Required external agency which may be

#### Abiotic

- Anemophily** (by wind), e.g. Palm, buoarcane, bamboo, Coconut, cannabil, Typha, etc.
- Hydrophily** (by water), e.g. *Vallisneria*, Ruppia, Ceratophyllum, Najas, Zostera, etc.

#### Biotic

- Entomophily** (by insects), e.g. *Aristolochia*, *Salvia* (bee), *Mussaenda*, *Yuca* (*Pronuba* moth), etc
- Ornithophily** (by birds), e.g. *Bombax*, *Bauhinia* (by humming bird)
- Chiropterophily** (by bats) e.g kigelia Pinnate onthocephalus
- Malacophily** (by snails & slugs), e.g. aroids
- Myrmecophily** (by ants), e.g. rubiaceae, Aeacia, etc
- Malmacophiluy** (by snails), e.g. Aspidistra, etc. chrysanthemum, etc
- Malmacophily (by snails)** e.g. Aspidistra, Chrysanthemum, etc.

## Post Fertilization Events

It involves development of endosperm, embryo, ovules and seeds

**Endosperm** – Endosperm is the nutritive tissue which provides nourishment to the embryo in seed plant. It also protects the embryo from mechanical injury. It may be completely consumed by developing embryo before it matures (e.g. beans and peas) or it may persist in the mature seed and used up during seed germination, e.g., coconut.

**Embryo** – The process of development of mature embryo from zygote or oospore is called embryogeny. Zygote starts dividing to produce embryo, together with the development of endosperm.

**Seed** – Seed is a fertilized ovule. It is the final product of fertilization in angiosperm and acts as a main propagative unit in plants. Ovules mature into seed and simultaneously ovary develops into a fruit.

- Transformation of various units of ovary during seed formation are.

- |                |   |            |
|----------------|---|------------|
| (i) Ovary wall | – | Fruit wall |
| (ii) Ovary     | – | Fruit      |

(iii) Integuments – Seed coats

(iv) Outer – Testa

(v) Inner – Tegmen

(vi) Ovule – Seed

### Handy Facts

- Apomixis is the production of seed without fertilization.
- The normal process of cell cycle involving meiosis and fertilization is called amphimixis.
- Polyembryony is the state of occurrence of more than one embryo in a seed, e.g. onion and groundnut.

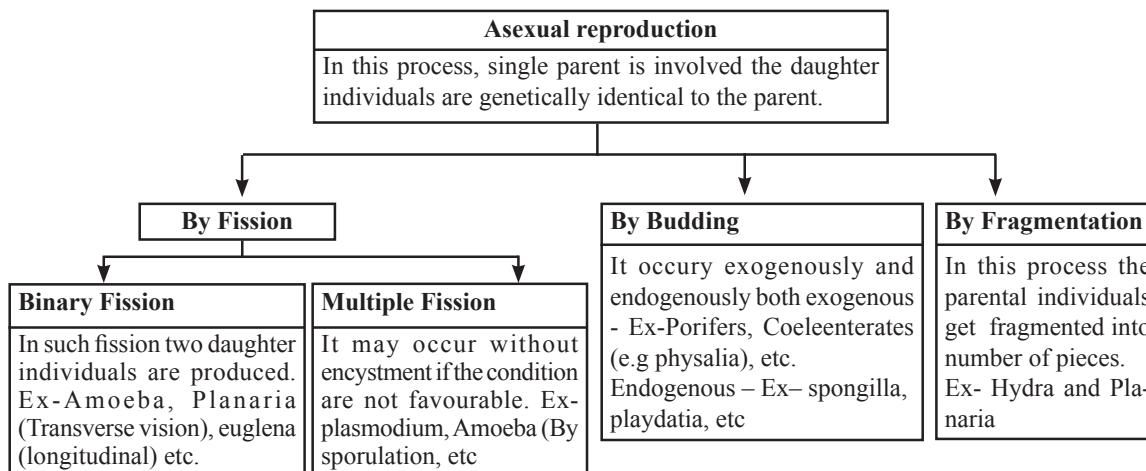
### Handy Facts

- Emasculation – It is the process of removal of another from the flower bud before the another dehiscens
- Artificial hybridisation – It is the process in which the desired ae taken out by emasculation and then pollination

## FRUIT

- Most fruits develop only from the ovary are called **true fruits**. E.g. cucumber, tomato, coconut. Now a days many seedless grapes, oranges and water melons are being developed by horticulturists. These are seedless fruits that are formed without fertilization, e.g. banana.
- When floral parts other than ovary, particularly thalamus contributes to fruit formation, such fruits are called **false fruits**, e.g. apple, strawberry, cashew etc.

## REPRODUCTION IN ANIMALS



### Cloning

It is the process used to create an exact copy of a cell tissue or a complete organism. It was performed by Ian Wilmut and his colleagues at Roslin institute edinburg, scotland. They cloned sheep named "Dolly". she was born on 5<sup>th</sup> july 1996 and was the 1st mammal cloned from adult somatic cell. She died on 14<sup>th</sup> feb 2003 due to lung disease.

## SEXUAL REPRODUCTION

- In this process Two parents are involved and Gametes formation occurs.
- The daughter individuals are genetically different from both the parents.
- The parental individuals may be unisexual (**dioecious**) or bisexual/ hermaphrodite (**monoecious**)  
e.g. *Paramecium*, *Plasmodium*, *Hydra*, tape worm and earthworm.

### Reproduction in Human

In human beings reproduction is much the same as for mammals specialized reproductive organs are located in their lower abdomen.

- Male consists glands called testes that make microscopic, tadpole - shaped sperm cell
- The female has glands called ovaries that make pin point - sized egg cell.

### Some common fruits with their edible part.

Fruits can also be classified on the macro level :

- Simple fruit** : It results from the ripening of simple or compound ovary. E.g., Mustard, Mango, Lemon.
- Aggregate fruit** : It results from several corsets derived from the same flower. E.g., Raspberry, Strawberry.
- Composite fruit** : It develops from an inflorescence rather than from a single flower. E.g., Jackfruit, Mulberry

- Humans are sexually reproducing and viviparous.
- Rate of reproduction is slower in sexual reproduction.
- Human are unisexual. The reproductive system of each sex consists of many organs. The latter are distinguishable into primary and secondary sex organs. Besides these, there are some accessory sex characters.

Puberty is the name for the time when your body begins to develop and change as you move them kid to adult. Usually, puberty starts between ages 8 and 13 in girls and ages 9 and 15 boys.

### Male Reproductive System

- Its Accessory or external sexual character are low pitch voice, beard, broad shoulder, Moustaches, Narrow lips, breathing by means of diaphragm

### Female Reproductive System

- Accessory or external sex characters of female are high pitched voice, smooth face, narrow shoulder, broad hips, sternal breathing

## REPRODUCTIVE HEALTH

- According to the World Health Organisation (WHO), reproductive health means a total well-being in all aspects of reproduction, i.e., physical, emotional, behavioural and social.

Table : Method of Birth control

S. No.	Method	Action
(1)	Withdrawal	Penis is withdrawn before ejaculation.
(2)	Tubectomy / Tubal ligation	Woman's fallopian tubes are cut and tied, permanently blocking sperm release.
(3)	Lactational amenorrhea	As long as mother breast feeds the child, chances of conception is nil
(4)	Vasectomy	Man's vasa deferentia are cut and tied permanently blocking sperm passage.
(5)	Tubectomy	a small part of the fallopian tube is removed or tied up through a small incision in the abdomen or through vagina.
(6)	Intrauterine device (IUD) non-medicated IUDs (e.g., Lippes loop), copper releasing IUDs (CuT, Cu7, Multiload 375) and the hormone releasing IUDs (Progestasert, LNG-20).	Small plastic or metal device placed in the uterus to prevent implantation. Some contain copper, others release hormones.
(7)	Oral contraceptive eg – saheli, MalaD, etc.	Synthetic estrogens and progestin prevent normal menstrual cycle; primarily prevent ovulation.
(8)	Male condom	Thin rubber sheath on erect penis collects ejaculated semen.
(9)	Female condom	Plastic pouch inserted into vagina catches semen.
(10)	Diaphragm	Soft rubber cup covers entrance to uterus, prevents sperm from reaching egg and holds spermicide.
(11)	Cervical cap	Miniature diaphragm covers cervix closely, prevents sperm from reaching egg and holds spermicide.

- MTP is used to get rid of unwanted pregnancies and where continuation of the pregnancy could be harmful or even fatal either to mother or to the foetus or both.

## SEXUALLY TRANSMITTED DISEASES

- Diseases which are transmitted through sexual intercourse are collectively called sexually transmitted diseases (STD) or venereal diseases (VD) or reproductive tract infections (RTI).
- These diseases are caused by a wide range of bacterial, viral, protozoan, fungal agents and ectoparasites.

Table : Some STDs and their pathogens

Disease		Pathogen
<b>Bacterial</b>		
1.	Syphilis	Treponema pallidum
2.	Gonorrhoea	Neisseria gonorrhoeae
3.	Chancroid	Haemophilus ducreyi
4.	Vaginitis	Gardnerella vaginalis
5.	Chlamydiasis	Chlamydia trachomatis
<b>Viral</b>		
6.	Herpes genitalis	HSV-2 (DNA) virus
7.	Condyloma acuminatum	Papova (DNA) virus
8.	Molluscum contagiosum	Pox (DNA) virus

## Protozoan

9.	Trichomoniasis	Trichomonas Vaginalis
----	----------------	-----------------------

## INFERTILITY

- Inability to conceive or produce children even after 2 years of unprotected sexual cohabitation is called infertility.
- Various methods are now available to help such couples. The main ART-Techniques i.e (Assisted reproductive technology)

### The main ART-techniques includes:

- In vitro fertilization (IVF)  
 Zygote intra fallopian transfer (ZIFT)  
 Intra cytoplasmic sperm injection (ICSI).  
 Gamete intra fallopian transfer (GIFT).  
 Surrogacy or surrogate motherhood.

# EXERCISE

1. Pick out the mismatched pair in the following pairs:-  
 A. Sperms → testes  
 B. Eggs → ovaries  
 C. Pollen → anther  
 D. Ovule → somatic cell  
 (a) A (b) B  
 (c) C (d) D
2. Contraception (to avoid pregnancy) can be attained by.  
 (a) use of condoms (b) oral pills  
 (c) copper-T (d) all of these above
3. All are hormones except  
 (a) Estrogen (b) Testosterone  
 (c) FSH (d) Tocopherol
4. All are sexually transmitted diseases except  
 (a) AIDS (b) Breast cancer  
 (c) Gonorrhea (d) Syphilis
5. External fertilization takes place in  
 (a) Crocodiles (b) Frogs  
 (c) Tortoise (d) Amoeba
6. All the following are male reproductive parts except:-  
 (a) Prostate gland (b) Penis  
 (c) Testes (d) Vagina
7. The other name of stamens is  
 (a) Gynoecium (b) Calyx  
 (c) Androecium (d) Corolla
8. Fertilization is  
 (a) Formation of seedling from seeds  
 (b) Transfer of pollen to the carpel part  
 (c) Fusion of sperm and ovum.  
 (d) All the above
9. The development of off spring from any part of body is called  
 (a) Asexual reproduction  
 (b) Sexual reproduction  
 (c) Vegetative reproduction  
 (d) All the above
10. The migration of pollen grains to stigma is called as  
 (a) Fertilization (b) Pollination  
 (c) Fusion (d) Reproduction
11. The anther contains  
 (a) Sepals. (b) Ovules.  
 (c) Carpels. (d) Pollen grains.
12. When a seed matures into a seedling under favourable conditions it is called  
 (a) Fertilization (b) Reproduction  
 (c) Pollination (d) Germination
13. In sweet potato vegetative propagation takes place by  
 (a) Root (b) Stem  
 (c) Leaves (d) All of them
14. The process of development of organism like itself is called  
 (a) Budding (b) Flowering  
 (c) Reproduction (d) None of the above
15. Progesterone is secreted by  
 (a) Corpus luteum (b) Thyroid  
 (c) Thymus (d) Testes
16. **Column-I**                   **Column-II**  
 A. Pollen & stigma      P. female part in plants
- B. Radicle in a cotyledon  
 C. Ovule  
 D. Pcumule
 Q. root  
 R. root  
 S. male reproductive parts in a plant.  
 (a) A-P ; B-Q ; C-R ; D-P  
 (b) A-S ; B-Q ; C-R ; D-R  
 (c) A-P ; B-Q ; C-S ; D-R  
 (d) A-S ; B-P ; C-R ; D-Q
17. The capacity of organisms to reproduce after being cut into many pieces is called  
 (a) Budding (b) Fission  
 (c) Regeneration (d) Reproduction
18. Which is common method of multiplication of *Yeast* and *Hydra*.  
 (a) Budding  
 (b) Fragmentation  
 (c) Binary fission  
 (d) Vegetative reproduction
19. In which of the following pair, Uric acid is present in the excreta?  
 (a) Bird – Shark (b) Frog – Lizard  
 (c) Man – Insect (d) Insect – Shark
20. Callus formation in plants means  
 (a) growth of cancer cells.  
 (b) microorganism attack only.  
 (c) a disease.  
 (d) tissue culture technique.
21. Where pollination is done by animals it is  
 (a) Anemophily  
 (b) Hydrophily  
 (c) Zoophily  
 (d) Chiropterophily
22. The number of chromosomes in a female fertilized egg cell is  
 (a) 44 (b) 21  
 (c) 23 (d) 46
23. Menstruation takes place as  
 (a) The egg is fertilized and is nourished.  
 (b) The egg is released from the ovaries and comes to the uterus.  
 (c) The egg released is not fertilized, the lining becomes thick and breaks down.  
 (d) None of the above.
24. Fertilization takes place in the  
 (a) ovary sacs (b) fallopian tube  
 (c) urethra (d) vagina
25. Ovulation in mammals is caused by  
 (a) FSH and TSH (b) FSH and LH  
 (c) FSH and LTH (d) LTH and LH
26. Cowper's glands are found in  
 (a) male mammals (b) female mammals  
 (c) male amphibians (d) female amphibians
27. Vegetative propagation refers to formation of new plants from  
 (a) stem, roots and flowers  
 (b) stem, roots and leaves

- (c) stem, flowers and fruits  
 (d) stem, leaves and flowers

**28.** Cross pollination brings about ..... recombination in new plants.  
 (a) Genetic                    (b) chromosomes  
 (c) Genes                    (d) chromatids

**29.** ‘Saheli’ a new oral contraceptive developed by  
 (a) All Indian Institute of Medical Science  
 (b) Central Drug Research Institute  
 (c) Health Care Pvt. Ltd.  
 (d) Bharat Immunologicals & Biologicals corp. Ltd.

**30.** IUDs stands for  
 (a) Intra Uterine Devices  
 (b) Internal Uterine Devices  
 (c) Inseminated Uterine Devices  
 (d) Injected Uterine Devices

**31.** The most important component of the oral contraceptive pills is  
 (a) progesterone  
 (b) growth hormone  
 (c) thyroxine  
 (d) luteinizing hormone

**32.** **Assertion (A) :** *Amoeba* reproduces by fission.  
**Reason (R) :** All unicellular organisms reproduce by asexual methods. [IAS Prelim]

(a) Both A and R are individually true and R is the correct explanation of A  
 (b) Both A and R are individually true but R is not the correct explanation of A  
 (c) A is true but R is false  
 (d) A is false but R is true

**33.** Polar body is produced during the formation of –  
 (a) Sperm                    (b) Secondary oocyte  
 (c) Oogonium                (d) Spermatocytes

**34.** Egg is liberated from ovary in  
 (a) Secondary oocyte stage  
 (b) Primary oocyte stage  
 (c) Oogonial stage  
 (d) Mature ovum stage

**35.** Which of the following statements are true for flowers?  
 A. Flowers are always bisexual.  
 B. They are the sexual reproductive organs.  
 C. They are produced in all groups of plants.  
 D. After fertilization they give rise to fruits.  
 (a) A and D                    (b) B and C  
 (c) A and C                    (d) B and D

**36.** Consider the following statements :  
 A. Plants are divided into five groups: Thallophytes, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.  
 B. Lichens are examples of liverworts.  
 C. The algae are vascular plants.  
 D. Angiosperm is the least diversified form than any other plant groups.  
 Which of these statement(s) is/are correct ?  
 (a) A, B and C                (2) B, C and D  
 (c) A and D                    (d) All are correct

**37.** According to which of the following organization “reproductive health means a total well-being in all aspects of reproduction”?  
 (a) WHL                      (b) UNESCO  
 (c) WHO                      (d) WWW

**38.** In a bisexual flower, if androecium and gynoecium mature at different times, the phenomenon is known as [IAS Prelim]  
 (a) dichogamy                (b) herkogamy  
 (c) heterogamy                (d) monogamy

**39.** Which one of the following is monogamous? [IAS Prelim]  
 (a) Wolf                      (b) Walrus  
 (c) Seal                      (d) Deer

**40.** Which one of the following genetic diseases is sex-linked? [IAS Prelim]  
 (a) Royal haemophilia  
 (b) Tay-Sachs disease  
 (c) Cystic fibrosis  
 (d) Hypertension

---

**ANSWER KEY**

ANSWER KEY															
1.	(d)	2.	(d)	3.	(c)	4.	(b)	5.	(b)	6.	(d)	7.	(c)	8.	(c)
9.	(a)	10.	(b)	11.	(d)	12.	(d)	13	(a)	14	(c)	15	(a)	16	(b)
17	(c)	18	(a)	19	(b)	20	(d)	21	(c)	22	(d)	23	(c)	24	(b)
25	(a)	26	(a)	27	(b)	28	(a)	29	(b)	30	(a)	31	(a)	32	(a)
33	(b)	34	(a)	35	(d)	36	(c)	37	(c)	38	(a)	39	(d)	40	(c)

# Chapter

# 6

# NUTRITION, HEALTH AND DISEASES

## NUTRITION

Nutrition is the process of intake and utilisation of nutrients/ food, by an organisms to get energy which is further used in various life processes. The substance that is needed to keep them living is called nutrient.

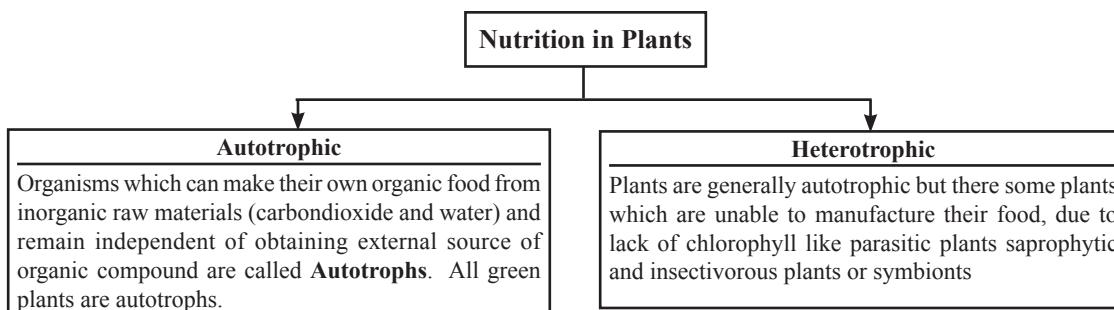
Nutrients are organic and inorganic substances which the organism obtains from its surroundings and uses it as a source of energy or for biosynthesis of its body constituents.

*Organic nutrients - Carbohydrates, Proteins, Fats*

*Inorganic nutrients - Water, Carbon dioxide, Minerals (Iron, copper, zinc, etc.)*

### NUTRITION IN PLANTS

Various organisms live in different environmental conditions and they have different methods of obtaining nutrients from the environment. The method of obtaining food by the organism is called **mode of nutrition**. Depending on the mode of nutrition, all organisms can be classified into two major groups – **Autotrophic and Heterotrophic**.



- In addition to carbon, hydrogen and oxygen plants require a variety of mineral elements for their survival. Absorption of minerals and their utilization by plant is called **mineral nutrition**.
- The technique of growing plants in a nutrient solution is known as **hydroponics or soilless growth. this was discovered by julius von sachs**.
- Aeroponics is a system of growing plants with their roots bathed in nutrient mist (a cloud of moisture in air). The rooted plants are placed.

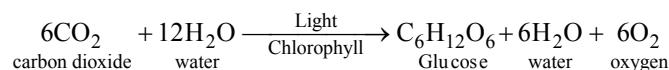
### Role of Micro and Macro Elements and Their Deficiency Symptoms

S. no.	Name of element (location)	Functions	Deficiency symptoms
1.	<b>Nitrogen</b> ( $\text{NO}_2^-$ , $\text{NO}_3^-$ or $\text{NH}_4^+$ )	Major constituent of proteins, nucleic acids, vitamins and minerals.	<b>Chlorosis</b> of leaves, stunting of plants, dormancy of lateral buds, inhibition of cell division etc.
2.	<b>Phosphorous</b> ( $\text{H}_2\text{PO}_4^-$ , or $\text{HPO}_4^{2-}$ )	Constituent of cell membrane, nucleic acids, nucleotides and some proteins.	Delay in seed germination, reduced growth, purple or red spots on leaves etc.
3.	<b>Potassium</b> ( $\text{K}^+$ )	Determine cation- anion balance in cell. Involved in protein synthesis, closing & opening of stomata.	<b>Scorched leaf tips</b> , shorter internodes, chlorosis in interveinal, loss of apical dominance, loss of cambial activity.
4.	<b>Calcium</b> ( $\text{Ca}^{2+}$ )	Activate certain enzymes and regulates metabolic activities. Used in synthesis of cell wall (middle lamella). Help to stabilize the structure of the chromosomes.	Stunted growth, necrosis (death of tissue) of meristematic regions, chlorosis along the margins of young leaves, <b>wither tip disease</b> , premature flower abscission, <b>blossoms end rots of tomato</b> .

5.	<b>Magnesium</b> (divalent $Mg^{2+}$ )	Activate enzymes in respiration, photo-synthesis, DNA and RNA synthesis.	Chlorosis between leaf veins, necrosis on older leaves. Premature leaf abscission, reduced growth.
6.	<b>Sulphur</b> ( $SO_4^{2-}$ )	Constituent of amino acids like cystine and methionine and Main constituent of several coenzymes, vitamins (thymine, Co-A and ferredoxin, biotin)	Chlorosis of younger leaves, stunted growth, anthocyanin accumulation, leaf curl, less juice content in citrus, <b>yellow disease of tea, marsh spots (peas).</b>
7.	<b>Iron</b> ( $Fe^{3+}$ )	Constituent of ferredoxin and cytochromes. Involves in electron transfer. Activates catalase and Helps in formation of chlorophyll.	<b>Chlorosis</b> -initiates in intravenous regions and then in the complete leaf, growth reduced, inhibition of chloroplast formation.

## PHOTOSYNTHESIS

Green plants are autotrophic in the sense that they synthesize their own organic food from inorganic raw materials. This is done by the process of **photosynthesis**.



## PHOTOSYNTHESIS IN HIGHER PLANTS

- In higher plants photosynthesis occurs particularly in specialized cells called mesophyll cells of leaves. These cells contain **chloroplast**, which is the actual sites for photosynthesis. It fixes  $CO_2$  into carbohydrates.
- Chloroplasts are double membrane bound organelle. The space limited by the inner membrane of the chloroplast is called the **stroma**.
- A number of organised flattened membranous sacs (called the **thylakoids**) are present in the stroma. Thylakoids are arranged in stacks like the piles of coins called **grana**.

## Photosynthetic Pigments

- Pigments** are the organic molecules that absorb light of specific wavelengths in the visible region due to presence of conjugated double bonds in their structures.
- Chlorophyll-a**
- Chlorophyll b**
- Chlorophyll c**

**Carotenes** –  $C_{40}H_{56}$  and **Xanthophylls** –  $C_{40}H_{56}O_2$ .

- Chl-a and carotenes are universal pigment, which are found in all  $O_2$  liberating cells. Chlorophylls are soluble only in organic solvents like ketones, ethers etc.
- Carotenoids** absorb light energy and transfer it to Chl a and thus act as **accessory pigments**.

## MECHANISM OF PHOTOSYNTHESIS

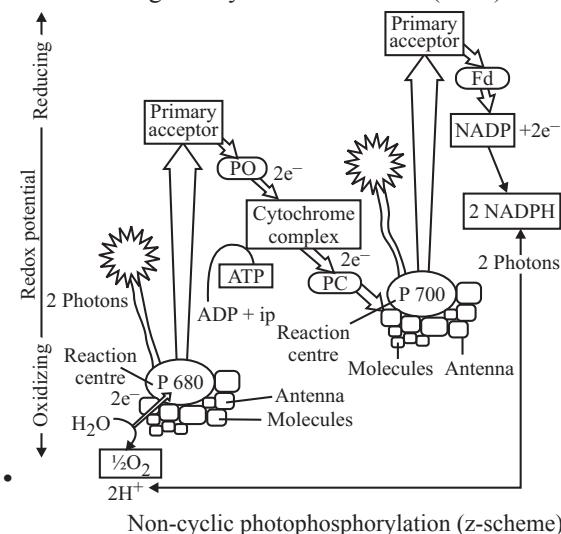
- Photosynthesis is an oxidation reduction** process in which water is oxidised to release  $O_2$  and  $CO_2$  is reduced to form starch and sugars.
- These are of two types
  - light Reaction
  - Dark Reaction

### Light reaction

It occurs in **grana fraction** of chloroplast and in this reaction are included those activities, which are dependent on light. Assimilatory powers (ATP and  $NADPH_2$ ) are mainly produced in this light reaction.

### Non Cyclic Photophosphorylation

- In light reaction, the formation of ATP from ADP in presence of light called **non-cyclic photophosphorylation**. The system is dominant in green plants. It involves both PS-I and PS-II.
- Flow of electrons is **unidirectional**. Here  $H_2O$  is utilized and  $O_2$  evolution occurs. In this chain, high energy electrons released from 'P-680' do not return to 'P-680' but pass through pheophytin, plastoquinone, cytochrome  $b_6/f$  complex plastocyanin (Cu containing pigment) and then enter P-700. Because in this process high energy electrons released from 'P-680' do not return to 'P-680' and ATP (1 molecule) is formed, this is called **Noncyclic photophosphorylation. ATP is synthesized at only one step**.
- This non-cyclic photophosphorylation* is also known as Z-scheme (because of shape of path of electron-flow) and this was given by Hill and Bendall (1960).



Non-cyclic photophosphorylation (z-scheme)

### Cyclic Photophosphorylation

In this light reaction of photosynthesis, the formation of ATP from  $ADP$  and  $H_3PO_4$  in the presence of light & chlorophyll *a* during the cyclic transfer of electrons is called **cyclic photophosphorylation**. The system is *found dominantly in bacteria. It involves only PS I*.

**Flow of electron is cyclic.** If NADP is not available then this process will occur. When the photons activate PS I, a pair of electrons are raised to a higher energy level. They are captured by primary acceptor which passes them on to ferredoxin, plastoquinone, cytochrome complex, plastocyanin and finally

back to reaction centre of PS I i.e., P<sub>700</sub>. At each step of electron transfer, the electrons lose potential energy. Their trip down hill is caused by the transport chain to pump H<sup>+</sup> across the thylakoid membrane.

### Dark Reaction

Dark reaction is a thermochemical reaction. It takes place in the **stroma of the chloroplast**.

It is also called *CO<sub>2</sub> fixation or carbon assimilation*.

The dark reaction involves thermochemical reduction of CO<sub>2</sub> to form carbohydrates. This was first established by **Blackman (1905)**, hence it is also called **Blackman reaction**.

There are two main pathways for the biosynthetic or dark phase – *Calvin cycle (C<sub>3</sub>)* and *C<sub>4</sub> (dicarboxylic acid) cycle*.

### Calvin Cycle-(C<sub>3</sub> Cycle)

Carbon assimilation in C<sub>3</sub> plants were explained by **Melvin Calvin**

1 This is known as **C<sub>3</sub> cycle** because CO<sub>2</sub> reduction is cyclic process and first stable product in this cycle is a 3-C compound (i.e., 3-Phosphoglyceric acid or -PGA). Calvin cycle occurs in all photosynthetic plants whether they have C<sub>3</sub> or C<sub>4</sub> pathway.

### C<sub>4</sub> Cycle

- C<sub>4</sub> acid (dicarboxylic acid) is formed due to carboxylation. It was shown by **Kortschak et al** in sugarcane. **Kortschak** and **Hart** supplied CO<sub>2</sub> to the leaves of sugarcane, they found that the first stable product is a four carbon (C<sub>4</sub>) compound oxaloacetic acid instead of 3-carbon atom compound. The detailed study of this cycle was introduced by **M.D. Hatch and C.R. Slack (1966)**. So it is called as “**Hatch and Slack cycle**”. The stable product in C<sub>4</sub> plant is a dicarboxylic substance. Hence, it is called **dicarboxylic acid cycle or DCA-cycle**.
- C<sub>4</sub> plants are **true xerophytic plants**. They are adapted for hot and dry climate. The important **C<sub>4</sub> plants** are **sugarcane, maize, sorghum, Cyperus rotundus, Digitaria brownii, Amaranthus**, etc.
- These plants have “**Kranz**” (German term meaning halo or wreath) **type of leaf anatomy**. The vascular bundles in C<sub>4</sub> leaves are surrounded by a layer of bundle sheath cells that contain large number of chloroplasts.

**Table Difference between C<sub>3</sub> and C<sub>4</sub> Plants**

	C <sub>3</sub> Plants	C <sub>4</sub> Plants
1.	Photosynthesis occurs in mesophyll cells.	Photosynthesis occurs in mesophyll and bundle sheath cells.
2.	Kranz anatomy is absent.	Kranz anatomy is present.
3.	RuBP is the primary carbon dioxide acceptor.	PEP is the primary carbon dioxide acceptor.
4.	3-phosphoglyceric acid (3-PGA), a 3C-compound is the first stable product.	Oxaloacetic acid, a 4C-compound is the first stable product of photosynthesis.
5.	Chloroplast are of only one type, i.e., granal.	Chloroplasts are dimorphic, i.e., granal in the mesophyll cells and agranal in the bundle sheath cells.

## NUTRITION IN ANIMALS

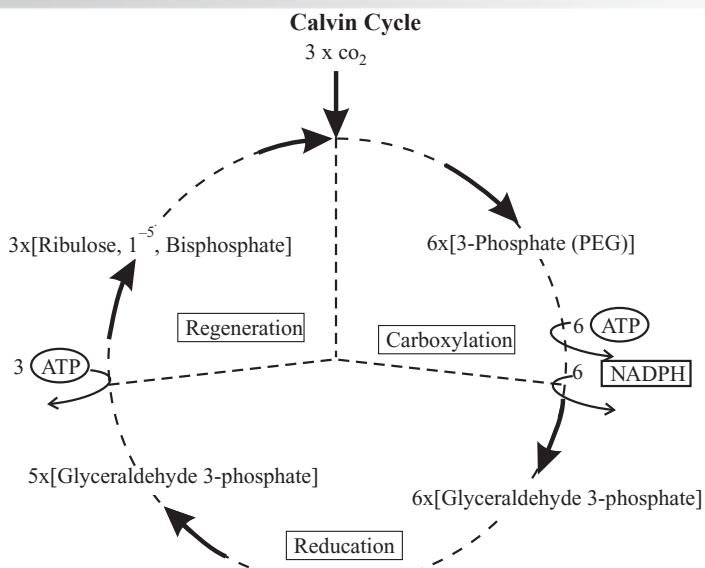
It is a biochemical process in which animals derives nutrients in the form of organic and inorganic substances for the proper maintenance and for all metabolic and catabolic activities occurs in the body.

### Nutrition

Nutrition is divided into three types :

#### Holozoic

- Holozoic nutrition:- This literally means feeding like an animal. Holozoic nutrition is a mode of heterotrophic nutrition in which an organism takes the complex organic food



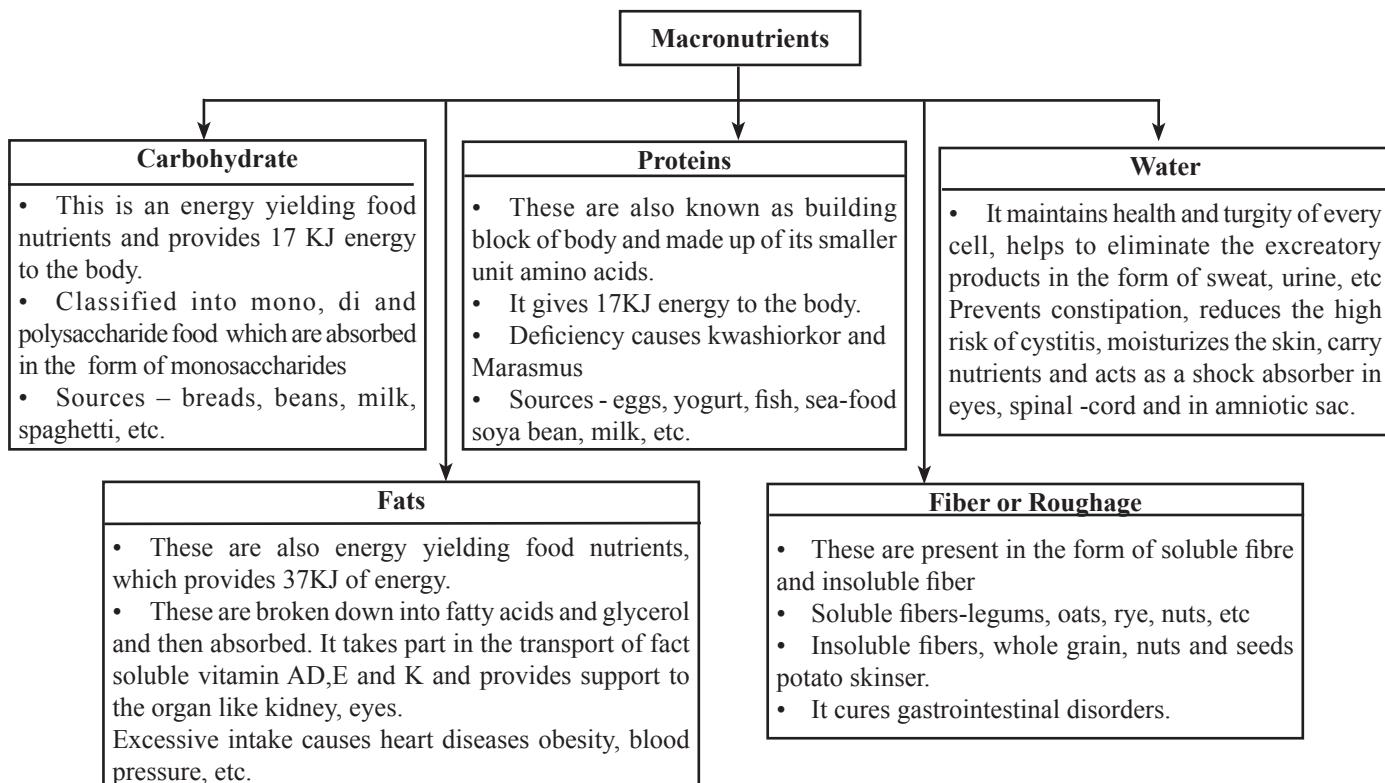
material into its body by the process of ingestion, which is then digested, absorbed and assimilated in the body cells of the organism.

- Holozoic nutrition is of three types :
  - (i) Herbivores , (ii) Carnivores , (iii) Omnivores
- It is a type of nutrition in which, animals derives nutrients from dead and decayed animals.  
Ex-insects in drainage, on pickles, etc.

#### Parasitic

- Organism derives its food from the host cell ex- plasmodium (causes malaria in man), etc
- Parasitic nutrition is of two types :

## Macronutrients Can be Summarized in the Flow Chart give Below:



## VITAMINS

Vitamins are organic compounds essential in trace amounts to the health of animals. Vitamins can be water soluble or fat soluble.

**Fat Soluble Vitamins:** These vitamins are stored in the liver in fat droplets.

Name	Source	Functions	Deficiency symptoms
<b>Vitamin A (Retinol)</b>	Carrot, tomato, papaya, mango, milk, eggs, cod-liver oil	Essential role for vision, growth, differentiation of epithelial tissue.	Night blindness, xerophthalmia poor growth, rough and dry skin.
<b>Vitamin D</b> It exists in two Forms <b>D<sub>2</sub> (Ergocalciferol) and D<sub>3</sub> (cholecalciferol).</b>	Cod liver oil. Skin can synthesize Vitamin D in the presence of sunlight.	It promotes growth of bones and teeth	Rickets in children and osteomalacia in adult.
<b>Vitamin E (Tocopherol)</b>	Wheat germ, green leafy vegetables. Fats of vegetable origin	Acts as good antioxidant, essential for normal functioning of reproductive organs	Reproductive failure, muscular dystrophy increased haemolysis leading to macrocytic anaemia
<b>Vitamin K</b> There are three derivatives of vitamin K.	Leafy vegetables, wheat germ, Vitamin K is synthesized by bacteria of large intestine.	I helps in blood clotting, prevention of excessive bleeding.	Facultative blood clotting.

## Water soluble Vitamins

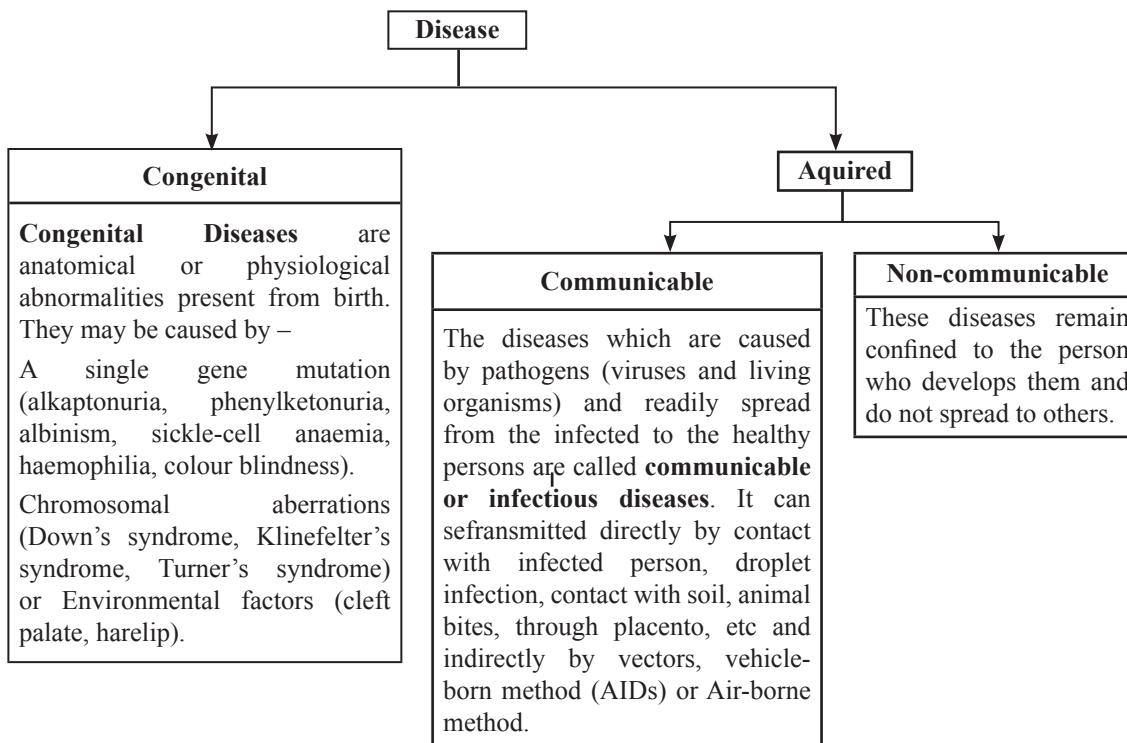
Water soluble vitamins travel freely through the body, and excess amounts usually are excreted by the kidneys. The body needs water soluble vitamins in frequent small doses. Important water soluble vitamins are summarized below in the table.

<b>B- Complex</b> <b>Vitamin B<sub>1</sub> (Thiamine)</b>	Whole grain wheat germ, legumes, nuts, fish.	It acts as thiamine pyrophosphate (TPP) in TCA cycle (Krebs Cycle)	<b>Beri beri</b> disease (B1) deficiency in alcoholics causes <b>Wernicke's syndrome and Korsakoff's syndrome</b>
<b>Vitamin B<sub>1</sub> (Riboflavin)</b>	Milk, cheese, meats, eggs, legumes, wheat germ, mushrooms, green leafy vegetables.	It helps in RBCs production. It acts as FMN and FAD. FMN acts in ETC, however FAD acts in both TCA cycle and ETC.	Cheilosis

Vitamin C (Ascorbic acid)	Cirrus fruits amla, guava, tomato.	Essential for the formation of RBCs and the production of antibodies.	Its deficiency causes <b>Scurvy</b>
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## HEALTH AND DISEASE

Anything that disturbs the proper functioning of cells, tissues and organs will result in the lack of proper activity of the body or unhealthy body. Thus, health is considered to be the state of perfect functioning of body and mind, unhindered by diseases.



### Communicable Disease

- Depending upon the type of causative agent communicable disease are the following types - bacterial, viral, rickettsial, spirochaetal, protozoan, fungal and helminthes etc.

Table : Bacterial Diseases in Human

S. No.	Disease	Pathogen	Main Symptoms
1.	Cholera (Haiza)	Comma shaped - <i>Vibrio comma</i> ( <i>V.cholerae</i> )	Severe diarrhoea and vomiting
2.	Pneumonia	<i>Diplococcus</i> or <i>Streptococcus pneumoniae</i>	Sudden chill, chest pain, difficulty in breathing
3.	Typhoid	Rod like motile <i>Salmonella typhi</i>	Constant fever
6.	Tuberculosis	<i>Mycobacterium tuberculosis</i> (rod shaped)..	Cough, bloody sputum, chest pain, loss of weight

### Viral Diseases

- Viral diseases are transmitted by contact fomite and droplet method. Types of viral disease are-influenza, small pox, etc.

Table : Viral Diseases in Humans

S.No.	Disease	Pathogen	Main Symptoms
1.	Influenza (Flu)	<i>Myxovirus Influenzae</i>	Nasal discharge, sneezing, coughing, fever, body ache

2.	Chicken pox	<i>Varicella zoster</i> (DNA virus)	Skin sores that open & emit fluid
3.	Poliomyelitis (polio) (Highly infectious disease of infants and childrens)	<i>Polio virus</i>	Inflammation of nervous system, muscle shrinkage, limb paralysis
4.	Dengue	<i>Arbo virus (RNA)</i>	Mild conjunctivitis, high fever, backache, nausea vomiting etc.
5.	Hepatitis (Epidemic jaundice)	<i>Infectious &amp; serum hepatitis viruses (A, B, C, D &amp; E)</i>	Jaundice due to damaged liver cells
	– Hepatitis A (also called catarrhal jaundice)	<i>A virus</i>	Hepatic anorexia resulting in liver damage
	– Hepatitis B	<i>B virus</i>	Swelling of liver cells

### Protozoan disease

	Disease	Causative agent	Symptom
1	Malaria	<i>Plasmodium</i> (female <i>anopheles</i> as vector)	It results in anaemia, toxæmia and splenomegaly. <b>Antimalarial drugs</b> are quinine, chloroquine etc. <i>Dalaprim</i> drug kills the parasitic stages present in both liver cells and RBC's of blood.
2	Amoebiasis	<i>Entamoeba histolytica</i>	It is characterized by abdominal pain alternating diarrhoea and constipation etc Entamoeba secretes cytolsin that erodes the mucous membrane of intestine.

**Table : Sexually Transmitted Diseases (STD) in Human**

S. No.	Disease	Causative organism	Symptoms-Treatment
1.	AIDS	<i>Retrovirus – HIV</i>	Enlarged lymph nodes, long fever, weight loss – Nil
2.	Genital Herpes	<i>Herpes simplex virus</i>	Painful ulcer on genitals – Nil
3.	Genital warts	<i>Human papilloma virus (HPVs)</i>	Tumor of the vulva, vagina, anus and penis – Nil
4.	Syphilis	<i>Treponema pallidum</i>	Cancer and skin eruption – Benzene and Penicillin

### Non-Communicable Diseases

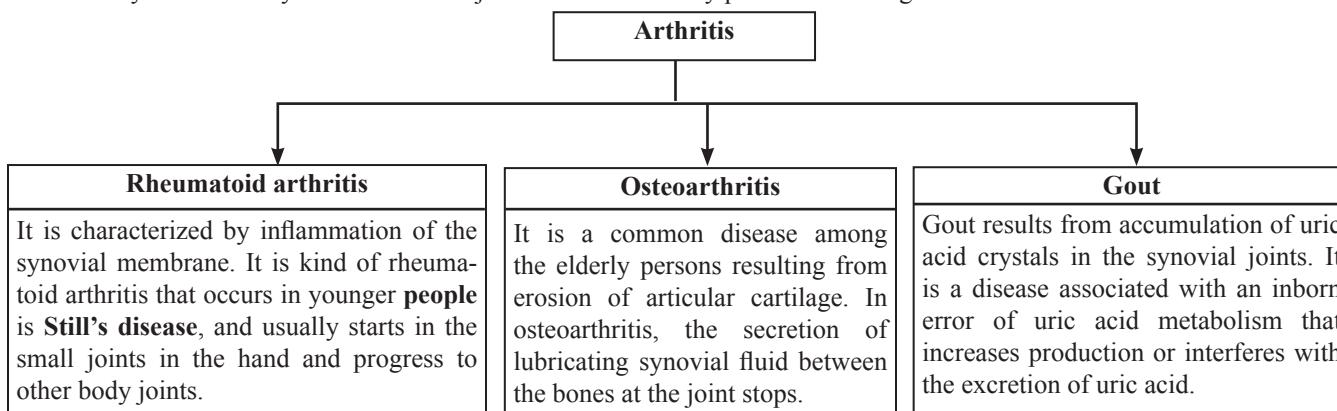
The main non-communicable diseases are *diabetes*, *inflammatory diseases of joints* such as arthritis, gout, cardiovascular diseases and cancer.

#### Diabetes Mellitus

Diabetes is characterized by chronic hyperglycemia which is excessive concentration of glucose in the blood. It primarily a result of relative or complete lack of insulin secretion by the  $\beta$  cells of islets of Langerhans in pancreas.

#### Arthritis

Arthritis is any inflammatory condition of the joints characterized by pain and swelling.



### Cardiovascular Diseases

- Cardiovascular diseases refer to a number of diseases associated with the blood vascular system.
- Some major cardiovascular diseases are **rheumatic heart disease**, **hypertensive heart disease** and **coronary heart disease**.

### CANCER

Cancer is an abnormal and uncontrolled division of cells, known as cancer cells, that invade and destroy the surrounding tissues.

**Neoplasm** (called **tumor**) is a new abnormal tissue which is capable of continued growth. Tumors may be **benign** and **malignant**.

Tumor	
Benign	Malignant
<b>Benign tumor</b> is a large localized mass of abnormal tissue enclosed in connective tissue which does not invade adjacent tissue.	<b>Malignant tumor</b> is not encapsulated and is capable of invading adjacent tissues and distant sites.

### Symptoms of Cancer

- Thickening or lump in the breast or any other part of the body.
- Changes in bowel or bladder habits.
- Indigestion or difficulty in swallowing.
- Unexplained changes in weight.

### Causes of Cancer

- Chemical or physical agents** that can cause cancer are known as **carcinogen**. Depending on their mode action, carcinogens fall into the following main categories:
  - Agents that can cause alterations in the genetic material (DNA), resulting in oncogenic transformation.
  - Agents that promote the proliferation of cells, which have already undergone genetic alterations responsible for oncogenic transformation. These agents are called **tumour promoter**, e.g. some growth factors and hormone.
  - Cancer causing DNA and RNA viruses (tumour viruses) have been shown to be associated with oncogenic transformation.

### Treatment

- Surgery** : By removing the entire cancerous tissue and infected lymph nodes.
- Radiation**: Cobalt therapy (Co-60), X-rays radiations are given. These radiations destroy the rapidly dividing cells.
- Chemotherapy**: Anti-cancerous drugs like: Vincristine and Vinblastine obtained from Catharanthus roseus (vinca rosea)
- Most of cancer are treated by combination therapy of surgery, radiation and anti cancerous drug.

### AIDS

- AIDS (Acquired Immuno Deficiency Syndrome) is a chronic life threatening disorder which damages the hu-

man body's immune system. It is **caused by HIV** (human immuno-deficiency virus) which belong to retrovirus (group of RNA virus). The HIV can only survive in body fluids like blood, semen, vaginal secretion etc.

- HIV is transmitted through body fluids by- Sexual contact (most common mode of transmission) (Probability < 1 %), blood contact (100%), and By mother to child by placenta (33%), By mother milk
- HIV is not transmitted through - ordinary contact (hugging, dancing, talking, touching etc.) with someone who has HIV or AIDS; sweat, tears or saliva etc. The major cell affected by HIV is the *helper-T-lymphocyte*.

### Investigation

- Screening test is Enzyme Linked Immuno sorbent assay (E.L.I.S.A.).
- Confirmatory tests : **Western blot test** Detects antibodies (proteins) in patient's serum.

### Treatment

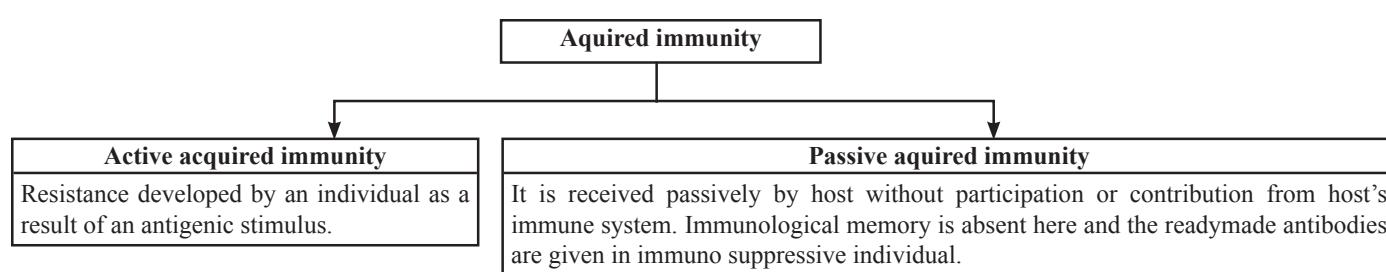
- Drugs used are -
  - AZT (Azidothymidine) or Zidowdine
  - DDI (Dideoxyinosine)
  - Foscarnet
 These drugs inhibit the enzyme of HIV.
- Highly active antiretroviral therapy (HAART) is a combination of three or more antiretroviral agents (called triple therapy or HAART), which has been highly effective in reducing the number of HIV particles in the blood stream and as a result increase the CD4 count.

### IMMUNE SYSTEM

- System which protect the body from disease is called **immune system**.
- The immune system consisting several organs as well as WBC in blood and lymph has the job of fighting off invading pathogens and preventing growth and spread of cancers.
- Lymphoid organs are those organs where origin and maturation and proliferation of lymphocyte occur.
- The primary lymphoid organs are **bone marrow** and **thymus**.
- Bone marrow** manufactures the billions of WBC needed by the body every day. Some newly produced WBC remain in the bone marrow to mature and specialize and while others travel to the **thymus** to mature.

### Acquired Immunity

- It is the resistance that an individual acquires during life. This is generated in response to an exposure to the microorganism in question. This type of immunity is founds only in vertebrates. It is also called **adaptive or specific immunity**. This immunity is acquired after birth by experience and recognises and selectively eliminate the pathogen.



**Antibodies:** These are complex glycoproteins made up of polypeptide chains.

S. No.	Group of Antibodies	Main Characters and occurrence	Functions
1.	IgA	The primary antibodies present in colostrum, present in saliva, mucus and other secretions.	Protection of mucous membranes and outer surface of body and protection from inhaled ingested pathogens.
2.	IgD	Present in trace amount on the surface of lymphocytes in blood.	Activation of B-lymphocytes and development and maturation of immune reactions.
3.	IgE	Present in very small quantities, show specific linkage with mast cells and basophils.	Stimulation of mast cells. Related to allergic reactions and protection from parasites.
4.	IgG	Most abundantly found antibodies, main immunoglobulin of blood and interstitial fluid which has capacity to pass through placenta.	Stimulate the complementary system, provide immune power to human embryo and specific linkage with phagocytic cells for phagocytosis.
5.	IgM	Oldest and first antibody generated in response to antigens, present in blood plasma (80%) and interstitial fluids and largest sized immunoglobulin with pentameric form, M.W.	First line of defence against bacteria, perfection of agglutination, related to complement system.

**Table : Some Important Vaccines**

S. No.	Name of Vaccine	Used for treatment of
1.	B.C.G.	Tuberculosis
2.	Cholera vaccine	Cholera
3.	Oral Polio Vaccine (OPV)	Polio, 1st dose given when child is 3 months old. Booster dose is given after 1 year
4.	Tetanus toxoid (TT)	Tetanus

## EXERCISE

1. The site of photosynthesis in plants is
    - (a) mitochondria
    - (b) chloroplasts
    - (c) leucoplasts
    - (d) dictyosomes
  2. Autotrophic nutrition occurs in
    - (a) fungi
    - (b) plants
    - (c) some protists and prokaryotes
    - (d) Both (b) and (c)
  3. Select the correct statement.
    - (a) Heterotrophs do not synthesise their own food.
    - (b) Heterotrophs utilise solar energy for photosynthesis.
    - (c) Heterotrophs synthesise their own food.
    - (d) Heterotrophs are capable of converting carbon dioxide and water into carbo-hydrates.
  4. Select the statement which does not occur during the process of photosynthesis.
    - A. Absorption of light energy by chlorophyll.
    - B. Conversion of chemical energy to light energy and splitting of water molecules into hydrogen and oxygen.
    - C. Oxidation of carbon dioxide to carbohydrates.
    - (a) A and B
    - (b) A and C
    - (c) B and C
    - (d) All of the above
- 
- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>5. <b>Column-I</b></li> </ol>   | <ol style="list-style-type: none"> <li><b>Column-II</b></li> </ol>                    |
| A. parasites<br>B. saprophytes<br>C. Autotrophs<br>D. Holozoic<br>(a) A-P ; B-Q ; C-R ; D-S<br>(b) A-R ; B-P ; C-S ; D-Q<br>(c) A-P ; B-R ; C-Q ; D-S<br>(d) A-R ; B-S ; C-P ; D-Q | P. fungi<br>Q. Humans<br>R. Leech<br>S. Algae.<br>(a) Mg<br>(b) K<br>(c) Ca<br>(d) Zn |
| 6. Which of the following is a micronutrient element-  | (a) Iron<br>(b) Oxygen<br>(c) Protein<br>(d) None of the above                        |
| 7. Erythropoiesis may be stimulated by the deficiency of   | (a) cuticles<br>(b) pores<br>(c) stomata<br>(d) lenticels                             |
| 8. Stomata : gaseous exchange from leaves : gaseous exchange from bark cells   | (a) tentacles<br>(b) skin of the leaf<br>(c) stomata<br>(d) root hair                 |
| 9. Exchange of gases in leaf occurs through  | (a) A and B<br>(b) A and C<br>(c) B and C<br>(d) All of the above                     |

- 10.** Which mineral is obtained from the atmosphere?
- Potassium
  - Iron
  - Magnesium
  - Nitrogen
- 11.** Photosynthesis is an important mode of autotrophic nutrition. The event which does not occur in photosynthesis is
- Conversion of light energy to chemical energy
  - Reduction of carbon dioxide to carbohydrate
  - Oxidation of carbon to carbondioxide
  - Absorption of light energy by chlorophyll
- 12.** Hydroponics refers to the plant development
- without soil.
  - in saline soil.
  - in water without soil.
  - without soil with alkaline pH.
- 13.** The major role of minor elements inside living organisms is to act as
- binder of cell structure.
  - co-factors of enzymes.
  - building blocks of important amino acids.
  - constituent of hormones.
- 14.** Which of the following is not caused by deficiency of mineral nutrition?
- Necrosis
  - Chlorosis
  - Etiolation
  - Shortening of internodes
- 15.** Boron in green plants assists in
- sugar transport
  - activation of enzymes
  - acting as enzyme cofactor
  - photosynthesis
- 16.** Which of the following elements are constituents of protein?
- Nitrogen and phosphorus
  - Nitrogen and chlorine
  - Phosphorus and boron
  - Chlorine and potassium
- 17.** Nitrogen fixation is a process of
- converting nitrogen in the air to form a usable form by plants.
  - recycling nitrogen from organic matter in the soil.
  - absorbing nitrogen from the soil.
  - conversion of  $\text{NO}_3$  to  $\text{N}_2$ .
- 18.** Which of the following statements is not correct about macro-nutrients?
- They are present in plant tissues in excess of 100 m mole per kg of dry matter.
  - They include C, H, O, N, P, S, K, Ca, Mg.
  - Some elements attained from  $\text{CO}_2$  and  $\text{H}_2\text{O}$  while the others are absorbed from the soil.
  - C, H & O are mainly obtained from  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .
- 19.** **Column-I (Minerals)**
- |       |                                  |
|-------|----------------------------------|
| A. K  | I. Stomatal opening              |
| B. Mo | II. Constituent of cell membrane |
| C. P  | III. Photolysis of water         |
| D. Mn | IV. Free ion                     |
- Column-II (Functions)**
- |   |            |            |            |               |
|---|------------|------------|------------|---------------|
| V. Component of nitrogenase and nitrate reductase | A. II, III | B. III, II | C. II, III | D. III, II, V |
| (a) I, IV   | V          | II         | III        |               |
| (b) I, V  | IV         | III        | II         |               |
| (c) I, V  | IV         | II         | III        |               |
| (d) IV  | I          | III        | II, V      |               |
- 20.** **Column -I**
- |               |                        |
|---------------|------------------------|
| A. Zinc       | I. Chlorophyll         |
| B. Sulphur    | II. IAA                |
| C. Magnesium  | III. Nitrate reductase |
| D. Molybdenum | IV. Cysteine           |
- Column-II**
- |                                    |          |
|------------------------------------|----------|
| (a) A – I, B – II, C – III, D – IV | I – IV   |
| (b) A – III, B – IV, C – I, D – II | II – III |
| (c) A – III, B – I, C – II, D – IV | III – IV |
| (d) A – II, B – IV, C – I, D – III | II – III |
- 21.** Passive immunity was discovered by
- Robert Koch
  - L. Pasteur
  - Edward Jenner
  - Eemil Von Behring
- 22.** The term “antibiotic” was coined by
- Alexander Fleming
  - Edward Jenner
  - Louis Pasteur
  - Selman waksman
- 23.** The malignant tertian malaria is caused by
- Plasmodium vivax*
  - Plasmodium falciparum*
  - Plasmodium ovale*
  - Plasmodium malaria*
- 24.** ‘Black death’ is related with
- plague
  - cancer
  - tuberculosis
  - measles
- 25.** **Column-I (Drug/Cure)**
- |                 |                               |
|-----------------|-------------------------------|
| A. Streptomycin | P. Viral Disease              |
| B. Chloroquine  | Q. Diabetes Mellitus          |
| C. Penicillin   | R. Disease caused by Bacteria |
| D. insulin      | S. Malaria                    |
- Column-II (Diseases)**
- |                        |                               |
|------------------------|-------------------------------|
| (a) A-R; B-S; C-P; D-Q | P. Viral Disease              |
| (b) A-R; B-S; C-Q; D-P | Q. Diabetes Mellitus          |
| (c) A-R; B-Q; C-P; D-S | R. Disease caused by Bacteria |
| (d) A-P; B-Q; C-R; D-S | S. Malaria                    |

- |   |   |                           |            |  |                      |              |
|---|---|---------------------------|------------|--|----------------------|--------------|
| <b>26.</b>  | <b>Column-I</b>   | <b>Column-II</b>          | <b>35.</b> | Consider the following statements.   | [IAS Prelim]         |              |
| A.  | Small pox   | P. Bacteria               |            | AIDS -is transmitted   |                      |              |
| B.  | Cholera   | Q. Virus                  |            | 1. By sexual intercourse   |                      |              |
| C.  | Malaria   | R. Deficiency of minerals |            | 2. By blood transfusion  |                      |              |
| D.  | Anaemia   | S. Female mosquito        |            | 3. By mosquitoes and other blood sucking insects   |                      |              |
| (a)   | A-S; B-Q; C-R; D-P  |                           |            | 4. Across the placenta   |                      |              |
| (b)   | A-Q; B-P; C-S; D-R  |                           |            | (a) 1, 2 and 3 are correct   |                      |              |
| (c)   | A-S; B-R; C-Q; D-P  |                           |            | (b) 1, 2 and 4 are correct   |                      |              |
| (d)   | A-R; B-S; C-P; D-Q  |                           |            | (c) 1, 3 and 4 are correct   |                      |              |
| (e)   |   |                           |            | (d) 1 and 3 are correct  |                      |              |
| <b>27.</b>  | DPT vaccine stands for  |                           | <b>36.</b> | People drinking water from a shallow hand pump, are likely to suffer from all of the following diseases except | [IAS Prelim]         |              |
| (a)   | diphtheria, polio & tuberculosis  |                           |            | (a) Cholera  | (b) Typhoid          |              |
| (b)   | diphtheria, pertussis & tuberculosis  |                           |            | (c) Jaundice   | (d) Fluorosis        |              |
| (c)   | diphtheria, polio & tetanus   |                           | <b>37.</b> | The major chemical compound found in kidney stones is :  | [IAS Prelim]         |              |
| (d)   | diphtheria, pertussis and tetanus   |                           |            | (a) urea   |                      |              |
| <b>28.</b>  | Which Vector Spread the yellow fever disease?   |                           |            | (b) calcium carbonate  |                      |              |
| (a)   | <i>Musca sp</i>   | (b) <i>Anopheles sp</i>   |            | (c) calcium oxalate  |                      |              |
| (c)   | <i>Culex sp</i>   | (d) <i>Aedes aegypti</i>  |            | (d) calcium sulphate   |                      |              |
| <b>29.</b>  | Which of the following is an air-borne disease?   |                           | <b>38.</b> | Antigen is a substance which   | [IAS Prelim]         |              |
| (a)   | Tuberculosis  | (b) Cholera               |            | (a) lowers body temperatures   |                      |              |
| (c)   | Jaundice  | (d) Brain fever           |            | (b) destroys harmful bacteria  |                      |              |
| <b>30.</b>  | Which of the following is a communicable disease?   |                           |            | (c) triggers the immune system   |                      |              |
| (a)   | Phenylketonuria   | (b) Cancer                |            | (d) is used as an antidote to poison   |                      |              |
| (c)   | Rabies  | (d) Alkaptonuria          | <b>39.</b> | Haemophilia is a genetic disorder which leads to   | [IAS Prelim]         |              |
| <b>31.</b>  | Which of the following disease is confirmed by 'wald test'?   |                           |            | (a) decrease in haemoglobin level  |                      |              |
| (a)   | Tuberculosis  | (b) Typhoid               |            | (b) rheumatic heart disease  |                      |              |
| (c)   | Plague  | (d) Tetanus               |            | (c) decrease in WBC  |                      |              |
| <b>32.</b>  | "Athlete's Foot" is a disease' caused by  |                           |            | (d) non-clotting of blood  |                      |              |
| (a)   | Bacteria  | (b) Fungus                | <b>40.</b> | <b>List-I</b>  | <b>List-II</b>       | [IAS Prelim] |
| (c)   | Protozoan   | (d) Nematode              |            | A. Atropine  | 1. Local anaesthesia |              |
| <b>33.</b>  | According to the World Health Organisation (WHO), the disease which causes the death of the largest number of people today is |                           |            | B. Ether   | 2. Heart trouble     |              |
| (a)   | AIDS  | (b) Tuberculosis          |            | C. Nitroglycerine  | 3. Dilation of pupil |              |
| (c)   | Malaria   | (d) Ebola                 |            | D. Pyrethrin   | 4. Mosquito control  |              |
| <b>34.</b>  | Which of the following are associated with <i>Diabetes mellitus</i> , a common disease in adults ?                            |                           |            | <b>Codes :</b>   |                      |              |
| 1.  | Higher sugar level in blood   |                           |            | (a) A – 1; B – 3; C – 2; D – 4   |                      |              |
| 2.  | Lower sugar level in blood  |                           |            | (b) A – 1; B – 3; C – 4; D – 2   |                      |              |
| 3.  | Lower insulin level in blood  |                           |            | (c) A – 3; B – 1; C – 4; D – 2   |                      |              |
| 4.  | Higher insulin level in blood   |                           |            | (d) A – 3; B – 1; C – 2; D – 4   |                      |              |
| Select the correct answer by using the codes given below: |   |                           |            |  |                      |              |
| <b>Codes:</b>   |   |                           |            |  |                      |              |
| (a)   | 2 and 4   | (b)                       | 1 and 2    |  |                      |              |
| (c)   | 2 and 3   | (d)                       | 1 and 3    |  |                      |              |

**ANSWER KEY**

ANSWER KEY															
1.	(b)	2.	(d)	3.	(a)	4.	(c)	5.	(b)	6.	(d)	7.	(b)	8.	(d)
9.	(c)	10.	(d)	11.	(c)	12.	(c)	13.	(b)	14.	(c)	15.	(a)	16.	(a)
17.	(a)	18.	(a)	19.	(a)	20.	(d)	21.	(d)	22.	(d)	23.	(b)	24.	(a)
25.	(a)	26.	(b)	27.	(d)	28.	(d)	29.	(a)	30.	(c)	31.	(b)	32.	(b)
33.	(b)	34.	(d)	35.	(b)	36.	(d)	37.	(c)	38.	(c)	39.	(d)	40.	(b)

# Chapter

# 7

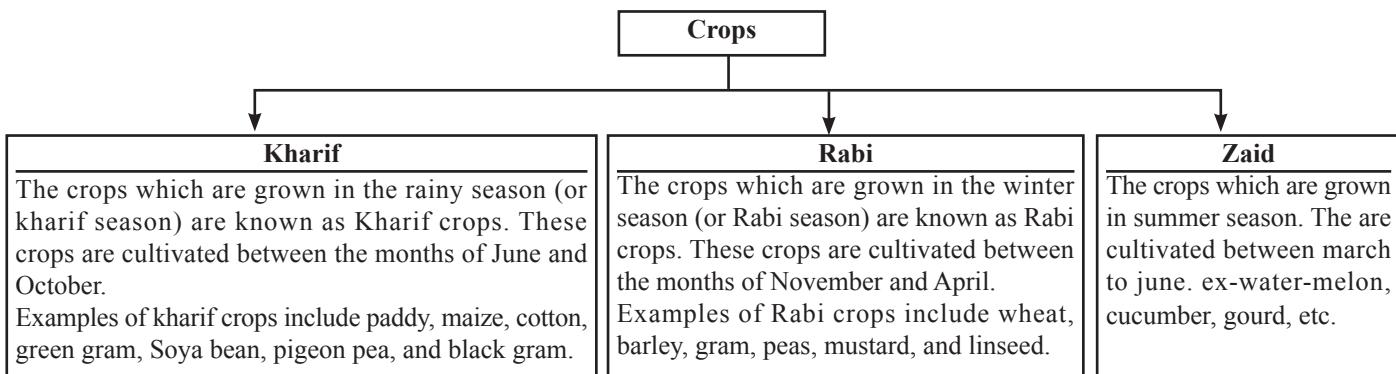
# FOOD PRODUCTION

## FOOD PRODUCTION

All living organisms require food for survival. Food is the basic need for existence of life on earth. Our country is over-populated and supports around one billion people. Therefore, in order to feed such a large population, we need to produce several million tones of grains every year along with higher requirement of milk, eggs and meat. Therefore, we need to increase production of both plant and animal products. The only possibility is to increase production efficiency of both plants and animals. We can increase the production by the development and use of improved varieties with high yield and better agricultural practices.

<i>Agriculture revolution</i>	<i>Production</i>
Green revolution	Cereals
White revolution	Milk
Blue revolution	Fish
Grey revolution	Fertilizers
Red revolution	Meat/Tomatoes
Golden revolution	Horticulture

### Classification of crops on the basis of season



## IMPROVEMENT IN CROP PRODUCTION

The yield of a crop can be increased by adopting a number of improved agricultural activities, which includes three scientific approaches :-*Crop variety improvement, Crop production improvement and Crop protection management*

### Crop Variety Improvement Methods

The high yield from the crops is directly related with the inputs and the agricultural practices which the farmers adopt. Higher the inputs, more is the yield.

Pink revolution	Prawn/Onion/pharmaceutical (India)
Silver revolution	Eggs and Chicken
Round revolution	Potato
Yellow revolution	Oil seeds

## AGRICULTURE

The term “agriculture” is derived from two Latin words: *Ager-field* and *culta-cultivation*. Thus, agriculture is the branch of science that deals with the mass production of plants and animals useful to human beings. It involves study of:

### CROP

Crop is a plant grown in the fields on a large scale to obtain food. *For example*, if all the plants of rice are grown in the field, then it is called a rice crop. Similarly, if all the plants of wheat are grown, then it is called a wheat crop. Crops are cultivated by humans for food, fodder and other materials. **Let us discuss some important types of crops:**

*The various aspects for which crop variety improvement is carried out are as follows:*

- (i) To obtain higher yield of crop
- (ii) To enhance the desirable quality of food items.
- (iii) To produce crop variety that is resistant to biotic and abiotic factors.
- (iv) To change the maturity duration of crop.
- (v) To induce desirable agronomic traits.
- (vi) To develop plant varieties with wider adaptability.

## GM CROPS

Food items	Crop	Varieties
Cereals	Rice	Kasturi, Jaya, Padma, IR-8, Ponne, Pusa Basmati rice - 1509, Casalath
	Wheat	Sharbati Sonora, Sonalika, Kalyan Sona, Hira Moti, Pusa Lerma
	Maize	Vikram, Navjot, Shakti, Ganga 101, Deccan hybrid
Pulses	Pigeon pea	Pusa 84, Manak
	Chick pea	Pusa 240, Pant 114
Oil seeds	Sunflower	Arun, Pusa
	Mustard	Kranti, Pusa Bold
Vegetables	Lady Finger	Pusa Savani
	Brinjal	Pusa Purple, Pusa Kranti

## Nutrient Management

The plants absorb the nutrients and inorganic raw materials from their surroundings and utilize the same building up their organic matter. The main sources of nutrients for plants are air, soil and water. In total, there are sixteen nutrients required by plants.

- Out of these, two nutrients (Carbon and Oxygen) are obtained from air.
- Hydrogen is obtained from water.
- These three elements - Carbon, Oxygen and Hydrogen are called non-essential elements as they are not obtained from soil.
- The remaining thirteen nutrients are obtained from soil with the help of roots. They are called mineral nutrients or essential nutrients.
- Micronutrients:** Nutrients required in small quantities are called micronutrients. (Ph, Mg, K, N, Ca, S)
- Macronutrients:** Nutrients required in larger quantities are called macronutrients. Nutrients are essential elements, which are used by plants in large quantities.(Mo, Mn, Cl, Cu, B, Zn, Fe)

## Manure

Manure is a natural fertilizer. It is prepared by the decomposition of plant and animal waste.

### Composition of manure

- Manure is a source of many plant nutrients.
- It is composed of organic matter and minerals. Ammonia, nitrate, organic substances, etc. are predominant organic matters found in manures.
- These are mostly composed of micronutrients such as zinc, manganese, copper, magnesium, sodium, etc.

### Advantages of manure

- It enriches the soil with organic material called humus to the soil.

- It increases the water holding capacity of soil.
- It aerates the soil by making it porous.
- It helps in growth of micro-organisms. The organic matter of manures provides food for the soil organisms which help in making nutrients available to plants.
- It improves the soil texture.
- It increases the crop production.

## Disadvantages of manure

- Manures are bulky with low nutrient content.
- They are inconvenient to handle, store and transport.
- Manures are not nutrient specific. Hence, it is not much useful when a particular nutrient is required in the soil for a particular crop.
- The nutrients of manures are released slowly, not keeping pace with high and rapid demand of nutrients by crops.

## Fertilizers

Fertilizers are plant nutrients, which are commercially available. They can be organic or inorganic in nature. They ensure healthy growth and development in plants by providing them with nitrogen, phosphorus, potassium, etc.

### Advantages of fertilizers

- They are mostly inorganic compounds, which can readily dissolve in water. They are easily available for plants.
- They are a good source of nitrogen, phosphorus, and potassium. However, they are good only for a short term use.
- They are nutrient specific.
- They are compact, easy to store and transport.
- They are required in very small amount.

### Disadvantages of fertilizers

- They get washed away because of irrigation. Hence, they are a cause of water pollution.
- Continuous use of fertilizers causes harm to useful or symbiotic micro-organisms living in soil.
- They can also result in the reduction of soil fertility.
- They cannot replenish the organic matter of soil.
- They are quite expensive.
- They have only short term benefits
- Therefore, to get an optimum yield, it is necessary to use a balanced combination of manures and fertilizers.

## Organic Farming

Organic farming is the practice of raising unpolluted crops through limited use of chemicals such as fertilizers, pesticides, herbicides, genetically-modified organisms, etc. Sometimes they are not used at all.

### Advantages of organic farming

- It does not cause pollution of crop plants, soil, air and water.
- It helps in recycling of waste materials.
- The food obtained from organic farming is free from pesticides and chemicals.
- It maintains the health of soil.
- It keeps insects, pests and weeds under check.

## Irrigation

The process of supplying water to crops in the fields is called *irrigation*. The various sources of irrigation are wells, canals, rivers, dams, ponds and lakes.

### Importance of irrigation

- (i) It makes the soil soft due to which ploughing becomes easier.
- (ii) It provides moisture for germination of seeds as seeds do not germinate in dry soils.
- (iii) Irrigation water helps in absorption of nutrient elements by plants from soil. The water dissolves the nutrient present in the soil to form a solution, which is then absorbed by the roots for the development of plants.
- (iv) Irrigation is essential for the growth and elongation of the roots of the crop plants as roots of crop plants fail to develop and elongate in dry soil.

### Irrigation systems

There are number of irrigation systems in India depending on the availability of water resources and the requirement of water by crops. The various sources of irrigation are wells, canals, rivers, dams, ponds and lakes.

*Based on water resources, the various irrigation systems are as follows:*

- *Tanks:* Tanks are small storage reservoirs, which catch and store the runoff of smaller catchment areas. Small dams are built below the higher elevation of catchment areas. The outflows are regulated according to the water availability.
- *Canal system:* In this system, human made canals receive water from rivers, storage lakes, dams etc. Main canal passes into branch canal, which in turn divide into distributaries. The distributaries ultimately supply water to the individual fields or group of fields. Each field or group of fields is given water by rotation.
- *Wells:* Wells are shafts sunk into ground that reaches water table and are used to draw water.
- *River lift system:* In this system, water is directly drawn from the rivers for supplementing irrigation in the areas near to rivers. This type of system is more useful in areas where canal flow is insufficient or irregular due to inadequate water release.
- *River valley system:* In riverine valleys with heavy rains, the slopes and valleys remain wet for long duration to grow perennial crops like coconut, rubber and tapioca.
- *Drip system:* In this method, water is delivered at or near the roots of plant drop by drop. Water is passed through plastic pipes that have holes in it. These plastic pipes are then laid along the rows of crops. It is the most efficient method of irrigation as there is no wastage of water at all.
- *Sprinkler system:* This system supplies water to plants in the form of rain. The water is supplied using pipes to one or more central locations within the field. When water is allowed to flow under high pressure with the help of pump, it gets sprinkled on the crops.

## Cropping Patterns

*Cropping patterns* are models of raising crops which help in obtaining maximum benefit from a single piece of land.

**The common types of cropping patterns are:**

**Crop rotation:** The practice of growing two or more varieties of crops on the same field in a sequential season is known as *crop rotation*.

### Advantages of crop rotation:

- (i) It improves the fertility of soil and hence brings about an increase in food production.
- (ii) It helps in weed control.
- (iii) It protects crop from diseases.
- (iv) It reduces the dependence on fertilizers.
- (v) It results in optimum utilization of nutrients as different crops obtain nutrients from different layers of soil.

**Multiple cropping:** Multiple cropping is the growing of two or more crops one after another in the same field. *It is of two types:*

**Mixed cropping :** It is the technique of growing two or more different crops simultaneously on the same field. The farmers mix the seeds of two crops and sow in the field. It is like an insurance against crop failure due to abnormal weather conditions and attack of pests and pathogens.

### For example:

- (i) Maize + Urad bean
- (ii) Soyabean + Pigeon pea
- (iii) Wheat + Chick pea
- (iv) Wheat + Mustard
- (v) Barley + Gram

### Advantages of Mixed Cropping

- It reduces the risk of total crop failure.
- It tends to harvest variety of produce such as pulses, cereals, vegetables etc.
- It improves the fertility of soil and reduces the requirement of fertilizers.
- It helps in optimum utilization of the soil.
- It reduces the chances of pest infestation.
- It enhances the optimum utilization of nutrients as they are absorbed from different layers of the soil.

### Disadvantages of Mixed Cropping

- The seeds of two crops are mixed and there is no set pattern of rows of crops. As a result, harvesting and threshing of crops separately is not easy.
- Farmers face difficulty in spraying pesticides and applying fertilizers to individual crops.
- *Inter cropping:* It the practice of growing two or more crops simultaneously in a same field in a definite row patterns. This technique enhances the productivity per unit area. The crops selected have different nutrient requirements, different sowing and harvesting dates.

### For example:

- i. Soyabean + Maize
- ii. Bajra + Lobia

# EXERCISE

1. The principal cereal crop in India is
    - (a) wheat
    - (b) rice
    - (c) maize
    - (d) sorghum
  2. The cheapest high energy fruit crop of India is
    - (a) Banana
    - (b) Guava
    - (c) Apple
    - (d) Mango
  3. Number of queens in a hive is
    - (a) 20
    - (b) 15
    - (c) 20
    - (d) 1
  4. Crop rotation is carried out for
    - (a) increasing acidity of soil
    - (b) decreasing fertility of soil
    - (c) increasing fertility of soil
    - (d) all the above
  5. Nitrogen, Phosphorus, Potassium are examples of
    - (a) micro-nutrients
    - (b) macronutrients
    - (c) fertilizer
    - (d) both (a) and (b)
  6. Kranti, Pusa Agarni and Pusa Bold are improved varieties
    - (a) Urad bean
    - (b) Sunflower
    - (c) Chick Pea
    - (d) Mustard
  7. Which one of the following is an Italian bee variety?
    - (a) *Apis mellifera*
    - (b) *Apis dorsata*
    - (c) *Apis florae*
    - (d) *Apis cerana indica*
  8. All these are fodder crops except
    - (a) mustard oil
    - (b) berseem
    - (c) oats
    - (d) sudan grass
  9. Dams are used for
    - A. irrigation
    - B. stopping the rainwater from flowing away.
    - C. decreasing chances of soil erosion.
    - D. increasing ground water level.
    - (a) A, B & C
    - (b) B, C & D
    - (c) A, C & D
    - (d) all these.
  10. This is not a biotic agent for oiling crops.
    - (a) rodents
    - (b) moisture
    - (c) insects
    - (d) fungi
  11. The uses of honey is/are in
    - (a) making medicines
    - (b) in making waxes
    - (c) generating money
    - (d) all the above.
  12. \_\_\_\_\_ is not a natural insecticide.
    - (a) Neem
    - (b) khapra beetle
    - (c) Nicotine
    - (d) pyrethrum
  13. Which of the following rotation of crops will reduce dependence on the use of chemical fertilizers?
    - (a) Rice and Chilli
    - (b) Wheat and Potato
    - (c) Potato and Rice
    - (d) Gram and Rice
  14. Which of the following will result in loss of soil fertility?
    - A. Crop rotation
    - B. Shifting cultivation
  15. Excessive use of chemical fertilizers
    - (a) Only A and B
    - (b) Only A and C
    - (c) Only B and C
    - (d) A, B and C
- | Column I               | Column II       |
|------------------------|-----------------|
| A. Marine fish         | P. Carp culture |
| B. Fresh water fish    | Q. Apiculture   |
| C. Bee Keeping         | R. Mariculture  |
| D. Composite fish      | S. aquaculture  |
| (a) A-R; B-S; C-Q; D-P |                 |
| (b) A-P; B-R; C-Q; D-S |                 |
| (c) A-S; B-Q; C-P; D-R |                 |
| (d) A-S; B-Q; C-R; D-P |                 |
16. Column I      Column II
 

A. Rock bee	P. Exotic fish
B. Silver carp	Q. Marine fish
C. Bombay duck	R. Carp
D. Rohu and Catla	S. <i>Apis dorsata</i>
(a) A-P; B-Q; C-R; D-S	
(b) A-P; B-R; C-Q; D-S	
(c) A-S; B-P; C-Q; D-R	
(d) A-S; B-Q; C-R; D-P	
  17. Column I (Food)      Column II (Content)
 

A. cereals	P. fats
B. pulses	Q. vitamins and minerals
C. oil seeds	R. proteins
D. fruits & spices	S. carbohydrates
(a) A-P; B-Q; C-R; D-S	
(b) A-S; B-C; C-Q; D-P	
(c) A-S; B-R; C-P; D-Q	
(d) A-Q; B-P; C-R; D-S	
  18. Column I (Mineral)      Column II (Source)
 

A. H	P. water
B. C & O	Q. air
C. B	R. macro nutrient
D. Ca	S. micro nutrient
(a) A-P; B-Q; C-R; D-S	
(b) A-P; B-Q; C-S; D-R	
(c) A-Q; B-P; C-R; D-S	
(d) A-S; B-R; C-Q; D-P	
  19. Find out the correct sentence about manure
    - A. Manure contains large quantities of organic matter and small quantities of nutrients
    - B. It increases the water holding capacity of sandy soil.
    - C. It helps in draining out of excess of water from clayey soil.
    - D. Its excessive use pollutes environment because it is made of animal excretory waste.
    - (a) A and C
    - (b) A and B
    - (c) B and C
    - (d) C and D
  20. Which one of the following is an improved variety of wheat?
    - (a) A.77
    - (b) Sonalika
    - (c) Chandramukhi
    - (d) Kuber

- 21.** Nutritional diet of poultry birds includes  
 (a) cereals, oil cakes, milk cakes, green vegetables  
 (b) millets, proteins, oil cakes only  
 (c) cereals, millets , proteins, oil cakes, green vegetables  
 (d) proteins, oil cakes, cereals only

**22.** Weeds can be controlled by  
 A. mechanical removal  
 B. inter cropping & crop rotation  
 C. Eco friendly weedicide (chemicals)  
 D. proper seedbed preparation.  
 (a) A, B, C                   (b) B, C, D  
 (c) A, C                   (d) all of these

**23.** He is known as an Architect of green revolution  
 (a) Dr. Norman E Borlaug.  
 (b) Dr. Radha Krishnan  
 (c) Dr. A.P.J. Kalam  
 (d) M.S. Swaminathan

**24.** An example of a common herbicide is  
 A. 2, 4 – D (2 – 4, dichlorophenoxyacetic acid).  
 B. DDT (dichloro dimethyl tri phenolic acid)  
 C. BHC (benzene hexa chloride)  
 D. Atrazine.  
 (a) A & B                   (b) A & C  
 (c) A & D                   (d) All of these

**25.** **Column I**                           **Column II**  
 A. Cattle used for tilling and carting     P. Milk producing female  
 B. Indian breed of chicken                 Q. Broiler  
 C. Sahiwal, Red Sindhi                   R. Drought animals  
 D. Milch                                   S. Local breed of cattle  
 E. Chicken better fed for obtaining meat     T. Aseel  
 (a) A-P; B-Q; C-R; D-S; E-T  
 (b) A-R; B-T; C-S; D-P; E-Q  
 (c) A-S; B-Q; C-S; D-R; E-T  
 (d) A-S; B-Q; C-R; D-P; E-T

**26.** Find out the false statement:  
 (a) Poultry farming is related with rearing of domestic fowls.  
 (b) Marine fish capture is guided by eco sounders and satellites  
 (c) In rainy season, Rabi crops are grown  
 (d) All of these

**27.** Find out the false statement:  
 (a) Queen bee secretes wax to make bee hive  
 (b) Cochin is exotic chicken breed.

**28.** State ‘T’ for True and ‘F’ for false statements and then choose the correct option.  
 A. Hybridisation is always useful to obtain a better yield.  
 B. Good fertilizers should be used by farmers.  
 C. Only macro nutrients are enough for plants.  
 D. Farmers should depend upon good irrigation method for watering crops.  
 (a) FFTT                           (b) FTFT  
 (c) TFTF                           (d) TTFF

**29.** Which of these is incorrect statement in regard to factors for the cause of crop variety improvement  
 (a) Higher & improved Quality yield.  
 (b) Resistance of Biotic & non-biotic agents.  
 (c) Desirable traits and wider availability.  
 (d) Reaction with the dyes.

**30.** Which one of the following plants is preferred for mixed cropping in order to enhance the bioavailability of nitrogen? [CDS]  
 (a) Wheat                           (b) Gram  
 (c) Maize                           (d) Barley

**31.** Which among the following oils has the maximum protein content? [CDS]  
 (a) Castor oil                           (b) Sunflower oil  
 (c) Soyabean oil                       (d) Safflower oil

**32.** Which one of the following plants is used for green manuring in India? [CDS]  
 (a) Wheat                           (b) Sunnhemp  
 (c) Cotton                           (d) Rice

**33.** Which one among the following cattle breed produces highest amount of milk ? [CDS]  
 (a) Brown Swiss                      (b) Holstein  
 (c) Dutch belted                   (d) Blaarkop

**34.** Consider the following statements: [IAS Prelim]  
 1. Molasses is a by-product of sugar production process.  
 2. Bagasse obtained in the sugar mills is used as a fuel in the boilers to generate steam for the sugar factories.  
 3. Sugar can only be produced from sugarcane as the raw material.  
 Which of these statements are correct?  
 (a) 1 and 2                           (b) 2 and 3  
 (c) 1 and 3                           (d) 1, 2 and 3

**35.** Consider the following statements about probiotic food: [IAS Prelim]  
 1. Probiotic food contains live bacteria which are considered beneficial to humans.  
 2. Probiotic food helps in maintaining gut flora.  
 Which of the statements given above is/are correct?  
 (a) 1 only                           (b) 2 only  
 (c) Both 1 and 2                   (d) Neither 1 nor 2

**ANSWER KEY**

**Chapter****1****COMPUTER  
AND TECHNOLOGY**

The word computer originated from the English word compute, which means to do calculation. The new definition of the computer can be "defined as an electronic device through which different kinds of informations are processed on the basis of definite set of instructions called program and with this device both mathematical and non -mathematical informations can be processed.

**COMPUTER GENERATIONS**

Till today five generations of computers have been developed.

**Computer Generations**

<b>Generation</b>	<b>Period</b>	<b>Main Electronic Component</b>	<b>Main Computers</b>
I	1951-1958	Electronic tube/Vaccum tubes	EDSAC, EDVAC, UNIVAC
II	1959-64	Transistor	IBM-700, IBM-1401, IBM-1620, CDC-1604, CDC-3600 ATLAS, ICL-1901
III	1965-1971	Integrated circuit (IC)	IBM-360, IBM-370, NCR-395, CDC-1700, ICL-2903
IV	1971-2010	Large Integrated Circuits, Microprocessor VLSI	APPLE, DCM

**Fifth Generation (2010 to Present)****Artificial Intelligence**

Fifth generation computing devices, based on artificial intelligence, are still in development, though there are some applications, such as voice recognition, that are being used today. The goal of fifth-generation computing is to develop devices that respond to natural language input and are capable of learning and self-organization.

**TYPES OF COMPUTER**

Computers are classified on the basis of its size and its uses.

**On the Basis of Size**

**Micro computers:** In such computers ALU are based in same chip.

**Personal computers:** It is single user system which is used in offices, workshops, business etc.

**Mini computers:** It is power full than micro computer. It can be used by many users at same time. Its processing speed is very fast.

**Main frame computers:** These are larger in size and fabricated in steel frames. They can process an ample amount

**HISTORY**

Abacus is considered as first calculating device, which was originated in China during 16<sup>th</sup> century. But first calculating machine was invented by Blaise Pascal in 1642, which was named as *Pascalene*. Later in 1833 *Charles Babbage* made an automatic calculator. He is also known as *father of modern computer*.

of data very rapidly. Banks, educational institute and insurance company mainly use this type of computer.

**Super computers:** These are the most powerful computers, which can process extremely complex data very quickly and its storage capacity is also very large. It is the costliest and fastest working computer. Super computers are used in weather forecasting, space research, computerized nuclear tests, satellite launching, etc.

The super computer developed in India are Flo Solver. (developed by NAL, Bangalore), Multi Micro (developed by IIS, Bangalore), Param -10,000 (by C-DAC Pune), Mach (by IIT, Mumbai)

**On the Basis of Uses**

(i) **Digital computer:** These computers do calculations digitally by algebraic addition. The special feature of these computers is accurate numerical calculations. These are used mainly in banking.

(ii) **Analog computers:** It measures temperature, length, pressure, etc. (all physical quantities) and converts it into numerical values. These are used in scientific and engineering works.

(iii) **Hybrid computers:** In hybrid computers digital and analogue both types of computers are utilized. These are used in automatic operating devices like a versatile robot, in factories and machines etc.

## COMPONENTS OF A COMPUTER

### Input Unit

It receives data and instructions from the user.  
It sends converted instructions to CPU for processing

### CPU (Central Processing Unit)

It controls all the parts of computer processing  
It performs processing works of computer.

**The CPU consists of three components are :**

#### 1. ALU ( Arithmetic and Logic Unit)

It performs all arithmetic and logic operations.

#### 2. Control Unit

It controls the transfer of data from the input device to memory and from memory to ALU. It also transfers the results from memory to output unit.

#### 3. Memory

It holds the received data from input device temporarily/permanently.

**Example :** RAM (Random Access Memory) & ROM (Read only Memory)

### Output Unit

It receives processed data from CUP.

It converts the output into simple language and displays result on the screen.

## HARDWARE

All the components and mechanical equipments that we can touch are known as hardware.

### Input Devices

The devices which are used to give instructions and data to the computer are called input device. Some of main input devices are: Scanner, Touch screen, Optical Character Reader

Magnetic Ink character Reader(MICR), Bar code Reader, Optical Mark-Reader (OMR), Voice input device, etc.

### Output Devices

These are the devices through which computer gives output. Some of the main output devices are monitor, printer, projector, sound card, speaker, video card etc.

## INFORMATION TECHNOLOGY

Information technology (also referred to as IT) is the application of computers and telecommunications equipment to *store, retrieve, transmit and manipulate data*, often in the context of a business or other enterprise. Several industries are associated with information technology, such as computer hardware software, electronics, semiconductors, internet, telecom equipment, e-commerce and computer services.

### Application

Information Technology has applications in almost all aspects of our life. Some of the important ones are:

Science and Engineering, Business & Commerce, Education, Governance, Medicine, Entertainment, Geographic information system (GIS), E-Banking, Core Banking, Electronic Clearing Service (ECS), Multi-application Smart Cards, etc.

## STORAGE DEVICES

Storage devices are also called storage media. It is a hardware device that can hold information. Two main storage devices are used in computers.

- The primary storage device also known as RAM,
- The secondary storage device such as a computer hard drive. Secondary storage can be either internal or external storage.

Storage device is required by the computer to save any settings or additional information.

Example :

## TYPE OF SECONDARY STORAGE DEVICES

**There are following different types of storage devices Includes :**

Magnetic Disks, Optical Disks, Magnetic Tape , Floppy Diskette CD-ROM disc, CD-R and CD-RW disc, Recordable DVD Drives, Jump drive and USB Flash Drive, Hard Drive, Memory Card, Memory Stick, Zip Diskette, Blue Ray Disk, etc

## INFORMATION & COMMUNICATIONS TECHNOLOGY (ICT)

ICT refers to all the technology used to handle telecommunications, broadcast media, intelligent building management systems, audiovisual processing and transmission systems, and network-based control and monitoring functions.

## COMPUTER TECHNOLOGY

Computer technology is the activity of designing and constructing and programming computers.

The first major development in computer technology was in 1946, with a vacuum tube-based computer model that was produced to aid in military efforts. Since the invention of computers and the internet, technology including operating systems, platforms, hardware and software has rapidly advanced.

### Type of computer technology

**They are some computer technology includes :**

An Embedded Systems, Microcomputer, Workstation, Mini-computer, Supercomputer, A Parallel Processing System, etc.

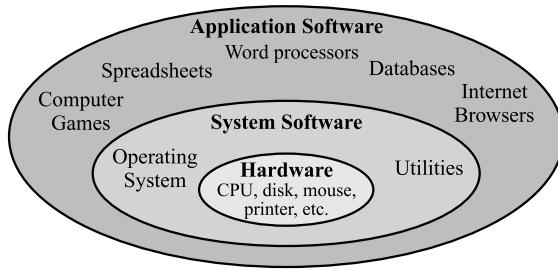
## COMPUTER SOFTWARE

*Computer Programs are called as Computer software, or just software. A computer Software is set of programs that guides the hardware through its job.*

### Types of Software

Computer softwares are mainly divided into two parts:

- (a) System Software (b) Application Software



## (A) SYSTEM SOFTWARE

System software is the software which manages and controls the hardware components and allows interaction between the hardware and the other different types of software.

System software can be separated into two different categories: **Operating systems and Utility software.**

### Operating System

A program that acts as an intermediary between a user of a computer and the computer hardware is called an operating system. Application programs usually require an operating system to function.

Ex : UNIX, MS-DOS, WINDOWS, 98/2000/XP/7/8/10.

#### Functions of an operating system –

The basic functions of an operating system are:

- I. Booting the computer
- II. Performs basic computer tasks e.g. managing the various peripheral devices e.g. mouse, keyboard
- III. Provides a user interface, e.g. command line, graphical user interface (GUI)
- IV. Handles system resources such as computer's memory and sharing of the central processing unit (CPU) time by various applications or peripheral devices
- V. Provides file management which refers to the way that the operating system manipulates, stores, retrieves and saves data.

There are different types of operating system to support the computer system. Includes :

Single-user, Single Task Operating System, Single-user, Multi-tasking Operating System, Multi-user Operating System, Real Time Operating System, Time-sharing Operating System, Dis-

tributed Operating System, Network Operating System, Stand-alone Operating System, Embedded Operating System, Mobile Operating System, Microsoft Windows operating system, Linux Operating System, MS DOS (Microsoft Disk Operating System), etc

## (B) APPLICATION SOFTWARE

Application Software are designed to achieve a complete task or a set of tasks. Application software consists of the programs for performing varied tasks particular to the machine's utilization. There are various examples of application software that include MS Word, MS Excel, a console game, database systems, desktop publishing systems, program development software, a library management system, graphics software, etc.

## PROGRAMMING LANGUAGES

A programming language is a set of commands, instructions, and other syntax used to create a software program. Languages that programmers use to write code are called "high-level languages." This code can be compiled into a "low-level language," which is recognized directly by the computer hardware.

#### (a) Low Level Languages

Low level computer languages are machine codes or close to it. Computer cannot understand instructions given in high level languages or in English. It can only understand and execute instructions given in the form of machine language i.e. language of 0 and 1.

#### Example : Machine & Assembly language

#### (b) High-Level Language

High-level programming languages allowed the specification of writing a program closer to those used by human beings. With the advent of high level languages, programming became far easier, less error-prone and also removed the programmer from having to know the details of the internal structure of a particular computer. Fortran II was one of the first high level language introduced in 1957.

Many high level languages were developed since Fortran II among the most widely used have been:

Language	Application Area	Developer
FORTRAN (Formula Translation)	Engineering & Scientific Applications	IBM in 1957
LISP (List Processing)	Artificial Intelligence	John Mc carthy in 1958
COBOL(Common Business Oriented Language)	Business applications	Grace Hopper in 1959
PASCAL	General use and as a teaching tool	Niklaus wirth in 1972
C & C++	General Purpose - currently most popular	C, Dennis Ritchie in 1972 C++ Bjarne Stroustrup in 1983.
JAVA	General Purpose - Internet Oriented Programming	James gosling in 1995

## COMPUTER NETWORK

A computer Network is a group of computer systems and other computing hardware devices that are linked together through communication channels to facilitate communication and resource-sharing among a wide range of users.

### TYPES OF COMPUTER NETWORKS

There are many types of Computer Networks includes:

1. **Personal Area Network (PAN):** It is smallest network which and very personal to a user. This may include Bluetooth enabled devices or infra-red enabled devices. PAN has connectivity range up to 10 meters.
2. **LocalArea Network (LAN):** It is operated inside a building and under single administrative system. For e.g.s. offices, schools, college/universities etc. Number of systems may vary from as least as two to as much as 16 million. Resources like Printers, File Servers, Scanners and internet is easy sharable among computers.
3. **Metropolitan Area Network (MAN):** It, generally expands throughout a city such as cable TV network. It can be in form of Ethernet, Token-ring, ATM or FDDI.
4. **Wide Area Network (WAN):** It covers a wide area which may span across provinces and even a whole country. Generally, telecommunication networks are Wide Area Network. These networks provides connectivity to MANs and LANs.
5. **Virtual Private Network (VPN):** It is constructed by using public wires usually the Internet to connect to a private network, such as a company's internal network.
6. **Internet:** A network of networks is called internetwork, or simply Internet or net. It is the largest network in existence on this planet. Internet hugely connects all WANs and it can have connection to LANs and Home networks. Internet uses TCP/IP protocol suite and uses IP as its addressing protocol. Present day, Internet is widely implemented using IPv4. Because of shortage of address spaces, it is gradually migrating from IPv4 to IPv6.

## INTERNET

Internet, also called the Net, is an electronic communication device. It is one of the largest networks that links millions or trillions of computers all over the world. You can access this network via communication devices and media such as, modems, cables, telephone lines and satellites. No one knows exactly how many computers are connected to the Internet. It is certain, however, that these numbers are in millions and are increasing at a rapid rate.

A networking project called ARPA or Advanced Research Projects Agency was launched, which was to work as a network that would allow scientists and military personnel to exchange information in a war scenario without disruption in communications. This network, called ARPANET, became functional in September 1969, linking scientific and academic researchers in the United States. By 1984, ARPANET had more than 1,000 individual computers linked as hosts. Internet, the outgrowth of ARPANET today attracts hundreds of millions of hosts.

## INTERNET ADDRESSES

Because the Internet is a global network of computers each computer connected to the Internet **must** have a unique address. Internet addresses are in the form **bbbb.bbbb.bbbb.bbbb** where bbbb must be a number from 0 - 255. This address is known as an Internet Protocol (IP) address.



Diagram

## DOMAIN NAME SYSTEM

The Domain Name System (DNS) is a hierarchical decentralized naming system for computers, services, or any resource connected to the Internet or a private network. It associates various information with domain names assigned to each of the participating entities. Most prominently, it translates more readily memorized domain names to the numerical IP addresses needed for the purpose of locating and identifying computer services and devices with the underlying network protocols. By providing a worldwide, distributed directory service, the Domain Name System is an essential component of the functionality of the Internet, and has been in use since the 1980s.

## INTRANETS AND EXTRANETS

### Intranets

Intranets typically start by publishing web pages about company events, health and safety policies, and staff newsletters. Popular applications follow, such as forms to reclaim expenses or request holidays. All these help eliminate paperwork and speed up workflows.

The intranet is protected from the global internet by firewalls and by the need to log on with a secure password. Staff working outside the organization may be able to access the intranet by using a VPN (virtual private network). This means all communications between the intranet and the user's personal computer are encrypted.

### Extranets

Extranets take this process a step further, by providing access to people who work for different organizations. For example, a company could provide access to a supplier for online ordering, order tracking and inventory management.

An extranet should be more efficient because everyone has access to the same data in the same format. Because all extranet communications can be encrypted over a VPN, it should also be more secure than sending data over the public internet.

## Application of The Internet

There are some application of internet given below.

**E-mail (electronic mail)**

**Information fatch**

**Entertainment**

**Programs creation**

## **Computer and Technology**

Online discussion groups

On-line shopping

Chat

## **NETWORK DEVICES**

### **Node**

A network is a collection of computers or other devices, commonly called **nodes**, that are able to communicate with each other.

### **HUB**

The most common type of network is the Ethernet network where all nodes are connected to a central device. In its simplest form this central node is called a **hub**.

### **Switch**

A commonly used solution today is a **switch**. A switch still connects all nodes to each other, like a hub, but is more intelligent in which messages are passed on to which node.

### **Segments and Bridges**

A large network can be divided into multiple parts which are called **segments**. Nodes on different segments cannot directly communicate with each other. To make this possible, a **bridge** is added between the segments.

### **Router**

A router is connected between two networks and passes packets between them choosing the shortest path and deliver high security, reliable service to the user.

### **Gateway**

A gateway is the same as a router, except in that it also translates between one network system or protocol and another. It routes the traffic from a work station to the outside network that serves the web pages.

### **Firewall**

A firewall acts as a barrier between a trusted network and untrusted network. It controls access to the resources of a network through a passive control model.

## **INTERNET GOVERNANCE**

Internet governance is the development and application by Governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programmes that shape the evolution and use of the Internet

Internet governance should not be confused with E-Governance, which refers to governments' use of technology to carry out their governing duties.

## **COMPUTER SECURITY :**

Computer security (also known as cyber security or IT security) is information security as applied to computing devices such as computers and smart phones, as well as computer networks such as private and public networks, including the whole Internet.

## **The Basic Components of Computer Security**

- Confidentiality
- Integrity
- Availability
- Access Control System
- Transport Layer Security

## **COMPUTER VIRUSES**

A computer virus or worm is a program that replicates itself on its own by inserting copies of itself into other programs or documents. It can spread by email also. These viruses or worms are malicious programs that are designed to infect and gain control over a computer without the owner's knowledge.

## **Top Some Sources of Computer Virus Attack**

The top sources of virus attacks are highlighted below:

- Downloadable Programs
- Illegal Software
- Email Attachments
- Using Internet
- Booting from Unknown CD
- Using Pendrive/USB Flash drive
- Not running the latest updates

## **Solutions to Computer Security Threats**

Some safeguards or solutions to protect a computer system from accidental access. These are.

- Install Anti-Virus Software
- Employ a firewall to protect networks
- Filter all email traffic
- Scan Internet Downloads
- Implement a vulnerability management program
- Develop an Information Security Policy
- Password
- Certificate

## **CYBERCRIME**

Cybercrime is a fast-growing area of crime. Cyber crime encompasses any criminal act dealing with computers and networks (called hacking). More and more criminals are exploiting the speed, convenience and anonymity of the Internet to commit a diverse range of criminal activities that know no borders, either physical or virtual, cause serious harm and pose very real threats to victims worldwide. Some techniques are used to reduce the cyber crime.

- (i) Biometric technology.
- (ii) Biometric passport.
- (iii) Policing cyber crime.
- (iv) Data encryption.
- (v) Digital signature.

## IT INDUSTRY IN INDIA

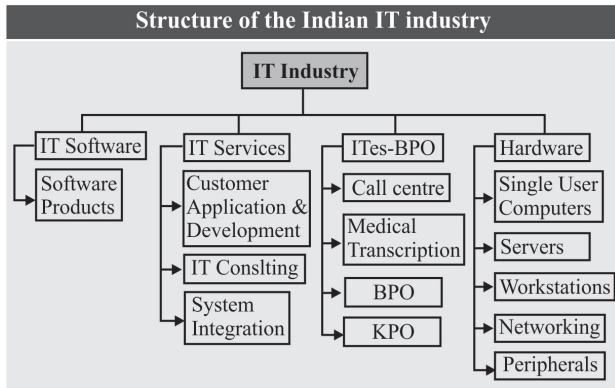
The IT industry in India is a key part of the country's economy. In 2013, information technology and its various subsectors represented 8 percent of the nation's overall GDP, making it the fifth largest industry in India. In the 2014/15 financial year alone, the IT industry in India generated an annual revenue of around 120 billion U.S. dollars, a significant increase from around 60 billion U.S. dollars in 2008/09. Of this revenue in 2015. The majority, 98.1 billion U.S. dollars, was generated in exports while domestic revenue totaled more than 20 billion U.S. dollars. The revenue of Indian IT industry approx 160 billion U.S. dollars in 2016.

### Evaluation of (Indian it Industry)

The IT industry in India came into existence in the year 1974. It was the time when mainframe manufacturer Burroughs asked Tata Consultancy Services (TCS) to export programmers for installing system software for a U.S. client. Import tariffs were high (135% on hardware and 100% on software) and software was not considered an "industry", so that exporters were ineligible for bank finance. Government policy towards IT sector changed when Rajiv Gandhi became Prime Minister in 1984. His New Computer Policy (NCP-1984) consisted of a package of reduced import tariffs on hardware and software.

The industry structure in the IT sector has four major categories:

- IT Software,
- IT services,
- BPO & IT enabled services,
- Hardware



## Computer Hardware Industry in India

The computer hardware market consists of the following segments: computers, peripherals and devices, and storage devices.

- The Indian computer hardware market had total revenues of \$4.8bn in 2014, representing a compound annual growth rate (CAGR) of 16.3% between 2010 and 2014 after that total revenues of computer hardware \$15.8 bn in 2015.

## It Enabled Services:

India is regarded as the back office of the world owing mainly to its IT and ITES industry. The sector in India grew at a Compound Annual Growth rate (CAGR) of 15 % over 2010-15, which is 3-4 times higher than the global IT-ITES spend, and is estimated to expand at a CAGR of 9.5% to US\$ 300 bn by 2020. India is also the world's largest sourcing destination for the information technology (IT) industry, accounting for approximately 67% of the US\$ 124-130 bn market.

## IT AND GOVERNMENT IN INDIA

### Indian Government Department of Information Technology

Department of Information Technology was set up in year 2000 to implement the Information Technology (IT) Policy of Govt. of National Capital Territory of Delhi. Department of Information Technology is working to put technology to its highest and best use throughout Delhi Government Department/Autonomous Bodies to improve the administration of State programs and services.

### E-Governance

The "e" in e-Governance stands for 'electronic'. Thus, e-Governance is basically associated with carrying out the functions and achieving the results of governance through the utilization of ICT (Information and Communications Technology).

### National Informatics Centre (NIC)

National Informatics Centre (NIC) was established in 1976, and has since emerged as a "prime builder" of e-Government / e-Governance applications up to the grassroots level as well as a promoter of digital opportunities for sustainable development. NIC, through its ICT Network, "NICNET", has institutional linkages with all the Ministries /Departments of the Central Government, 36 State Governments/ Union Territories, and about 688 District administrations of India. NIC has been instrumental in steering e-Government/e-Governance applications in government ministries/departments at the Centre, States, Districts and Blocks, facilitating improvement in government services, wider transparency, promoting decentralized planning and management, resulting in better efficiency and accountability to the people of India.

## DIGITAL INDIA

The Digital India programme is a flag-ship programme of the Government of India with a vision to transform India into a digitally empowered society and knowledge economy.

### Some Recent Indian Digital Initiatives

#### Top 10 digital initiatives taken by the Indian government are:

Digital Locker, Digital Life Certificates, Digital Boost to MGNREGA, Twitter Samvad, Madad (Help), SMS-Based Cyclone Warning System, Online Facility for Firms to File Single Return, Online facility to Issue PAN Card in 48 hours, eMoney, pragati.

## COMPUTER TERMINOLOGY

### There are some important computer terminology includes :

**Analog Computer :** A computer in which numerical data are represented by measurable physical variables, such as electrical.

**Antivirus :** Computer antivirus refers to a software program that can protect your computer from unwanted viruses and remove any that penetrate your computer's defenses.

**Artificial Intelligence :** Artificial intelligence (AI) is the intelligence of machines and the branch of computer science that aims to create it. AI textbooks define the field as “the study and design of intelligent agents” where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success.

**ASCII (American Standard Code for Information Interchange) :** ASCII, a code for information exchange between computers made by different companies; a string of 7 binary digits represents each character; used in most microcomputers.

**Android :** It is linux based operating system designed primarily for touch screen mobile devices such as smartphones and tablets computers.

**Biometric Device :** Biometrics (biometric authentication) consists of methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits.

**Bluetooth :** Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions in the ISM band from 2400-2480 MHz) between fixed and mobile devices, creating personal area networks (PANs) with high levels of security.

**Booting :** To boot (as a verb; also “to boot up”) a computer is to load an operating system into the computer’s main memory or random access memory (RAM).

**Bit.** A contraction of the term binary digit. The bit is the basic unit of digital data. It may be in one of two states, logic 1 or logic 0.

**Compressed File :** Computer files that have been reduced in size by a compression program. Such programs are available for all computer systems.

**Cookie.** A packet of information that travels between a browser and web server.

**CD ROM (Compact Disk- Read Only Memory) :** a type of optical disk capable of storing large amounts of data -- up to 1GB, although the most common size is 700 MB (megabytes).

**Digital Computer :** A reference to any system based on discrete data, such as the binary nature of computers.

**Digital Video/ Versatile Disk (DVD) :** The successor technology to the CD-ROM, that can store up to 10 gigabytes or more.

**Downloading :** Retrieving a file or group of files from the Internet so that they can be stored on a local hard drive.

**Error :** A discrepancy between a computed, observed, or measured value or condition and the true, specified, or theoretically correct value or condition.

**Electronic Mail:** When a message is sent, the message is sent first to the SMTP server, which acts as an “outbox” for users. The message is then relayed to the appropriate mail server, which can be found listed after the @ symbol in the recipient’s E-mail address. The message then waits on that server until the recipient accesses the message.

**Fault :** An incorrect step, process, or data definition in a computer program which causes the program to perform in an unintended or unanticipated manner.

**Fiber optics :** Communications systems that use optical fibers for transmission.

**Gigahertz :** One gigahertz is equivalent to 1000 megahertz, or 1,000,000,000 hertz.

**Hacker :** An individual with vast experience with security protocols who attempts to illegally access secure servers in an attempt to download private information, damage systems, or act in some other way to “free information”.

**HTTP:** Acronym for «Hypertext Transfer Protocol» The protocol that forms the basis of World Wide Web technology. HTTP is the set of rules governing the software that transports hyperlinked files along the Internet.

**Internet :** Internet is the largest wide area network in the world which links millions of computers. Through internet information can be shared, business can be conducted and research can be done.

**Intranet :** An Internet-like network whose scope is restricted to the networks within a particular organization.

**JPEG (Joint Photographic Experts Group) :** A bit-mapped file format that compresses image size.

**Kernel :** It is a fundamental part pf program, such as an operating system, that resides in a memory at all times.

**Keyboard :** is one of computer components which used to input data to a computer. It is called an input device.

**LCD :** Acronym for “Liquid Crystal Display”. It is the technology used for displays in notebooks and monitors for computers.

**Linux :** An open source spinoff of the UNIX operating system that runs on a number of hardware platforms and is made available for free over the Internet.

**Motherboard :** is the core of a computer system. It is the circuit board where all other parts connect. It communicates and controls the overall system. No motherboard means no computer system.

**MP3 :** this stands for “MPEG I Audio Layer- 3” and is a digital. compressed music file (their file names always end with an mp3 extension). MP3 files are often downloaded or exchanged between people online.

**Microprocessor:** A computer on a single chip. The central processing component of a microcomputer.

**Nibble :** Half a byte, or four bits.

**Node :** A junction or connection point in a network, e.g. a terminal or a computer.

**Online :** Pertaining to data and/or hardware devices accessible to and under the control of a networked computer system.

**Operating System or Platform :** Operating systems create an environment in which a user and hardware interact to each other. These terms refer to the software that your computer uses to operate (otherwise known as your OS) and not to a manufacturer or company. Windows 2000, Windows XP, and OSX (Mac) are common platforms.

**Programming :** The act of writing a computer program.

**Pixel :** In computer graphics, the smallest element of a display surface that can be assigned independent characteristics.

**Query :** A request for information from a database.

**Routing.** The process of choosing the best path throughout the LAN.

**Search Engine :** A tool used which matches key words you enter with titles and description on the Internet. It then displays the matches allowing you to easily locate a subject. Similar to a card catalog, but not as efficient. Common search engines are Webcrawler, Yahoo, Alta Vista, Infoseek, Google and Lycos.

**Surfing :** The random, aimless exploration of web pages achieved through following links that look interesting within a document

**Testing :** The process of operating a system or component under specified conditions, observing or recording the results, and making an evaluation of some aspect of the system or component.

**USB :** Acronym for “Universal Serial Bus”. This is a style of port connection that is used by many peripheral devices such as Palm Pilots, phones, scanners, printers etc. This type of connection is much faster than more traditional kinds of connections such as serial and parallel ports.

**URL:** Acronym for “Universal Resource Locator” The specific path to a World Wide Web file, including filename and extension.

**Virus :** A virus is a program that will seek to duplicate itself in memory and on disks, but in a subtle way that will not

immediately be noticed. A computer on the same network as an infected computer or that uses an infected disk (even a floppy) or that downloads and runs an infected program can itself become infected.

**World Wide Web or WWW :** This is the part of the Internet that you access. The World Wide Web is so named because each page in the WWW has links to other pages, which have links to other pages, and so on, creating what could visually be seen as a web-like network of links.

**XML:** Stands for “Extensible Markup Language.” technically it should be EML. XML is used to define documents with a standard format that can be read by any XML-compatible application. The language can be used with HTML pages, but XML itself is not a markup language. Instead, it is a “meta-language” that can be used to create markup languages for specific applications. For example, it can describe items that may be accessed when a Web page loads. Basically, XML allows you to create a database of information without having an actual database. While it is commonly used in Web applications, many other programs can use XML documents as well.

**YOBIBYTE :** A yobi-byte is a unit of data storage that equals 2 to the 80th power, or 1,208,925,819,614,629,174,706 ,176 bytes.

**ZIP :** A ZIP file (ZIP) is a “zipped” or compressed file.

## EXERCISE

1. **Assertion (A) :** Information technology is fast becoming a very important field of activity in India.

**Reason (R) :** Software is one of the major exports of the country and India has a very strong base in hardware.

[IAS Prelim]

**Codes:**

- (a) Both A and R are true and R is the correct explanation of A
  - (b) Both A and R are true but R is not a correct explanation of A
  - (c) A is true but R is false
  - (d) A is false but R is true
2. The memory of a computer is commonly expressed in terms of kilobytes or megabytes. A byte is made up of:

[IAS Prelim]

- (a) eight binary digits
- (b) eight decimal digits
- (c) two binary digits
- (d) two decimal digits

3. Consider the following statements: [IAS Prelim]

1. Smart card is a plastic card with an embedded microchip.
2. Digital technology is primarily used with new physical communication medium such as satellite and fibre optics transmission.

3. A digital library is a collection of documents in an organized electronic form available on the internet only.

Which of the statements given above is/are correct?

- (a) 3 only
- (b) 1 and 2
- (c) 2 and 3
- (d) 1, 2 and 3

4. Consider the following: [IAS Prelim]

1. Bluetooth device
2. Cordless phone
3. Microwave oven
4. Wi-Fi device

Which of the above can operate between 2.4 and 2.5 GHz range of radio frequency band?

- (a) 1 and 2 only
- (b) 3 and 4 only
- (c) 1, 2 and 4 only
- (d) 1, 2, 3 and 4

5. Which among the following do/does not belong/belongs to the GSM family of wireless technologies? [IAS Prelim]

- (a) EDGE
- (b) LTE
- (c) DSL
- (d) Both EDGE and LTE

6. What is the difference between Blue-tooth and Wi-Fi devices? [IAS Prelim]

- (a) Bluetooth uses 2.4 GHz radio frequency band, whereas Wi-Fi can use 2.4 GHz or 5 GHz frequency band
- (b) Bluetooth is used for Wireless Local Area Networks (WLAN) only, whereas Wi-Fi is used for wireless wide area networks (WWAN) only

- (c) When information is transmitted between two devices using Bluetooth technology, the devices have to be in the line of sight of each other, but when Wi-Fi technology is used the devices need not be in the line of sight of each other
- (d) The statements (a) and (b) given above are correct in this context
7. A new optical disc format known as the Blu-ray Disc (BD) is becoming popular. In what way is it different from the traditional DVD ? **[IAS Prelim]**
1. DVD supports Standard Definition video while BD supports high definition video
  2. Compared to a DVD, the BD format has several times more storage capacity
  3. Thickness of BD is 2.4 mm while that of DVD is 1.2 mm.
- Which of the statements given above is/are correct?
- (a) 1 only (b) 1 and 2 only
  - (c) 2 and 3 only (d) 1,2 and 3
8. What is “Virtual Private Network”? **[IAS Prelim]**
- (a) It is a private computer network of an organization where the remote users can transmit encrypted information through the server of the organization.
  - (b) It is a computer network across a public internet that provides users access to their organization’s network while maintaining the security of the information transmitted.
  - (c) It is a computer network in which users can access a shared pool of computing resources through a service provider.
  - (d) None of the statements (a), (b) and (c) given above is correct description of Virtual Private Network.
9. With reference to the use of nano-technology in health sector, which of the following statements is/are correct? **[IAS Prelim]**
1. Targeted drug delivery is made possible by nanotechnology.
  2. Nanotechnology can largely contribute to gene therapy.
- Select the correct answer using the code given below.
- (a) 1 only (b) 2 Only
  - (c) Both 1 and 2 (d) Neither 1 nor 2
10. With reference to ‘Near Field Communication (NFC) Technology’, which of the following statements is/are correct? **[IAS Prelim]**
1. It is a contactless communication technology that uses electromagnetic radio fields.
  2. NFC is designed for use by devices which can be at a distance of even a metre from each other
  3. NFC can use encryption when sending sensitive information.
- Select the correct answer using the code given below.
- (a) 1 and 2 only (b) 3 Only
  - (c) 1 and 3 only (d) 1, 2 and 3
11. Apple Computers of USA has launched a touch pad which allows a user to operate desktop computer with finger gestures, eliminating the need for a mouse. What is the name of the device? **[IAS Prelim]**
- (a) Mirror image pad (b) Virtual pad
  - (c) Fingertrip track pad
  - (d) Magic track pad
12. Which one among the following is the fastest Indian Supercomputer recently developed by ISRO? **[IAS Prelim]**
- (a) Aakash A-1 (b) Saga 220
  - (c) Jaguar-Cray (d) Tianhe-IA
13. The technology that stores only the essential instructions on a microprocessor chip and thus enhances its speed is referred to as
- (a) CISC (b) RISC
  - (c) CD-ROM (d) Wi-Fi
14. The ... is the amount of data that a storage device can move from the storage medium to the Computer per second
- (a) data migration rate (b) data digitizing rate
  - (c) data transfer rate (d) data access rate
15. In most IBM PCs, the CPU, the device drives, memory expansion slots and active components are mounted on a single board. What is the name of this board?
- (a) Motherboard (b) Breadboard
  - (c) Daughter board (d) Grandmother board
16. Personal computers use a number of chips mounted on a main circuit board. What is the common name for such boards?
- (a) Daughter board (b) Motherboard
  - (c) Father board (d) Breadboard
17. In latest generation computers, the instructions are executed
- (a) Parallel only
  - (b) Sequentially only
  - (c) Both sequentially and parallel
  - (d) All of above
18. The output quality of a printer is measured by
- (a) Dot per inch
  - (b) Dot per sq. inch
  - (c) Dots printed per unit time
  - (d) All of above
19. Which of the following devices can be used to directly image printed text?
- (a) OCR (b) OMR
  - (c) MICR (d) All of above
20. Which programming languages are classified as low level languages?
- (a) BASIC, COBOL, FORTRAN
  - (b) Prolog
  - (c) C, C+
  - (d) Assembly languages
21. FORTRAN is
- (a) File Translation
  - (b) Format Translation
  - (c) Formula Translation
  - (d) Flopy Translation

- 22.** What do you call the programs that are used to find out possible faults and their causes?
- operating system extensions
  - cookies
  - diagnostic software
  - boot diskettes
- 23.** What is embedded system?
- The program which arrives by being wrapped in box.
  - The program which is the permanent part of the computer
  - The computer which is the part of a big computer
  - The computer and software system that control the machine
- 24.** What type of computers are client computers (most of the time) in a client-server system?
- Mainframe
  - Mini-computer
  - Microcomputer
  - PDA
- 25.** Which of the following statements is true ?
- Minicomputer works faster than Micro-computer
  - Microcomputer works faster than Mini-computer
  - Speed of both the computers is the same
  - The speeds of both these computers cannot be compared with the speed of advanced
- 26.** Consider the following statements regarding pan-India mobile tele network
- The Pan-India mobile tele-network was launched in Coimbatore.
  - The aim of the initiative is to strengthen the spice farming community with the help of latest technologies.
  - The purpose of the scheme is to get in direct touch with the spice farmers of the state who are the core section of the society.
- Correct statement is/are:
- 1 and 2
  - 1 and 3
  - 2 and 3
  - All of the above
- 27.** Consider the following guiding principles and objectives that would underpin the public-private partnership (PPP) in cyber security has been identified by JWC and select incorrect one.
- Given the diverse stakeholders in cyber security, institutional mechanisms should be set up to promote convergence of efforts both in public and private domains.
- 2.** Use existing institutions and organizations to the extent possible in both private sector and government and create new institutions where required to enhance cyber security.
- 3.** Identify areas where public sector can build capacities for cyber security.
- 4.** Put in place appropriate policy and legal frameworks to ensure compliance with cyber security efforts.
- 1 only
  - 2 only
  - 3 only
  - 4 only
- 28.** Consider the following statements
- International Organization for Standardization is the world's leading organization for the preparation and publication of International Standards for all electrical, electronic and related technologies.
  - International Telecommunication Union allocate global radio spectrum and satellite orbits, develop the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs to underserved communities worldwide.
- Correct statement is/are
- 1 only
  - 2 only
  - Both 1 and 2
  - None of above
- 29.** Identify the correct statement(s):
- Tianhe is a Chinese Supercomputer.
  - SAGA 220 is the supercomputer of ISRO.
- 1 only
  - 2 only
  - Both 1 and 2
  - None
- 30.** Consider the following statement:
- Musical Instrument Digital Interface (MIDI) ports connected special types of music instruments to sound cards
  - Software you can use to create a budget is called utility software.
  - CPU consists of the development of the computer programme.
- Correct statement is /are
- 1, 2 and 3
  - 1 and 2
  - 1 and 3
  - 1 only

#### ANSWER KEY

1.	(c)	2.	(a)	3.	(b)	4.	(d)	5.	(c)	6.	(a)	7.	(b)	8.	(b)
9.	(c)	10.	(c)	11.	(d)	12.	(b)	13.	(b)	14.	(c)	15.	(a)	16.	(b)
17.	(c)	18.	(b)	19.	(a)	20.	(d)	21.	(c)	22.	(c)	23.	(d)	24.	(c)
25.	(a)	26.	(d)	27.	(c)	28.	(b)	29.	(c)	30.	(d)				

## Chapter

# 2

# COMMUNICATION

Communication is the transfer of information from one place to another and some means of ensuring that what is sent is also received. Technology increases the ways in which information can be communicated, the speed of transmission, and the total volume that can be handled at any one time.

## RECENT COMMUNICATION TECHNOLOGY

### 5G (Fifth Generation)

As the next step in the continuous innovation and evolution of the mobile industry, 5G will not only be about a new air interface with faster speeds, but it will also address network congestion, energy efficiency, cost, reliability, and connection to billions of people and devices.

### Cognitive Networks, Big Data

Communication systems handle volumes of data generated by embedded devices, mobile users, enterprises, contextual information, network protocols, location information and such. It is a vast amount of information: A global IP backbone generates over 20 billion records per day, amounting to over 1 TB per day! Processing and analyzing this “big data” and presenting insights in a timely fashion are becoming a reality with advanced analytics to understand the environment, to interpret events, and to act on them.

### Cyber Security

2014 was most remarkable for demonstrating that everything connected to the Internet can, and will be hacked. On daily basis we heard of retailers (Target, Home Depot, Neiman Marcus), financial institutions (Chase), technology companies (Snapchat, eBay, Sony) being hacked. No one is cyber-safe, and the road to the future leads through new cybersecurity technologies beyond current perimeter firewall-like defenses.

### Green Communications

It is being reported that communications technologies are responsible for about 2-4% of all of carbon footprint generated by human activity. This highlights the need to focus on managing these numbers, and Green communications is doing just that. The trend is tackling first mobile networks because of their high energy use. Basestations and switching centers could count for between 60% and 85% of the energy used by an entire communication system.

### Smarter Smartphones, Connected Sensors

The indisputable rock-start of devices is the smartphone, and its future can't be brighter. In 2014 we saw that only a few

days after the iPhone 6 was released, there are already articles being written about the next-generation iPhone 7. Size, shape, and capabilities of these ubiquitous communication devices continue evolving, and so are prices which, driven by cost and performance improvements in digital technologies, are falling rapidly. The average selling price of a smart-phone went down in 2014, and we expect this to continue in coming days with low-cost OEMs such as Xiaomi and Lenovo leading the trend.

### Network Neutrality, Internet Governance

The Internet has been operating since its inception under “open” principles, i.e. an open standards-based network that treats all traffic in roughly the same way, i.e. no connection blocking, bandwidth transparency, universal connectivity, and best effort service. Can these principles be sustained in a new world of data-hungry applications and services? Is regulation needed to prevent traffic throttling, unfair raise of fees, and construction of preferential high-speed Internet lanes? In 2014, Network Neutrality (NetNeutrality) discussions covered these questions in the context of ISPs transit and peering, and CDNs. Governments and institutions around the world will continue working on it during days to come.

### Molecular Communications

Molecular communication is an emerging paradigm where bio-nano-machines(e.g.,artificialcells,geneticallyengineeredcells)communicate to perform coordinated actions. Unlike traditional communication systems which utilize electromagnetic waves, molecular communications utilize biological molecules both as carriers and as information. The advantages provided by this “molecular” approach to communications are size, biocompatibility, and bio-stability.

## MODERN TELECOMMUNICATION SYSTEM

Most modern day telecommunications systems are best described in terms of a network. There are six basic components to a telecommunications network.

**1. Input and output devices, also referred to as ‘terminals’.** These provide the starting and stopping points of all communication. A telephone is an example of a terminal. In computer networks, these devices are commonly referred to as ‘nodes’ and consist of computer and peripheral devices.

**2. Telecommunication channels, which transmit and receive data.**

This includes various types of cables and wireless radio frequencies.

### **3. Telecommunication processors, which provide a number of control and support functions.**

For example, in many systems, data needs to be converted from analog to digital and back.

**4. Control software**, which is responsible for controlling the functionality and activities of the network.

**5. Messages represent the actual data that is being transmitted.**

In the case of a telephone network, the messages would consist of audio as well as data.

### **6. Protocols specify how each type of telecommunication systems handles the messages.**

For example, GSM, CDMA, 3G and 4G are protocols for mobile phone communications, and TCP/IP is a protocol used for communications over the Internet.

## **INFORMATION COMMUNICATION TECHNOLOGY (ICT) APPLICATIONS**

ICT applications, such as e-Government, e-commerce, e-Education, e-Health and e-Environment, are seen as enablers for development, as they provide an efficient channel to deliver a wide range of basic services in remote and rural areas. ICT applications can facilitate the achievements of millennium development targets, reducing poverty and improving health and environmental conditions in developing countries.

ICT applications can deliver basic services in a wide range of sectors including: health, agriculture, education, public administration, commerce, etc. ICT applications constitute one of the priority domains for ITU-D programme 2 (2010) and the ITU-D ICT Applications and Cyber-security Division. Improving social conditions and building an entry ramp into the information society are amongst the purposes of ITU's ICT Applications work Programme for Developing Countries.

## **NEAR FIELD COMMUNICATION TECHNOLOGY**

Near field communication (NFC), is a form of contactless communication between devices like smart-phones or tablets. Contactless communication allows a user to wave the smart-phone over a NFC compatible device to send information without needing to touch the devices together or go through multiple steps setting up a connection. Fast and convenient, NFC technology is popular in parts of Europe and Asia, and is quickly spreading throughout the United States.

## **WIRE COMMUNICATION**

Every telecommunications system involves the transmission of an information-bearing electro-magnetic signal through a physical medium that separates the transmitter from the receiver. All transmitted signals are to some extent degraded by the environment through which they propagate. Signal degradation can take many forms, but generally it falls into three types: noise, distortion, and attenuation (reduction in power).

### **Types of wires**

There are many types of wires used in wire communication these are :

### **Single-wire Cable**

In the early days of the telegraph, a single un-insulated iron wire, strung above ground, was used as a transmission line. Return conduction was provided through an earth ground. This arrangement, known as the single-wire line, was quite satisfactory for the low-frequency transmission requirements of manual telegraph signaling

### **Multi Pair Cable**

In multi pair cable anywhere from a half-dozen to several thousand twisted-pair circuits are bundled into a common sheath. The twisted pair was developed in the late 19th century in order to reduce cross talk in multi pair cables.

### **Coaxial Cable**

By enclosing a single conducting wire in a dielectric insulator and an outer conducting shell, an electrically shielded transmission circuit called coaxial cable is obtained.

### **Optical Fibre System**

Like all other communication system, the primary objective of optical fiber communication system also is to transfer the signal containing information (voice, data, and video) from the source to the destination. The source provides information in the form of electrical signal to the transmitter. The electrical stage of the transmitter drives an optical source to produce modulated light wave carrier.

## **NETWORKING DEVICES**

**Networking hardware's** are also known as computer networking devices, are physical devices which are required for communication and interaction between devices on a computer network. Specifically, they mediate data in a computer network.

Networking devices may include gateways, routers, network bridges, modems, cable modem, wireless access points, networking cables, line drivers, switches, hubs, and repeaters; and may also include hybrid network devices such as multilayer switches, protocol converters, bridge routers, proxy servers, firewalls, network address translators, multiplexers, network interface controllers, wireless network interface controllers, ISDN terminal adapters and other related hardware.

## **NANOTECHNOLOGY IN TELECOMMUNICATION**

Nanotechnology is set to have a profound impact on telecommunications leading to easier convergence of related technologies, massive storage data, compact storage devices, and higher performance computing. Nanotechnology for Telecommunications covers research and developmental issues as well as future directions of MEMs and nanotechnology as they apply to telecommunications. It discusses the impact of nanotechnology on devices such as photonic crystals lasers, light emitters (LED), compact fluorescent lamp (CFL), sensors.

## WIRELESS COMMUNICATIONS

Wireless communication is the transmission of information over a distance without help of wires, cables or any other forms of electrical conductors. The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilo-meters (for example, radio communication).

## THE RADIO-FREQUENCY SPECTRUM

The radio spectrum is the radio frequency (RF) portion of the electromagnetic spectrum.

**Radio frequency bands are divided into 3 broad categories:**

- Frequencies that are not usable for commercial purposes and are kept reserved for radio astronomy and Defence forces.
- Frequencies that are unlicensed and are open for personal or commercial use for free which includes 2.4GHz and 5GHz WiFi, Bluetooth, cordless phones, etc.
- Frequencies that are licenced by the government for purposes like telecommunication.

The frequency bands used for telecommunication worldwide follow an international convention where the ITU has identified 3 distinct 'International telecommunication regions' and each region have its own distinct set of frequency bands that it uses for telecom.

## TELECOM SPECTRUM

In 2010, 3G and 4G telecom spectrum were auctioned in a highly competitive bidding. The winners were awarded spectrum in September, and Tata Docomo was the first private operator to launch 3G services in India. The Government earned US\$16 billion in 2016 from the 3G spectrum auction and the broadband wireless spectrum auction generated a revenue of US\$9.0 billion in 2016 for a total revenue of US\$25 billion in 2016 from both auctions.

## MOBILE NETWORK

A mobile network is a communication network where the last link is wireless. The network is distributed over land areas called cells, each served by at least one fixed-location transceiver,

## Difference Between GSM/CDMA

Features	GSM	CDMA
Stands For	Global System for Mobile communication	Code Division Multiple Access
Evolution	1990	1995
Presence	Europe, Asia and Middle East	US and Asian Countries
Handset Compatibility	850/900/1800/1900 MHz	850/1900 MHz
Switching B/W Service Providers	Simply Change Your SIM Card	Handset Needs To Be Changed
Handset Availability	Wide Range of Handsets Available In The Market	A Limited Range of Handsets Support CDMA
Voice Quality	Fluctuates From Time To Time	Comparatively Better Voice Quality
Data Transfer Speed	Lower Data Speed	BREW Facilitates Faster Data Transfer

known as a cell site or base station. This base station provides the cell with the network coverage which can be used for transmission of voice, data and others.

## Cell Signal Encoding

To distinguish signals from several different transmitters, time division multiple access (TDMA), frequency division multiple access (FDMA), code division multiple access (CDMA), and Global System for Mobile communication (GSM) were developed. First we understand three different access technologies. FDMA, TDMA and CDMA.

Suppose you have got 100 people to sing and you want to record them singing without any interference. You can do it in three ways.

First way: All the 100 people are allocated different rooms and they can sing at same time and get recording done without interference. This technique is called FDMA. Frequency Division Multiple Access.

Second way: All the 100 people stay in the same room and sing one after another in queue. This way everyone will be recorded without interference because they are not singing simultaneously. This is TDMA. Time Division Multiple Access.

Third way: All the 100 people sing simultaneously and in the same room. But, they sing in different languages so that they can be identified later without any interference. This is CDMA. Code Division Multiple Access.

Now that you have understood these three techniques, the most important difference between GSM and CDMA will become clear easily.

## GSM is combination of FDMA and TDMA

Meaning, the 100 people who want to communicate can be divided into five groups of 20 each in different rooms where they can communicate one after another in a queue.

## CDMA is Just as the Name Suggests CDMA Access Technology

All the 100 people will communicate simultaneously in same room, but each person will have a unique code to differentiate that person from others.

International Roaming	Easy and Convenient	Hardly Any CDMA Network Provider Offers International Roaming
International Usage	Easy to use	Difficult to use

## GENERATION OF INTERNET TECHNOLOGY:

The “G” in wireless networks refers to the “generation” of the underlying wireless network technology.

Technically generations are defined as follows:

**1G networks** (NMT, C-Nets, AMPS, TACS) are considered to be the first analog cellular systems, which started early 1980s. There were radio telephone systems even before that. 1G networks were conceived and designed purely for voice calls with almost no consideration of data services.

**2G networks** (GSM, CDMAOne, D-AMPS) are the first digital cellular systems launched early 1990s, offering improved sound quality, better security and higher total capacity. GSM supports circuit-switched data (CSD), allowing users to place dial-up data calls digitally, so that the network's switching station receives actual ones and zeroes rather than the screech of an analog modem.

**2.5G networks** (GPRS, CDMA2000 1x) are the enhanced versions of 2G networks with theoretical data rates up to about 144kbit/s. GPRS offered the first always-on data service.

**3G networks** (UMTS FDD and TDD, CDMA2000 1x EVDO, CDMA2000 3x, TD-SCDMA, Arib WCDMA, EDGE, IMT-2000 DECT) are newer cellular networks that have data rates of 384kbit/s and more.

The UN’s International Telecommunications Union IMT-2000 standard requires stationary speeds of 2Mbps and mobile speeds of 384kbps for a “true” 3G.

**4G technology** refers to the fourth generation of mobile phone communication standards. LTE and WiMAX are marketed as parts of this generation, even though they fall short of the actual standard.

**The term “4G”** references to the speed standard in wireless connectivity.

4G technology is meant to provide what is known as “ultra-broadband” access for mobile devices, and the International Telecommunications Union-Radio communications sector (ITU-R) created a set of standards that networks must meet in order to be considered 4G, known as the International Mobile Telecommunications Advanced (IMT-Advanced) specification.

### 4G Standards

First, 4G networks must be based on an all Internet protocol (IP) packet switching instead of circuit-switched technology, and use multi-carrier transmission methods or other frequency-domain equalization (FDE) methods instead of current spread spectrum radio technology. In addition, peak data rates for 4G networks must be close to 100 megabit per second for a user on a highly mobile network and 1 gigabit per second for a user with local wireless access or a nomadic connection.

## 5G

5G stands for the fifth generation of wireless technologies and it will be faster than 4G. That is a no-brainer but how much faster is the question. The details are a bit sketchy at this point but the speeds are supposed to be upwards of 1 to 10Gbps compare to the 4G standards which are 100Mbps up to 1Gbps. But will those speeds ever be realized is another question that we will find out sometime around the year 2020. That is the expected date of the rollout.

## TELECOMMUNICATION

Telecommunication is the transmission of signs, signals, messages, writings, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems. Telecommunication occurs when the exchange of information between communication participants includes the use of technology. It is transmitted either electrically over physical media, such as cables, or via electromagnetic radiation, etc.

## HISTORY OF INNOVATIONS IN TELECOMMUNICATION

**Pre-1902** – Cable telegraph

**1902** – First wireless telegraph station established between Sagar Island and Sand-head.

**1907** – First Central Battery of telephones introduced in Kanpur.

**1913–1914** – First Automatic Exchange installed in Shimla.

**1927** – Radio-telegraph system between the UK and India, with Imperial Wireless Chain beam stations at Khadki and Daund. Inaugurated by Lord Irwin on 23 July by exchanging greetings with King George V.

**1933** – Radiotelephone system inaugurated between the UK and India.

**1953** – 12 channel carrier system introduced.

**1960** – First subscriber trunk dialling route commissioned between Lucknow and Kanpur.

**1975** – First PCM system commissioned between Mumbai City and Andheri telephone exchanges.

**1976** – First digital microwave junction.

**1979** – First optical fibre system for local junction commissioned at Pune.

**1980** – First satellite earth station for domestic communications established at Sikandarabad, U.P..

**1983** – First analogue Stored Programme Control exchange for trunk lines commissioned at Mumbai.

**1984** – C-DOT established for indigenous development and production of digital exchanges.

**1995** – First mobile telephone service started on non-commercial basis on 15 August 1995 in Delhi.

**1995** – Internet Introduced in India starting with Laxmi Nagar, Delhi 15 August 1995.

## TELECOMMUNICATION IN INDIA

India is currently the world's second-largest tele-communications market and has registered strong growth in the past decade and half. The Indian mobile economy is growing rapidly and will contribute substantially to India's Gross Domestic Product (GDP), according to report prepared by GSM Association (GSMA) in collaboration with the Boston Consulting Group (BCG).

International Data Corporation (IDC) predicts India to overtake US as the second-largest smart-phone market globally by 2017.

India is expected to have over 180 million smart-phones by 2019, contributing around 13.5 % to the global smart-phone market.

According to a report by leading research firm Market Research Store, the Indian telecommunication services market will likely grow by 10.3 % year-on-year to reach US\$ 103.9 billion by 2020.

According to the Ericsson Mobility Report India, smart-phone subscriptions in India is expected to increase four-fold to 810 million users by 2021, while the total smart-phone traffic is expected to grow seventeen-fold to 4.2 Exabyte's (EB) per month by 2021.

## DIGITAL TELEVISION

Digital television (DTV) is the transmission of television signals using digital rather than conventional analog methods.

Digital television is not the same thing as HDTV (high-definition television). HDTV describes a new television format (including a new aspect ratio and pixel density), but not how the format will be transmitted.

Digital television can be either standard or high definition.

Advantages of DTV over analog TV include:

- Interactivity
- Superior audio quality
- Consistency of reception over varying distances
- Superior image resolution.
- Smaller bandwidth for a given image resolution
- Compatibility with computers and the Internet.

## CABLE TELEVISION

Cable television is a system that distributes television signals by means of coaxial or fibre-optic cables. The term also includes systems that distribute signals solely via satellite. Cable-television systems originated in the United States in the late 1940s and were designed to improve reception of commercial network broadcasts in remote and hilly areas.

During the 1960s they were introduced in many large metropolitan areas where local television reception is degraded by the reflection of signals from tall buildings. Commonly known as community antenna television (CATV).

Since the mid-1970s there has been a proliferation of cable-television systems offering special services. Some of these systems can deliver 50 or more channels.

## HDTV

HDTV (high definition television) is a television display technology that provides picture quality similar to 35 mm movies with sound quality similar to that of today's compact disc. Some television stations have begun transmitting HDTV broadcasts to users on a limited number of channels.

HDTV generally uses digital rather than analog signal transmission. However, in Japan, the first analog HDTV program was broadcast on June 3, 1989.

## DTV India

DTV India is an entertainment revolution that delivers LIVE TV on your android phone, PC, Tablet and other android based devices; anytime, anywhere absolutely free. With DTV, you can watch movies, television shows, sports, the latest news & updates, at your own time and convenience; even when you are away from home!

## India's PAY TV

Indian cable and DTH operators rank as one among the top in the world in the number of subscribers in terms of Pay-TV or digital. The Media Partners Asia (MPA) – Media Route 26 India report released recently showed a list of India & global pay-TV operators in terms of the subscribers.

## Direct To Home

In India, direct-to-home (DTH) Broadcasting Service refers to the distribution of multi channel TV programmers in Ku Band by using a satellite system by providing TV signals direct to subscribers' premises. For DTH connection the broadcasting company provides a set that comprises the dish and a receiving set. The company beams an encrypted signal that only the set installed in your household can receive and enable viewing.

## Interactive TV (iTV)

Interactive TV (iTV) is any television with what is called a "return path". Information flows not only from broadcaster to viewer, but also back from viewer to broadcaster. Another feature common to all iTV systems is the ability to offer each TV set, or each viewer who uses that TV set, a different choice of content.

## Digital cinema

Digital cinema refers to the use of digital technology to distribute or project motion pictures as opposed to the historical use of reels of motion picture film, such as 35 mm film. Whereas traditional film reels had to be shipped to movie theaters, a digital movie can be distributed to cinemas in a number of ways: over the Internet or dedicated satellite links or by sending hard drives or optical discs such as Blu-ray discs.

Digital Cinema is a complete system to deliver "cinema-quality" programs to "theaters" (including consumer homes) throughout the world using digital technology.

In digital cinema, resolutions are represented by the horizontal pixel count, usually 2K (2048×1080 or 2.2 megapixels) or 4K (4096×2160 or 8.8 megapixels).

## CLOSED CIRCUIT TELEVISION (CCTV):

CCTV (closed-circuit television) is a TV system in which signals are not publicly distributed but are monitored, primarily for surveillance and security purposes.

## EXERCISE

1. A modem is classified as low speed if data rate handled is
  - (a) upto 100 bps
  - (b) upto 250 bps
  - (c) upto 400 bps
  - (d) upto 600 bps
2. In colour TV receiver, varactor diode is used for
  - (a) detection
  - (b) rectification
  - (c) tuning
  - (d) both (a) and (b)
3. Which of the following is/are the main part(s) of basic cellular system.
  - (a) A mobile Unit
  - (b) A cell Site
  - (c) A mobile Telephone Switching Office
  - (d) All of the above
4. Fading of the received radio signals in a mobile communication environment occurs because of .....
  - (a) Direct propagation
  - (b) Multipath Propagation
  - (c) Bi-path Propagation
  - (d) None of the above
5. The basic GSM is based on ..... traffic channels.
  - (a) connection oriented.
  - (b) connection less.
  - (c) packet switching.
  - (d) circuit switching.
6. .... are typically characterized by very small cells, especially in densely populated areas.
  - (a) 2G system.
  - (b) 3G system.
  - (c) 2.5G system.
  - (d) 3.5G system.
7. A antenna which attempts to direct all its energy in a particular direction is called as a .....
  - (a) Directional Antenna
  - (b) One to One Antenna
  - (c) Propagation Antenna
  - (d) Single Direction Antenna
8. Which mode is used for installing networks in wireless communication device characteristics?
  - (a) Fixed and wired.
  - (b) Mobile and wired.
  - (c) Fixed and wired.
  - (d) Mobile and wireless.
9. Which of the following is not a reason to use fiber-optic cables for point to point data transmission?
  - (a) Need to assure data security.
  - (b) Avoidance of ground loops.
  - (c) Data-transfer rates too low to use metal cables.
  - (d) Elimination of spark hazards.
10. Speeds of laboratory fiber optic Local Area Networks are now in the range of
  - (a) 1 Mbits/s.
  - (b) 10 Mbits/s.
  - (c) gigabits per second.
  - (d) hundreds of megabits per second.
11. Which of the following happen to be the limitations of optical fiber ?
  - I. The architecture of their couplers.
  - II. Costs of implementing them.
  - III. Modification of the software and hardware on existing systems.
  - IV. The difficulty of installing the cables.
  - (a) II and IV only.
  - (b) I,II and III only.
  - (c) I,III and IV only.
  - (d) I,II,III and IV.
12. What types of handover are supported in LTE?
  - (a) Hard handover only
  - (b) Hard and soft handovers
  - (c) Hard, soft and softer handovers
  - (d) Handover is not supported
13. Nanoscience can be studied with the help of...
  - (a) Quantum mechanics
  - (b) Newtonian mechanics
  - (c) macro-dynamics
  - (d) Geophysics
14. Which of the following does not apply to nanotechnology?
  - (a) It is a general-purpose technology.
  - (b) It can be called Green technology.
  - (c) Newtonian mechanics can describe it.
  - (d) It involves rearrangement of atoms.
15. What types of handover are supported in LTE?
  - (a) Hard handover only
  - (b) Hard and soft handovers
  - (c) Hard, soft and softer handovers
  - (d) Handover is not supported
16. In TV transmission, picture signal is ..... modulated.
  - (a) Frequency
  - (b) Phase
  - (c) Amplitude
  - (d) None of the above
17. Which type of access used in GSM technology?
  - (a) FDMA/TDMA
  - (b) CDMA
  - (c) OFDMA
  - (d) None of the above
18. The type of Access technology which can enhance the battery life is
  - (a) CDMA
  - (b) TDMA
  - (c) OFDMA
  - (d) None of the above
19. The process of channel coding, Encryption, Multiplexing and modulation for Trans direction and reverse for reception are to be carried out by
  - (a) BTS
  - (b) BSC
  - (c) MSC
  - (d) MS
20. Which type of handoff used in CDMA?
  - (a) Soft handoff
  - (b) Hard handoff
  - (c) Soft & hard handoff
  - (d) None of the above

21. \_\_\_\_\_ is a second-generation cellular phone system.

  - (a) GSM
  - (b) D-AMPS
  - (c) IS-95
  - (d) none of the above

22. In a \_\_\_\_\_ handoff, a mobile station can communicate with two base stations at the same time.

  - (a) hard
  - (b) soft
  - (c) medium
  - (d) none of the above

23. Modulation refers to \_\_\_\_\_.

  - (a) the distance between the uplink and downlink frequencies
  - (b) the separation between adjacent carrier frequencies
  - (c) the process of changing the characteristics of a carrier frequency
  - (d) the number of cycles per unit of time

24. which of the following are not telephony services supported by GSM?

  - (a) dual-tone multi-frequency
  - (b) voice mail
  - (c) fax mail
  - (d) call waiting

25. Communication is bidirectional in

  - (a) Traditional cable TV
  - (b) Hybrid Fiber Coaxial
  - (c) TV network
  - (d) Telephone

26. 3G W-CDMA is also known as

  - (a) UMTS (Universal Mobile Telecommunication System)
  - (b) DECT
  - (c) DCS-1800
  - (d) ETACS

27. Commonly used mode for 3G networks is

  - (a) TDMA
  - (b) FDMA
  - (c) TDD (Time-division duplexing)
  - (d) FDD(Frequency-division duplexing)

28. Communication in traditional cable TV network is

  - (a) 180 degree direction
  - (b) Omni directional
  - (c) bidirectional
  - (d) unidirectional

29. Coaxial cable has a bandwidth that ranges from

  - (a) 5- 750MHz
  - (b) 10-300 MHz
  - (c) 5-550 MHz
  - (d) 10-3000MHz

30. An organization's profitability depends on

  - (a) Quality of data processed
  - (b) Quantity of data processed
  - (c) Speed of processing the data
  - (d) Both (a) and (c)

---

**ANSWER KEY**

ANSWER KEY															
1.	(d)	2.	(c)	3.	(d)	4.	(b)	5.	(a)	6.	(c)	7.	(a)	8.	(c)
9.	(c)	10.	(d)	11.	(c)	12.	(a)	13.	(a)	14.	(c)	15.	(a)	16.	(c)
17.	(a)	18.	(b)	19.	(a)	20.	(a)	21.	(a)	22.	(b)	23.	(c)	24.	(d)
25.	(b)	26.	(a)	27.	(d)	28.	(d)	29.	(a)	30.	(d)				

## Chapter

# 3

# DEFENCE

The Republic of India has world's 3<sup>rd</sup> largest military force and has the world's largest volunteer army. The President of India is the Supreme Commander of the Indian Armed Forces and is looked after by the Ministry of Defence (MoD). It is led by the Union Cabinet Minister of Defence. It consists of three professional uniformed services: the Indian Army, Indian Navy, and Indian Air Force.

The President of India is the Supreme Commander of the Armed Force. However, the Cabinet is responsible for National Defence. The Administrative control of armed forces is exercised by the Ministry of Defence, which constitutes the following.

- (a) Department of Defence
- (b) Department of Defence Production and Supplies
- (c) Department of Defence Research and Development (DDRD).
- (d) The department of ex-servicemen welfare.

## DEPARTMENTS OF DEFENCE

### ARMY

Headed by Chief of the Army Staff

Headquarters New Delhi

Approximate strength of 1,200,000 approximately army personnel

Further, the three services Headquarters, which were used to be attached offices of Ministry of Defence are now integrated with the Ministry and known as Integrated Headquarters of the Ministry of Defence.

Number of Commands		
	Command	Headquarters
1.	Western Command	Chandimandir
2.	Eastern Command	Calcutta
3.	Northern Command	Udhampur
4.	Southern Command	Pune
5.	Central Command	Lucknow
6.	Training Command (added in 1991)	Mhow
7.	South Western Command (added in 2005)	Jaipur

Each command is under a General Officer Commanding-in-Chief who is of the rank of Lt General. The command is further divided into areas and independent sub-areas, commanded by a Major-General and a Brigadier, respectively.

### AIR FORCE

Headed By Chief of the Air Staff  
Headquarters New Delhi  
Approximate strength of 115,000 approximately Air Force personnel :-

Number of Commands		
	Command	Headquarters
1.	Western Air Command	Delhi
2.	South-Western Air Command	Gandhinagar
3.	Central Air Command	Allahabad
4.	Eastern Air Command	Shillong
5.	Southern Air Command	Thiruvananthapuram

In addition to the above main command, there are two support commands, or functional commands, namely:

1. Training Command – Bangalore
2. Maintenance Command – Nagpur

Today, the Air Force has an array of modern aircraft on its inventory besides other hi-tech electronic and support equipment. The aircraft fleet consists of fighter-bombers, air-superiority fighters, interceptors, transport, and logistic aircraft and helicopters.

### NAVY

Headed by Chief of Naval Staff  
Headquarters New Delhi  
Approximate Strength 62,000 approximately

Number of Commands		
	Command	Headquarters
1.	Western Naval Command	Mumbai
2.	Eastern Naval Command	Visakhapatnam Operational command
3.	Southern Naval Command	Kochi used for training

Each command is commanded by a flag officer commanding-in-chief.

The Indian Navy is a well-balanced three-dimensional force consisting of sophisticated missile-capable warships, aircraft carriers, minesweepers, advanced submarines, and the latest aircraft in its inventory. At present, the Navy has two major Naval bases at Mumbai and Visakhapatnam. Goa and Arkonam are the major Naval air bases.

## LOCATION OF DEFENCE ESTABLISHMENTS

### Army

Indian Military Academy	Dehradun
The College of Military Engineering	Kirkee (Pune)
The School of Signals	Mhow
The Infantry School	Mhow
The Corps of Military Police Centre and School	Faizabad
The Army Education Corps and Training College	Pachmarhi

### Navy

Indian Naval Academy	Kochi
Naval Air Station Garuda	Kochi
INS Agram (Petty Officer's School)	Coimbatore
Naval Gunnery School	Kochi
Torpedo Anti-Submarine School	Kochi
Navigation Direction School	Mormugao

### Air Force

Pilot Training Establishment	Allahabad
Jet Training and Transport Training	Hyderabad
Wings, Air Force Station	Jalahalli
The Air Force Technical Training College	Agra
Paratroopers Training School	

### Inter-services Institutes

National Defence Academy	Khadakwasla
National Defence College	New Delhi
Defence Services Staff College	Wellington
School of Land/Air Warfare	Secunderabad
Rashtriya Indian Military College	Dehradun
Armed Forces Medical College	Pune

## DEFENCE PRODUCTION UNDERTAKINGS

Eight public sector undertakings (PSUs) currently function under the Department of Defence Production and Supplies. They are HAL, Bharat Electronics Limited (BEL), Bharat Earth Movers Limited (BEML), Mazgaon Dock Limited (MDL), Garden Reach Shipbuilders and Engineers Limited (GRSE), Goa Shipyard Limited (GSC), Bharat Dynamic Limited (BDL), and Mishra Dhatu Nigam Limited (MIDHANI).

## NODAL AGENCIES OF DEFENCE SECTOR

India's defence mechanism is growing stronger with the advancement of science and technologies. Various nodal agencies have been created and maintained by minister of Defence of India which aimed at obtaining policies from central government so as to implement the defence related research on its several branches

## DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION (DRDO)

Looks after various areas of military technology such as aeronautic armament, combat vehicles, electronics instrumentation engineering systems, missiles, materials, naval systems, advanced computing, simulation and life sciences.

It was established in 1958 by amalgamating Defence Science Organization and some of the Technical Development Institutions.

The major achievements towards indigenous development of defence weapons and systems are (i) development leading to production of surface-to-surface missile, Prithvi; (ii) state-of-the-art MBT, Arjun; (iii) flight simulators for aircraft; (iv) pilotless target aircraft, Lakshya; (v) parallel super-computer; and (vi) the submarine sonar and weapon control system, Panchendriya.

## DEFENCE RESEARCH AND DEVELOPMENT LABORATORY (DRDL)

It works as multi-disciplinary missile system which aims at designing, developing and evaluating the fleet of various types of missiles used by armed forces.

## DEFENCE AVIONICS RESEARCH ESTABLISHMENTS (DARE)

It was initially a project laboratory known as advanced systems integration and Evaluation Organisation (ASIEO), which aimed at enhancing the operational capabilities of Indian Air force with the help of modern technology. But over the time it has witnessed a rapid progress in the area of Airborne Electronic warfare Airborne Processors, testing Evaluation of Electronics warfare etc.

## INDIAN SPACE RESEARCH ORGANISATION (ISRO)

It is the parented agency of Indian space agencies which was established on 15th August 1969. The head quarter of this organisation is at Bangalore and it was founded by Vikram Sarabhai with a vision to harness space technology for national development, while pursuing space science research and planetary exploration. The first satellite made by ISRO was Aryabhata and it was launched by Russia on 19th April 1975. Thereafter it has developed numerous satellites and spacecrafts for serving different technology such as communication Earth's observation, navigation, climatic observations etc.

## INDIA'S INTERNAL SECURITY

### Police

Police is a state subject under the Constitution. The head of a police force in a state is the Director-General of Police (DGP) or Inspector-General of Police (IGP). For administrative purposes, each state is divided into ranges headed by the Deputy-Inspector General of Police (DIG) and a range is further divided into districts, each under the control of a Superintendent of Police (SP). All senior police posts in various states are included in the Indian Police Service (IPS) cadres, recruitment for which is made on an All-India basis. However, for lower ranks up to Deputy Superintendent (DSP), the recruitment is done at the state levels.

## Paramilitary Forces

**There are some paramilitary forces these are :**

1. Assam Rifles (1853)
2. Railway Protection Force (RPF) (1861)
3. Intelligence Bureau (IB) (1887)
4. Central Reserve Railway Protection Force (CRPF) (1949)
5. Indo-Tibetan Border Police (ITBP) (1962)
6. Border Security Force (BSF) (1965)
7. Central Industrial Security Force-CISF (1969)
8. Sashastra Seema Bal (SSB) (1969)
9. Anti Terrorist Squad (1990)

10. Rapid Action Force (1991)

11. Garud Commando Force (2004)

## Important Submarines/Missile Boats/Warships

Submarines	Warships	Missile Boats
INS Chakra	INS Savitri	INS Vibhuti
INS Shahkul	INS Delhi	INS Prahar
INS Shalki	INS Mysore	INS Prashant
INS Sindhushastra	INS Brahmaputra INS Ghariyal INS Kulish INS Satpura INS Talwar INS Tillanchang	INS Nashak INS Vipul

## India's Missile System : At a Glance

S. No.	Missile	Feature	Range
1	Astra Missile	Beyond Visual range air-to-air Missile	A range of over 80 km in head on mode and 20 km in tail-chase mode.
2	Shourya Missile	Canisterised Surface-to-surface missile.	600 km
3	Sagarika Missile (K-15)	Submarine-to-Surface Missile.	More than 700 km
4	Akash Missile	Medium range Surface-to-Air Missile.	25 km
5	Nag Missile	Third Generation-fire and forget-anti-tank guided missile.	4 to 6 km
6	Nirbhay Missile	Long range subsonic cruise missile.	1000 km
7	Dhanush Missile	The Ship-based Surface-to-surface ballistic missile.	300 to 350 km
8	Brahmos Missile (Joint Indo-Russia Venture)	Supersonic cruise missile (can be launched from ships, submarines, aircrafts and land)	290 km
9	(a) Prithvi-I (Army version)	A single stage liquid-fuelled surface-to-surface missile.	150 km
	(b) Prithvi-II (Air force version)	A single stage liquid-fuelled surface-to-surface missile. Developed In Nov 2006, by DRDO.	250 km
	(c) Prithvi-III (Naval Version)	A two-stage surface-to-surface missile (first stage is solid fuelled and second stage is liquid fuelled).	350 km
10	(a) Agni-I	Short range ballistic missile	700-800 km
	(b) Agni-II	Medium range ballistic missile	2500 km
	(c) Agni-III	Intermediate range ballistic missile	3500 km
	(d) Agni-IV	Intermediate, it is a surface to surface	4000 km
	(e) Agni-V	Range ballistic missile	5500-5800 km
	(f) Agni-VI	Intercontinental ballistic missile	8000-12000 km

## Tanks in India

Type	Quantity (Estimated)	Origin	Description
Arjun MBT	248	India	The Indian Army ordered 124 'Arjun' Mk1 MBTs in 2000 and placed another order for additional 124 'Arjun' Mk1 MBTs and 124 'Arjun' Mk2 MBTs in 2010, after Arjun tank had conclusively outperformed the T-90. Indian Army is set to acquire 124 Arjun Mk2 tanks as a follow-on order, according to the Defence Minister.

T-90	1,050	Russia	Procured in three separate orders. Two batches (310 tanks and knockdown kits in 2000 and a further 300 in 2006) were purchased from Russia. A further 1000 were to be produced locally by 2020. Of those, the first batch of 10 were delivered in August 2009.
T-72	2,414	Soviet Union Poland	Upgraded to advanced Ajeya Mk1 and MK2 standard mainly based on Polish PT-91 Twardy Tank features developed by DRDO

### Indian sea-based nuclear-armed ballistic missiles

Name	Type	Maximum range (km)	Status
Dhanush	Short-range	350	Developed, but not deployed
Sagarika (K-15)	SLBM	700	Awaiting deployment on INS
K-4	SLBM3	500	Tested

### Nuclear-powered submarines

Class	Type	Boats	Displacement	Note
Chakra (Akula II)-class	Attack submarine (SSN)	INS Chakra (S71)	12,770 tonnes	Under a 10 year lease from Russia since 2012.
Arihant-class	Ballistic Missile submarine (SSBN)	INS Arihant (S73)	6,000 tonnes, surfaced	Undergoing sea trials, expected to be commissioned by 2014-2015.

### Aircraft carriers

Class	Type	Ships	Displacement	Description
Centaur-class	Aircraft carrier	INS Viraat (R22)	28,700 tonnes	STOVL carrier. Scheduled to be decommissioned by 2018 and replaced by INS Vikrant
Modified Kiev-class	Aircraft carrier	INS Vikramaditya (R33)	45,400 tonnes	STOBAR carrier.

### Replenishment ships

Class	Type	Ships	Origin	Displacement
Deepak-class	Replenishment oiler	INS Deepak (A50) INS Shakti (A57)	Italy	27,500 tonnes
Jyoti-class	Replenishment oiler	INS Jyoti (A58)	Russia	35,900 tonnes
Aditya-class	Replenishment oiler & Repair ship	INS Aditya (A59)	India	24,612 tonnes

Sandhayak-class	Survey vessel	INS Nirupak (J14)	India	1,800 tonnes
		INS Investigator (J15) INS Jamuna (J16) INS Sutlej (J17) INS Sandhayak (J18) INS Nirdeshak (J19) INS Darshak (J20) INS Sarvekshak (J22)		
Makar-class	Survey vessel	INS Makar (J31)	India	500 tonnes

### INDIAN COST-GUARDSHIP (ICGS) AVUSH:

Indian Coast Guard (ICG) has augmented its growing strength when vice admiral A R Larve, flag officer commanding-in-chief, Southern Naval Command, commissioned CGS Ayush, the final vessel in the series of twenty fast patrol vessels (FPVs) designed and built by the Cochin Shipyard Ltd (CSL). The 50-m-long ship having a maximum speed of 33 knots was delivered to the CG. It was made public at Kochi on 18 Feb 2017.

### Research and survey ships

Class	Type	Ships	Origin	Displacement
Sagardhwani	Research vessel	INS Sagardhwani (A74)	India	2,050 tonnes

## **BARAK-ANTI MISSILE**

Barak-anti missile' is known as (LR-SAM), it is designed to defined against any type of airborne threat including aircraft helicopters Anti-ship missiles and combat jets out to a maximum range of 70 km to 90 km. India and Israel jointly developed Long Range Surface to Air Missile (LRSAM) Barak 8 was successfully test fired from INS Kolkata. The firing trial of the LR SAM has been jointly carried out by the Indian Navy, Defence Research and Development Organisation (DRDO) and Israel Aerospace Industries. This successful test marks a significant milestone in enhancing Indian Navy's Anti Air Warfare capability and also India-Israel relations.

## **SHAURYA MISSILE**

It is a canister launched hypersonic surface-to-surface tactical missile developed by the Indian Defence Research and Development Organization (DRDO) for use by the Indian Armed Forces. It has a range of between 750 to 1,900 km (470 to 1,180 mi) and is capable of carrying a payload of one ton conventional or nuclear warhead. It gives the potential to strike in the short-intermediate range against any adversary.

Shaurya can reach a velocity of Mach 7.5 even at low altitudes. On 12 November 2008, the missile reached a velocity of Mach 5 as it crossed a distance of 300 km, with a surface temperature of 70° Celsius. The missile performed rolls to spread the heat uniformly on its surface. Flight time is between 500 seconds and 700 seconds.

## **DHRUV**

The Advanced Light Helicopter (ALH), also known as 'Dhruv', is the first indigenously designed and manufactured helicopter by HAL Bangalore. Dhruv was designed against then futuristic benchmarks and its design and technology is indicative of this fact. At the time of inception in the early Eighties. There were several budding technological options in rotor blades, gear boxes, that promised large jumps in performance and other benefits.

The ALH is being employed for a variety of missions including Advanced Search and Rescue, Special Heli-Borne Operations, Armed Patrol, Sniper Ops, VVIP Carriage and Night SAR.

## **INDARC**

IndARC is the India's first underwater moored observatory anchored in the Kongsfjorden fjord, half way between Norway (1100km away from Norway) and the North Pole at a depth of 192 metres. It has been deployed for the continuous monitoring of the oceanographic parameters from various depths in order to obtain significant inputs in the understanding of the Arctic climate and its possible link to tropical processes, specifically the Indian monsoon. IndARC was Designed and developed by scientists from the Earth System Science Organisation (ESSO), National Centre for Antarctic and Ocean Research (NCAOR), National Institute of Ocean Technology (NIOT) and Indian National Centre for Ocean Information Services (INCOIS).

## **NETRA**

The Indian Airforce (IAF) has formally inducted the first ever indigenously built Airborne Early Warning and Control System (AEW&C) dubbed as NETRA. NETRA has been indigenously developed by the DRDO. It was made public at the Aero India exhibition held in Bengaluru, Karnataka on 14 Feb 2017. AEW&C are airborne radar systems mounted on a carrier jet for airborne surveillance system i.e. to spot and track aircraft, missiles, ships and vehicles and offer command and organize direct friendly forces.

## **INDIAN AIRCRAFT CARRIER**

Indian Aircraft Carrier will use STOBAR (Short take off but arrested recovery) by using or sky-jump for take off, just like: INS Vikramaditya, INS Vishal, INS Virat, etc.

Russia has offered its nuclear aircraft carrier, dubbed "Storm," to India for purchase, a senior Indian Navy official said. The offer comes as India and the US discuss the transfer of technology for India's future nuclear aircraft carrier, the INS Vishal.

India plans to build its second homegrown aircraft carrier, INS Vishal, which will be nuclear-powered, 300 meters long, 70 meters wide and displace 65,000 tons.

INS Viraat: It is a centaur-class air-craft carrier in service with the Indian Navy.

## **INSV TARINI**

The main objective of INSV Tarini, It carries a suite of six sails including a main sail, head sails, downwind sails and storm sail gonoa sails and stay sails, and it is the first all woman crew to take up such challenging task, It was inducted into the Indian navy at Goa on 18 feb 2017.

## **SOME LATEST AIRCRAFTS**

**C-130J:** The aircraft is capable of performing paradrop, heavy drop, casualty evacuation and can also operate from short and semi prepared surfaces. C-130J is the heaviest aircraft to land at DBO in Aug 2013.

**C-17:** The aircraft is capable of carrying a payload of 40-70 tons up to a distance of 4200-9000 km in a single hop.

**IL-76:** A four engine heavy duty/long haul military transport aircraft of Russian origin with a max speed of 850 km/hr. It has a twin 23 mm cannon in tail turret and capacity to carry 225 paratroopers or 40 tones freight, wheeled or tracked armored vehicles.

**AN-32:** Twin engine turboprop, medium tactical transport aircraft of Russian origin with a crew of five and capacity to carry 39 paratroopers or max load of 6.7 tonnes. It has a max cruise speed of 530 km/hr.

**EMBRAER:** The main role of employment of this executive Jet Air craft is to convey VVIPs/VIPs to destinations within India and abroad. Air HQ Communication Squadron operates this aircrafts and it has maintained a flawless incident/accident free track record till date.

**AVRO:** Twin engine turboprop, military transport and freighter of British origin having a capacity of 48 paratroopers or 6 tonnes freight and max cruise speed of 452 km/hr.

**Dornier:** Twin engine turboprop, logistic air support staff transport aircraft of German origin capable of carrying 19 passengers or 2057 kg freight. It has a max speed of 428 km/hr.

**Boeing 737-200:** Twin engine turbofan, VIP passenger aircraft of American origin with total seating capacity of upto 60 passengers. It has a max cruise speed of 943 km/hr.

**MI-25/MI-35:** Twin engine turboshaft, assault and anti armour helicopter capable of carrying 8 men assault squad with four barrel 12.7 mm rotary gun in nose barbette and upto 1500 Kg of external ordnance including Scorpion anti-tank missiles. It has a max cruise speed of 310 km/hr.

**MI-26:** Twin engine turboshaft, military heavy lift helicopter of Russian origin with carrying capacity of 70 combat equipped troops or 20,000 kg payload. It has a max speed of 295 km/hr.

**MI-17 V5:** The Mi-17 V5 is a potent helicopter platform, equipped with modern avionics and glass cockpit instrumentation. They are equipped with state-of-art navigational equipment, avionics, weather radar and are NVG-compatible.

## LIST OF ACTIVE INDIAN MILITARY AIRCRAFT

The following list of active Indian military aircraft is a list of military aircraft currently in service with the Indian Armed Forces. For a list of historical aircraft used by the Indian Military, see list of historical aircraft of the Indian Air Force.

Type	Origin	Role	Version	Number	Notes
Sukhois-30Mk	India & Russia	Multirole air superiority fighter	Su - 30 Mk1 Trainer	230	All aircraft to be upgraded to super sukhois standards and introduced from 2020-21.
HAL Tejas	India	Multirole combat aircraft	Mk.1 Trainer	2 1	103 LCA (20 x Mk. 1 + 83 x Mk. 1-A) aircraft to be acquired. Final operational certification (FOC) scheduled for early-mid 2017, 2 Mk.1 aircraft inducted; SP-3 ready for induction. Full squadron of 20 Mk.1 aircraft to be introduced by 2018; improved Mk.1-A to be introduced from 2020-21.
HAL Rudra	India	Attack	ALH-WSI	7	Total of 38 on order.
HAL Light Combat Helicopter	India	Attack	LCH	3 prototypes	65 on order. 3 prototypes delivered.
HAL HJT-16 Kiran	India	Trainer	HJT-16 HJT-16II	81	To be phased out by 2017 and eventually be replaced by BAE Hawk (20 Hawks currently on order).
HAL Dhruv	India	Utility	Dhruv	66	65 more on order.
HAL Chetak	India	Utility	SA316B SA319	74	Being withdrawn from service and replaced by HAL Dhruv
HAL Cheetah	India	Utility	Cheetah	14	Hal Cheetah manufactured with HAL Turbomecca TM 333-2M2 Shakti engine.

## EXERCISE

1. Consider the following statements: **[IAS Prelim]**
  1. In November, 2006, DRDO successfully conducted the interception test using Prithvi-II missile.
  2. Prithvi-II is a surface-to-surface missile and can be deployed to guard the metros against air attacks.

Which of the statements given above is/are correct?

  - (a) 1 only
  - (b) 2 only
  - (c) Both 1 and 2
  - (d) Neither 1 nor 2
2. What is the Galileo Project which has been in news recently? **[IAS Prelim]**
  - (a) An intercountry programme of missile shield developed by the United States of America
  - (b) A project developed by India with assistance from Canada
  - (c) An environmental protection project being developed by Japan
  - (d) A multi-satellite navigation project being developed by the European Union
3. In which one of the following did India buy the Barak anti-missile defence systems? **[IAS Prelim]**
  - (a) Israel
  - (b) France
  - (c) Russia
  - (d) USA
4. In which one of the following locations is the International Thermonuclear Experimental Reactor (ITER) project to be built? **[IAS Prelim]**
  - (a) Northern Spain
  - (b) Southern France
  - (c) Eastern Germany
  - (d) Southern Italy
5. In the context of the Indian defence, what is 'Dhruv'? **[IAS Prelim]**
  - (a) Aircraft-carrying warship
  - (b) Missile-carrying submarine
  - (c) Advanced light helicopter
  - (d) Intercontinental ballistic missile
6. In the context of Indian defence, consider the following statements: **[IAS Prelim]**
  1. The Shourya missile flies with a speed of more than 8 Mach.
  2. The range of Shourya missile is more than 1600 km. Which of the statements given above is/are correct?
  - (a) 1 only
  - (b) 2 only
  - (c) Both 1 and 2
  - (d) Neither 1 nor 2
7. Consider the following statements: **[IAS Prelim]**
  1. INS Sindhughosh is an aircraft carrier.
  2. INS Viraat is a submarine.

Which of the statements given above is/are correct?

  - (a) 1 only
  - (b) 2 only
  - (c) Both 1 and 2
  - (d) Neither 1 nor 2
8. With reference to Agni-IV Missile, which of the following statements is/are correct? **[IAS Prelim]**
  1. It is a surface-to-surface missile.
  2. It is fuelled by liquid propellant only
  3. It can deliver one-tonne nuclear warheads about 7500 km away

Select the correct answer using the code given below.

  - (a) 1 only
  - (b) 2 and 3 only
  - (c) 1 and 3 only
  - (d) 1, 2 and 3
9. The term 'IndARC', sometimes seen in the news, is the name of **[IAS Prelim]**
  - (a) an indigenously developed radar system inducted into Indian Defence
  - (b) India's satellite to provide services to the countries of Indian Ocean Rim
  - (c) a scientific establishment set up by India in Antarctic region
  - (d) India's underwater observatory to scientifically study the Arctic region
10. What is Jugnu?
  1. Unmanned air vehicle designed by DRDO
  2. Latest LCA acquired by Indian Air force
  3. Micro Satellite built by IITB
  4. Energy efficient LED designed by sony

Which of the above is true

  - (a) 1 only
  - (b) 3 only
  - (c) 2 only
  - (d) 4 only
11. Consider the following:
  1. INS Jalashva
  2. C130J
  3. P8I maritime aircraft

The Indian armed forces have procured which among the above from United States of America?

  - (a) 2 only
  - (b) 1 and 2
  - (c) 2 and 3
  - (d) All 1, 2 and 3
12. Consider the following Statements: -
  1. Brahmos armed with su-30MKI would be a game changer in the India ocean because it has a range of 290Km and can also travel at a top speed of mach 2.8 barely 3-4 metres above the sea Surface, the missile cannot be intercepted by any known weapon system in the world.
  2. BrahMos Aerospace, a joint venture between India and Russia has started designing a hypersonic version of the Brahmos missile Brahmos - II

Which of the above statement is / are correct?

  - (a) 1 only
  - (b) 2 only
  - (c) Both 1 and 2
  - (d) Neither 1 nor 2



- 25.** With reference to Indian defence. Which one of following statements is NOT correct?

  - With the induction of Prithvi-II, the IAF is the only air force in the world with surface to surface ballistic missiles under its command
  - Sukhoi-30 MKI jet fighters can launch air-to-air and air-to-surface precision missiles
  - Trishul is a supersonic surface to air missile with a range of 30 km
  - The indigenously built INS Prabal can launch

**26.** Sukhoi-30 MKI Squadron is not stationed at

  - Tezpur
  - Pune
  - Jamnagar
  - Bareilly

**27.** The aircraft carrier Admiral Gorshkov procured by India from Russia is renamed as

  - INS Virat
  - INS Godavari
  - INS Trishul
  - INS Vikramaditya

**28.** Arihant is a

  - Multi barrel rocket launcher
  - Airborne Early Warning and Control System
  - Unmanned Combat Aerial Vehicle
  - Nuclear-powered ballistic missile submarine

**29.** Which one of the following is the solitary aircraft carrier of the Indian Navy that turns 50 in 2009, and has the distinction of being the oldest floating airfield in service?

  - INS Viraat
  - INS Trishul
  - INS Godavari
  - INS Vikramaditya

**30.** In which one of the following pair of states has the Indian Army launched “Operation Good Samaritan”?

  - Asom and Manipur
  - Manipur and Nagaland
  - Asom and Nagaland
  - Nagaland and Jammu and Kashmir

**31.** Which one of the following is nuclear-capable submarine-launched ballistic missile?

  - Sagarika
  - Shourya
  - Prithvi
  - Nag

**32.** Which one of the following statement with respect to India Air Force is not correct?

  - Chetak is a single engine turboshaft helicopter of Russian origin
  - SU-30 is a twin engine fighter of Russian origin
  - Mirage-2000 is a multi-role fighter of French origin
  - MiG-29 is a twin engine fighter aircraft of Russian origin.

**33.** The acronym of which one of the following missile is perceived as the confluence of the two nations (India and Russia) represented by two rivers?

  - Astra
  - Akash
  - Prithvi
  - BrahMos

**34.** Which one of the following pairs is not correctly matched?

  - Arjun : Indigenously produced Main Battle Tank (MBT)
  - Phalcon : Cruise missile supplied by Russia to India.
  - Saras : Indigenously developed civilian passenger aircraft.
  - Operation Seabird: New Indian naval base at Karwar.

<b>35. List I</b>	<b>List II</b>
<b>(Name of warhead)</b>	<b>(Type)</b>
A. Tejas	1. Air-to-air missile
B. Arjun	2. Ship-based missile
C. Dhanush	3. Main battle tank
D. Astra	4. Light combat aircraft

**Codes:**

A	B	C	D
(a) 4	3	2	1
(b) 1	2	3	4
(c) 4	2	3	1
(d) 1	3	2	4

**ANSWER KEY**

## Chapter

# 4

# SPACE TECHNOLOGY

It is the technology developed by the aerospace industry for implementation in spaceflight, satellites, space exploration, space stations and support infrastructure. plenty of daily services such as weather forecasting, remote sensing, GPS systems, satellite television, and long distance communications systems rely on space technology.

## APPLICATION OF SPACE TECHNOLOGY

There are many applications of space technology such as:

- Earth Observation
- Satellite Communication
- Disaster Management Support
- Satellite Navigation
- Climate and Environment

## SPACE SHUTTLE

The primary vehicle for research and exploration is the space shuttle. The space shuttle takes off like a rocket, orbits the earth like a spacecraft and lands, like an aeroplane. It consists of an orbiter, an external tank and two solid rocket boosters.

## ARTIFICIAL SATELLITES

An artificial satellite is a manufactured ‘moon’. It circles the earth in space along a path called an orbit. An artificial satellite may be designed in almost any space. It does not have to be streamlined, because there is little or no air where it travels in space. Artificial satellite may be classified according to the jobs they do as : weather satellites, communications satellites, navigation satellites, scientific satellites and military satellites.

## SPACE PROBES

Space Probes are the automated space craft which are operated and managed by robots so as to explore space after leaving Earth’s orbit. They can reach the moon; enter into interplanetary space; act as fly by and last but not the least they can land on other planetary bodies.

## ORBIT

An orbit can be a circular or elliptical path which is generally followed around an object in space. In object in an orbit is continuously moving unless and unfill some external force will be applied to it. More or less every celestial body in space has their own orbit.

## A GEOSYNCHRONOUS ORBIT

A geosynchronous orbit (GEO) is an orbit about the Earth of a satellite with an orbital period that matches the rotation of the Earth on its axis (one sidereal day) of approximately 23 hours 56 minutes and 4 seconds, The synchronization of rotation and orbital period means that, for an observer on the surface of the Earth, an object in geosynchronous orbit returns to exactly the same position in the sky after a period of one sidereal day.

Geosynchronous Orbit (GEO) is the region in which satellites orbit at approximately 22,236 miles above the Earth’s surface, in the plane of the equator, where near-geostationary orbits may be implemented. At this altitude, the orbital period is equal to the period of rotation of the Earth, so the satellite appears to move neither East nor west. When a geosynchronous orbital path remains above the Earth’s equator (00 latitude) at all times, with a period and an orbital eccentricity of approximately zero.

## JET ENGINE

A Jet engine is a machine that converts energy-rich, liquid fuel into a powerful pushing force called thrust. The thrust from one or more engines pushes a plane forward forcing air past its scientifically shaped wings to create an upword force called lift powers it into the sky its known as jet engine. It is also known as Reaction engine.

Reaction Engines idea was to design a device that could use the oxygen already present in the atmosphere through combustion like an ordinary jet engine. So jet engine uses the surrounding air for its oxygen supply and so is unsuitable for motion in space.

## SPACECRAFT

A spacecraft is a vehicle, or machine designed to fly in outer space. Spacecraft are used for a variety of purposes, including communications, earth observation, meteorology, navigation, space colonization, planetary exploration, and transportation of humans and cargo. There are two types of spacecraft:

### 1. Manned spacecraft

As of 2016, only three nations have flown manned spacecraft: USSR/Russia, USA, and China. The first manned spacecraft was, Vostok which carried Soviet cosmonaut Yuri Gagarin into space in 1961, and completed a full Earth orbit. There were five other manned missions which used a Vostok spacecraft. The second manned spacecraft was named Freedom 7, and it performed a sub-orbital spaceflight in 1961 carrying American astronaut Alan Shepard to an altitude of just over 187 kilometers (116 mi), other manned spacecraft include the Voskhod, Soyuz, Mir manned space stations.

## 2. Unmanned spacecraft

Unmanned spacecraft are spacecraft without people ("man") on board, used for unmanned spaceflight. The unmanned spacecraft stations are Salyut 7 and cassini, and the ISS module Zarya were capable of unmanned remote guided station-keeping, and docking maneuvers with both resupply craft and new modules.

Cassini is an unmanned spacecraft sent to the planet Saturn. It is a Flagship-class NASA–ESA–ASI robotic spacecraft. Cassini is the fourth space probe to visit Saturn and the first to enter orbit, and its mission is ongoing as of 2017. It has studied the planet and its many natural satellites since arriving there in 2004.

## NASA'S DEEP IMPACT SPACECRAFT

Deep impact is a NASA space probe, it was launched on a clear winter day in 12 January 2005 from Cape Canaveral air force station. NASA's Deep Impact spacecraft spanned 268 million miles (431 million kilometers) of deep space in 172 days, then reached out and touched comet Tempel 1.

NASA's Deep Impact space mission was employed to takes detailed pictures of Tempel-1 comet nucleus.

The collision between the coffee table-sized impact and city-sized comet occurred on July 4, 2005, at 1:52 a.m. EDT.

## SELENE-1

SELENE-1 is a lunar mission of JAXA (Japan Aerospace Exploration Agency). The mission objectives are the global survey of the moon, and to develop technologies for the lunar orbit insertion and spacecraft attitude and orbit control. The global survey of the moon is made for better understanding the origin and evolution of the moon, measuring the gravity field, elemental/chemical composition, etc. It also includes the measurement of the lunar and solar-terrestrial environment, and research on the possibility of future utilization of the moon. The nominal SELENE observation period is planned for one year.

## BHUVAN

Bhuvan is a software application which allows users to explore a 2D/3D representation of the surface of the earth. ISRO launched the beta version of its web-based GIS tool, bhuvan, on august 12, 2009. Bhuvan offers detailed imagery of Indian locations compared to other virtual Globe software, with spatial resolutions ranging up to 1 meter.

Bhuvan, which uses high-resolution images, will comply with India's remote sensing data policy, which does not allow online mapping services to show sensitive locations such as military and nuclear installations. High-resolution images are those that show locations of 1 sq. m or less on earth.

## THEMIS-MISSION

The time history of events and macro scale interactions during substorms (Themis) mission was originally a constellation of five NASA Satellites. These five NASA Satellites are Themis is A to Themis E.

The Name of the mission is acronym alluding to the titan, is known as themis.

The Themis mission, comprising five identical probes, aims to gain new insights into the colourful displays in high-latitude skies.

A US space agency (Nasa) mission to study auroras - the Northern Lights - has blasted off from Cape Canaveral in Florida, after it was delayed by wind.

## GALILEO IS EUROPE'S GLOBAL SATELLITE NAVIGATION SYSTEM

Galileo is Europe's Global Satellite Navigation System (GNSS), providing improved positioning and timing information with significant positive implications for many European services and users. For example:

- Galileo allows users to know their exact position with greater precision than what is offered by other available systems.
- The products that people use every day, from the navigation device in your car to a mobile phone, benefit from the increased accuracy that Galileo provides.
- Critical, emergency response-services benefit from Galileo.
- Galileo's services will make Europe's roads and railways safer and more efficient.
- It boosts European innovation, contributing to the creation of many new products and services, creating jobs and allowing Europe to own a greater share of the EUR 175 billion global GNSS market (Source: GSA Market Report Issue IV).

## SPACE CENTRES AND UNITS

- Vikram Sarabhai Space Centre (VSSC) - Thumba (Thiruvananthapuram)
- ISRO Satellite Centre (ISAC) - Bengaluru
- SHAR Centre - Shriharikota (Andhra Pradesh)
- Liquid Propulsion Systems Centre (LPSC) - Bengaluru
- Space Application Centre - Ahmedabad
- Developmental and Educational Communication - Ahmedabad unit (DECU)
- ISRO Telemetry Tracking and Command Network (ISTRAC) - Bengaluru
- National Remote Sensing Agency (NRSA) - Hyderabad
- Master Control Facility (MCF) - Hassan (Karnataka)
- The Antrix Corporation Limited - Bengaluru
- North Eastern-Space Applications Centre (NE-SAC) - Shillong
- Physical Research Laboratory (PRL) - Ahmedabad
- Laboratory for Electro Optical System (LEOS)
- ISRO Internal System Unit (IISU)
- Indian Institute of Remote Sensing
- Regional Remote Sensing Service Centre (RRSC)
- Development and Education Communication (DECU)
- Space Application Centre (SAC)
- National Remote Sensing Centre (NRSC)
- ISRO Telemetry Racking and Command Network (ISTRAC)
- Indian Institute of Space Science and Technology (IIST)
- Antrix Corporation Limited.
- National Atmospheric Research Laboratory (NARL)
- Semi-Conductor Laboratory (SCL)

## **INDIAN SPACE PROGRAMME**

Indian Space Programme have been initiated during 1960 when the space researches were generally carried out with the help of sounding rockets.

In 1969 Indian Space Research Organisation (ISRO) was formed which is known to be the pioneer institution for conducting space programmes in India. Later two other institution were added to the list named as Space Commission and Department of Space so as to gear up the space research activities. Today's India is facilitated with robust launch vehicle programmes for launching it indigenously.

In the initial stages of space programmes, satellite experiments such Aryabhatta, Bhaskar, Rohini and Apple were conducted. But with due course of time operational satellite programmes were also being executed. INSAT (Indian National Satellite System) and IRS (Indian Remote Servicing Satellite System) are the now among the major space programmes conducted by ISRO.

## **INSAT SYSTEM**

The Indian National Satellite (INSAT) system is a multi-agency, multi-purpose and operational satellite system for domestic telecommunications, meteorological observations and data relay, nationwide direct satellite television broadcasting and nationwide radio and television distribution programme.

REMOTE SENSING

The term ‘remote sensing’ refers to the process of sensing, identifying and delineating various objects on ground from a distance without coming into direct physical contact with them. ISRO and the Indian Council of Agricultural Research conducted during 1974-75 a joint experiment called the Agricultural Resources Inventory and Survey Experiment (ARISE). Indian experimental satellites, Bhaskara I and II carried out remote sensing for land cover mapping, geology and vegetation cover of the country. Today, India has the largest group of remote sensing satellites providing services at both the national and global levels.

## **Indian Remote Sensing (IRS) Satellite System**

The Indian Remote Sensing (IRS) satellite system is one of the largest constellations of remote sensing satellites in operation in the world today. The IRS programme commissioned with the launch of IRS-1A in 1988, presently includes thirteen satellites that in services continue to provide imageries in a variety of spatial resolutions ranging from better than one metre upto 506 kilometres.

**CARTOSAT –2D** Launched on 15 Feb, 2017 by PSLV-C  
36 (104 Satellites in one ago)

RESOURCESAT-2A Lunched on 7 Dec 2016 by PSLV-C36

SARAL Launched on Feb 25, 2013 by PSLV-C20

RISAT-1 Launched on Apr 26, 2012 by PSLV-C19

Megha-Tropiques Launched on Oct 12, 2011 by PSLV-C18  
RESOURCESAT-2 Launched on Apr 29, 2011 by

<b>RESOURCESAT-2</b>	Launched on April 20, 2011 by PSLV-C16
<b>CARTOSAT-2B</b>	Launched on July 12, 2010 by PSLV-C10

OCEANSAT-2	Launched on Sept 23, 2009 by PSLV-C14
RISAT-2	Launched on Apr 20, 2009 by PSLV-C12
CARTOSAT-2A	Launched on Apr 28, 2008 by PSLV-C9
CARTOSAT - 2	Launched on Jan 10, 2007 by PSLV-C7
CARTOSAT-1	Launched on May 05, 2005 by PSLV-C6
RESOURCESAT-1	Launched on Oct 17, 2003 by PSLV-C5

## Oceansat-2 satellite

Indian Space Research Organization (ISRO) successfully launched the Oceansat-2 and six nano-satellites into a 720 km. intended Sun Synchronous Polar Orbit (SSPO) on September 23, 2009.

The main objectives of oceansat-2 are to study surface winds and ocean surface strata, observation of chlorophyll concentration, monitoring of phytoplankton blooms, study of atmospheric aerosol and suspended sediments. So we can say oceansat-2 satellite will help identify potential fishing zones, monitor the ocean, climate studies and provide inputs for weather forecasting.

Example:

- Predicting the onset of monsoons
  - Monitoring the pollution of coastal water
  - Estimating the water vapour content in the Atmosphere.

## Meteorological Satellite

- INSAT-3D Launched on Jul 26, 2013
  - INSAT-3A Launched on Apr 10, 2003
  - KALPANA-1 Launched on Sep 12, 2002

## **Launch Vehicle Technology**

**SLV** : The indigenous capability for the development of satellite launch vehicle (SLV), was demonstrated through the first successful launch of SLV-3 in July 1980, carrying the 40-kilogram Rohini satellite.

**ASLV** : The Augumented Satellite Launch Vehicle (ASLV), basically derived from SLV-3, was originally meant for putting 150 Kilogram class technological/ scientific payloads into near-circular orbit.

**PSLV**: The PSLV, the country's first operational launch vehicle, is a four-stage rocket. The first stage is a solid propellant, the second stage is based on the liquid engine technology, the third stage is a solid propellant motor and the fourth, a liquid propellant stage.

**GSLV** : On March 28, 2001, the ISRO's efforts to launch the geosynchronous satellite launch vehicle ended in failure. On April 18, ISRO managed to prepare the GSLV again and launch it successfully from Sriharikota. The GSLV was commissioned after its successful second flight in 2003.

## **Export Promotion**

Antrix Corporation Ltd. a wholly government-owned company, is the commercial arm of ISRO. It has been formed in Bengaluru to market technologies and services relating to assembly and sub-assemblies of satellite systems. Antrix has further expanded the international marketing of IRS data, with IRS coverage extending into the Latin American region and central Europe.

## ISRO C25 CRYOGENIC UPPER STAGE OF GSLV MKIII TESTS

ISRO was developed a Cryogenic Upper Stage for GSLV MkIII on January 25, 2017. The cryogenic stage designated as C25 was tested for a duration of 50 seconds at ISRO Propulsion Complex (IPRC) in Mahendragiri demonstrating all the stage operations. The performance of the Stage during the test was as predicted. This is the first test in a series of two tests. The next test is planned for flight duration of 640 seconds.

This 50 second test is a significant milestone in the development of indigenous cryogenic propulsion technology. The successful hot test of the stage in the first attempt itself demonstrates ISRO's ability to work in new areas like cryogenic technology.

The development of C25 cryogenic stage began with the approval of GSLV MKIII, the next generation launch vehicle of ISRO, capable of launching 4 ton class spacecraft in Geosynchronous Transfer Orbit (GTO). The vehicle consists of two solid strap-on motors (S200), one earth storable liquid core stage (L110) and the cryogenic stage upper stage (C25).

## SPACE MISSION

Space mission 1975-2017		
Satellite	Launch Date	Launch Vehicle
Aryabhata	19-Apr-75	u-11 Interkosmos
Bhaskara-I	7-Jun-79	C-1 Interkosmos
Rohini Technology Payload	10-Aug-79	SLV-3
Rohini RS-1	18-Jul-80	SLV-3
Rohini RS-D1	31-May-81	SLV-3
Ariane Passenger Payload Experiment	19-Jun-81	Ariane-1 (V-3)
Bhaskara -II	20-Nov-81	C-1 Intercosmos
INSAT-1A	10-Apr-82	Delta 3910 PAM-D
Rohini RS-D2	17-Apr-83	SLV-3
INSAT-1B	30-Aug-83	Shuttle [PAM-D]
Stretched Rohini Satellite Series (SROSS-1)	24-Mar-87	ASLV
IRS-1A	17-Mar-88	Vostok
Stretched Rohini Satellite Series (SROSS-2)	13-Jul-88	ASLV
INSAT-1C	21-Jul-88	Ariane-3
INSAT-1D	12-Jun-90	Delta 4925
IRS-1B	29-Aug-91	Vostok
INSAT-2DT	26-Feb-92	Ariane-44L H10
Stretched Rohini Satellite Series (SROSS-C)	20-May-92	ASLV
INSAT-2A	10-Jul-92	Ariane-44L H10
INSAT-2B	23-Jul-93	Ariane-44L H10+
IRS-1E	20-Sep-93	PSLV-D1
Stretched Rohini Satellite Series (SROSS-C2)	4-May-94	ASLV
IRS-P2	15-Oct-94	PSLV-D2

INSAT-2C	7-Dec-95	Ariane-44L H10-3
IRS-1C	29-Dec-95	Molniya
IRS-P3	21-Mar-96	PSLV-D3
INSAT-2D	4-Jun-97	Ariane-44L H10-3
IRS-1D	29-Sep-97	PSLV-C1
INSAT-2E	3-Apr-99	Ariane-42P H10-3
Oceansat-1 (IRS-P4)	26-May-99	PSLV-C2
INSAT-3B	22-Mar-00	Ariane-5G
GSAT-1	18-Apr-01	GSLV-D1
Technology Experiment Satellite (TES)	22-Oct-01	PSLV-C3
INSAT-3C	24-Jan-02	Ariane-42L H10-3
Kalpana-1 (METSAT)	12-Sep-02	PSLV-C4
INSAT-3A	10-Apr-03	Ariane-5G
GSAT-2	8-May-03	GSLV-D2
INSAT-3E	28-Sep-03	Ariane-5G
RESOURCESAT-1 (IRS-P6)	17-Oct-03	PSLV-C5
EDUSAT	20-Oct-04	GSLV-F01
HAMSAT	5-May-05	PSLV-C6
CARTOSAT-1	5-May-05	PSLV-C6
INSAT-4A	22-Dec-05	Ariane-5GS
INSAT-4C	10-Jul-06	GSLV-F02
CARTOSAT-2	10-Jan-07	PSLV-C7
Space Capsule Recovery Experiment (SRE-1)	10-Jan-07	PSLV-C7
INSAT-4B	12-Mar-07	Ariane-5ECA
INSAT-4CR	2-Sep-07	GSLV-F04
CARTOSAT-2A	28-Apr-08	PSLV-C9
IMS-1 (Third World Satellite – TWsat)	28-Apr-08	PSLV-C9
Chandrayaan-1	22-Oct-08	PSLV-C11
RISAT-2	20-Apr-09	PSLV-C12
ANUSAT	20-Apr-09	PSLV-C12
Oceansat-2 (IRS-P4)	23-Sep-09	PSLV-C14
GSAT-4	15-Apr-10	GSLV-D3
CARTOSAT-2B	12-Jul-10	PSLV-C15
StudSat	12-Jul-10	PSLV-C15
GSAT-5P / INSAT-4D	25-Dec-10	GSLV-F06
RESOURCESAT-2	20-Apr-11	PSLV-C16
Youthsat	20-Apr-11	PSLV-C16
GSAT-8 / INSAT-4G	21-May-11	Ariane-5 VA-202
GSAT-12	15-Jul-11	PSLV-C17
Megha-Tropiques	12-Oct-11	PSLV-C18
Jugnu	12-Oct-11	PSLV-C18
RISAT-1	26-Apr-12	PSLV-C19
SRMSAT	26-Apr-12	PSLV-C18

GSAT-10	29-Sep-12	Ariane-5 VA-209
SARAL	25-Feb-13	PSLV-C20
IRNSS-1A	1-Jul-13	PSLV-C22
INSAT-3D	26-Jul-13	Ariane-5
GSAT-7	30-Aug-13	Ariane-5
Mars Orbiter Mission (MOM)	5-Nov-13	PSLV-C25
GSAT-14	5-Jan-14	GSLV-D5
IRNSS-1B	4-Apr-14	PSLV-C24
IRNSS-1C	10-Nov-14	PSLV-C26
GSAT-16	7-Dec-14	Ariane-5
IRNSS-1D	28-Mar-15	PSLV-C27

GSAT-6	27-Aug-15	GSLV-D6
Astrosat	28-Sep-15	PSLV-C30
GSAT-15	11-Nov-15	Ariane 5 VA-227
IRNSS-1E	20-Jan-16	PSLV-C31
IRNSS-1F	10-Mar-16	PSLV-C32
IRNSS-1G	28-Apr-16	PSLV-C33
Corbo Set-2C	22-Jun-16	PSLV-C34
Insat 3DR	8-Sep-16	GSLV-F05
SCATSAT-1	26-Sep-16	PSLV-C35
GSAT-18	5-Oct-16	Ariane 5 ECA VA-231
RESOURCE SAT -2A	7-Dec-16	PSLV-36
CARTO SAT-2D	15-Feb-17	PSLV-C37

## EXERCISE

1. With reference to Indian satellites and their launchers, consider the following statements: [IAS Prelim]
  1. All the INSAT series of satellites and their launched abroad
  2. PSL-Vs were used to launch IRS-series of satellites
  3. India used the indigenously built cryogenic engines for the first time for powering the third stage of GSLV
  4. GSAT, launched in the year 2001, has payloads to demonstrate digital broadcast and internet services

Which of these statements are correct?

  - (a) 1, 2, 3 and 4
  - (b) 2, 3 and 4
  - (c) 1, 2 and 4
  - (d) 1 and 3
2. **Assertion (A) :** Artificial satellites are always launched from the earth in the eastward direction.  
**Reason (R) :** The earth rotates from west to east and so the satellite attains the escape velocity. [IAS Prelim]
  - (a) Both A and R are true and R is the correct explanation of A
  - (b) Both A and R are true but R is not a correct explanation of A
  - (c) A is true but R is false
  - (d) A is false but R is true
3. Consider the following statements: [IAS Prelim]
  1. India launch its first full-fledged meteoro-logical satellite (METSAT) in September, 2002
  2. For the first time, the space vehicle PSLV C-4 carried a payload of more than 1000 kg into a geosynchronous orbit

Which of these statement is/are correct?

  - (a) Only 1
  - (b) Only 2
  - (c) Both 1 and 2
  - (d) Neither 1 nor 2
4. NASA's Deep Impact space mission was employed to take detailed pictures of which comet nucleus? [IAS Prelim]
  - (a) Halley's Comet
  - (b) Hale-Bopp
  - (c) Hyakutake
  - (d) Tempel 1
5. Which one of the following pairs is not correctly matched? [IAS Prelim]
  - (a) Cosmic Background Explorer (COBE): Satellite Programme
  - (b) Falcon: Under - sea cable system
  - (c) Discovery: Space shuttle
  - (d) Atlantis: Space station
6. Selene-1, the lunar orbiter mission belongs to which one of the followings? [IAS Prelim]
  - (a) China
  - (b) European Union
  - (c) Japan
  - (d) USA
7. ISRO successfully conducted a rocket test using cryogenic engines in the year 2007. Where is the teststand used for the purpose, located? [IAS Prelim]
  - (a) Balasore
  - (b) Thiruvananthapuram
  - (c) Mahendragiri
  - (d) Karwar
8. Which one of the following is a spacecraft? [IAS Prelim]
  - (a) Apophis
  - (b) Cassini
  - (c) Spitzer
  - (d) TechSar
9. What is the purpose of the US Space Agency's Themis Mission, which was recently in the news? [IAS Prelim]
  - (a) To study the possibility of life on Mars
  - (b) To study the satellites of Saturn
  - (c) To study the colourfull display of high latitude skies
  - (d) To build a space laboratory to study the stellar explosions
10. Consider the following statements in respect of a jet engine and a rocket: [IAS Prelim]
  1. A jet engine uses the surrounding air for its oxygen supply and so is unsuitable for motion in space.
  2. A rocket carries its own supply of oxygen in the gas form, and fuel.

Which of the statements given above is/are correct?

  - (a) 1 only
  - (b) 2 only
  - (c) Both 1 and 2
  - (d) Neither 1 nor 2

- 11.** Consider the following statements: [IAS Prelim]  
 The satellite Oceansat-2 launched by India helps in  
 1. estimating the water vapour content in the atmosphere.  
 2. predicting the onset of monsoons.  
 3. monitoring the pollution of coastal waters.  
 Which of the statements given above is/are correct?  
 (a) 1 and 2 only      (b) 2 only  
 (c) 1 and 3 only      (d) 1, 2 and 3
- 12.** Satellites used for telecommunication relay are kept in a geostationary orbit. A satellite is said to be in such as orbit when : [IAS Prelim]  
 1. The orbit is geosynchronous.  
 2. The orbit is circular.  
 3. The orbit lies in the plane of the earth's equator.  
 4. The orbit is at an altitude of 22,236.  
 Select the correct answer using the codes given below :  
 (a) 1, 2 and 3 only      (b) 1, 3 and 4 only  
 (c) 2 and 4 only      (d) 1, 2, 3 and 4
- 13.** An artificial satellite orbiting around the Earth does not fall down. This is so because the attraction of Earth  
 (a) does not exist at such distance      [IAS Prelim]  
 (b) is neutralized by the attraction of the moon  
 (c) provides the necessary speed for its steady motion  
 (d) provides the necessary acceleration for its motion
- 14.** Which of the following pairs is/are correctly matched? [IAS Prelim]
- | <b>Spacecraft</b>  | <b>Purpose</b>  |
|--------------------|---|
| 1. Cassini-Huygens | : Orbiting the Venus and transmitting data to the Earth |
| 2. Messenger       | : Mapping and investigating the Mercury                 |
| 3. Voyager 1 and 2 | : Exploring the outer solar system                      |
- Select the correct answer using the code given below.  
 (a) 1 only      (b) 2 and 3 only  
 (c) 1 and 3 only      (d) 1, 2 and 3
- 15.** In the context of space technology, what is "Bhuvan", recently in the news? [IAS Prelim]  
 (a) A mini satellite launched by ISRO for promoting the distance education in India  
 (b) The name given to the next Moon Impact Probe, for Chandrayan-II  
 (c) A geoportal of ISRO with 3 D imaging capabilities of India  
 (d) A space telescope developed by India
- 16.** Which among the following statements is/are correct regarding the failed launch of Geosynchronous Satellite Launch Vehicle (GSLV-F06)?  
 1. This was the second consecutive failure of GSLV.  
 2. The 2,300 kg satellite was to be used to boost television broadcast, telemedicine and tele-education.  
 (a) 1 only      (b) 2 only  
 (c) Both 1 and 2      (d) Neither 1 nor 2
- 17.** Which of the statements is true about Higgs-Boson?  
 1. Higgs-Boson is called as God's particle  
 2. It is named after English physicist Peter Higgs and Indian physicist J. C. Bose  
 3. It is based on Standard model  
 (a) 1 and 2      (b) 1 and 3  
 (c) 1, 2 and 3      (d) 3 only
- 18.** Satellites used for telecommunication relay are kept in a geostationary orbit. A satellite is said to be in such as orbit when :  
 1. The orbit is geosynchronous.  
 2. The orbit is circular.  
 3. The orbit lies in the plane of the earth's equator.  
 4. The orbit is at an altitude of 22,236.  
 Select the correct answer using the codes given below:  
 (a) 1, 2 and 3      (b) 1, 3 and 4  
 (c) 2 and 4      (d) 1, 2, 3 and 4
- 19.** Consider the following statements:  
 1. ISRO's Polar Satellite launch Vehicle (PSLV-C13) has successfully put five satellite in the orbit.  
 2. This was the 16th Consecutive Successful flight of PSLV.  
 Which of the above statement is/are correct?  
 (a) 1 only      (b) 2 only  
 (c) Both 1 and 2      (d) Neither 1 nor 2
- 20.** Consider the following statements with respect to Intelligent Flight Control System (IFCS):  
 1. It is developed by NASA  
 2. It is used in NF-15B aircraft  
 3. The IFCS Generation-I flight was first tested in 2003.  
 4. An artificial neural network is used in this control system.  
 Which of the following statement codes are correct?  
 (a) 1 and 2 only      (b) 2, 3 and 4 only  
 (c) 1, 2, 3 and 4      (d) None of these
- 21.** Consider the following statements regarding Indian polar research station:  
 1. India established a research station named "Bharti" at Ny-Alesund in Svalbard region of Norway.  
 2. India established a research station named "Himadri" in the Larsemann Hills region of East Antarctica.  
 Which of the statements given above is/are correct?  
 (a) 1 only      (b) 2 only  
 (c) Both 1 and 2      (d) Neither 1 nor 2
- 22.** The scientists at ISRO will launch a GSLV-D5 from the space post in Sriharikota in July to place a communication satellite GSAT-14 into orbit.  
 Which of the following settlements are correct?  
 1. GSAT-14 is satellite with six extended C b and 6 Ku band transponders  
 2. The communication satellite GSAT-14 will enhance the communication transponder capacity.  
 3. The GSLV D-5 is fitted with the indigenously developed cryogenic engine  
 Which of the above statement(s) is/are correct?  
 (a) 1 only      (b) 2 only  
 (c) 1 and 3      (d) 1, 2 and 3

**ANSWER KEY**

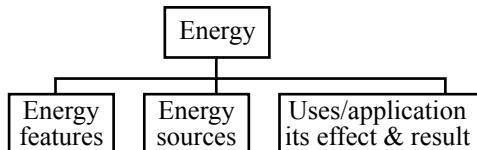
1	(a)	2	(c)	3	(c)	4	(d)	5	(d)	6	(c)	7	(c)	8	(b)
9	(c)	10	(a)	11	(d)	12	(a)	13	(d)	14	(b)	15	(c)	16	(c)
17	(b)	18	(a)	19	(b)	20	(c)	21	(d)	22	(d)	23	(a)	24	(a)
25	(b)	26	(d)	27	(c)	28	(b)	29	(c)	30	(c)				

## Chapter

# 5

# ENERGY

Energy is a property of objects which can be transferred to other objects or converted into different forms. The “ability of a system to perform work” is known as energy.



### Feature of Energy

Energy is measured in J (Joules) and power in W (Watts). Electric energy is generally measured in kWh.

The features of energy are:

Energy can be transferred from one object to another.

Energy comes in many different forms, which can generally be divided into Potential or Kinetic energy.

Energy can be converted from any one of these forms into any other, and vice versa.

Energy is never created or destroyed - this is called the First Law of Thermodynamics

Energy is capacity to do work

### Source of Energy

Source of energy can be classified as:

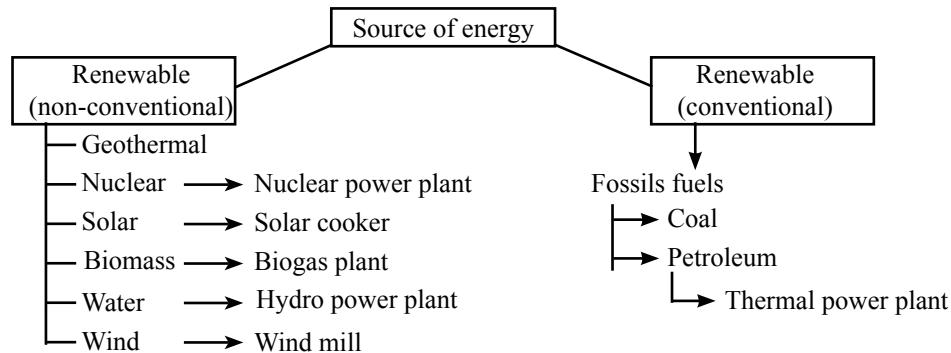
- Artificial sources
- Natural sources

### ARTIFICIAL SOURCES

Artificial energy can be defined in contradiction with natural energy. It must be produced without transformation of material, by the mere functioning of material implements. A possibility of production of artificial energy is in the form of mechanical work.

A mechanical work requires the action of a force and must therefore call an implement of propulsion. The analysis of relations between force and power shows that only particular propulsion implements can generate artificial energy, e.g.s. dynamo, generator, etc.

### NATURAL SOURCES OF ENERGY



### NATURAL SOURCE

Natural source of energy can be classified as two ways

1. Conventional source.
2. Nonconventional source.

### Conventional Source

Sources which are being used since long time like: coal, oil and gas, wood etc.

### Non-Conventional Source of Energy

Sources whose use has started only recently like sun (**Solar energy**), wave (**Wind energy**), geothermal energy, hydroelectric energy, biogas, biomass etc.

### Application of Energy

General uses of energy are divided into three economic sectors; they are:

1. Residential uses of energy
2. Commercial uses of energy
3. Transportation uses of energy.

### **World Without Energy! What will Happen?**

At the present time everybody is touched with the power of energy but what about the time when there will be no energy. Will the life be the same, many think life will perish.

Here's the thing: energy is nearly as important as the air we breathe and the water we drink, yet not everyone has ready, reliable access to energy.

### **How to Mechanical Energy Covert into Electric Energy**

A generator is used to convert mechanical energy to electrical energy. A motor converts electrical energy to mechanical energy. An electric generator is a device used to convert mechanical energy into electrical energy. Example: **Car**.

The cars are useful in ourlife, In car dynamo, mechanical energy changes into the electric energy, a part of the electrical energy changes into the light energy in the car lamps.

### **Dynamo Generator**

Dynamos produce electric current by rotating a wire within a magnetic field. Another method rotates a permanent magnet around coils of wire. Both processes produce alternating current because the wire passes between two magnetic poles every half turn. A commutator can turn the alternating current into direct current pulses, a common practice in early days before alternating current became the standard.

### **Energy Conservation:**

Energy conservation refers to the reducing of energy consumption through using less of an energy service. Energy conservation differs from efficient energy use, which refers to using less energy for a constant service. Driving less is an example of energy conservation.

### **Techniques of Energy Conservation**

There are energy conservation techniques that can help you to reduce your overall carbon footprint and save money in the long run.

- Install CFL Lights
- Lower the Room Temperature
- Fix Air Leaks
- Use Maximum Daylight
- Get Energy Audit Done
- Drive Less, Walk More and Carpooling
- Switch off Appliances when Not in Use
- Plant Shady Landscaping
- Install Energy Efficient Windows
- Use Energy Efficient Appliances

### **Energy Efficiency**

Energy efficiency is not energy conservation. Energy conservation is reducing or going without a service to save energy.

Energy efficiency is "using less energy to provide the same service".

In other words,

Energy efficiency is a way of managing and restraining the growth in energy consumption. Something is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input. For example (CFL).

### **The Bureau of Energy Efficiency (BEE)**

Bureau of Energy Efficiency (BEE) was established in March 2002, as a statutory body by the Government of India under the Energy Conservation Act 2001. It coordinates with State level agencies and energy consumers to perform functions and exercise powers that may be necessary for efficient use of energy and its conservation in India. Bureau of Energy Efficiency is responsible for spearheading the improvement of energy efficiency of the economy through various regulatory and promotional instruments. The primary goal of BEE is to reduce the energy intensity in the Indian economy.

## **Importances of Energy in Economic Development**

### **The Use of Energy for the Economic Development of Any Country**

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them. Energy can be classified into several types based on the following criteria:

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy

## **FOSSIL (CONVENTIONAL) ENERGY SOURCES**

It is the part of conventional energy sources, which are being used since long time like, oil, coal and natural gas are non-renewable resources that formed when prehistoric plants and animals died and were gradually buried by layers of rock.

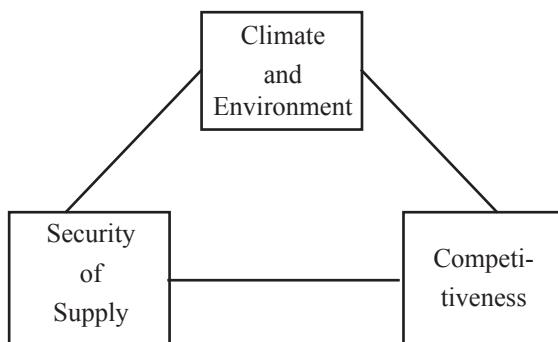
Over millions of years, different types of fossil fuels formed depending on what combination of organic matter was present, how long it was buried and what temperature and pressure conditions existed as time passed. These can not be replenish within a short period of time. Hence, it is a non-renewable or exhaustible source of energy. These fossil fuels are coal, oil and gas.

### **Coal**

An efficient and inexpensive energy source, coal provides stable and large-scale electricity generation. Power plants use two types of coal: lignite and hard coal. Lignite evolved from former bog forests under high pressure 15 to 20 million years ago. Hard coal developed the same way, but was exposed to additional pressure and heat for 300 to 350 million years deep within the Earth.

The lignite contains 30% carbon content while hard cool 80%.

## Coal Characteristics



**Security of supply:** Coal power plants provide stable and large-scale electricity generation. Of the Earth's fossil fuels, coal is the most abundant and widely dispersed.

**Competitiveness:** Coal power has a competitive production cost. Fuel costs are low and coal markets are well-functioning. However, technologies to reduce coal power plant CO<sub>2</sub> emissions are expensive.

**Climate and environment:** Coal power plants emit high levels of CO<sub>2</sub>. Coal mining also impacts significantly with the landscape and infrastructure.

## Types of Coal

Coal are classified into different categories based on properties, Gross Calorific Value (GCV), uses for different purposes. For examples: 1. Coking coal, 2. Non coking coal, 3. Semicoking coal, 4. NLW coking coal, 5. Washed and Beneficiated coal.

## Production of coal region in India:

The production of coal was 612.44 million metric tons (675.10 million short tons) in 2014-15, a growth of 8.25% over the previous year. The production of lignite was 48.26 million metric tons (53.20 million short tons) in 2014-15, 9% higher than the previous fiscal. India is ranked 4th in world coal production.

The top producing states are:

- Jharkhand
- Odisha
- Chhattisgarh

Notable coal-mining areas include:

- Singareni collieries in Khammam district, Telangana
- Jharia mines in Dhanbad district, Jharkhand
- Nagpur & Chandrapur district, Maharashtra
- Raniganj in Bardhaman district, West Bengal
- Neyveli lignite mines in Cuddalore district, Tamil Nadu
- Singrauli Coalfield and Umaria Coalfield in Madhya Pradesh
- Talcher mines in Angul district, Odisha.
- Mand-Raigarh Coalfield in Raigarh.
- Korba, Coal field, in korba.

## Some other coal mining areas are:

Tatapani, Sohagpur, Sonhat, Jhilimili, Chirimiri, Bisrampur, Lakhnupur, Sendurgarh, Panchbahini, Hasdoarand in chhattisgarh.

**Distribution of coal reserve by states in India:** The following table shows the estimated coal reserves in India by state as:

State	Coal Reserve (in million metric tonnes)	Type of Coalified
Jharkhand	80,356.20	Gondwana
Odisha	71,447.41	Gondwana
Chhattisgarh	50,846.15	Gondwana
West Bengal	30,615.72	Gondwana
Madhya Pradesh	24,376.26	Gondwana
Telangana	22,154.86	Gondwana
Maharashtra	10,882.09	Gondwana
Uttar Pradesh	1,061.80	Gondwana
Meghalaya	576.48	Tertiary
Assam	510.52	Tertiary
Nagaland	315.41	Tertiary
Bihar	160.00	Gondwana
Sikkim	101.23	Gondwana
Arunachal Pradesh	90.23	Tertiary
Assam	2.79	Gondwana
<b>TOTAL</b>	<b>293,497.15</b>	<b>Gondwana</b>

## Fossil Fuel Energy - Oil

Oil is a thick, black, gooey liquid also called petroleum or crude oil. It's found way down in the ground, usually between layers of rock. To get oil out, a well is dug. Digging a well is like putting a straw into a can of pop. The oil is then pumped out of the ground, just like when you suck pop up the straw. Oil is carried in pipelines and large tanker ships. A refinery changes the crude oil into petroleum products like gasoline, jet fuel and diesel petrol, etc. It's also burned in factories and power plants to make electricity. The oil is burned, which produces gases that turn a turbine to create electricity.

## Crude Oil Refining

After crude oil is removed from the ground, it is sent to a refinery where different parts of the crude oil are separated into usable petroleum products. These petroleum products include gasoline, distillates such as diesel fuel and heating oil, jet fuel, petrochemical feed-stocks, waxes, lubricating oils, and asphalt.

## Natural Gas

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas.

## Environment effect from natural gas

Cleaner burning than other fossil fuels, the combustion of natural gas produces negligible amounts of sulfur, mercury, and particulates. Burning natural gas does produce nitrogen oxides (NO<sub>x</sub>), which are precursors to smog, but at lower levels than gasoline and diesel used for motor vehicles.

## Wood

It is obtained from garden, forests, etc.. These are used in cooking, brick making, etc. As a result deforestation at a faster rate has caused a reduction in the number of forests on the Earth. It takes hundreds of years to grow a forest. If deforestation is continued at this rate, then there would be no wood left on the Earth. Hence, wood is an exhaustible source of energy.

## OIL SHALE

The term oil shale generally refers to any sedimentary rock that contains solid bituminous materials (called kerogen) that are released as petroleum-like liquids when the rock is heated in the chemical process of pyrolysis. Oil shale was formed millions of years ago by deposition of silt and organic debris on lake beds and sea bottoms. Over long periods of time, heat and pressure transformed the materials into oil shale in a process similar to the process that forms oil; however, the heat and pressure were not as great. Oil shale generally contains enough oil that it will burn without any additional processing, and it is known as "the rock that burns".

## Oil Shale Resources

While oil shale is found in many places worldwide, by far the largest deposits in the world are found in the United States in the Green River Formation, which covers portions of Colorado, Utah, and Wyoming. Estimates of the oil resource in place within

the Green River Formation range from 1.2 to 1.8 trillion barrels. Not all resources in place are recoverable; however, even a moderate estimate of 800 billion barrels of recoverable oil from oil shale in the Green River Formation is three times greater than the proven oil reserves of Saudi Arabia. Present U.S. demand for petroleum products is about 20 million barrels per day. If oil shale could be used to meet a quarter of that demand, the estimated 800 billion barrels of recoverable oil from the Green River Formation would last for more than 400 years.

More than 70% of the total oil shale acreage in the Green River Formation, including the richest and thickest oil shale deposits, is under federally owned and managed lands. Thus, the federal government directly controls access to the most commercially attractive portions of the oil shale resource base.

## Use of Oil Shale

The hydrocarbons in oil shale can be used as an alternative to petroleum or natural gas.

Oil shale is a type of sedimentary rock that is rich in kerogen. Kerogen is a part of rock that breaks down and releases hydrocarbons when heated. Hydrocarbons are substances made entirely of hydrogen and carbon. Petroleum and natural gas are probably the most familiar hydrocarbons.

Like traditional petroleum, natural gas, and coal, oil shale and kerogen are fossil fuels. Fossil fuels developed from the remains of algae, spores, plants, pollen, and a variety of other organisms that lived millions of years ago in ancient lakes, seas, and wetlands.

Many industries used industrial processes to heat shale in order to extract oil. Shale oil was used for a variety of products, like paraffin wax, pave roads and caulk ships, etc.

## Distribution Oil Shale

Resource Distribution Oil Shale deposits are found on all major continents with the USA holding the largest volume of undeveloped economic reserves. However, currently there are only 3 areas which have commercial mining operations (China, Estonia and Brazil.)

## NON-CONVENTIONAL SOURCES OF ENERGY

Sources whose use has started only recently like sun (solar energy), wave (Wind energy), biogas, biomass, etc.

There are many type of renewable or non conventional sources of energy

## Wind Energy

Wind energy is derived from fast blowing air. Wind energy is harnessed by windmills in order to generate electricity. Air blows because of uneven heating of the Earth. Since the heating of the Earth will continue forever therefore wind energy will also be available forever.

## Solar Energy

The energy derived from the Sun is known as solar energy. Solar energy is produced by the fusion of hydrogen into helium, fusion of helium into other heavy elements, and so on. A large amount of hydrogen and helium is present in the Sun. The Sun has billions years more to burn. Therefore solar energy is a renewable source of energy.

It is the most important of the non-conventional sources of energy because it is non-polluting and, therefore, helps in lessening the greenhouse effect.

Solar energy can also be used to meet our electricity requirements. Through Solar Photovoltaic (SPV) cells, solar radiation gets converted into DC electricity directly. This electricity can either be used as it is or can be stored in the battery. This stored electrical energy then can be used at night. SPV can be used for a number of applications such as:

- domestic lighting.
- street lighting.
- village electrification.
- water pumping.
- desalination of salty water.
- powering of remote telecommunication repeater stations and railway signals.

### **Biogas**

Biogas refers to a mixture of gases produced by the anaerobic decomposition of organic matter such as agricultural waste, municipal waste, plant residue, food waste etc. Biogas consists of methane, carbon dioxide along with small amount of hydrogen sulphide, and moisture.

### **Biomass**

Power generating systems based on biomass combustion as well as biomass gasification were launched in different centers in India.

### **Energy from Urban and Industrial Waste**

Energy from Urban waste plant under construction at Timarpur in Delhi will generate 3,745 mw of power from 300 tons per day of municipal solid waste. The project for generation of 6 mw power from bagasse at a co-operative sugar mill Tamil Nadu has been undertaken.

### **Geothermal Energy**

Geothermal energy is energy derived from the heat of the earth. The earth's centre is a distance of approximately 4000 miles and is so hot that it is molten. Temperatures are understood to be at least 5000 degrees centigrade. Heat from the centre of the earth conducts outwards and heats up the outer layers of rock called the mantle. When this type of rock melts and becomes molten it is called magma.

### **Hydro-electric energy**

Hydroelectric power is power harnessed from converting the energy coming from running water. The mechanical energy is transferred from a rotating turbine to a generator, which produces energy.

## **CONTRIBUTION OF NON-CONVENTIONAL SOURCES OF ENERGY FOR DEVELOPMENT OF INDIA**

India was the first country in the world to set up a ministry of non-conventional energy resources, in early 1980s. As of September 30, 2016 India's cumulative grid interactive or grid tied renewable energy capacity (excluding large hydro) reached about 44.24 GW. 61% of the renewable power came from wind, while solar contributed nearly 19%. Large hydro installed capacity was 43.11 GW as of September 30, 2016 and is administered separately by the Ministry of Power and not included in MNRE targets.

### **Installed Grid Interactive Renewable Power Capacity in India as of November 30, 2016 (RES MNRE)**

Source	Total Installed Capacity (MW)	%	2022 target (MW)
Wind Power	28419.40	61%	60,000.00
Solar Power	8874.87	19%	100,000.00
Biomass Power (Biomass & Gasification and Bagasse Cogeneration)	4932.33	11%	*10,000.00
Waste-to-Power	114.08	0.3%	
Small Hydro Power	4324.85	9%	5,000.00
<b>Total</b>	<b>46,665.53</b>		<b>175,000.00</b>

### **WIND ENERGY IN INDIA**

The capacity has significantly increased in the last few years and as of 2016 the installed capacity of wind power in India was 28,082.95 MW, mainly spread across the South, West and North regions. Although a relative newcomer to the wind industry, compared with countries such as Denmark or the United States, in the year 2015-2016 India had the fourth largest installed wind power capacity in the world. (Behind 1. China, 2. USA and 3. Germany), having overtaken 4. Spain in session 2015-2016 and ahead of 5. UK.

State	Total Capacity (MW)
Andhra Pradesh	1,866.35
Gujarat	4,227.31
Karnataka	3,082.45
Kerala	43.50
Madhya Pradesh	2,288.60
Maharashtra	4,664.08
Others	4.30
Rajasthan	4,123.35
Tamil Nadu	7,684.31
Telangana	98.70
<b>Total</b>	<b>28,082.95</b>

### **SOLAR ENERGY IN INDIA**

India has tremendous scope of generating solar energy. The reason being India is a tropical country and it receives solar radiation almost throughout the year. Use of solar energy can reduce the use of firewood and dung cakes by rural household.

In solar energy sector, many large projects have been proposed in India.

- That Desert has some of India's best solar power projects, estimated to generate 700 to 2,100 GW.
- The Jawaharlal Nehru National Solar Mission (JNNSM) launched by the Centre is targeting 20,000 MW of solar energy power by 2022
- In July 2009, a \$19 billion solar power plan was unveiled which projected to produce 20 GW of solar power by 2020.

## BIOMASS IN INDIA

Biomass is a carbon neutral fuel source for the generation of electricity; and apart from providing the much needed relief from power shortages; biomass power projects could generate employment in rural areas.

State wise biomass power and cogeneration projects	
State	Capacity (MW)
Andhra Pradesh*	389.75
Bihar	43.42
Chhattisgarh	264.90
Gujarat	55.90
Haryana	52.30
Karnataka	737.28
Madhya Pradesh	36.00
Maharashtra	1,112.78
Odisha	20.00
Punjab	.50
Rajasthan	111.30
Tamil Nadu	662.30
Uttarakhand	30.00
Uttar Pradesh	936.70
West Bengal	26.00
<b>Total</b>	<b>4,761.00</b>

\*Capacity includes projects of both Andhra Pradesh and Telangana

## BIOGAS PLANTS IN INDIA

Biogas in India is being produced using degradable organic waste like cattle dung (gobar), poultry waste, kitchen waste etc as raw material. The waste generated is also used as bio-fertilizer.

The compressed biogas can be used as substitute not only for LPG but also for electricity generation, transportation, etc. Bio-fertilizer increases the natural fertility of the soil with its high macro & micro nutrients content and also give benefits to the farmers with its easy to applied application.

## WASTE FACTORS RESPONSIBLE FOR ENERGY POTENTIAL

The two main factors which determine the potential of recovery of energy from wastes are the quantity and quality (physico-chemical characteristics) of the waste. Some of the important physico-chemical parameters requiring consideration include:

- Size of constituents
- Density
- Moisture content
- Volatile solids / Organic matter
- Fixed carbon
- Total inerts
- Calorific value

Often, an analysis of waste to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulfur (ultimate analysis) is done to make mass balance calculations, for both thermo chemical and biochemical processes.

## ELECTRIC POWER

Electricity is the set of physical phenomena associated with the presence and flow of electric charge. Electricity gives a wide variety of well-known effects, such as lightning, static electricity, electromagnetic induction and electric current. In addition, electricity permits the creation and reception of electromagnetic radiation such as radio waves.

The electricity that we use is a secondary energy source because it is produced by converting primary sources of energy such as coal, natural gas, nuclear energy, solar energy, and wind energy into electrical power. It also referred to as an energy carrier, which means it can be converted to other forms of energy such as mechanical energy or heat. Primary energy sources are renewable or nonrenewable energy, but the electricity we use is nonrenewable.

### Application of Electricity

Electricity is a natural phenomenon that occurs throughout nature and takes many different forms. In this we focus on current electricity: the stuff that powers our electronic gadgets. Our goal is to understand how electricity flows from a power source through wires, lighting up LEDs, spinning motors, and powering our communication devices.

Electricity is all around us—powering technology like our cell phones, computers, lights, soldering irons, and air conditioners.

## Electricity Generation in India

There are following organizations which generated electricity in India

### National Thermal Power Corporation (NTPC)

NTPC is the largest power generating company in India. NTPC was incorporated on 7th November, 1975 with the objective of building large size thermal power stations, along with associated transmission systems, to accelerate the integrated development of power sector in the country. NTPC has made foray into Hydro power, Coal mining, Power trading, Ash business, Equipment manufacturing, Renewable energy, Power distribution, etc.

On 19th May, 2010, NTPC was granted the coveted status of 'Maharatna Company' by Govt. of India.

**Electric Capacity of NTPC:** Present installed capacity of NTPC is 48,028 MW (including 6,966MW through JVs.) Comprising of 45 NTPC stations (19 Coal based, 7 combined cycle gas/ liquid fuel based, 1 hydro based), 9 Joint Ventures (8 coal 1 gas based) and 9 renewable energy projects.

NTPC Sources	Numbers	Capacity (MW)
A. NTPC owned		
Coal	19	35,885
Gas/Liquid Fuel	07	04017
Hydro	01	800
Renewable Projects (Solar PV)	09	360
Total	36	41,062
B. Owned by JVs/Subsidiaries		
Coal and Gas	09	6966
G. Total	45	48,028

## National Hydroelectric Power Corporation (NHPC)

National Hydroelectric Power Corporation Ltd. (NHPC) was incorporated in 1975 under Companies Act, 1956. The mission of NHPC is to harness the vast hydro, tidal and wind potential of the country to produce cheap/ pollution-free and inexhaustible power. Present installed capacity of NHPC is 6717 MW, comprising 22 power stations including joint ventures and others. There are 3 projects under constructions.

## Rural Electrification Corporation (REC)

Rural Electrification Corporation (REC) was set up in 1969 with the primary objective of providing financial assistance for rural electrification in the country. REC was declared a Public Financial Institution under Section 4-A of the Companies Act in 1992. In February 1998, the Corporation was registered as a Non-Banking Financial Company under Section 45-1A of the RBI Act, 1934. The company sanctioned loans worth ₹ 65,471 crore during 2015-16. It also disbursed a total sum of ₹ 46,025 crore during 2015-16.

## BASIC POWER GENERATIONS CONCEPT

Energy exists in various forms like mechanical energy, electrical energy, thermal energy and so on. One form of energy can be converted into another form by suitable arrangements. Out of these forms, electrical energy is preferred due to the following reasons.

- (i) It can be easily transported from one form to another,
- (ii) Losses in energy transportation are minimum,
- (iii) It can be easily controlled and regulated to suit requirements,
- (iv) It can be easily converted into other forms of energy particularly mechanical and thermal,
- (v) It can be easily sub-divided.

In all power stations, electric energy is generated from other forms of energy e.g.,

- (i) Chemical energy of fuel (thermal energy),
- (ii) Energy of falling water (hydraulic energy),
- (iii) Atomic energy (nuclear energy).

## Type of Power Station

Accordingly power stations are classified as :

### (A) Thermal Power Stations

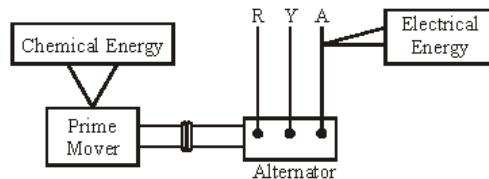
Those power stations which convert chemical energy of fuel (coal, diesel etc.) into electrical energy are called thermal power stations. The fuel used in thermal power stations may be solid fuel (coal) or liquid fuel (diesel).

The chemical energy of fuel is used to run the prime mover to which is coupled the alternator (A.C. generator). Thus electrical energy is obtained from the alternator.

According to the prime-mover employed for driving the alternator, thermal power stations may be broadly divided into the following two important types :

- (a) Steam power stations : Steam power stations employing steam engine or turbine as the prime-mover. Coal is used fuel.

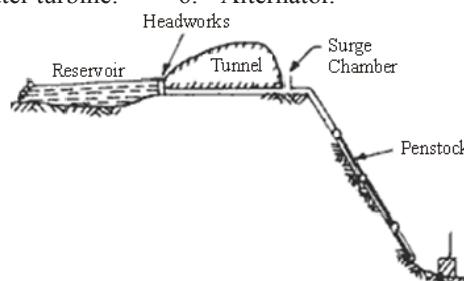
- (b) Diesel power stations : Diesel power stations employing diesel engine as the prime-mover.



### (B) Hydro-electric Power Stations

These convert energy of falling water (hydraulic) into Electrical energy. The entire arrangements can be divided into the following stages for the sake of simplicity :

1. Water reservoir.
2. Dam.
3. Valve house.
4. Penstock.
5. Water turbine.
6. Alternator.



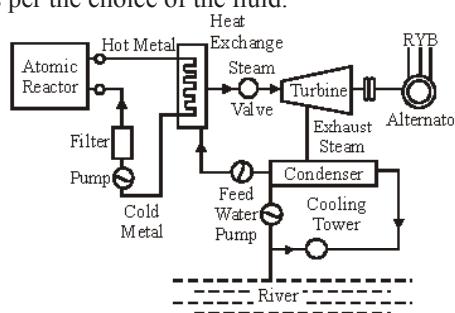
Hydro Electric Power Station

### (C) Nuclear Power Stations

These convert nuclear energy into electrical energy.

Nuclear power reactor :

Nuclear power reactor is basically that part of nuclear power plant where energy released as a result of nuclear fission of radioactive material is utilized to heat the coolant which may in turn generate steam or be used in a gas turbine. The nuclear reactor may thus be regarded as a substitute for the boiler fire box of steam plant or combustion chamber or a gas turbine plane. The steam or the gas may be used as working fluid in nuclear power plant. The nuclear power plant may be of steam driven turbine or gas driven turbine as per the choice of the fluid.



Nuclear Power Station

The following functions are associated with the working of nuclear reactor:

- (i) Producing a chain reacting or critical system,
- (ii) Controlling the level of power release from the system,
- (iii) Using spare neutrons to convert fertile into fissile material,
- (iv) Protecting personnel from harmful radiations emanating from the core.

Three different types of fuel used in nuclear reactors are:

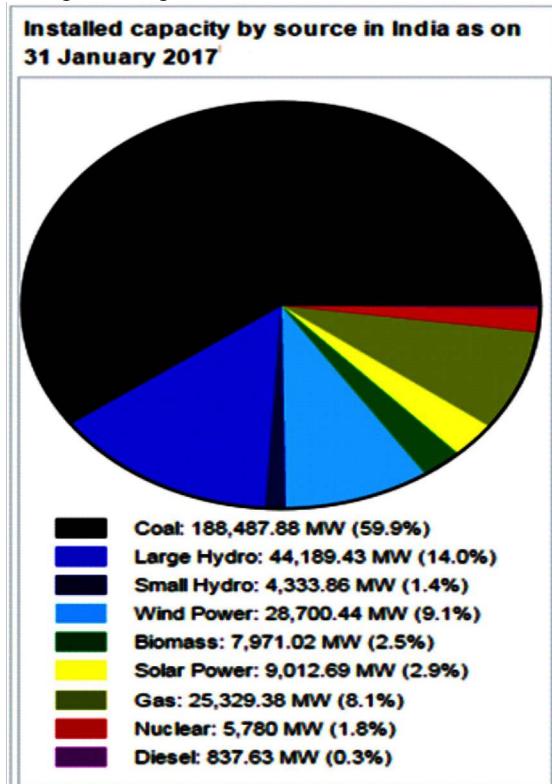
- (i) Uranium 92 U 235
- (ii) Secondary Uranium 92 U 235
- (iii) Plutonium 92 U 235

## INSTALLED CAPACITY OF ELECTRICITY SECTOR IN INDIA

The utility of electricity sector in India had an installed capacity of 314.64 GW as on 31 January 2017. Renewable power plants constituted 29.9% of total installed capacity. During the fiscal year 2015-16, the gross electricity generated by utilities in India was 1,116.84 TWh and the total electricity generation (utilities and non utilities) in the country was 1,352 TWh or 1,075.64 kWh per capita. India is the world's third largest producer and fourth largest consumer of electricity. Electric energy consumption in agriculture was recorded highest (17.89%) in 2015-16 among all countries. The per capita electricity consumption is lower compared to many countries despite cheaper electricity tariff in India.

In order to address the lack of adequate electricity availability to all the people in the country by March 2019, GoI has launched a scheme called "Power for All". This scheme will ensure continuous and uninterrupted electricity supply to all households, industries and commercial establishments by creating and improving necessary infrastructure. Its a joint collaboration of GoI with states to share funding and create overall economic growth.

Draft National Electricity Plan, 2016 prepared by GoI states that India does not need additional non-renewable power plants till 2027 with the commissioning of 50,025 MW coal based power plants under construction and additional 100,000 MW renewable power capacities.



## ENERGY SCENARIO IN INDIA

- India is a seventh largest country and have a population of 1.2 billion people.
- To maintain growth rate, need rapid growth in energy sector.
- 41% of electricity generation from thermal power plant.
- By 2016-2017, total domestic energy production of 670 million tons of oil equivalent (MTOE). This meet only 71% of the expected demand.
- As per the 2011 Census, 55.3% rural households had access to electricity.
- Still most of the rural area have limited supply hours of electricity.
- India ready to exploit renewable energy resources.

The energy scenario depends upon the energy sources supply.

### Energy Scenario up to the Year 2020:

- The population of the country, which is likely to cross the 970x106 mark by the end of 1998, may exceed 1315x106 by the end of the year 2019-20. Based on the present trends available in the rate of urbanisation, the share of urban population is projected to increase from 25.38% in 1990-91 to 43% in the year 2020. That will raise the energy demand.

## POWER GENERATING CAPACITY OF INDIA

The Indian power sector has made remarkable progress since Independence. The total installed capacity has gone up from 1,362 MW in 1947 to 3, 03,118.21 MW on 30 June 2016 and the transmission network has increased from the isolated system concentrated around urban and industrial areas to country wide National Grid. However, the demand of electricity has always been overstepping the supply. The importance of electricity as a prime mover of growth is very well acknowledged and in order to boost the development of power system the Indian government has participated in a big way through creation of various corporations viz State Electricity Boards (SEB), National Thermal Power Corporation (NTPC), National Hydro-Electric Power Corporation (NHPC) and Power Grid Corporation Limited (PGCL) etc. However, even after this the country is facing power shortage in terms of energy as well as peak demand to the tune of 10.9% and 13.8% respectively. Here are some facts about the scenario of power sector in India:

- 17 % of world's population.
- Population growth rate of 1.58 % annually.
- 6th (IEA Report) largest energy producer of the world.
- Ranks 5th in energy consumption.
- Energy consumption per capita among the lowest in the world (900 kWh/year approx.).

## EXERCISE

1. Energy resources derived from natural organic materials are called \_\_\_\_\_.  
 (a) geothermal energy sources  
 (b) fossil fuels  
 (c) biomass  
 (d) all of these
2. Nuclear energy is derived by \_\_\_\_\_.  
 (a) combustion of atoms of U 235  
 (b) fission of atoms of U 235  
 (c) fusion of atoms of U 235  
 (d) the breaking of U 235 bonds
3. Solar energy stored in material such as wood, grain, sugar, and municipal waste is called \_\_\_\_\_.  
 (a) fossil fuels  
 (b) biomass  
 (c) geothermal energy  
 (d) natural gas.
4. The world faces an energy crisis because \_\_\_\_\_.  
 (a) world demand for energy will increase  
 (b) world oil production will peak and begin to decline  
 (c) shortages and the resulting escalation of prices can shock the economic and political order  
 (d) all of the above
5. Crude oil is:  
 (a) Colourless  
 (b) Odourless  
 (c) Smelly yellow to black liquid  
 (d) Odourless yellow to black liquid.
6. The process that converts solid coal into liquid hydrocarbon fuel is called:  
 (a) Liquefaction  
 (b) Carbonation  
 (c) Catalytic conversion  
 (d) Cracking
7. Both power and manure is provided by:  
 (a) Nuclear plants      (b) Thermal plants  
 (c) Biogas plants      (d) Hydroelectric plant
8. Fuel cells are:  
 (a) Carbon cell      (b) Hydrogen battery  
 (c) Nuclear cell      (d) Chromium cell
9. A fuel cell, in order to produce electricity, burns:  
 (a) Helium      (b) Nitrogen  
 (c) Hydrogen      (d) None of the above
10. Steam reforming is currently the least expensive method of producing:  
 (a) Coal      (b) Biogas  
 (c) Hydrogen      (d) Natural gas
11. Compared to oil, an advantage of using natural gas is that it  
 (a) causes less air pollution  
 (b) prevents respiratory problems  
 (c) prevents headaches  
 (d) prevents over combustion
12. A nonrenewable resource of energy formed from remains of plants and animals that lived long ago is known as  
 (a) gas      (b) fossil fuel  
 (c) petrol      (d) coal
13. Water gas is a mixture of  
 (a) CO<sub>2</sub> and O<sub>2</sub>      (b) O<sub>2</sub> and H<sub>2</sub>  
 (c) H<sub>2</sub>, N<sub>2</sub> and O<sub>2</sub>      (d) CO, N<sub>2</sub> and H<sub>2</sub>.
14. Which of the following contributes to the improvement of efficiency of Rankine cycle in a thermal power plant?  
 (a) Reheating of steam at intermediate stage  
 (b) Regeneration use of steam for heating boiler feed water  
 (c) Use of high pressures  
 (d) All of the above.
15. Which of the following is considered as superior quality of coal ?  
 (a) Bituminous coal      (b) Peat  
 (c) Lignite      (d) Coke
16. A natural resource that can be replaced in same rate at which it is consumed or used is known as  
 (a) Artificial Resources  
 (b) Natural Resources  
 (c) Renewable Resources  
 (d) Nonrenewable Resources
17. When coal is burnt, it releases sulfur dioxide which combines with moisture in air to form  
 (a) sulfuric alkali      (b) sulfuric alcohol  
 (c) sulfuric acid      (d) sulfuric poison
18. Crude oil is so valuable that it is often called  
 (a) white gold      (b) platinum  
 (c) black gold      (d) black pearl
19. Compared to combustion engines, fuel cells are  
 (a) less efficient  
 (b) moderately efficient  
 (c) more efficient  
 (d) more violent

20. Most common activity to conserve natural resources is by  
 (a) turning extra light off  
 (b) turning washing machine off  
 (c) turning AC generators on  
 (d) turning UPS (utility power supply) on
21. Petroleum and natural gas are generally removed from Earth's crust by  
 (a) mining  
 (b) digging bores  
 (c) digging shallow wells  
 (d) shuttles
22. Joining of two or more nuclei to form a large nucleus is known as  
 (a) Fission  
 (b) Fusion  
 (c) Radioactivity  
 (d) Hydroxylation
23. A resource that forms at a much slower rate at which it is consumed is known as  
 (a) Artificial Resources  
 (b) Natural Resources  
 (c) Renewable Resources  
 (d) Nonrenewable Resources
24. In a hydro power plant  
 (a) Potential energy possessed by stored water is converted into electricity.  
 (b) Kinetic energy possessed by stored water is converted into potential energy.  
 (c) Electricity is extracted from water.  
 (d) Water is converted into steam to produce electricity.
25. When uranium is bombarded by a neutron it splits into \_\_\_\_\_.  
 (a) barium and lanthanum  
 (b) barium and krypton  
 (c) lanthanum and boron  
 (d) boron and krypton
26. Which of the following is not associated with solar energy ?  
 (a) Fossil fuel  
 (b) Hydel energy  
 (c) Geothermal energy  
 (d) Wind energy
27. Which of the following is an optional form of energy?  
 (a) Geothermal energy  
 (b) Natural gas  
 (c) Petroleum  
 (d) Hydrogen
28. Energy can neither be created nor be destroyed, but it can be changed from one form to another. This law is known as  
 (a) kinetic energy  
 (b) potential energy  
 (c) conservation of energy  
 (d) conservation principle
29. Uses the Sun's energy to heat something directly.  
 (a) Biomass Fuel  
 (b) Passive Solar Heating  
 (c) Active Solar Heating  
 (d) Geothermal Energy
30. The use of temperature differences in ocean water to produce electricity  
 (a) Active Solar Heating  
 (b) Ocean Thermal Energy Conversion (OTEC)  
 (c) Geothermal Energy  
 (d) Fuel Cell

ANSWER KEY											
1.	(b)	2.	(b)	3.	(b)	4.	(d)	5.	(c)	6.	(a)
7.	(c)	8.	(b)	9.	(c)	10.	(c)	11.	(a)	12.	(b)
13.	(d)	14.	(d)	15.	(a)	16.	(c)	17.	(c)	18.	(c)
19.	(c)	20.	(a)	21.	(b)	22.	(b)	23.	(d)	24.	(a)
25.	(b)	26.	(b)	27.	(a)	28.	(c)	29.	(b)	30.	(b)

1.	(b)	2.	(b)	3.	(b)	4.	(d)	5.	(c)	6.	(a)
7.	(c)	8.	(b)	9.	(c)	10.	(c)	11.	(a)	12.	(b)
13.	(d)	14.	(d)	15.	(a)	16.	(c)	17.	(c)	18.	(c)
19.	(c)	20.	(a)	21.	(b)	22.	(b)	23.	(d)	24.	(a)
25.	(b)	26.	(b)	27.	(a)	28.	(c)	29.	(b)	30.	(b)

## Chapter

# 6

# NUCLEAR SCIENCE

Nuclear energy is the energy that comes from the core or the nucleus of an atom. The bonds which hold the atoms together contain a massive amount of energy. This energy must be released in order to make electricity. This energy can be freed in two ways: nuclear fission and nuclear fusion.

### Uses of Nuclear energy

Today most people are aware of the important use of nuclear energy makes in cleanly providing a significant proportion of the world's electricity.

### Applications of Nuclear Energy

Nuclear energy is the production of electric energy. Nuclear power plants are responsible for generating electricity. Nuclear fission reactions are generated in the nuclear reactors of the nuclear power plants. With these reactions thermal energy is obtained which will be transformed into mechanical energy and later into electrical energy.

There are many applications of nuclear energy where nuclear technology is used directly or indirectly. These are:

1. Military applications, nuclear weapons.
2. Nuclear medicine.
3. Gamma Sterilisation.
4. Smoke detectors
5. Radio therapy
6. Gamma radiography.
7. Industrial tracers.
8. Dating.

### NUCLEAR REACTORS

A nuclear reactor, formerly known as an atomic pile, it is a device used to initiate and control a sustained nuclear chain reaction. Nuclear reactors are used at nuclear power plants for electricity generation and in propulsion of ships.

Nuclear reactors are divided into two categories:

- **Thermal Reactors:** Almost all of the current reactors which have been built use thermal neutrons to sustain the chain reaction. These reactors also contain neutron moderator that slows neutrons from fission
- **Fast Neutron Reactors:** Fast reactors contains no neutron moderator and use less-moderating primary coolants, because they use fast neutrons to cause fission in their fuel.

### Types of Nuclear Reactors

#### Breeder Reactor

A breeder reactor is essentially a particular configuration of a fast reactor. The most common breeding reaction is an absorption reaction on uranium-238, where a plutonium-239 from non-fissionable uranium-238 is produced.

#### Pressurized Water Reactor – PWR

Pressurized water reactors use a reactor pressure vessel (RPV) to contain the nuclear fuel, moderator, control rods and coolant. They are cooled and moderated by high-pressure liquid water.

#### Boiling water reactor – BWR

A boiling water reactor is cooled and moderated by water like a PWR, but at a lower pressure (7MPa), which allows the water to boil inside the pressure vessel producing the steam that runs the turbines.

#### CANDU – Heavy Water Reactor

The CANDU reactor design (or PHWR – Pressurized Heavy Water Reactor) has been developed since the 1950s in Canada, and more recently also in India. These reactors are heavy water cooled and moderated pressurized water reactors. Instead of using a single large reactor vessel as in a PWR or BWR, the nuclear core is contained in hundreds of pressure tubes. PHWRs generally use natural uranium (0.7% U-235) oxide as fuel, hence needs a more efficient moderator, in this case heavy water (D<sub>2</sub>O).

### NUCLEAR POWER

Nuclear power for civil use is well established in India. Since building the two small boiling water reactors at Tarapur in the 1960s, its civil nuclear strategy has been directed towards complete independence in the nuclear fuel cycle, necessary because it is excluded from the 1970 Nuclear Non-Proliferation Treaty (NPT) due to it acquiring nuclear weapons capability after 1970.

### ORGANISATION OF INDIA NUCLEAR ENERGY PROGRAM:

The Atomic Energy Commission was set up in August 1948 to look after atomic energy activities in the country. The functions of the Atomic Energy Commission are:

- (i) To organize research in atomic science in the country;

- (ii) To train, atomic scientists in the country;
- (iii) To promote nuclear research in commissions own laboratories as well as in India;
- (iv) To undertake prospecting of atomic minerals in India and to extract such minerals for use on industrial scale.

It has five research centres viz.

- Bhabha Atomic Research Centre (BARC), Mumbai
- Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam (Tamil Nadu)

- Raja Ramanna Centre for Advanced Technology (RRCAT), Indore
- Variable Energy Cyclotron Centre (VECC), Kolkata
- Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad.

It also gives financial assistance to autonomous national institutes doing research in the field and has various other organizations under it.

## NUCLEAR POWER PLANTS IN INDIA

Unit	Type	Capacity (MWe)	Since
TAPS-1 (Tarapur, Maharashtra)	BWR	160	28 October 1969
TAPS-2 (Tarapur, Maharashtra)	BWR	160	28 October 1969
TAPS-3 (Tarapur, Maharashtra)	PHWR	540	18 August 2006
TAPS-4 (Tarapur, Maharashtra)	PHWR	540	15 September 2005
RAPS-1 (Rawatbhata, Rajasthan)	PHWR	100	16 December 1973
RAPS-2 (Rawatbhata, Rajasthan)	PHWR	200	1 April 1981
RAPS-3 (Rawatbhata, Rajasthan)	PHWR	220	1 June 2000
RAPS-4 (Rawatbhata, Rajasthan)	PHWR	220	23 December 2000
RAPS-5 (Rawatbhata, Rajasthan)	PHWR	220	4 February 2010
RAPS-6 (Rawatbhata, Rajasthan)	PHWR	220	31 March 2010
MAPS-1 (Kalpakkam, Tamil Nadu)	PHWR	220	21 March 1986
MAPS-2 (Kalpakkam, Tamil Nadu)	PHWR	220	12 March 1986
NAPS-1 (Narora, Uttar Pradesh)	PHWR	220	1 January 1991
NAPS-2 (Narora, Uttar Pradesh)	PHWR	220	1 July 1992
KAPS-1 (Kakrapar, Gujarat)	PHWR	220	6 May 1993
KAPS-2 (Kakrapar, Gujarat)	PHWR	220	1 September 1995
KGS-1 (Kaiga, Karnataka)	PHWR	220	6 November 2000
KGS-2 (Kaiga, Karnataka)	PHWR	220	6 May 2000
KGS-3 (Kaiga, Karnataka)	PHWR	220	6 May 2007
KGS-4 (Kaiga, Karnataka)	PHWR	220	27 November 2010
KKNPP-1 (Kudankulam, Tamil Nadu)	VVER	1000	22 October 2013
KKNPP-2 (Kudankulam, Tamil Nadu)	VVER	1000	July-2016
Total Capacity		6780	

## EXERCISE

1. In which one of the following areas did the Indira Gandhi Centre for Atomic Research make significant progress in the year 2005? **[IAS Prelim]**
  - Reprocessing the uranium-plutonium mixed carbide fuel of the Fast Breeder Test Reactor.
  - New applications of radioisotopes in metallurgy.
  - A new technology for production of heavy water.
  - A new technology for high level nuclear waste management.
2. In the year 2008, which one of the following conducted a complex scientific experiment in which sub-atomic particles were accelerated to nearly the speed of light? **[IAS Prelim]**
  - European Space Agency
  - European Organization for Nuclear Research
  - International Atomic Energy Agency
  - National Aeronautics and Space administration
3. Consider the following organizations:
  1. Atomic Minerals Directorate for Research & Exploration
  2. Heavy Water Board
  3. Indian Rare Earths Limited
  4. Uranium Corporation of India

Which of these is/are under the Department of Atomic Energy?

  - 1 only
  - 1 and 4
  - 2, 3 and 4
  - 1, 2, 3 and 4
4. To meet its rapidly growing energy demand, some opine that India should pursue research and development on thorium as the future fuel of nuclear energy. In this context, what advantage does thorium hold over uranium?
  1. Thorium is far more abundant in nature than uranium.
  2. On the basis of per unit mass of mined mineral, thorium can generate more energy compared to natural uranium.
  3. Thorium produces less harmful waste compared to uranium.

Which of the statements given above is/are correct?

  - 1 only
  - 2 and 3
  - 1 and 3
  - Neither 1 nor 2
5. Consider the following statements about Jaitapur Project:
  1. It will be India's largest Atomic Reactor in terms of power generation.
  2. Areva which is going to establish this project is an South Korean giant.

Which of the above statement are / is true?

  - Both 1 and 2
  - 2 only
  - Neither 1 nor 2
  - 1 only
6. Consider the following statements:
  1. In 2008, Government of India adopted the Guidelines developed by the International Commission on Non-Ionizing Radiation Protection from mobile towers.
  2. The values chosen for the permissible Power Density (Mobile radiation) are 4.5 W/Sqm for 900 Mhz & 9 W/Sqm for 1800 Mhz.

Which of the above statement are/is true?

  - 1 only
  - Both 1 and 2
  - Neither 1 nor 2
  - 2 only
7. Consider the following statements:
  1. 10 Nuclear Power Plants of India comes under the AERB (Atomic energy regulatory Board).
  2. Meckani committee recommended that the Nuclear Regulator be created as a statutory Body.
  3. Kudankulam Nuclear Project will operate by AERB.

Which of the above statement are / is true?

  - 1 and 2
  - 1, 2 and 3
  - 1 and 3
  - 1 and 2
8. Consider the following statements : -
  1. Cobalt - 60 was leaked when a worker cut open a piece of metal in a Delhi market this cobalt-60 is used for medical purposes, industrial radiography for nondestructive testing and in the food processing industry for irradiation process.
  2. The Atomic Energy Regulatory Board (AERB) is meant to maintain a "Cradle to grave" System to keep track of such equipment, including through on-site inspection.

Which of the above statement is/are correct?

  - 1 only
  - 2 only
  - Both 1 and 2
  - None of the above.
9. Consider the following Statements :
  1. The Fast Breeder test Reactor (FBTR) is at the heart of the Indira Gandhi Centre for Atomic Research (IGCAR) at kalpakkam, and it is a forerunner to the second stage of the country's nuclear power programme.
  2. Fast Reactors use "Fast" (high energy) neutrons to sustain the fission process, in contrast to water cooled reactors that use thermal (low energy) neutrons. Fast reactors are commonly known as breeders because they breed more fuel than they consume.

Which of the above statements is /are correct ?

  - 1 only
  - 2 only
  - Both 1 and 2
  - Neither 1 nor 2

- 10.** Consider the following statements regarding India's Nuclear programme
1. In the first stage, India is using natural uranium as fuel to pressurised Heavy water Reactors (PHWR).
  2. In the Second Stage, plutonium reprocessed from the spent fuel of the PHWRs, depleted uranium and thorium kept in the blanket form will be used as fuel to power a series of breeder reactors. Thorium used in the breeders gets converted into uranium- 233, a fissile material.
  3. In the third stage, reactors will use thorium and uranium- 233 to generate electricity.
  4. India's Nuclear Fuel Complex is in Hyderabad.
- Which of the above statements are correct ?
- (a) 1 and 3, (b) 1, 3 and 4  
 (c) 1, 2, and 3 (d) All of the above
- 11.** Consider the following statements :-
1. The department of Atomic Energy (DAE) is get permission to locate the India- based neutrino observatory(INO) at Singara in Nilgiri district in Tamil Nadu.
  2. The INO is a major underground experimental facility to study the elusive and nearly mass- less fundamental particles of nature called neutrinos.
- Which of the above statement is /are in correct?
- (a) 1 only (b) 2 only  
 (c) Both 1 and 2 (d) Neither 1 nor 2.
- 12.** In the case of the nuclear disaster which of the following options for cooling the nuclear reactors may be adopted?
1. Pumping of water to the reactors.
  2. Use of boric acid.
  3. Taking out the fuel rods and keeping them in a cooling pond.
- Select the correct answer using the code given below
- (a) 1, 2 and 3 (b) 1 and 2  
 (c) 2 and 3 (d) 3 only
- 13.** Consider the following statements
1. India has a published nuclear doctrine.
  2. The doctrine advocates 'no-first-use' policy.
  3. The authority to release nuclear weapons for use resides in the person of the President of India.
- Which of the statements given above is/are correct?
- (a) 1 only (b) Both 1 and 2  
 (c) Both 2 and 3 (d) 1, 2 and 3
- 14.** Consider the following statements:
1. India has 10 Pressurized Heavy Water Reactors (PHWRs)
  2. The spent fuel from the PHWRs is reprocessed into plutonium.
  3. All imported reactors are under the safeguards of the international Atomic Energy Agency (IAEA).
- Which of the statements given above is/are correct?
- (a) 1 only (b) 2 only  
 (c) 2 and 3 (d) 1, 2 and 3
- 15.** Consider the following statements:
1. Cirus was the third Indian Research Reactor.
  2. Fast Breeder Test Reactor is at Kalpakkam.
- Correct statement/statements is/are
- (a) 1 and 2 (b) 1 only  
 (c) 2 only (d) None of them
- 16.** Consider the following statements in relations to the nuclear reactors and choose the correct alternative:
1. The Pressurized Heavy Water Reactor (PHWR) uses natural Uranium as the Fuel.
  2. The Fast Breeder Reactor (FBR) uses liquid Sodium as the moderator.
  3. The Advanced Heavy Water Reactor (AHWR) will be based on U233 as the Fuel.
  4. The French Company Areva is building the European Pressurized Reactors (EPR) at Jaitapur in Maharashtra.
- (a) 1, 3 and 4 (b) 2, 3 and 4  
 (c) 1, 2 and 4 (d) 1 and 4
- 17.** The stages of India's Nuclear Power Programme differs with respect to:
1. Fuel used 2. Technology
  3. Stage of development
- (a) 1 and 2 (b) 2 and 3  
 (c) 1 and 2 (d) All
- 18.** Identify the correct statement(s):
1. The Department of Atomic Energy is directly under the Prime Minister of India.
  2. The Rajasthan Atomic Power Station (RAPS) is largest power producing nuclear site.
- (a) 1 only (b) 2 only  
 (c) Both 1 and 2 (d) None
- 19.** The correct order of the countries from top to bottom in the Nuclear Safety Index is:
1. Belarus 2. France
  3. Israel 4. U.K.
- (a) 2, 4, 3 and 1 (b) 2, 3, 4 and 1  
 (c) 4, 1, 2 and 3 (d) 4, 3, 2 and 1
- 20.** Consider the following statements:
1. The Nuclear Suppliers Group has 24 countries as its members.
  2. India is a member of the Nuclear Suppliers Group. Which of the statements given above is/are correct?
- (a) 1 only (b) 2 only  
 (c) 1 and 2 both (d) None
- 21.** Consider the following statements:
1. United States-India Peaceful Atomic Energy Cooperation Act, 2006 was named in honour of the Chairman of the House Committee on International Relations.
  2. About 25% of world's total thorium reserves are in India.
- Which of the statements given above is/are correct?
- (a) 1 only (b) 2 only  
 (c) 1 and 2 both (d) None

- 22.** Consider the following statements about IAEA
1. It was set-up as the world's Atoms for Peace organisation in 1957.
  2. The IAEA Secretariat is headquartered at the Vienna International Centre in Vienna, Austria.
  3. In terms of its statute, the IAEA reports annually to the UN General Assembly.
- Which of the statements given above is/are correct?
- (a) 1, 2 and 3      (b) Only 1  
 (c) 2 and 3      (d) Only 3
- 23.** Consider the following statements
1. India has 10 Pressurized Heavy Water Reactors (PHWRs).
  2. The spent fuel from the PHWRs is reprocessed into plutonium.
  3. All imported reactors are under the safeguards of the international Atomic Energy Agency (IAEA).
- Which of the statements given above is/are correct?
- (a) Only 1      (b) Only 2  
 (c) 2 and 3      (d) All of these
- 24.** In the case of the nuclear disaster which of the following options for cooling the nuclear reactors may be adopted?
1. Pumping of water to the reactors.
  2. Use of boric acid.
  3. Taking out the fuel rods and keeping them in a cooling pond.
- Select the correct answer using the codes given below
- (a) Only 3      (b) 1 and 2  
 (c) 2 and 3      (d) All of these
- 25.** Non-nuclear weapons of mass destruction
- (a) are far less dangerous than nuclear weapons, so the international community is trying to eliminate nuclear weapons first.  
 (b) include chemical and biological weapons, which have been around for decades.
- 26.** (c) are much easier to keep track of than nuclear weapons.  
 (d) are more difficult to build than nuclear weapons, so fewer states have them.
- 26.** The Government of India is planning to establish a new independent nuclear safety regulatory authority. Who among the following will head this new authority?
- (a) Prime Minister  
 (b) President  
 (c) Minister of Science & Technology  
 (d) A professional with extensive experience in atomic energy
- 27.** Scientists at the Indira Gandhi centre for Atomic Research, Kalpakkam, have successfully extended the life of Fast Breeder Test Reactor (FBTR) by another 20 years. This centre is located in:
- (a) Karnataka      (b) Gujarat  
 (c) Maharashtra      (d) Tamil Nadu
- 28.** In the year 2011, a missile named 'PRHAR', developed by DRDO was test fired. This is a
- (a) short-range surface to air missile  
 (b) long-range surface to air missile  
 (c) short-range surface to surface missile  
 (d) long-range surface to surface missile
- 29.** Heat is generated in a nuclear reactor (thermal) by
- (a) Combustion of a nuclear fuel e.g. uranium.  
 (b) Fusion of atoms of uranium.  
 (c) Absorption of neutrons in uranium atoms.  
 (d) Fission of U-235 by neutrons.
- 30.** Which one is different for the neutral atoms of the isotopes of an element?
- (a) Number of protons  
 (b) Atomic weights  
 (c) Atomic numbers  
 (d) Number of electrons

**ANSWER KEY**

1.	(a)	2.	(b)	3.	(d)	4.	(a)	5.	(a)	6.	(b)	7.	(a)	8.	(c)
9.	(c)	10.	(d)	11.	(c)	12.	(b)	13.	(d)	14.	(c)	15.	(c)	16.	(a)
17.	(d)	18.	(c)	19.	(c)	20.	(d)	21.	(c)	22.	(a)	23.	(b)	24.	(b)
25.	(b)	26.	(d)	27.	(d)	28.	(c)	29.	(d)	30.	(b)				