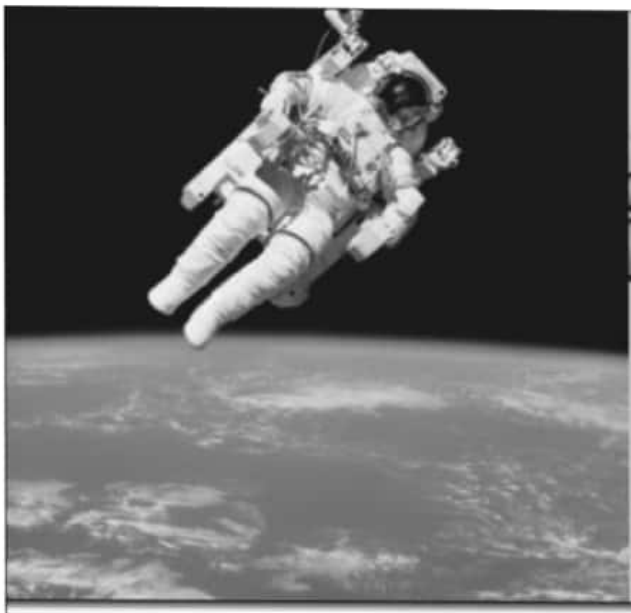

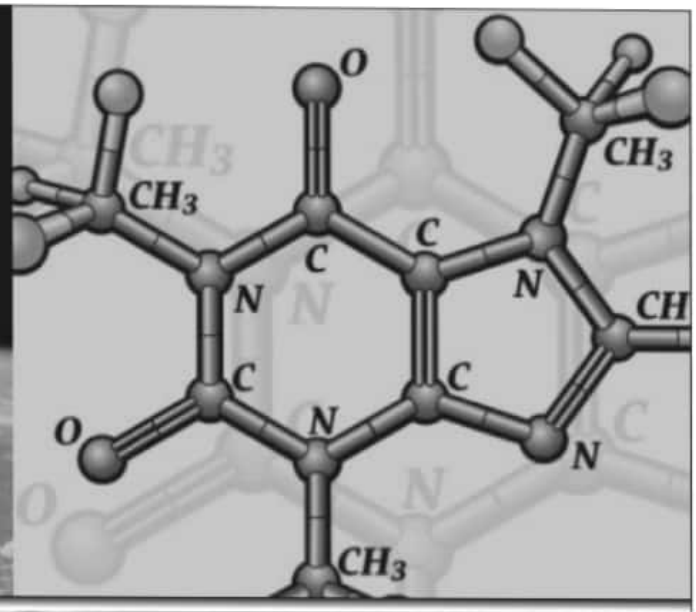

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Physics

MECHANICS

Physical Quantities

Those quantities which can describe the laws of physics and possible to measure are called physical quantities.

The physical quantities which do not depend upon other physical quantities are called ***fundamental quantities.***

In Standard International (**S.I.**) system the fundamental quantities are mass, length, time, temperature, luminous intensity, electric current and amount of substance.

The physical quantities which depend on fundamental quantities are called ***derived quantities*** *e.g. speed, acceleration, force, etc.*

Units

The unit of a physical quantity is the reference standard used to measure it.

1. **Fundamental Units:** The units defined for the fundamental quantities are called fundamental or base units.
   Fundamental Unit for Mass-Kilogram (Kg), Length-metre (m), Time-second(s), Temperature-kelvin (K), Electric Current-ampere (A), Luminous intensity - Candela (cd), Amount of Substance - mole (mol).
2. **Derived Units:** The units defined for the derived quantities are called derived units. e.g. unit of speed or velocity (metre per second), acceleration (metre per second^2) etc.

Some Important Conversions

(i) 1 yard = 0.9144 m ≅ 0.91m
(ii) 1 foot (1') = 0.305 m
(iii) 1 inch (1") = 2.54 cm = 0.025 m
(iv) 1 mile - 1609 m = 1.609 km
(v) 1 ltr. = 1000 cc = 10^{-3} m^3
(vi) 1 cm^2 = 10^{-4} m^2
(vii) 1 mm = 10^{-3} m
(viii) 1 atomic mass unit 1 (amu) = 1.67×10^{-27}
(ix) 1 slug = 14.57 kg
(x) 1 tonne = 10 quintal = 1000kg
(xi) 1 kg/m^3 = 1000 g/cm^3
(xii) 1 km/h = $\frac{5}{18}$ m/s and 1 m/s = $\frac{18}{5}$ km/h
(xiii) 1 newton = 10^5 dyne, 1 kg wt = 9.8 N and 1 g wt = 981 dyne
(xiv) 1 joule = 10^7 erg, 1 eV = 1.6×10^{-19} J
(xv) 1 atm = 76 cm of Hg = 1.01 × 105 $\frac{N}{m^2} = 1.01 \times \frac{dy}{cm^2}$
(xvi) 1 h.p. = 746 watt
(xvii) 1 kw h = 3.6×10^6 J
(xviii) 1 tesla = 1 web/m^2 = 10^4 gauss

Path Length or Distance: The length of the actual path between initial and final positions of a particle in a given interval of time is called distance covered by the particle.

Displacement: The shortest distance from the initial position to the final position of the particle is called displacement.

Speed, Velocity and Acceleration

$$\text{Speed} = \frac{\textit{Distance travelled}}{\textit{Time Taken}}$$

$$\textit{Velocity} = \frac{\textit{Displacement}}{\textit{Time interval}}$$

$$\textit{Acceleration} = \frac{\textit{Change in velocity}}{\textit{Time interval}}$$

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Kinematic Equations for Uniformly Accelerated Motion

Motion under uniform acceleration is described by the following equations.

$v = u + at$; $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$

Distance Travelled in n^{th} Second of Uniformly Accelerated Motion

$$S_{n^{th}} = u + \frac{a}{2}(2n-1)$$

Relative Velocity: If $\vec{v}_A$ and $\vec{v}_B$ be the respective velocities of object A and B then relative velocity of A w.r.t. B is $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

Similarly, relative velocity of B w.r.t. A is $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$

Scalars and Vectors

The physical quantities which require only magnitude to express, are called ***scalar quantities***. **Ex.** Mass, distance, time, speed, volume, density, pressure, work, energy, power, charge, electric current, temperature, potential, specific heat, frequency, etc. Certain *physicsl quantities have both magnitude and direction, they are called vector quantities.* **Ex.** Displacement, velocity, acceleration, force, momentum, impulse, electric field, magnetic field, current density, etc.

Newton's Laws of Motion

1st law: *Every body continues to be in its state of rest or of uniform motion in a straight line unless compelled by an external force to change its state.* This fundamental property of the body is called **inertia**. This law is known as Newton's first law of motion or law of inertia.

Inertia: *Inertia is the property of a body due to which it opposes the change in its state.* Inertia of a body is measured by mass of the body. It is directly proportional to the mass of the body i.e., Inertia $\propto$ mass.

Momentum: The linear momentum of a body ($\vec{p}$) is defined as the product of the mass of the body (m) and its velocity. i.e., $\vec{P} = m\vec{v}$.

Relation between momentum and kinetic energy:

Consider a body of mass m moving with velocity v. Linear momentum of the body, $p = mv$.

KE of a particle can be expressed as

$$E = \frac{P^2}{2m} \text{ and } p = \sqrt{2mE}$$

2nd law: *The rate of change of momentum of a body is directly proportional to the unbalanced external force applied on it.*

i.e., $\vec{F} \propto \frac{d\vec{p}}{dt}$ or, $\vec{F} = k\frac{d\vec{p}}{dt}$ or $\vec{F} = m\vec{a}$

Impulse: If a large force acts on a body or particle for a smaller time, then impulse = product of force and time.

Impulse = $\vec{F}\Delta t$

3rd law: According to this law, every action has equal and opposite reaction. Action and reaction act on two different bodies and they are simultaneous. There can be no reaction without action.

Law of Conservation of Linear Momentum

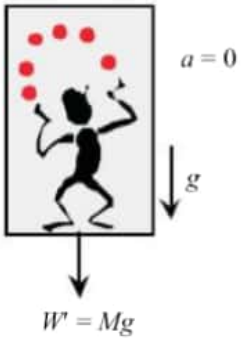
If the total external force acting on a system is equal to zero, then the final value of the total momentum of the system is equal to the initial value of the total momentum of the system.

$\vec{p}$ = constant or $\vec{p}f = \vec{p}i$

Motion in a Lift

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.



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In this case there is no accelerated motion hence no pseudo force experienced by observer 'O' inside the lift.

So apparent weight, W' = actual weight W

Case (b): If the lift is accelerated i.e., a = constant and in upward direction.

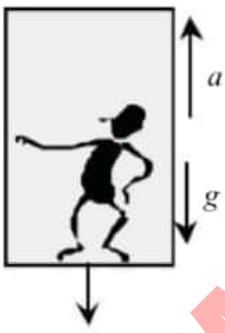
Then net forces acting on the man are

(i) weight W = Mg downward

(ii) fictitious force F_0 = Ma downward.

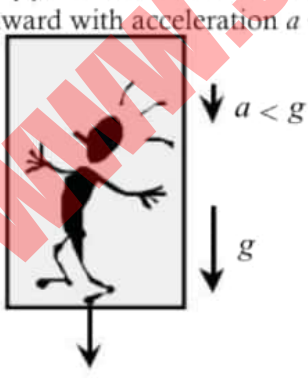
So apparent weight,

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



$W' = M(g+a)$

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



$W' = M(g - a)$

The fictitious force $F_0 = Ma$ acts upward while weight of a man $W = Mg$ always acts downward, therefore apparent weight, $W' = W + F_0 = Mg - Ma = M(g - a)$

Friction

Whenever a body moves or tends to move over the surface of another body, a force comes into play which acts parallel to the surface of contact and opposes the relative motion. This opposing force is called friction.

Centripetal force: The force directed towards the centre required for traversing a circular path is called centripetal force.

Centripetal force = $F = \frac{mv^2}{r} = m\omega^2 r$.

- In a banked path with curvature (q) with friction, the safe velocity is given by
  $v = \sqrt{[rg(\tan\theta + \mu)/(1 - \mu\tan\theta)]}$.
- **Bending of cyclist:** In order to take a circular turn of radius r with speed v, the cyclist should bend himself through an angle q from the vertical such that
  $$\tan\theta = \frac{v^2}{rg}$$

Work: *Work done by a force on a body is defined as the product of force and the displacement of the body in the direction of force.* SI unit of work is joule.

$W = \vec{F}.\vec{S} = FS\cos\theta$ where θ is the angle between $\vec{F}$ and $\vec{S}$.

Power: ***Power is the rate of doing work.***

$$\text{Power} = P = \frac{dW}{dt} = \frac{\vec{F}.d\vec{S}}{dt} = \vec{F}.\vec{v}$$

Its SI unit is watt.

1 Horse power [1HP] = 746 W,
1 calorie = 4.2J and
1 kW h = 3.6×10^6 J

Energy

Energy is the capacity of doing work. It is also a scalar quantity. The SI unit is joule.

Work-energy theorem states that the work done on a body is equal to the change in its kinetic energy.

Kinetic energy: K.E. is the energy possessed by the body due to its motion.

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

Potential energy: P.E. is the energy possessed by the body due to its position or shape.

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Gravitational P.E. = mgh (due to change in position)

Law of conservation of energy states that energy can neither be created nor be destroyed but it can be transformed from one form to another.

Mass-energy equivalence: According to this theorem mass and energy are inter-convertible.

$$E = mc^2.$$

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

Collision

If the path of a body is affected by another body when two bodies physically come in contact, then collision is said to have taken place.

Elastic collision: Both momentum and K.E. are conserved.

For elastic collision in one dimension,

Inelastic collision: Only momentum is conserved.

Coefficient of restitution is defined as *the ratio of velocity of separation to the velocity of approach.*

Coefficient of restitution

$$= e = \frac{v_2 - v_1}{u_1 - u_2}$$

$e = 1$ for perfectly elastic collision

$e = 0$ for perfectly inelastic collision

Centre of Mass: *It is an imaginary point at which the whole mass of a body is supposed to be concentrated.*

Torque and Angular Momentum

Torque is the moment of force. It is the cross product of the force with the perpendicular distance between the axis of rotation and the point of application of force with the force.

Torque = $\vec{t} = \vec{r} \times \vec{F}$; S.I. unit is N – m

Angular momentum is the moment of linear momentum. It is also the product of the linear momentum and the perpendicular distance of the mass from the axis of rotation.

$\vec{t} = \vec{r} \times \vec{p}$ where $\vec{p}$ = position relative to origin

= linear momentum at position.

Angular momentum $L = \vec{r} \times \vec{p}$ =: S.I unit kg m²/s

Relation between torque and angular momentum,

$$\vec{T} = \frac{d\vec{L}}{dt}$$

Moment of Inertia

It is equivalent to mass in rotational motion. It is defined as *the sum of the product of the constituent masses and the square of their perpendicular distances from the axis of rotation.*

For an n-particle system having mass points $m_1, m_2, m_3, \ldots\ldots\ldots\ldots, m_n$ at perpendicular distances $r_1, r_2, \ldots\ldots\ldots\ldots, r_n$, moment of inertia,

$$I = m_1 r_1^2\ m_2 r_2^2 \ldots\ldots\ldots\ldots + m_n r_n^2$$

$$= \sum_{i=1}^{n} m_i r_i^2$$

S.I. unit is kgm² and it is a scalar quantity.

Gravitation

It is the force of attraction between any two bodies.

Newton's Universal Law of Gravitation: Every body in this universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F \propto m_1 m_2 \text{ and } F \propto \frac{1}{r^2} \Rightarrow F \propto \frac{m_1 m_2}{r^2}$$

$$\therefore F = G\frac{m_1 m_2}{r^2}$$

G = Universal gravitational constant = $6.67 \times 10^{-11}\ Nm^2/kg^2$

Acceleration due to gravity: The acceleration produced in a body due to gravitational force of the earth is called acceleration due to gravity (g).

$$g = \frac{GM_e}{Re^2} \text{ (on the surface of the earth);}$$

M_e = mass on the earth and R_e = radius of the earth.

$$M_e = \frac{gR_e^2}{G} = 6 \times 10^{24}\ kg,$$

$R_e = 6400$ km;

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Acceleration due to gravity. g is maximum at poles and least (zero) at equator.

Gravitational Potential: Gravitational potential at a point in a gravitational field is defined as *the work done in taking a unit mass from infinity to the point*.

Gravitational potential = $V = \frac{-GM}{r}$

Escape Speed: Minimum speed required to escape the earth's gravitational pull.

$$v_e = \sqrt{2gr} = \sqrt{2} \times v_o \text{ (For earth } v_e = 11.2 \text{ km/s)}$$

where v_0 = orbital speed

Satellite

It is a heavenly body or an artificial object which revolves round a planet in a particular orbit. The required centripetal force is provided by the gravitational force. Kepler's laws of planetary motion are applicable to them.

(a) **Orbital velocity of a satellite:** Velocity with which the satellite orbits around the planet.

$$v_0 = \sqrt{\frac{GM}{R+h}}$$

(b) **Time period of a satellite:** Time taken by it to complete one revolution around the planet.

$$T = \sqrt{\frac{3\pi(R+h)^3}{G\rho R^3}} = \frac{2\pi}{R}\sqrt{\frac{(R+h)^3}{g}}$$

(c) **Height of a satellite above the surface of the planet:**

$$H = \left(\frac{T^2R^2g}{4\pi^2}\right) - R$$

(d) **"Total energy of a satellite** orbiting on a circular path is negative" with potential energy being negative but twice as the magnitude of positive kinetic energy.

(e) **Binding energy** of a satellite is the energy required to remove it from its orbit to infinity.

B.E. = $\frac{GMm}{2r}$ No energy is required to keep the satellite in its orbit.

Geostationary satellites: The satellites in a circular orbit around the earth in the equatorial plane with a time period of 24 hours, appears to be fixed from any point on earth are called geostationary satellite.

For geostationary satellite, height above the earth's surface = 35800 km and orbital velocity = 3.1 km/s.

Polar Satellites: A satellite that revolves in a polar orbit along north-south direction while the earth rotates around its axis in east west direction.

Weightlessness: A situation where the effective weight of the object becomes zero. An astronaut experiences weightlessness in space satellite because the astronaut as well as the satellite are in a free fall state towards the earth.

PROPERTIES OF MATTER

Elasticity and Plasticity

The property of the body to regain its original configuration (length, or shape) when the deforming forces are removed is called ***elasticity***. On the other hand, *if the body does not have any tendency to regain its original configuration on removal of deforming force the body is called plastic body and this property is called* ***plasticity***.

Perfectly elastic body: A body which regains its original configuration immediately and completely after the removal of deforming force from

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it, is called perfectly elastic body. Quartz and phosphor bronze, are closed to perfectly plastic body.

Perfectly plastic body: A body which does not regain its original configuration at all on the removal of deforming force, however small the deforming force may be is called perfectly plastic body. Putty and mud are closed to perfectly plastic body.

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

i.e., *Stress = Restoring force / Area*

Strain: The ratio of change in configuration to the original configuration is called strain.

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

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

Elastic Limit

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.

Hooke's law

It states that *within the elastic limit stress is directly proportional to strain.*

i.e., Stress ∝ strain

or Stress = E × strain

Here E is the coefficient of proportionality and is called **modulus of elasticity** or **coefficient of elasticity** of a body.

Materials-Ductile, Brittle and Elastomers

(i) **Ductile materials:** *The materials which have large range of plastic extension* are called ductile materials. They can be drawn into thin wires, e.g., copper, silver, aluminium, iron, etc.

(ii) **Brittle materials:** *The materials which have very small range of plastic extension* are called brittle materials. These materials break as soon as the stress is increased beyond the elastic limit. e.g., glass, ceramics, cast iron, etc.

(iii) **Elastomers:** *The materials which can be stretched to large values of strain* are called elastomers. *e.g.*, rubber, elastic tissue of aorta, etc.

Young's modulus of elasticity (Y): It is defined as *the ratio of normal stress to the longitudinal strain within the elastic limit.*

$$\text{Thus, } Y = \frac{Normal\ stress}{Longitudinal\ strain}$$

Fluids

Fluids are the substances that can flow. Therefore liquids and gases both are fluids. The study of fluids at rest is called **fluid statics** or **hydrostatics** and the study of fluids in motion is called **fluid dynamics** or **hydrodynamics**. Both combined are called **fluid mechanics**.

Density (ρ)

Mass per unit volume is defined as density. So density at a point of a fluid is represented as

$$\rho = \lim_{\Delta v \to 0} \frac{dm}{dV} = \frac{dm}{dV}$$

Relative Density

It is defined as the ratio of the density of the given fluid to the density of pure water at 4°C.

Relative density (R.D).

$$= \frac{Density\ of\ given\ liquid}{Density\ of\ pure\ water\ at\ 4°C}$$

The density of water is maximum at 4°C and is equal to 1.0×10^3 kgm^{-3}

Pressure

If a uniform force is exerted normal to an area (A), then *average pressure (p_{av}) is defined as the normal force (F) per unit area.*

$$i.e.,\quad P_{av} = \frac{F}{A}$$

In limiting sense, *pressure* $p = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A}$ Pressure is a scalar quantity.

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SI unit: pascal (Pa), 1 Pa = 1 N/m^2

Practical units: atmospheric pressure (atm), bar and torr

1 atm = 1.01325 × 10^{5}Pa = 1.01325 bar = 760 torr = 760mm of Hg column pressure.

Pascal's Law of Transmission of Fluid Pressure

Pascal's law is stated in following ways:

- The pressure in a fluid at rest is same at all the points if gravity is ignored.
- A liquid exerts equal pressures in all directions.
- If the pressure in an enclosed fluid is changed at a particular point, the change is transmitted to every point of the fluid and to the walls of the container without being diminished in magnitude.

Applications of Pascal's law: Hydraulic machines, lifts, presses and brakes, are based on the Pascal's law.

Atmospheric Pressure

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

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

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.

Buoyancy and Archimed Principle

If a body is partially or wholly immersed in a fluid, it experiences an upward force due to the fluid surrounding it. This phenomenon of force exerted by fluid on the body is called **buoyancy** and force is called **buoyant force** or **upthrust**.

Archimedes' Principle: *It states that the buoyant force on a body that is partially or totally immersed in a fluid equal to the weight of the fluid displaced by it.*

Bernoulli's Principle

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.

i.e., $P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$

$$\therefore \quad P + \rho g h + \frac{\rho v^2}{2} = constant$$

Viscosity

The property of a fluid due to which it opposes the relative motion between its different layers is called viscosity (or fluid friction or internal friction) and the force between the layers opposing the relative motion is called **viscous force**.

Terminal Velocity

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

$$V_T = \frac{2r^2(\rho - \sigma)g}{9\eta}$$

Surface Tension

Surface tension is basically a property of liquid. The liquid surface behaves like a stretched elastic membrane which has a natural tendency to contract and tends to have a minimum possible surface area. This property of liquid is called surface tension.

$$Surface\ tension\ T = \frac{Force\ F}{Length\ L}$$

Examples of surface tension

(i) Raindrops are spherical in shape.

(ii) The hair of a shaving brush cling together when taken out of water.

(iii) Oil spread on cold water but remains as a drop on hot water etc.

Capillarity

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 **capillarity**.* Rise or fall of liquid in tubes of narrow bore (capillary tube) is called capillary action. Rise of kerosene in lanterns, rise of ink in fountain pen etc. are due to capillary action.

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HEAT

Temperature and Heat

Temperature *is defined as the degree of hotness or coldness of a body.* It is a scalar quantity. **Its S.I. unit** is kelvin (K).

Heat *is a form of energy which causes sensation of hotness or coldness.* The flow of heat is always from higher temperature to lower temperature. No heat flows from one body to other, when both the bodies are at the same temperature. The two bodies are said to be in **thermal equilibrium.** The **SI unit** of heat is **joule**. Its **CGS unit** is **calorie**, 1 cal = 4.2 joule

Measurement of Temperature

A branch of science which deals with the measurement of temperature of a substance is called **thermometry.**

Thermometer is a device used to measure the temperature. Thermometer used for measuring very high temperatures are called **pyrometer**.

Relationship Between Different Scales of Temperature

$$\frac{C-0}{100}=\frac{F-32}{212-32}=\frac{K-273.16}{373.16-273.16}$$

$$=\frac{R-0}{80-0}=\frac{Ra-460}{672-460}$$

T°(K) = (t°C + 273.16)

Normal temperature of human body is 310.15 k (37°C = 98.6°F)

STP or NTP implies 273.15 K (0°C = 32°F)

Ideal-gas Equation and Absolute Temperature

The equation, $PV = nRT$

where, n = number of moles in the sample of gas

R = universal gas constant; (its value is 8.31 J mol^{-1} K^{-1}), is known as **ideal-gas equation**

It is the combination of following three laws

(i) **Boyle's law:** *When temperature is held constant, the pressure is inversely proportional to volume.*

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

(ii) **Charle's law:** *When the pressure is held constant, the volume of the gas is directly porportional to the absolute temperature.*

i.e., $V \propto T$ (at constant pressure)

(iii) **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)

Absolute Temperature

The lowest temperature of –273.16 °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°C by Lord Kelvin as zero. This is called Kelvin scale or absolute scale of temperature.

T(K) = t°C + 273.16

Thermal Expansion

The increase in the dimensions of a body due to the increase in its temperature is called thermal expansion.

Linear expansion: *The fractional increase in length per °C rise in temperature is called* ***coefficient of linear expansion***.

Coefficient of linear expansion,

$$\alpha = \frac{\left(\frac{\Delta l}{l}\right)}{\Delta T} = \frac{dl}{l.dT}$$

Superficial expansion: On increasing the temperature of a solid, its area increases. This increase in area is referred as **superficial expansion**.

Coefficient of superficial expansion *is*

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defined as the fractional increase in area per °C rise in temperature.

i.e., Coefficient of a real expansion

$$\beta = \frac{DA/A}{DT} = \frac{dA}{A.dT}$$

Cubical expansion: On increasing the temperature of a solid, its volume increases. This increase in volume with increase in temperature is called cubical or volume expansion.

Coefficient of volume expansion *is defined as the fractional increase in volume per °C rise in temperature.*

i.e., Coefficient of volume expansion,

$$\gamma = \frac{\Delta V/V}{\Delta T} = \frac{dV}{V.dT}$$

Relation between coefficient of linear expansion (α), coefficient of superficial expansion (β) and coefficient of cubical expansion (γ)

$$\alpha = \frac{\beta}{2} = \frac{\gamma}{3} \Rightarrow \alpha : \beta : \gamma = 1:2:3$$

Anomalous Expansion of Water

Almost all liquids expand on heating but water when heated from 0°C to 4°C its volume decreases and hence density increases until its temperature reaches 4°C. Its density is maximum at 4°C on further heating its density decreases. This behaviour of water is called anomalous behaviour of water.

Specific Heat Capacity

It is *the amount of heat energy needed to raise the temperature of unit mass of substance by 1°C (or 1K).*

It is denoted by **s or c**.

$C_{water} = 1\ cal/g\ °C = 1\ cal/g\ K = 1\ kcal/kg\ K = 4200\ joule/kg\ K$

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**.

Change of State

Any state of a substance (solid/ liquid/ gas) can be changed into another by heating or cooling. The transition of a substance from one state to another is called a change of state.

Some common changes of states:

(i) **Melting:** When heat is supplied, solid substance changes into liquid, this change of state of substance is called melting.

$$\text{Solid} \xrightarrow{\text{Heat}} \text{Liquid}$$

The temperature at which the solid and the liquid states of a substance coexist in thermal equilibrium with each other is called its **melting point**.

(ii) **Freezing:** When heat is released, liquid changes into solid, this change of state of substance is called freezing.

$$\text{Liquid} \xrightarrow{\text{Cool}} \text{Solid}$$

(iii) **Condensation:** When vapour is cooled, it changes into liquid, this change of state is called condensation

$$\text{Vapour} \xrightarrow{\text{Cool}} \text{liquid}$$

(iv) **Evaporation:** Conversion of liquid into gaseous state at all the temperatures is called evaporation or boiling.

$$\text{Liquid} \xrightarrow{\text{Heat}} \text{Vapour}$$

The temperature at which the liquid and vapour states of a substance coexsist in thermal equilibrium with each other is called its **boiling point**.

It is a phenomenon that occurs at the surface of liquids. The rate of evaporation increases with rise in temperature. Heat required to change unit mass of liquid into vapour at a given temperature is called heat of evaporation at that temperature.

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

$$\text{Solid} \xrightarrow{\text{Heat}} \text{Vapour}$$

Sublimation takes place when boiling point is less than the melting point.

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Heat transfer: Heat energy transfer from a body at higher temperature to a body at lower temperature by three different methods. They are conduction, convection and radiation.

Conduction: *Conduction is that mode of transmission of heat in which heat is transferred from a region of higher temperature to a region of lower temperature by the aid of particles of the body without their actual migration. Conduction requires material medium.*

Convection: Convection like conduction requires a material medium. *It is the process in which heat is transferred from one place to other by actual movement of heated material particles.*

Radiation: When a body is heated and placed in vacuum, it loses heat even when there is no medium surrounding it.

The process by which heat is lost in this case is called radiation. This does not require the presence of any material medium. It is by radiation that the heat from the sun reaches the earth.

Newton's Law of Cooling

The rate of cooling of a body (rate of loss of heat) is directly proportional to the excess of temp. of the body over the surroundings, provided that this excess is small and loses of heat by radiation only.

If θ and θ_0 are the temperatures of the body and its surroundings respectively, then according to Newton's law of cooling,

Rate of loss of heat, $-\frac{dQ}{dt} \propto (\theta - \theta_0)$

Thermodynamics

The **thermodynamics** *is the branch of science in which the conversion of heat into mechanical work and vice versa is studied.*

Triple point of water: The triple point of water represents the co-existence of all the three phases of water ice, water and water vapour in equilibrium. The pressure corresponding to triple point of water is 6.03×10^{-3} atmosphere or 4.58 mm of Hg and temperature corresponding to it is 273.16 K.

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.

i.e., $\delta Q = \delta U + \delta W$

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.

Heat Engines

Heat engine is a device which converts heat energy into work.

Efficiency of heat engine,

$$\eta = \frac{\text{Work done}(W)}{\text{Heat taken from source}(Q_1)}$$

$$\eta = \frac{T_1 - T_2}{T_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

Refrigerators and Heat Pumps

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

The **coefficient of performance** of a refrigerator or heat pump.

$$\frac{Q_1}{W} = \frac{Q_2}{Q_1 - Q_2} \quad [\therefore W = Q_1 - Q_2]$$

Carnot Theorem

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

i.e., $\eta_R > \eta_I$ *or* $1 - \frac{T_2}{T_1} > 1 - \frac{Q_2}{Q_1}$

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SOUND

Periodic Motion

Any motion that repeats itself in equal intervals of time is called periodic motion. A periodic motion can be represented in terms of sines and cosines, so it is called a harmonic motion. The uniformly rotating earth represents a periodic motion that repeats itself at every 24 hours.

An oscillatory motion is always periodic but a periodic motion may not be oscillatory.

Examples of S.H.M. (i) clock pendulum, (ii) oscillating liquid in a U-tube, (iii) oscillating block in a liquid, (iv) oscillating frictionless piston fitted in a cylinder filled with ideal gas, etc.

Sound

Sound is a form of energy which produces a sensation of hearing in our ears.

Sound Needs a Material Medium for its Propagation

In the absence of medium (air) around the source, sound is not being propagated and light (electro-magnetic) waves travel through the vacuum.

Mechanical Waves

A mechanical wave is a periodic disturbance which requires a material medium for its propagation.

(a) 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. These waves travel in form of crests and troughs. These waves can travel in solids and liquids only.*

(b) 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 scrabbing 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 propagation are called electromagnetic waves. This means that these waves can travel through vacuum also. For example, light waves, X-rays, γ-rays, Infrared waves, radio waves, microwaves, etc. These waves of transverse type.

Difference between sound waves and electromagnetic waves

(i) Sound waves are longitudinal and electromagnetic waves are transverse.

(ii) Sound waves travel at a speed of 340 m/s whereas electromagnetic waves travel at a speed of 3×10^8 m/s

(iii) Sound waves do not pass through a vacuum but electromagnetic waves (light) do.

Characteristics of Sound Waves

Sound is characterised by three parameters:

(i) Pitch (ii) Loudness (iii) Quality

(i) 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.

(ii) 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.

The loudness of sound is measured in '**decibel** dB'. The

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loudness of sound of people talking quietly is about 65 dB, the loudness of sound in a very noisy factory is about 100 dB.

(iii) Quality (Timber): Quality or timber 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.

Reflection of Sound

When sound waves strike a surface, they return back into the same medium. This phenomenon is called reflection.

Laws of reflection of sound waves

(i) Angle of incidence is equal to the angle of reflection.

(ii) The incident wave, the reflected wave and the normal all lie in the same plane.

Echo

Phenomenon of hearing back our own sound is called an echo. It is due to successive reflection from the surface of obstacles of large size.

Conditions for the formation of Echoes

(i) The minimum distance between the source of sound and the reflecting body should be 17.2 metres.

(ii) The wavelength of sound should be less than the height of the reflecting body.

(iii) The intensity of sound should be sufficient so that it can be heard after reflection.

Reverberation

Persistence of sound after its production stopped, is called reverberation.

When a sound is produced in a big hall, its wave reflect from the walls and travel back and forth. Due to this energy does not reduce and the sound persist.

A short reverberation is desirable in a concert hall (where music is being played) because it gives 'life' to sound.

OPTICS

Optics

The branch of physics which deals with the propagation, nature and behaviour of light is known as **optics**.

Light

Light is a form of energy which enables human beings and creatures to 'see' things.

Light is an electromagnetic radiation which exhibits properties like a wave as well as a particle. It always propagates in a straight line.

Light travels with a speed nearly equal to 3×10^8 m/s. According to current theories, no material particle can travel at a speed greater than the speed of light.

Luminous and Non-luminous Objects

Luminous objects are those which emit its own light e.g., sun, glowworm, burning candle, electric lights. *Non-luminous objects do not give out its own light but are visible only when light from a luminous object falls on it. e.g.*, moon, earth, table, paper, etc.

Transparent, Translucent and Opaque materials

Transparent materials are those which allow most of light to pass through them. *Example:* Glass, water, air.

Translucent materials allow only a part of light to pass through it. We cannot see distinctly through them. *Example*: greased paper, paraffin wax, etc.

Opaque materials do not allow any light to pass through it. They reflect or absorb all the light that falls on

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them. *Example*: Books, desk, stone, rubber, trees, etc.

Reflection of Light

The turning back of light in the same medium is called reflection of light.

Laws of reflection

1. The angle of incidence '*i*' is equal to the angle of reflection '*r*'.
2. At the point of incidence, the incident rays, the normal to the surface and the reflected ray all lie in the same plane.

Images and their properties

An 'image' is defined as the impression of an object carried over and formed by light reflected from it. An image is said to be a **real image** if it can be caught on a screen, and a **virtual image** if it cannot be caught on the screen. For example, the image on the screen in a theatre is a real image and the image observed in a plane mirror is a virtual image.

Real image

1. When the rays of light actually meet, the image so formed is known as real image.
2. A real image can be caught on a screen since it is formed by actual meeting of rays.
3. A real image is always inverted.
4. A real image is formed by a convergent reflected beam.
5. In ray diagrams, for real image, the rays are represented by full lines.

Virtual image

1. When the rays of light appear to meet, the image so formed is known as virtual image.
2. A virtual image cannot be caught on a screen since it is formed by meeting of imaginary rays.
3. A virtual image is always erect.
4. A virtual image is formed by a divergent reflected beam.
5. In ray diagrams, for virtual image, the rays are generally represented by dotted lines.

Characteristics of images formed by a plane mirror

The image formed by a plane mirror is

(a) virtual (the image cannot be formed on a screen)
(b) upright
(c) laterally inverted (the left side of an image is formed by the right side of an object)
(d) the same size as the object
(e) the same distance behind the mirror as the object is in front of the mirror

Concave and Convex Mirror

Concave mirror: If the reflection takes place from the inner surface of a spherical mirror, then the mirror is called concave mirror.

Convex mirror: If the outer surface of the spherical mirror acts as a reflector then the mirror is called convex mirror.

Uses of concave mirrors:

(i) In torches, search-lights and vehicles headlights to get powerful beams of light.
(ii) As a shaving mirror to see a large image of the face.
(iii) As a dentists mirror to see large images of the teeth of patients.
(iv) Large sized concave mirror is used to concentrate sunlight to produce heat in solar furnaces.

Uses of convex mirrors:

(i) As a rear -view mirrors in vehicles.
(ii) For security purposes.

Mirror Formula

If an object is placed at a distance u from the pole of a mirror and its image is formed at a distance v (from the pole) then,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

Magnification

If a thin object linear size O situated vertically on the axis of a mirror at a distance u from the pole and its image of size I is formed at a distance v (from the pole), magnification (transverse) is defined as

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$$m = \left[\frac{I}{O}\right] = \left[\frac{v}{u}\right]$$

- → (+ve means erect image)
- → (–ve means inverted image)
- → (|m| >1 means large image)
- → (|m| < 1 means small image)

Refraction of Light

When a ray of light passes from one medium to another medium it bends – towards the normal when goes from rarer to denser and away from the normal when goes from denser to rarer medium. This phenomenon is called refraction of light.

Twinkling of stars, sun is visible to us about 2 minutes before the actual sunrise, and about 2 minutes after actual sunset etc. due to atmospheric refraction.

Refractive index

Refractive index of medium II with respect to medium I

$$\mu_{21} = \frac{\textit{Speed of light in medium I}}{\textit{Speed of light in medium II}}$$

Laws of Refraction

(i) **Snell's law:** For any two media and for light of a given wavelength, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

i.e., $\frac{\sin i}{\sin r}$ = constant where i = incidence angle, r = refraction angle.

(ii) The incident ray, the refracted ray and the normal at the incident point all lie in the same plane.

When object is in denser medium and observer is in rarer medium:

$$\textit{Refractive index } \mu = \frac{\textit{Real depth}}{\textit{Virtual depth}}$$

Lens

A lens is a piece of transparent material with two refracting surfaces such that atleast one is curved and refractive index of used material is different from that of the surroundings.

Refraction through a thin lens (lens formula)

If an object is placed at a distance u from the optical centre of a lens and its images is formed at a distance v (from the optical centre) and focal length of this length is f then

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

This is called lens formula.

Power of a lens

The power of a lens is defined as

$P = \frac{1}{f(\text{in } m)}$. The unit of power is diopter.

Focal length of a lens (lens maker's formula)

$$\frac{1}{f} = ({}_m\mu_\ell - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

where ${}_m\mu_\ell$ refractive index of lens with respect to medium.

R_1 = radius of curvature of first surface of lens, R_2 = radius of curvature of second surface of lens.

Total Internal Reflection

When the object is placed in an optically denser medium and if the incident angle is greater than the critical angle then the ray of light gets reflected back to the originating medium. This phenomenon is called total internal reflection.

Critical angle (i_c): When a ray passes from an optically denser medium to an optically rarer medium, the angle of refraction r is greater than the corresponding angle of incidence i. From Snell's law.

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Let $\mu_1 = \mu_2$ and $\mu_2 = 1$ and let for $i = i_c$, $r = 90^o$ then $\sin i_c = 1/\mu$

$\therefore i_c = \sin^{-1}\frac{1}{\mu}$; i_c is called the critical angle.

This phenomenon takes place in shining of air bubble, sparkling of diamond, mirage, looming, in optical communication, endoscopy using optical fibre.

Dispersion of Light

*When a white ray of light or sunlight passes through a prism it breakes into its seven constituents colours violet, indigo, blue, green, yellow, orange and red (VIBGYOR). This phenomenon is called **dispersion of light**.* The band of seven constituents colours is called **spectrum.** The deviation is maximum for violet colour and least for red colour.

The Rainbow

A rainbow is a spectrum of white light from the sun. This is a phenomenon due to combined effect of dispersion, refraction and reflection of sunlight by spherical water droplets of rain.

(i) **Primary rainbow:** It is formed due to two refractions and one total internal reflection of the light incident on the droplet. Sunlight is first refracted as it enters a raindrop which cause different colours of light to separate. The observer sees a rainbow with red colour on the top and violet on the bottom.

(ii) **Secondary rainbow:** It is formed due to two refractions and two total internal reflection of light incident on the water droplet. It is due to four - step process. The intensity of light is reduced at the second reflection and hence the secondary rainbow is fainter than the primary rainbow.

Scattering of Light

As sunlight travels through the earth's atmosphere it gets scattered by the small particles present in the atmosphere.

According to Rayleigh law, the amount of scattering is inversely proportional to the fourth power of the wavelength $\left(\frac{1}{\lambda^4}\right)$.

Phenomenon based on scattering of light

(i) **Blue colour of sky:** Blue colour has a shorter wavelength than red colour therefore blue colour is scattered strongly. Hence the bluish colour predominates in a clear sky.

(ii) **White colour of clouds:** Clouds contain large dust particles, water droplets or ice particles. These large sized Particles do not obey Rayleigh law of scattering. All wavelengths are scattered nearly equally. Hence clouds are generally white.

(iii) **Sun looks reddish at the Sunset or Sunrise:** At sunset or sunrise, the sun's rays have to pass through a larger distance in the atmosphere. Most of the blue and other shorter wavelengths are scattered. The least scattered light reaching our eyes, therefore the sun looks reddish.

Power of Accomodation of Eye

The ability of the lens to change its shape to focus near and distant objects is called accommodation.

A normal human eye can see objects clearly that are between 25 cm and infinity.

Microscope: It is an optical instrument used to see magnified image of a tiny objects.

Resolving power (R.P.) of a microscope

Resolving power of a microscope is defined as the reciprocal of the least separation between two close objects, so

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that they appear just separated, when seen through the microscope.

Telescope (Astronomical): *It is an optical instrument used to increase the visual angle of distant large objects.*

It is used to see far off objects clearly.

Resolving power (R.P.) of a telescope

Resolving power of telescope is defined as the reciprocal of the smallest angular separation between two distant objects, so that they appear just separated, when seen through the telescope.

$$\text{Resolving power of telescope} = \frac{D}{1.22\lambda}$$

Interference of Light Waves

The phenomenon of redistribution of light energy in a medium due to superposition of light waves from two coherent sources is called interference of light.

Conditions for sustained interference:

(i) Two sources must be coherent.

(ii) Amplitudes of waves should be either equal or approximately equal.

(iii) Light should be monochromatic.

Polarisation

It is the phenomenon of restricting the vibration of light in a particular plane. Light waves are transverse in nature i.e., the electric field vector associated with light wave is always at right angles to the direction of propagation of the wave. When unpolarised light is incident on a polaroid (Nicol Prism), the light wave gets linearly polarised i.e., the vibration of electric field vector are along a single direction.

ELECTRICITY

Electric Charges

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

The study of charges at rest is called **static electricity** or **electrostatics** while the study of charges in motion is called **current electricity**. There are two types of electric charge:

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

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

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

Basic Properties of Electric Charge

(1) *Similar charges repel and opposite charges attract.*

(2) *A charged body attracts light uncharged bodies.*

(3) *Accelerated charge radiates energy.*

Conductors and Insulators

The materials which allow electric charge (or electricity) to flow freely through them are called **conductors**. Metals are very good conductors of electric charge. Silver, copper and aluminium are some of the good conductors of electricity.

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

For example, most plastics, rubber, non-metals (except graphite), dry wood, wax, mica, porcelain, dry air etc., are insulators.

Coulomb's Law

It states that, *the electrostatic force of interaction (repulsion or attraction) between two electric charges q_1 and q_2 separated by a distance r, is directly proportional to the product of the charges and inversely proportional to the square of distance between them.*

i.e., $F \propto q_1 q_2$ and $F \propto 1/r^2$

or $F = k\frac{q_1 q_2}{r^2}$

$$K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \frac{Nm^2}{coul^2} \Rightarrow \varepsilon_0$$

$$= 8.85 \times 10^{-12} \frac{coul^2}{NM^2}$$

Electric Field

The region surrounding an electric charge or a group of charges in which another charge experiences a force of attraction or repulsion is called 'electric field'.

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$$\vec{E} = \frac{\vec{F}}{q_0}, \vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0}$$

The **S.I. unit** of electric field intensity is N/coul or volt/metre.

Electric Lines of Force

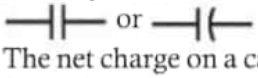
An electric line of force is that imaginary smooth curve drawn in an electric field along which a free isolated unit positive charge moves.

Two lines of force never intersect. If they are assumed to intersect, there will be two directions of electric field at the point of intersection, which is impossible.

Capacitors and Capacitance

A capacitor or condenser *is a device that stores electrical energy. It consists of conductors of any shape and size carrying charges of equal magnitude and opposite signs and separated by an insulating medium*

The symbol of a capacitor is



The net charge on a capacitor is zero.

Capacitance or **capacity** *of a capacitor is a measure of ability of the capacitor to store charge on it.*

When a conductor is charged then its potential rises. The increase in potential is directly proportional to the charge given to the conductor.

i.e., $Q \propto V$ or $Q = CV$ or, $C = \frac{Q}{V}$

The constant C is known as the **capacitance of the conductor.**

Its **SI unit** is farad (F) or coulomb/volt

Capacitance of the conductor depends upon:

(i) Size of conductor
(ii) Surrounding medium
(iii) Presence of other conductors nearby

Electric Current

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

If Δq charge passes through a cross-section in time Δt then,

average current $I_{av} = \frac{\Delta q}{\Delta t}$

Instantaneous current

$$I = \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

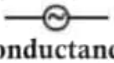
Electric current is measured in **ampere (A).**

Types of electric current:

(a) **Direct current:** *The current whose magnitude and direction does not vary with time is called direct current (dc).* The various sources are cells, dc dynamo, etc.

It's symbol is

(b) **Alternating current:** *The current whose magnitude continuously changes with time and periodically changes its direction is called alternating current.* It has constant amplitude and has alternate positive and negative halves. It is produced by ac dynamo.

It's symbol is 

Resistance, Conductance and Resistivity Resistance (R): *It is the property of a substance due to which it opposes the flow of current through it.*

Its **SI unit** volt/ampere called **ohm (Ω).**

$$R \propto L \text{ and } R \propto \frac{1}{A} \text{ so, } R \propto \frac{L}{A}$$

$$\text{or } R = \rho\frac{L}{A}$$

where L = length, A = area of cross-section of wire and ρ is called **resistivity** or **specific resistance**.

The reciprocal of specific resistance is **conductance** i.e. $\sigma = \frac{1}{\rho}$

Superconductors

At a very low temperature, the resistance of the conductor may vanish completely. When it happens, the conductor is called a **superconductor**. For example, helium is a super conductor at 4.2 K (– 268.8°C).

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Ohm's Law

It states that if the physical state i.e. temperature, nature of material and dimensions of a conductor remain unchanged then the ratio of potential difference applied across its ends to current flowing through it remains constant.

i.e., $V \propto I$ or $V = IR$, where $R = \frac{V}{I}$ is the resistance of conductor.

Electrical Energy, Power

When a current is passed through a resistor energy is wasted in overcoming the resistance of the wire. This energy is converted into heat.

The heat generated (in joule) when a current of I ampere flows through a resistance of R ohm for T second is given by:

$$H = I^2RT = VIt = \frac{V^2}{R}t \text{ joule}$$

$$= \frac{I^2RT}{4.2} \text{ calorie}$$

This is the joule's law of heating

1 *unit of electrical energy*

= 1 *Kilowatt hour* (1 *KWh*) = 3.6×10^6 *joule*

This is known as **Board of trade (B.O.T)** unit of electrical energy.

Energy liberated per second is called its ***power***. The electrical power P delivered or consumed by an electrical device is given by P = VI, where V = Potential difference across the device and I = current.

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

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.

Conversion of galvanometer into voltmeter:

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

Alternating Current

When an alternating voltage is applied across a coil or a bulb, it sends a similar varying current (i.e., of the same nature as that of voltage) through the coil. The current is called alternating current (A.C.).

The current flowing in only one direction in a circuit is called direct current (D.C.). Batteries, thermocouples and solar cells are some of the sources of direct current.

Advantages of Alternating Current Over Direct Current

(i) A.C. can be obtained over a wide range of voltages. These voltages can be easily stepped up or stepped down with the help of transformers.

(ii) The generation of A.C. is found to be economical than that of D.C.

Transformers

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.**

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Uses of Transformer

A transformer is used in almost all ac operation.

(i) In voltage regulators for TV, refrigerator, computer, air conditioner etc.

(ii) In the induction furnaces.

(iii) Step down transformer is used for welding purposes.

(iv) In the transmission of ac over long distance.

AC Generator/Dynamo/Alternator

An electrical machine used to convert mechanical energy into electrical energy is knownm as AC generator/alternator or dynamo.

Principle: It works on the principle of electromagnetic induction, i.e., when a coil is rotated in uniform magnetic field, an induced emf is produced in it.

DC Motor

A D.C. motor converts direct current energy from a battery into mechanical energy of rotation.

Principle: 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.

Efficiency of the d.c. motor:

$$\eta = \frac{EI}{VI} = \frac{E}{V} = \frac{Back\ e.m.f.}{Applied\ e.m.f.}$$

Uses of D.C Motor

1. The D.C. motors are used in D.C. fans (exhaust, ceiling or table) for cooling and ventilation.
2. They are used for pumping water.
3. Big D.C. motors are used for running tram-cars and even trains.

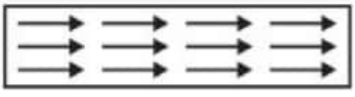
MAGNETISM

Magnetism

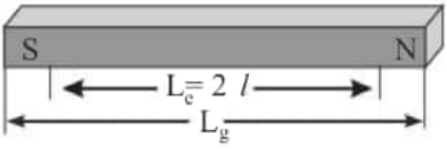
*The phenomenon of attracting magnetic substances like iron, cobalt, nickel etc. is called **magnetism**. A body possessing the property of magnetism is called **magnet**.*

Lodestone or **magnetite** is natural magnet. Earth is also a natural magnet.

In magnetised substance all the atomic magnets are aligned in same direction and thus resultant magnetism is non-zero.



Bar Magnet: A bar magnet consists of two equal and opposite magnetic poles separated by a small distance. Poles are not exactly at the ends. The shortest distance between two poles is called effective length (L_e) and is less than its geometric length (L_g). For bar magnet $L_e = 2l$ and $L_e = (5/6)\ L_g$.



Bar magnet

Properties of Magnet

(i) **Attractive property:** The places where its attracting power is maximum are called **poles**.

(ii) **Directive property:** When a magnet is suspended its length becomes parallel to N-S direction. The pole pointing north is called the north pole while the other pointing in the geographical south is called the south pole of the magnet.

(iii) **Poles of a magnet always exist in pairs:** In a magnet the two poles are found to be equal in strength and opposite in nature.

(iv) **Repulsive property:** A pole of a magnet attracts the opposite pole while repels similar pole.

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Demagnetisation of Magnet

A magnet gets demagnetised, i.e., loses its power of attraction if it is *heated*, *hammered* or *alternating current is passed through a wire wound over it*.

Permanent and Temporary Magnets (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

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. These are made from soft iron, non-metal and alloy. Electromagnets are stronger than permanent magnet.

Some Applications of Electromagnets

(i) Electric motors
(ii) Doorbells
(iii) In scrapyards to separate iron from other metals

Magnetic Field

The space around a magnet (or a current carrying conductor) in which its magnetic effect can be experienced is called the magnetic field.

Magnetic Lines of Force

Magnetic line of force is an imaginary curve tangent to which at a point gives the direction of magnetic field at that point or the magnetic field line is the imaginary path along which an isolated north pole will tend to move if it is free to do so.

Magnetic lines of force do not intersect each other. Because if they do, there will be two directions of magnetic field which is not possible.

The Earth's Magnetism

The branch of Physics which deals with the study of earth's magnetic field is called **terrestrial magnetism**. William Gilbert suggested that earth itself behaves like a huge magnet.

(a) A freely suspended magnet always comes to rest in N-S direction.
(b) A piece of soft iron buried in N-S direction inside the earth acquires magnetism.

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 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 euqator are at equal distance from magnetic poles.

Magnetic Elements

The physical quantities which determine the intensity of earth's total magnetic field completely both in magnitude and direction are called magnetic elements.

Angle of declination (ϕ): *The angle between the magnetic meridian and geographical meridian at a place is called angle of declination.*

Angle of dip or inclination (θ): *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°. At magnetic equator the angle of dip is 0°.

Horizontal component of earth's magnetic field: The total intensity of the earth's magnetic field makes an angle θ with horizontal. It has

(i) component in horizontal plane called **horizontal component B_H**.
(ii) component in vertical plane called **vertical component B_V**.

$B_V = B\sin\theta \qquad B_H = B\cos\theta$

So, $\frac{B_V}{B_H} = \tan\theta$ and $B = \sqrt{B_H^2 + B_V^2}$

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Comparison of properties of soft iron and steel:

(1) The area of hysteresis loop for soft iron is much smaller than for steel, so energy loss per unit volume per cycle for soft iron is smaller than steel.

(2) The retentivity of soft iron is greater than that of steel.

(3) The coercivity of steel is much larger than that of soft iron.

(4) The magnetisation and demagnetisation is easier in soft iron than steel.

(5) Soft iron acquires saturation magnetisation for quite low value of magnetising field than in case of steel or soft iron is much strongly magnetised than steel.

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.*

Some diamagnetic substances are Cu, Zn, Bi, Ag, Au, Pb, He, Ar, NaCl, H_2O, 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.*

Some paramagnetic substances are Al, Na, Sb, Pt, $CuCl_2$, 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.

SEMICONDUCTOR ELECTRONICS

Metals, Semiconductors and Insulators

On the basis of electrical conductivity (σ) or resistivity ($\rho = 1/\sigma$) the solids are classified as

(i) **Metals** – have low resistivity

$\rho \sim 10^{-2}$ to 10^{-8} Ωm

$\sigma \sim 10^{2}$ to 10^{8} Sm^{-1}

(ii) **Semiconductors** – have intermediate resistivity

$\rho \sim 10^{5}$ to 10^{0} Ωm

$\sigma \sim 10^{-5}$ to 10^{0} Sm^{-1}

(iii) **Insulators** – have high resistivity

$\rho \sim 10^{8}$ Ωm

$\sigma \sim 10^{-8}$ Sm^{-1}

i.e. the **Semiconductors** are the materials whose conductivity is more than insulators but less than conductors.

Types of Semiconductors

Intrinsic semiconductors or Pure semiconductors

In semiconductors forbidden energy gap Eg is more than metals or conductors and less than insulators. Silicon (Si) and Germanium (Ge) are the examples of pure semiconductors. In pure or intrinsic semiconductor,

$n_e = n_h = n_i$ where, n_e = no. of electrons; n_h = no. of holes and n_i = no. of intrinsic carrier concentration.

(a) ***n* – type semiconductor:** Si or Ge with pentavalent doping.

(b) ***p* - type semiconductor:** Si or Ge with trivalent doping. The trivalent atom is **negatively** charged as it acquires an electron and is called **acceptor** atom or impurity.

Formation of *p* – *n* junction: Part of p-type can be converted into *n* – type by adding pentavalent impurity. There is concentration gradient between *p* and *n* sides, holes diffuse from *p* side to *n* side ($p \rightarrow n$) and electrons move from ($n \rightarrow p$) creating a layer of positive and negative charges on n and p side respectively called **depletion layer**.

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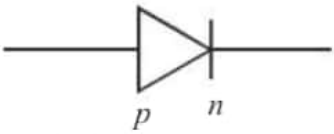
Symbol of *p-n* junction diode



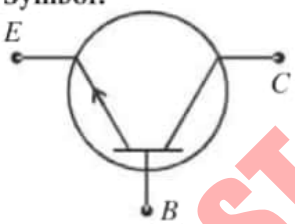
Special purpose $p-n$ junction diode:
Zener diode: It is fabricated by heavy doping of p and n sides of $p-n$ junction. Depletion region is thin < 10^{-6} m. Electric field of junction is high ~ 5×10^6 V/m. Reverse bias ~ 5V.
It is used as **voltage regulator**.
p-n junction diode is used as a **rectifier**.
Rectifier is a device which converts A.C. into D.C.
Inverter converts D.C. into A.C.

Optoelectronic junction devices:

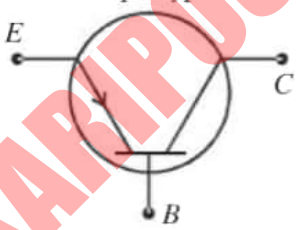
(a) **Photodiode:** It is a $p-n$ junction fabricated with a transparent window to allow light photons to fall on it. These photons generate electron hole pairs upon absorption. The generation of electron hole pair is near the junction and due to junction field they remain separated till external load is connected. The electron are collected on n–side and holes on p–side near junction and give rise to an emf.
When external load is connected, current flows. The magnitude of current depends on intensity of incident radiation.

(b) **Light emitting diode (LED):** It consists of heavily doped $p-n$ junction in forward bias. Electrons move from $n \square p$ and holes from $p \square n$ (minority carriers). Thus, near junction, minority carrier concentration increases (under no bias it is less) and they combine with majority carriers near the junction to release energy in form of photons with energy equal to or less than band gap energy. As forward bias increases, current increases till light intensity reaches maximum.

Junction Transistor:
Types: (i) *n-p-n* type, (ii) *p-n-p* type.
Structure: (i) Emitter (E), (ii) Base (B), (iii) Collector (C)
Symbol:



n-p-n type



p-n-p type

AC parameters:

(i) Input resistance

$$= \frac{\text{Change in base} - \text{emitter voltage}}{\text{Base current}}$$

$$\Rightarrow r_i = \left(\frac{\Delta V_{BE}}{\Delta I_C}\right)_{I_B}$$

$\rightarrow$ dynamic resistance

(ii) Output resistance, r_0

$$= \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$$

(iii) Current amplification factor (β)

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$$

$$\beta_{dc} = \frac{I_C}{I_B} \Rightarrow \beta_{ac} \simeq \beta_{dc}$$

Uses of Transistor:
As a switch, an amplifier, an oscillator, etc.

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Chemistry

NATURE OF MATTER

- **Substance (or chemical substance):** A "**substance**" is a kind of matter that can not be separated into other kinds of matter by any physical process. e.g. gold, silver, iron, sodium chloride, calcium carbonate etc.
- **Pure substance:** is one that is a *single substance* and has a *uniform composition.* Such a substance always have the *same texture* and *taste.* e.g. water, salt, sugar etc.
- **Testing the purity of a substance:** The purity of substance can easily be checked by checking its melting points in case of a solid substance or by checking its boiling points in case of a liquid substance.
- **Types of pure substances:** Two different types of pure substances are
  - **(i) Element:** An element is a substance which can not be split up into two or more simpler substances by usual chemical methods of applying heat, light or electric energy. e. g. hydrogen, oxygen, sodium, chlorine etc.
  - **(ii) Compound:** A compound is a substance made up of two or more elements chemically combined in a fixed ratio by weight e.g. H_2O (water), NaCl (sodium chloride) etc.
- **Mixture:** A mixture is a substance which consists of two or more elements or compounds not chemically combined together.
- **Types of mixtures:** Mixtures are *impure substances*. They are of two types:
  (i) Homogeneous mixture: It has a uniform composition throughout and its components can not be distinguished visually. e.g. a well mixed sample of vinegar.
  (ii) Heterogeneous mixture: It is one that is not uniform throughout. Different samples of a heterogeneous mixture may have different composition. e.g. a mixture of salt and pepper.
- **Solution:** It is a homogeneous mixture of two or more substances whose composition can be varied. e.g. solution of common salt in water, solution of ammonia in water. Some other examples are lemonade, coke, pepsi etc.
- **Separating the components of a mixture:** Depending upon the type of mixture (i.e. whether it is a homogeneous mixture or heterogeneous mixture) different methods used are given below:

S No.	Mixture	Separation Method
1.	Insoluble solid in solvent	Sedimentation followed by filtration. In case of a fine solid centrifugation is used instead of filtration
2.	Solution of solid in liquid	Evaporation, crystallization, distillation

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3.	Miscible mixture of liquids.	Fractional distillation
4.	Immiscible mixture of liquids.	Separating funnel
5.	Mixture of two solids one of which is sublime	Sublimation
6.	Mixture of substances in solution.	Chromatography

- **Solute:** The component of solution that is dissolved and present in smaller quantities in a solution is known as solute.
- **Solvent:** The component of solution in which solute is dissolved is known as solvent. It is always present in larger amount in a solution.
- **Saturated Solution:** A solution in which no more solute can be dissolved at the same temperature is called *saturated solution*.
- **Unsaturated Solution:** It is a solution in which more solute can be dissolved at the same temperature.
- **Super-saturated Solution:** It is a solution which contains more mass of the dissolved solute than the saturated solution at the same temperature and pressure.
- **Concentration of a solution:** *Concentration of a solution* is the amount of solute present in a given amount (mass or volume) of a solution or the amount of solute dissolved in a given mass or volume of a solvent.

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Amount of solvent}}$$

- **Solubility:** It is defined as the amount of solute dissolved in 100g of solvent to form a saturated solution.
- **Suspension:** It is a non-homogeneous mixture in which *solids* are *dispersed in liquids*. In it the solute particles do not dissolve but remains suspended through out the bulk of the medium.
- **Colloids or colloidal solution:** Colloid is a *heterogeneous mixture*. The size of particles of a colloid is intermediate between *true solutions* and *suspensions* (i.e between 1nm and 100 nm). The particles of a colloid can not be seen with naked eye.
- **Types of colloidal solution:** Since colloidal solution is heterogeneous mixture it consists of two *phases*. These are
  (i) *dispersed phase* (colloidal particles)
  (ii) *dispersion medium* (The medium in which colloidal particles are dispersed.)
- **Emulsion:** Emulsions are liquid-liquid colloids.
- **Types of Emulsion:** Emulsions are of two types:
  (i) water in oil (ii) oil in water
- **Emulsifiers** are those substances that help in forming stable emulsions of oil and water, e.g. milk, cod-liver oil, cold creams, vanishing creams, moisturising cream, paints, etc.
- **Physical change:** During such a change no new substances is formed and there is no change in the chemical properties of the substances.
- **Chemical change:** Such a change is accompanied by change in chemical properties and formation of new substances.

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STRUCTURE OF ATOM

- **Law of conservation of mass:** This law was stated by **Lavoisier** in 1744. It states that *"In all physical and chemical changes, the total mass of reactants is equal to total mass of products."*
- **Law of constant proportions (or constant composition):** This law was first stated by Proust in 1797. According to the law *"a chemical compound is always found to be made up of the same elements combined together in the same proportions by weight"* e.g. the ratio of hydrogen and oxygen in pure water is always 1: 8 by weight. This law is also called law of definite proportions.
- **Law of multiple proportions:** This law was given by **John Dalton (1803)** and states that "when two elements combine to form two or more compounds, the different mass of one of the elements and the fixed mass of the one with which it combines always form a whole number ratio". This law explains the concept of formation of more than one compound by two elements.
- **Dalton's Atomic theory:** *Postulates of Dalton's Atomic Theory*
  - (i) Matter is made up of extremely small indivisible particles called **atoms.**
  - (ii) Atoms of the same substance are identical in all respects i.e., they possess same *size, shape, mass, chemical properties* etc.
  - (iii) Atoms of different substances are different in all respects i.e., they possess different size, shape, mass etc.
  - (iv) Atom is the smallest particle that takes part in a chemical reaction.
  - (v) Atoms of different elements may combine with each other in a fixed simple, whole number ratio to form **compound atoms.**
  - (vi) Atoms can neither be created nor destroyed i.e., atoms are indestructible.
- **Atom:** It is the smallest particle of an element which can take part in a chemical change. It may or may not be capable of independent existence.
- **Symbol:** The abbreviation used for lengthy names of elements are termed as their symbols.
  The symbol of an element is the first letter or the first and another letter of English name or Latin name of the element.
  While writing a symbol, the first letter is always capital and the second is always small.
- **Molecule :** It is the smallest particle of an element or compound that is capable of independent existence land shows all the properties of that substance.
- **Atomicity:** The number of atoms present in a molecule of an element or a compound is known as its atomicity. e.g. the atomicity of oxygen is 2 while atomicity ozone is 3.
- **Formula of simple and molecular compounds**
  Binary compounds are those compounds which are made up of two different elements e.g. NaCl, KBr, CaO etc. Following rules are to be followed for writing the formula.
  - (i) The valencies or charges on the ions must be balanced.
  - (ii) For a compound made up of a **metal** and a **non-metal** the symbol of metal is written first.

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(iii) In compounds formed with polyatomic ions, the ion is enclosed in a bracket before writing the number to indicate the ratio.

- **Valency:** The electrons present in the outermost shell of an atom are known as valence electrons. These electrons determine the valency of an atom.
  Valency is equal to the number of valence electrons.
  In case the number of valence electrons is close to its full capacity. Then,
  Valency = 8 – valence electrons
- **Atomic number (Z):** Atomic number of an element is equal to the number of protons present in the nucleus of an atom.
  Atomic number (Z) = number of protons = number of electrons.
- **Mass number (A):** It refers to the total number of neutrons and protons (i.e., sum of protons and neutrons) called collectively as nucleus, present in an atom.
  Mass number (A) = number of protons + number of neutron
- **Isotopes:** Atoms of the same element having same atomic number but different mass numbers are known as **Isotopes** e.g. $^{35}_{17}Cl$ and $^{36}_{17}Cl$, and $^{1}_{1}H$ and $^{2}_{1}H$, $^{12}_{6}C$ and $^{14}_{6}C$ etc.
- **Applications of Isotopes:** Isotopes are used in various fields. For example.
  (i) Isotope of uranium is used as a fuel in nuclear reactor
  (ii) Isotope of cobalt is used in treatment of cancer
  (iii) Isotope of iodine is used in treatment of goitre.
- **Isobars:** Atoms of different elements having same mass numbers are known as **Isobars**, e.g K-40 and Ar-40
- The discovery of cathode rays was done by **J.J. Thomson** an English physicist.

Sub-atomic Particles:
Electron, proton and *neutron* are subatomic particles.
The credit for discovery of these particles goes to
Electron — J.J. Thomson and **Proton — E. Goldstein**.
Another subatomic particle which is neutral and has a mass approx. equal to that of a proton was called neutron and was discovered by chadwick. The neutron is a neutral particle found in the nucleus of an atoms.

Properties of atomic particles (Comparative)

	Particles	Electron	Proton	Neutron
(i)	Symbol	e or e–	p	n
(ii)	Nature	Negatively charged	Positively charged	neutral (no charge)
(iii)	(a) Charge (b) Unit charge	(a) -1.6×10^{-19} C (b) –1	(a) $+1.6 \times 10^{-19}$ C (b) + 1	0 0
(iv)	Mass (a) amu (b) kg	(a) 0.0005486 amu (b) 9.1×10^{-3}1kg	(a) 1.00753 amu (b) 1.67265×10^{-27} kg	(a) 1.00893 amu (b) 1.67495×10^{-27} kg
(v)	Location	Extra nuclear space	nucleus	nucleus
(vi)	Notation	-1^{e^0}	$^{1}_{1}P$	$_{0}n^{1}$
(vii)	Relative mass	1/1840	1	1

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GENERAL CONCEPTS OF CHEMISTRY

- **Definition**
  Chemistry is a branch of science which deals with study of matter and various changes it undergoes. It deals with the preparation, properties, reactions and structures of chemical elements and compounds.
  For convenience the study of chemistry is sub-divided into various branches such as:
  (i) Inorganic chemistry
  (ii) Organic chemistry
  (iii) Physical chemistry
  (iv) Analytical chemistry
  (v) Industrial chemistry
- **Ions or radicals**
  An **ion** is formed when electrons are removed from or added to an atoms or group of atoms.
  When electron(s) is/are removed the resulting ion is called a **cation or basic radical.** A cation is positively charged ion. (e.g. Na^+).
  When electron(s) is/are added the resulting ion is called an **anion or acidic radicals.** An anion is negatively charged ion (e.g. Cl^-, O_2^{2-})
  An ion or radical is classified as monovalent, divalent, trivalent or tetravalent when the number of charges over it is 1, 2, 3 or 4 respectively.
- **Formula of elements and compounds**
  Formula of elements: The molecule of an element is denoted by writing the symbol of the element and, to the right and below it, a number expressing the number of atoms in the molecule.
  Formula of compound: A molecule of a compound may be made up of atom of different elements linked up together chemically and in definite proportion by weight.
- **Chemical formula:** It is of two types:
  (i) Molecular formulae: Chemical formulae that indicate the actual number and type of atoms in a molecule is called molecular formulae.
  (ii) Empirical formulae: Chemical formulae that indicate only the relative number of atoms of each type in a molecule is called empirical formulae.
- **Equivalent weight**
  (i) Equivalent weight of element
  $$= \frac{\text{Molecular mass}}{\text{Basicity of acid / Acidity of base}}$$
  (ii) Eq. wt of an acid/base =
  $$\frac{\text{Molecular mass}}{\text{Basicity of acid / Acidity of base}}$$
  (iii) Eq. wt of salts =
  $$\frac{\text{Formula mass}}{(\text{Valency of cations})(\text{No. of cations})}$$
- **Expression of strength / concentration of solution**
  (i) Mass percent
  $$= \frac{\text{Weight of solute (gm)}}{\text{Weight of solution (gm)}} \times 100$$
  (ii) Normality =
  $$\frac{\text{Number of gram equivalents of solute}}{\text{Volume of solution (lit.)}}$$

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(iii) Molarity

$$= \frac{\text{Number of gram moles of solute}}{\text{volume of solution (lit.)}}$$

(iv) Molality

$$= \frac{\text{Gram moles of solute}}{\text{Weight of solvent (kg)}}$$

(v) Mole fraction: Mole fraction of solute

$$= X_A = \frac{n_A}{n_A + n_B}$$

Mole fraction of solvent

$$= X_B = \frac{n_B}{n_A + n_B}$$

$$X_A + X_B = 1$$

- **Chemical change:** A chemical change is generally accompanied by a *change of state, change of colour, evolution of a gas or change of temperature* etc.
- **Chemical equation:** The qualitative representation of a chemical reaction in a short hand or concise form in term of symbols and formulae, is called a chemical equation.
- **Skeletal chemical equation or symbol equation:** A chemical equation written in the form of symbols and formulae is called a skeletal chemical equation.
- **Balanced chemical equation:** A chemical equation in which number of atoms of each elements on L.H.S. (i.e. reactants) and R.H.S. (i.e.products) is equal is called a balanced chemical equation.
- **Balancing of chemical equations:** The process of making the number of different elements on both side of the equation equal is known as balancing of chemical equation.
- **Types of chemical reactions**

Various types of chemical reactions are:-

(i) Combination reactions: Combination reactions are those in which one element reacts with another to form a compound.

(ii) Decomposition reactions: Decomposition reactions are those reactions in which a compound breaks down into simpler compounds (or substances). These reactions require energy in the form of heat, light, electricity, etc.

(iii) Simple displacement reaction and simple substitutions: A displacement reaction is a reaction in which an atom, or group of atoms, present in a molecule is displaced by another atom. This type of reaction can be represented as follows:

$$AB + C \longrightarrow AC + B$$

(Compond) (New compound)

(iv) Double displacement reactions or Double decomposition: The reactions in which mutual exchange of radicals takes place are known as double decomposition reactions.

(v) Oxidation-Reduction Reactions

Oxidation: Oxidation is defined as a process which involve addition of oxygen or removal of hydrogen.

Reduction: The term reduction is defined as a process which involve the removal of oxygen or addition of hydrogen.

(vi) Redox reactions: Those reactions in which oxidation and reduction

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takes place simultaneously, are known as redox reactions.

Example:

(vii) **Exothermic and endothermic reaction:** Chemical reactions usually proceed with either liberation of heat or the absorption of heat.

When a chemical reaction liberates heat to the surroundings, it is said to be 'exothermic reaction' and when it absorbs the heat from the surroundings, it is said to be endothermic reaction.

- **Rancidity:** The most important cause of deterioration in fats and fatty foods is oxidation of fats. What we perceive is an unpleasant change in the flavour and odour of a food, called rancidity.

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

- **Doberiner's law of triads:** According to this law, *"in certain triads (group of three elements) the atomic mass of the central element was the arithmetic mean of the atomic masses of the other two elements."*

  Limitations of Doberiner's Triads: He could identify only a few such triads and so the law could not gain importance. In many traids like in the triad of Fe, Co, Ni, all the three elements have a nearly equal atomic mass and thus does not follow the above law.

- **Newland's law of octaves:** According to this law *"the elements are arranged in such a way that the eighth element starting from a given one has properties which are a repetition of those of the first if arranged in order of increasing atomic weight like the eight note of musical scale."*

  Drawback of Newland's law of octaves:

  (i) According to Newland only 56 elements exists in nature and no more elements would be discovered in the future. But later on several new element were discovered whose properties did not fit into law of octaves.

  (ii) In order to fit new elements into his table Newland adjust two elements in the same column, but put some unlike elements under the same column.

  Thus, Newland's classification was not accepted.

- **Mendeleev's periodic table:** Mendeleev arranged 63 elements known at that time in the periodic table. According to Mendeleev *"the properties of the elements are a periodic function of their atomic masses."* The table consists of eight vertical column called *'groups'* and horizontal rows called *'periods'*.

  Merits of Mendeleev's periodic table:

  (i) At some places the order of atomic weight was changed in order to justify the chemical and physical nature.

  (ii) Mendeleev left some gap for new elements which were not discovered at that time.

  (iii) One of the strengths of Mendeleev's periodic table was that, when inert gases

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were discovered they could be placed in a new group without disturbing the existing order.

Characteristics of the periodic table:

Its main characteristics are:

(i) In the periodic table, the elements are arranged in vertical rows called **groups** and horizontal rows called **periods**.

(ii) There are **eight groups** indicated by Roman Numerals I, II, III, IV, V, VI, VII, VIII. The elements belonging to first seven groups have been divided into **sub-groups** designated as **A** and **B** on the basis of similarities. Group VIII consists of nine elements arranged in **three triads.**

(iii) There are **six periods** (numbered 1, 2, 3, 4, 5 and 6). In order to accomodate more elements, the periods 4, 5, 6 are divided into two halves. The first half of the elements are placed in the upper left corners and the second half occupy lower right corners in each box.

Achievements of Mendeleev's periodic table

(i) The arrangement of elements in groups and periods *made the study of elements quite systematic*

(ii) **Prediction of new elements and their properties:** Many gaps were left in this table for undiscovered elements. The elements *silicon, gallium* and *germanium* were discovered in this manner.

(iii) **Correction of doubtful atomic masses:** Mendeleev corrected the atomic masses of certain elements with the help of their expected positions and properties.

Limitations of Mendeleev's classification:

(i) He could not assign a correct position of hydrogen in his periodic table, as the properties of hydrogen resembles both with alkali metals as well as with halogens.

(ii) The isotopes of the same element will be given different position if atomic number is taken as basis, which will disturb the symmetry of the periodic table.

(iii) The atomic masses do not increases in a regular manner in going from one elements to the next. So it was not possible to predict how many elements could be discovered between two elements.

- **Modern periodic law:** This law was given by **Henry Moseley** in 1913. It states, *"Properties of the elements are the periodic function of their atomic numbers".*

  Cause of periodicity: *Periodicity* may be defined as the *repetition of the similar properties of the elements placed in a group and separated by certain definite gap of atomic numbers.*

- **Modern periodic table**

  Moseley proposed this modern periodic table and according to which *"the physical and chemical properties of elements are periodic function of their atomic number and not the atomic weight."*

  (i) The modern periodic table has 18 vertical columns called *"groups"* and seven horizontal rows called *"periods"*. The groups have been numbered 1, 2, 3.....18 from left to right.

  (ii) The elements belonging to a particular group make a family and usually named after the first member. In a group all the elements contain the same number of valence electrons.

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(iii) In a period all the elements contain the same number of shells, but as we move from left to right the number of valence shell electrons increases by one unit.

The maximum number of electrons that can be accommodated in a shell can be calculated by the formula $2n^2$ where n is the number of the given shell from the nucleus.

- **Trends in modern periodic table:** The trends observed in some important properties of the elements in moving down the group (from top to bottom of the table) and across a period (from left to right in a period) are discussed below:

(i) Valency: Valency may be defined as *"the combining capacity of the atom of an element with atoms of other elements in order to acquire the stable configuration (i.e. 8 electron in valence shell. In some special cases it is 2 electrons)."*

(ii) Atomic size: It refers to the distance between the centre of nucleus of an isolated atom to its outermost shell containing electrons.

The atomic radius decreases on moving from left to right along a period. This is due to an increase in nuclear charge which tends to pull the electrons closer to the nucleus and reduces the size of the atom.

In a group atomic size decreases from top to bottom due to increase in number of shells.

(iii) Metallic and non-metallic properties: In a period from left to right metallic nature decreases while non-metallic character increases.

In a group metallic character increases from top to bottom while non-metallic character decrease.

(iv) Electronegativity: The relative tendency of an atom to attract the shared pair of electrons towards itself is called **electronegativity.**

In a period from left to right, the value of electronegativity increases while in a group from top to bottom the value of electronegativity decreases.

ACIDS, BASES AND SALTS

- **Acids and Bases:** The term acid, in fact, comes from the latin term acere, which means "Sour". In everyday life we come across many compounds that chemists classify as acids.

Bases are compounds which taste bitter eg. milk of magnesia.

- **Properties of acids and bases**

A. Properties of acids

Chemical properties:

(i) **Action of metals**

Metal + Acid → Salt + Hydrogen

(ii) **Action with metal oxides (Basic oxides)**

Basic oxide + Acid → Salt + Water (neutralisation reaction)

(iii) **A ction with metal carbonates and metal hydrogen carbonates**

Carbonate/bicarbonate + Acid → Salt + water + carbon dioxide.

B. Properties of bases

Chemical Properties:

(i) **Reaction of metals with bases:** Metals (e.g. Zn, Al, Sn) dissolve in NaOH (an alkali) to liberate hydrogen gas.

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(ii) **Action with acids:** It is a *neutralisation reaction.*

Base + Acid → Salt + Water

Non - metallic oxides react in the same way hence *non-metallic oxides are acidic in nature.*

- **Strength of Acids and Bases**

The strength of an acid or a base can be easily estimated by making use of **universal indicator** which is a *mixture of several indicators*. The universal indicator show different colours at different concentrations of hydrogen ions in solution.

- **pH Scale:** It is a scale that is used for measuring H^+ ion (hydrogen ion) concentration of a solution.

The term pH stands for "potential" of "hydrogen". It is *the amount of hydrogen ions in a particular solution.*

For acids pH < 7

For bases pH > 7

For neutral substances pH = 7

- **Importance of pH in Daily Life**

(i) **Blood pH:** For proper functioning our body needs to maintain blood pH between 7.35 and 7.45. Values of blood pH greater than 7.8 or less than 6.8 often results in death.

(ii) **Acid rain:** When pH of rain water is less than 5.6, it is called acid rain, when acid rain flows into rivers, it lowers the pH of river water.

(iii) **pH in our digestive system:** We know that hydrochloric acid (HCl) produced in our stomach helps in digestion of food without harming stomach. However excess of acid causes indigestion and leads to pain as well as irritation. To get rid of this people use bases called "antacids".

(iv) **pH of the soil:** For their healthy growth plants require a specific pH. Soils with high peat content or iron minerals or with rotting vegetation tend to become acidic and the soil pH can reach as low as 4.

(v) **pH change as the cause of tooth decay:** Tooth decay starts when the pH of mouth is lower than 5.5

- **Salts:** A **salt** is an *ionic compound* which dissociates to yield a positive ion other than hydrogen ion (H^+) and negative ion other than hydroxyl ion (OH^-) e.g. NaCl

Salts are formed by the reaction of acid and base which is also known as neutralisation.

(i) **Sodium hydroxide (NaOH) or Caustic soda:** It is prepared on commercial scale by the electrolysis of strong solution of sodium chloride (NaCl) also called brine. The process is called chlor-alkali process.

The overall reaction taking place is:

$$2NaCl(aq) + 2\,H_2O(l) \rightarrow H_2(g) + Cl_2(g) + 2NaOH(aq)$$

Uses:

(a) Sodium hydroxide is most used base in the laboratory.

(b) It is used in many industries, mostly as strong chemical base

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in manufacture of pulp and paper, textiles, drinking water, soap and detergents etc.

(ii) **Baking soda, Sodium hydrogen carbonate, ($NaHCO_3$)**

$$NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$$

When heated the following reaction occurs

$$2NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + H_2O + CO_2$$

The above reaction occurs when baking soda is heated during cooking.

Uses:

(a) **In baking powder:** The most practical use of baking soda is as a *leavening agent* in baking.

(b) **As an antacid:** Baking soda reacts with acid due to its alkaline nature and neutralizes acidity (i.e. acts as an antacid)

(c) **In fire extinguishers:** It is used in *soda-acid fire extinguisher.*

(iii) **Washing soda, $Na_2CO_3.10H_2O$, Sodium carbonate**

Sodium carbonate can be obtained by heating baking soda; recrystallisation of sodium carbonate gives washing soda. It is also a basic salt.

$$\underset{\text{sodium carbonate}}{Na_2CO_3} + 10H_2O \longrightarrow \underset{\text{Hydrated Sodium Carbonate (Washing Soda)}}{Na_2CO_3 + 10H_2O}$$

Uses:

(a) Sodium carbonate (washing soda) is used in glass, soap and paper industries.

(b) It is used for removing permanent hardness of water.

(iv) **Bleaching powder:** Calcium hypochlorite is a chemical compound with formula $CaOCl_2$. It is a yellowish powder with smell of chlorine. It is widely used for water treatment and as a bleaching agent (bleaching powder)

$$2Ca(OH)_2 + 2Cl_2 \rightarrow CaOCl_2 + CaCl_2 + 2H_2O$$

Calcium hypochlorite is used for the disinfection of drinking water or swimming pool water.

(v) **Plaster of Paris, $CaSO_4.1/2\ H_2O$**

It can be obtained by heating gypsum ($CaSO_4.\ 2H_2O$)

$$(CaSO_4.2H_2O + heat \rightarrow \left(CaSO_4.\frac{1}{2}H_2O\right) + \frac{3}{2}H_2O$$

Plaster of paris is a white powder and on mixing with water it changes to gypsum once again giving a hard solid mass

$$CaSO_4 \bullet \frac{1}{2}H_2O + 1\frac{1}{2}H_2O \rightarrow CaSO_4.2H_2O$$

Uses: It is used

(a) for making moulds or casts for toys, pottery, cermics etc.

(b) in surgical bandages for setting fractured bones.

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METALS AND NON-METALS

- **Metals and Non-metals:** There are more than 114 elements present in the periodic table. These elements can be broadly classified into two categories i.e., metals and non-metals. Out of 114 elements, 22 are non-metals.
- **Physical properties of metals:**
  (i) They are usually shiny i.e. have a metallic luster.
  (ii) Metals have a high density
  (iii) Metals are ductile i.e. they can be drawn into wires.
  (iv) Metals are malleable i.e. they can be founded into thin sheets.
  (v) Metals are good conductors of electricity.
  (vi) Metals have high melting point and are generally in solid state at room temperature.
  (vii) Metals are good conductors of heat and sound.
- **Uses of metals:** Metals are used in manufacturing of bridges, railways, aeroplanes, diesel mobile units (DMU), electric mobile units (EMU), motor cars, electric motors, telephones, televisions, interplanetary space vehicles, or even common articles like cooking utensils and coins. Metals are very important for the economy of a country. Some metals, such as titanium, chromium, manganese and zirconium are strategic metals. These metals and their alloys find wide applications in atomic energy, space science projects, jet engines and high grade steels. Gold and silver ornaments are obtained from small pieces of metals by hammering.
- **Noble metal:** Noble metals are metals that are resistant to corrosion or oxidation, unlike most base metals. Examples include tantalum, gold, platinum, and rhodium.
- **Precious metal:** A precious metal is a rare metallic chemical element of high economic value precious metals include the platinum group metals: ruthenium, rhodium, palladium, osmium, iridium, and platinum, of which platinum is the most widely traded.
- **Alloy:** An alloy is a mixture of two or more elements in solid solution in which the major component is a metal. Combining different ratios of metals as alloys modify the properties of pure metals to produce desirable characteristics.

	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, solding wire and electronic components etc.

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4	Duralumin	Al = 95.5%, Cu = 3%, Mn = 1.0%, Mg = 0.5%	Used in bodies of aircrafts, kitchen ware and automobile parts etc.
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.

- **Physical properties of non-metals:**
  (i) They are dull, however diamond, graphite and iodine are lustrous.
  (ii) They are poor conductors of heat and electricity. Graphite is a good conductor.
  (iii) They are weak and brittle (they easily break or shatter).
  (iv) They have a low density (they feel light for their size).
  (v) They do not make a ringing sound when they are hit.
  (vi) Melting points and boiling points are usually low.
  (vii) Non-metals are usually soft. (Diamond is an exception, it is quite hard. It is a crystalline solid).
  (viii) They exist in allotropic forms.

8. Uses of Non-Metals

(i) Oxygen is essential for survival of life.
(ii) Hydrogen is used to convert vegetable oil into vegetable ghee by hydrogenation.
(iii) Nitrogen is used to preserve food and for manufacturing proteins by plants.
(iv) Carbon in the form of diamond is used for cutting rocks and in the form of graphite as electrode and in manufacturing of lead pencils.
(v) Sulphur is used in vulcanization of rubber, as fungicide and in manufacture of dyes, gun powder etc.
(vi) Chlorine is used as water disinfectant and in the manufacture of pesticides like gammaxene.

- **Extraction of Metals**
  (i) **Minerals:** The natural substance in which the metals or their compounds occur in the earth is called minerals.
  (ii) **Ores:** The minerals from which the metals can be conveniently and economically extracted are called ores.
  (iii) **Native ores:** These ores contain metals in the free state, *e.g.*, silver, gold, platinum, etc.
  (iv) **Metallurgy:** The whole process of obtaining a pure metal from one of its ore is known as metallurgy.
  (v) **Gangue or matrix:** Ores usually contain soil, sand,

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stones and others useless silicates. These undesired impurities present in ores are called gangue or matrix.

(vi) The removal of unwanted earthy and silicious impurities from the ore is called **ore-dressing or concentration of ores** and the process used to concentrate an ore is called the **benefication process**.

(vii) Concentration of ore is achieved by

(1) **Physical methods:**

(a) **Hand-picking:** It is used in the case when the impurities are quite distinct from the ore so that these may be differentiated by naked eye.

(b) **Hydraulic washing or Levigation or Gravity separation:** The separation is based on the difference in the specific gravities of the gangue particles and the ore particles.

(c) **Electromagnetic separation:** When one component either the ore or impurity is magnetic in nature, this method can be used for separation.

(d) **Froth floatation process:** This method is used for the concentration of sulphide ores.

(2) **Chemical method (Leaching)** involves the treatment of the ore with a suitable reagent as to make it soluble while impurities remain insoluble. The ore is recovered from the solution by suitable chemical method.

(viii) **Extraction** process used to obtain metals in free state from concentrated ores is called extraction.

(ix) **Extraction of crude metal from the concentrated ore involves following chemical processes.**

(a) **Conversion of ore into metallic oxides.**

- Calcination involves heating the ore below its fusion temperature in the absence of air. It can remove moisture from hydrated oxide or CO_2 from carbonates. It makes the ore porous.
- Roasting is the heating of the ore in the presence of air below its fusion temperature.

(b) **Reduction to free metal:**

- **Smelting:** This involves the reduction of the ore to the molten metal at a high temperature. For the extraction of electropositive metals such as Pb, Fe, Sn, powerful reducing agent like C, H_2, CO, Al, Mg, etc., are used.
- **Self reduction process:** These processes are also called auto-reduction process.
- **Electrolytic process:** The oxides of

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highly electropositive metals like Na, K, Mg, Ca, Al, etc., are extracted by electrolysis of their oxides, hydroxides or chlorides in fused state. For example, Al is obtained by the electrolysis of alumina mixed with cryolite.

(x) **Refining** is the process of purifying the extracted metals.

(xi) **Chromatography** is based on the principle that the different components of a mixture are adsorbed to different extents on an adsorbent.

S. no.	Name of the ore	Formula of the ore	Types of ore	Metal obtained from the ore
1	Bauxite	$Al_2O_3.2H_2O$	Oxide	Aluminium (Al)
2.	Haematite	Fe_2O_3	Oxide	Iron (Fe)
3.	Magnetite	Fe_2O_4	Oxide	Iron (Fe)
4.	Zincite	ZnO	Oxide	Zinc (Zn)
5.	Cuprite	Cu_2O	Oxide	Copper (Cu)
6.	Litharge	PbO	Oxide	Lead (Pb)
7.	Malachite	$CuCO_3.Cu(OH)_2$	Carbonate	Copper (Cu)
8.	Magnesite	$MgCO_3$	Carbonate	Magnesium (Mg)
9.	Lime stone	$CaCO_3$	Carbonate	Calcium (Ca)
10.	Cinnabar	HgS	Sulphide	Mercury (Hg)
11.	Chalcopyrite	$CuFeS_2$	Sulphide	Copper (Cu)
12.	Zinc blende	ZnS	Sulphide	Zinc (Zn)
13.	Galena	PbS	Sulphide	Lead (Pb)
14.	Common salt	NaCl	Chloride (Halide)	Sodium (Na)
15.	Fluorspar	CaF_2	Fluoride (Halide)	Calcium (Ca)
16.	Horn silver	AgCl	Chloride (Halide)	Silver (Ag)
17.	Chalcocite	Cu_2S	Sulphide	Copper (Cu)

- **Corrosion of Metals:** Corrosion is an oxidation reaction with atmospheric oxygen in the presence of water on the surface of a metal. Rusting is

$$Fe(s) + \frac{3}{2}O_2(g) + xH_2O(l) \rightarrow Fe_2O_3.xH_2O(s)$$

i.e., rust is hydrated iron (III) oxide.

- **Prevention of Corrosion:** Iron and steel (alloy of iron) are most easily protected by paint which provides a barrier between the metal and air/water. Moving parts on machines can be protected by a water repellent oil or grease layer. Other important methods are

(i) **Alloying:** Iron or steel along with other metals can also be protected by 'alloying' or mixing with other metals

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(e.g., chromium) to make non-rusting alloys.

(ii) **Galvanizing:** Coating iron or steel with a thin zinc layer is called 'galvanizing'.

- **Purity of Gold:**
  24-Carat gold: The carat (abbreviation ct or Kt) is a measure of the purity of gold alloys. Carat is used to refer to the measure of mass for gemstones.

ENVIRONMENTAL POLLUTION

- The pollutants may be inorganic, biological or radiological in nature.
  (i) Bio-degradable pollutants are domestic wastes which are rapidly decomposed by micro-organisms.
  (ii) Non-biodegradable pollutants include chemicals, mercuric salts, lead compounds, pesticides, etc.
  (iii) Natural pollution is caused by radioactive substances, volcanic eruptions, forests and mines fires floods, etc.
  (iv) Artificial pollution is caused by industries, thermal plants, automobile, exhausts, sewage, etc.
- **Environment:** The conditions existing around animal or human life.
  Atmosphere: The gaseous envelop surrounding the earth. It has been classified into following regions:-
  (i) Stratosphere: The layer of the earth's atmosphere above the troposphere and below the mesosphere.
  (ii) Troposphere: The lowest region of the atmosphere extending from earth's surface to the lower boundary of the stratosphere. In this region, human beings along with other organisms live. It contains water vapour and is greatly affected by air pollution.
  Note: The other two layers are Thermosphere and Mesosphere.
- **Air pollution:** The major air pollutants are
  (i) **Carbon monoxide (CO):** It is produced by incomplete combustion of gasoline in motor vehicles, wood, coal, inceneration and forest fires. It is treacherous and deadly poisonous gas. It induces headache, visual difficulty coma and death. It blocks the normal transport of oxygen from the lungs to other parts of the body.
  (ii) **Sulphur dioxide (SO_2):** It is produced by petrol combustion, coal combustion, petrol refining and smelting operations.
  It hinders the movement of air in and out of lungs. It is particularly poisonous to trees causing chlorosis and dwarfing. In presence of air it is oxidised to which is also irritant.
  $2SO_2 + O_2\,(air) \rightarrow 2SO_3$
  In presence of moisture is converted into highly corrosive sulphuric acid.
  $SO_3 + H_2O\,(moisture) \rightarrow H_2SO_4$
  It attacks marble, limestone, vegetation, paper and textiles and injurious to human beings.

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(iii) **Oxides of nitrogen:** and NO, Source - combustion of coal, gasoline, natural gas, petroleum refining, chemical plants, manufacturing explosives and fertilizers, tobacco smoke.

Breathing NO_2 causes chlorosis to plants and chronic lung conditions leading to death. reacts with moisture to form acids.

$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

$3HNO_2 \rightarrow 2NO + HNO_3 + H_2O$

(iv) **Smoke, dust:**

Sources: cement works, iron and steel works, gas works, power generating stations.

Smog: It is a mixture of smoke and fog in suspended droplet form. It is of two types:

(a) **London smog or classical smog:** It is coal smoke plus fog. The fog part is mainly SO_2 and SO_3. It has sulphuric acid aerosol. It causes bronchial irritation and acid rain. It is reducing in nature.

(b) **Photochemical smog or Los Angeles smog:** The oxidised hydrocarbons and ozone in presence of humidity cause photochemical smog.

Hydrocarbons + O_2, NO_2, NO, O, $O_3 \rightarrow$ Per-oxides, formaldehyde, peroxyacetylnitrate (PAN), acrolein etc.

It is oxidising in nature and causes irritation to eyes, lungs, nose, asthamatic attack and damage plants.

Acid rain: The oxides of C, N and S present in the atmosphere, dissolve in water and produce acids and lower the pH of water below 5.5.

The acids are toxic to vegetation, react with marble and damage buildings.

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

Acids corrode water pipes and produce salts with heavy metals ions viz Cu, Pb, Hg and Al toxic in nature.

(v) **Green House effect:** The retention of heat by the earth and atmosphere from the sun and its prevention to escape into the outer space is known as green house effect.

Global warming is average increase in the temperature of earth due to increase in concentration of green house gases (CO_2, O_3, NO_x etc).

Consequences of global warming:

(i) Global warming would result in rise in sea level due to increased rate of melting of glaciers and floods.

(ii) Increase in infectious diseases like malaria, dengue, etc.

(vi) **Ozone layer and its depletion:** The ozone

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layer, existing between 20 to 35 km above the earth's surface, shield the earth from the harmful U. V. radiations from the sun. The U. V. radiations cause skin cancer, cataract of eye, and harm to vegetation.

Depletion of ozone is caused by oxides of nitrogen

$N_2O + h\upsilon \rightarrow NO + N$

reactive nitric oxide

$NO + O_3 \rightarrow NO_2 + O_2$,

$O_3 + h\upsilon \rightarrow O_2 + O$,

$NO_2 + O \rightarrow NO + O_2$

$2O_3 + h\upsilon \rightarrow 3O_2$ (Net reaction)

The presence of chlorofluorocarbons also increase the decomposition of O_3.

$CF_2Cl_2 + h\upsilon \rightarrow + CF_2Cl + Cl$

$CFCl_3 + h\upsilon \rightarrow CFCl_3 + Cl$,

$Cl + O_3 \rightarrow ClO + O$,

$ClO + O \rightarrow Cl + O_2$

$O_3 + O \rightarrow O_2$ (Net reaction)

(vii) **Control of air pollution:** It can be controlled by

1. Dissolving HCl, HF, in water and , , in alkaline solution.
2. Adsorbing gas and liquid molecules over activated charcoal and silica gel.
3. Chemical reactions.
4. Use of precipitators to settle charge particles.
5. Use of settling chambers under the action of gravity.
6. Use of natural gas in place of diesel, petrol, etc.

- **Water pollution:** The contamination of water by foreign substances which would constitute a health hazard and make it harmful for all purposes (domestic, industrial or agriculture etc.) is known as water pollution. The polluted water may have offensive odour, bad taste, unpleasant colour, murky oily, etc.

(i) **Sources of water pollution**

(a) Domestic sewage: Discharges from kitchens, baths, lavatories, etc.

(b) Industrial waters: Wastes from manufacturing processes which includes acids, alkalines, pesticides, insecticides, metals like copper, zinc, lead, mercury, fungicides, etc.

(c) Oil: from oil spills or washings of automobiles.

(d) Atomic explosion and processing of radioactive materials.

(e) Suspended particles (organic or inorganic) viruses, bacterias, algae, protozoa, etc.

(f) Wastes from fertilizer plants such as phosphates, nitrates ammonia, etc.

(g) Clay: Ores, minerals, fine particles of soil.

(ii) **Aerobic and anaerobic oxidation:** The oxidation of organic compounds present in sewage in presence of good amount of dissolved or free oxygen (approx. 8.5 ml/*l*) by aerobic bacterials is called *aerobic oxidation*. When dissolved or free oxygen is below a certain value the sewage is called *stale*. Anaerobic bacterias

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bring out putrefaction producing H_2S, NH_3, CH_4, $(NH_4)_2S$, etc. This type of oxidation is called *anaerobic* oxidation.

(iii) **Biological Oxygen Demand (BOD):** It is defined as the amount of free oxygen required for biological oxidation of the organic matter by aerobic conditions at 20°C for a period of five days. Its unit is mg/*l* or ppm. An average sewage has BOD of 100 to 150 mg/*l*.

(iv) **Chemical Oxygen Demand (COD):** It is a measure of all types of oxidisable impurities present in the sewage. COD values are higher than BOD values.

- **Soil pollution:** The addition of substances in an indefinite proportion changing the productivity of the soil is known as soil or land pollution.

Sources of soil pollution:

(i) Agricultural pollutants: Chemicals like pesticides, fertilizers, bacteriacides, fumigants, insecticides, herbicides, fungicides.

(ii) Domestic refuge and industrial wastes.

(iii) Radioactive wastes from research centres, and hospitals.

(iv) Soil conditioners containing toxic metals like Hg, Pb, As, Cd, etc.

(v) Farm wastes from poultries, dairies and piggery farms.

(vi) Improper disposal of human and animal extreta.

(vii) Pollutants present in air from chemical works.

SOME IMPORTANT MAN MADE MATERIALS

- **Glass**

It consists of a mixture of two or more silicates.

Preparation of glass:

Common glass (or soft glass): It is used to make bottles, glass wares etc. and is obtained by heating together silica (in the form of sand), sodium carbonate or sodium sulphate and chalk or lime stone (calcium carbonate). Some broken glass and a little coke are usually added. The glass so prepared consists of silicates of sodium and calcium.

$$Na_2CO_3(s) + \underset{\text{(silica)}}{SiO_2(s)} \rightarrow Na_2SiO_3(s) + CO_2(g)$$

$$Na_2SO_4(s) + SiO_2(s) \rightarrow Na_2SiO_3(s) + SO_3(g)$$

$$CaCO_3(s) + SiO_2(s) \rightarrow CaSiO_3(s) + CO_2(g)$$

Hard glass: For preparation of hard glass K_2CO_3 is used in place of Na_2CO_3. It consists of a mixture of calcium and potassium silicates.

Physical properties of glass: Hard, rigid, high viscosity, bad conductor of heat and electricity, brittle, etc.

Blowing: It is a method to cast the molten glass into different moulds. There are two different methods of glass blowing

(i) Free blowing and (ii) mould blowing

Free blowing: It involves the blowing of air to inflate the molten glass which is gathered at one end of the blow pipe to give the desired shape.

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Mould blowing: This method was developed after the technique of free blowing. In this method, molten glass is inflated into a wooden or metal carved mould with the help of blow pipe which gives the molten glass the shape and design of the interior of the mould.

Chemical properties of glass

(i) It is resistant to action of air and acids except hydroflouric acid.

(ii) It is alkaline in nature.

(iii) It slowly reacts with water to form alkaline solution.

Types of glass

(i) **Silica glass:** For this type of glass the raw material used is 100% pure form of *quartz*. It is quite *expensive*. It is used in the manufacture of laboratory apparatus. It has low thermal expansion. Its softening point is very high and it is resistant to a wide variety of chemicals.

(ii) **Alkali silicate glass:** For it the raw materials used are sand and soda. It is also called water glass because it is soluble in water and used only as a solution. It is generally used to make gums and adhesives.

(iii) **Lead glass:** For this type of glass lead oxide is added to ordinary glass. The addition of lead oxide increases the density and also the refractive index. This type of glass is used for the manufacture of ornamental glass ware, decorative articles etc.

(iv) **Optical glass:** This type of glass is used in the manufacture of optical instruments like binoculars, spectacles, lenses, prisons, telescopes, microscopes etc. It is transparent and can be grounded into the required shape. It generally contains phosphorus, and lead silicates with little cerium oxide which absorbs UV radiations.

(v) **Processed glass:** The properties and applications of glass also depend upon the processing of glass. Some types of processed glass and their applications are given here:

	Processed glass	Applications
1.	Laminated glass	Used for doors and windows of automobiles. (It has high strength).
2.	Fibre glass	Used for reinforcing purpose (It has enough tensile strength)
3.	Foam glass	Used for civil construction and insulation purposes (it is light weight).
4.	Opaque glass	In it non-transparent glass filters the light entering into it. Thus provides an aesthetic look.

(vi) Borosilicate glass: It contains silica and Boron oxide and small amount of oxides of sodium and aluminium. It is resistant to a wide variety of chemicals due to this property it is used in the manufacture of laboratory ware.

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- **Fertilizers**
  Fertilizers are chemical compounds which when added to the soil increase their fertility and directly supply the need of essential elements [N, P, K] of primary importance.
  Classification: Chemical fertilizers are broadly classified into the following three types:
  (i) **Nitrogenous fertilizers:** Ammonium sulphate, urea etc.
  (ii) **Phosphatic fertilizers:** Super phosphate, ammonium phosphate
  (iii) **Potash fertilizers:** Potassium chloride, potassium sulphate.
- **Soaps and detergents**
  Soap: Fatty acid salts of sodium and potassium are known as soaps. These are prepared by the action of fatty acids with sodium hydroxide or potassium hydroxide.
  Fatty acid + sodium hydroxide → Soap + glycerol.
  Detergents are sodium salt of long chain sulphonic acids or alkyl hydrogen sulphate.
  Advantages of detergents over soaps
  (i) Detergents can be used for laundering even with hard water as they are soluble even in hard water.
  (ii) Detergents possess better cleansing properties than soaps.
  Disadvantages of detergents over soap: Detergents are prepared from hydrocarbons, while soaps are prepared from edible fatty oils. Thus they are non biodegradable.
  Saponification: It is the process of making of soap by the hydrolysis of fats and oils with alkalis.
  Both soaps and detergents are soluble in water and act as surfactants which reduce the surface tension of water to a great extent. This increases the water - fabric interaction as a consequence of which dirt particles, grease spots etc are washed away effectively. In other words soaps and detergents enhance the cleansing action of water.
- **Portland cement:** It was first discovered in England. It is essentially a mixture of lime stone and clay. It was called Portland cement because in presence of water it sets to a hard stone-like mass resembling with the famous Portland rock. The approximate composition of Portland cement is

Calcium oxide (CaO)	62%
Silica (SiO_2)	22%
Alumina (Al2O_3)	7.5%
Magnesia (MgO)	2.5%
Ferric oxide (Fe_2O_3)	2.5%

  The above compounds are provided by the two raw materials, namely lime stone (which provides CaO) and clay (which provides SiO_2, Al2O3 and Fe_2O_3). In cement, almost entire amount of lime in present in the combined state as calcium silicate (2CaO. SiO_2 and 3CaO. SiO_2) and calcium aluminates (3CaO. Al_2O_3 and 4 CaO. Al_2O_3).
  (i) Cement containing excess amount of lime cracks during setting; while cement containing less amount of lime is weak in strength.
  (ii) Cement with excess of silica is slow-setting and that having an excess of alumina is quick-setting.

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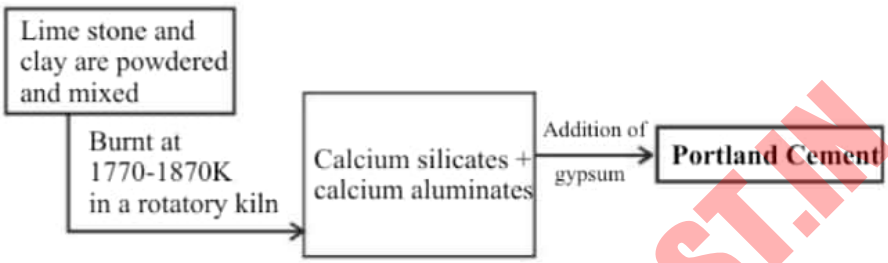
(iii) Cement containing no iron is white but hard to burn.

Cement is manufactured by two processes, viz. wet and dry. A small amount (2–3%) of gypsum is added to slow down the setting of the cement so that it gets sufficiently hardened. Setting of cement is an exothermic process and involves hydration of calcium aluminates and calcium silicates.



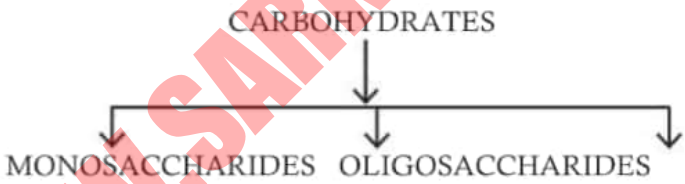
GENERAL ORGANIC CHEMISTRY

CARBOHYDRATES

Carbohydrates are defined as the optically active polyhydroxy aldehydes or ketones or substances which yield these on hydrolysis.

Classification of Carbohydrates

Based on Molecular Size



Based on Nature

Carbohydrates are also classified as reducing and non-reducing sugars depending on whether they reduce Fehlings and Tollen's reagent or not.

Based on Taste

Carbohydrates with sweet taste are called sugars while those without a sweet taste are called non-sugars.

LIPIDS

Lipids are organic compounds soluble in non-polar fat solvents such as acetone, ether, chloroform, benzene, etc. and insoluble in water. The most important role of lipids is that of biological fuel. Lipids supply more energy than carbohydrates, excess of lipids is stored in the body and used at the time of starvation.

PROTEINS

Proteins are highly complex, natural compounds, composed of a large number of different α–amino acids joined together with peptide linkage, i.e., they are naturally occurring polypeptides. The biological importance of proteins can be judge by the fact that the animals can live for a long time without fat or carbohydrate, but not without protein.

NUCLEIC ACIDS

Nucleic acids are colourless, complex, amorphous, compounds made up of three units: bases, sugar and phosphoric acid. These are macro-molecules of high molecular weight and are present in every living cell.

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Life Science

CELL BIOLOGY AND GENETICS

Cell is a basic structural and functional unit of life.

- **Robert Hooke** in 1665 coined the word 'cell'.
- **Anton von Leeuwenhoek** first saw and described a live cell.
- **Robert Brown** later had discovered the nucleus.
- Cell theory was proposed by Schleiden and Schwann in 1855 to explain the concept of the cellular nature of living organism.

Prokaryotic Cells

- P rokaryotic cells are morphologically most primitive.
- Prokaryotic cells are devoid of membrane bound organelles like plastids, mitochondria and advanced (9+2) flagella.
- Prokaryotic cells are represented by bacteria, cyanobacteria (blue green algae) mycoplasma and PPLO (pleuro-pneumonia like organisms).

Eukaryotic Cells

- A eukaryotic cell consists of the following components:

Cell Wall

- The cell wall is a non-living, semi-rigid, external protective covering of the cell.
- Cell wall is entirely lacking in animals.
- I t is made up of cellulose secreted by the cell itself.

Cell Mebrane

- The cell membrane is a living, thin, elastic and semi-permeable membranous covering of plant and animal cells.

Fluid mosaic model of plasma membrane

- S.J.Singer and G. Nicolson in 1972 proposed the most accepted model of membrane structure. The plasma membrane is a lipid-bilayer with proteins embedded in it.
- Lipids are amphipathic, i.e., they are structurally asymmetric with polar hydrophilic and non-polar hydrophobic group.
- One of the most important function of plasma membrane is the transport of the molecules across it.

Endoplasmic Reticulum (ER)

There are two types of endoplasmic reticulum i.e.,

- **Smooth or agranular ER** – They do not have attached ribosomes on their surface.
- **Rough or granular ER** – They bear ribosomes on their surface, for protein synthesis.

Golgi Apparatus

- Golgi apparatus or Golgi complex is a stack of flattened, membrane bounded, parallely arranged organelles that occur in the association of endoplasmic reticulum in the cytoplasmic matrix.
- The golgi apparatus principally performs the function of packaging materials to be delivered either to the intra-cellular targets or secreted outside the cell.

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Lysosomes

- Lysosomes are popularly called "suicide bags".

Vacuoles

- In plant cells, the vacuoles can occupy up to 90 percent of the volume of the cell. The vacuole is bound by a single membrane called tonoplast. They are responsible for maintenance of turgour pressure.

Mitochondria

- Mitochondria are also called as powerhouse of cells.

Plastids

- Plastids are found in plants and few protists Euglena.

Ribosomes

- Ribosomes are smallest cell organelles. They are protein synthesising factories.
  There are two types of ribosomes viz.,
  – Prokaryotic or 70S ribosomes
  – Eukaryotic or 80S ribosomes

Nucleus

- Nucleus is centrally located, spherical and largest component of the all eukaryotic cell. It contains the genetic material of the cell.

Structure of Nucleus

- A typical nucleus consists of four structures: (i) nuclear membrane, (ii) nucleoplasm (iii) chromatin and (iv) the nucleolus.

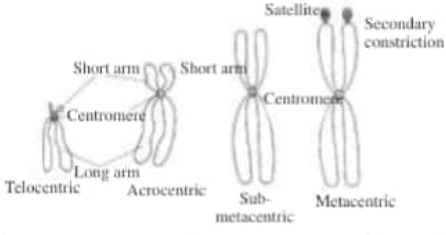

Fig. : Types of chromosomes based on the position of centromere

Nucleolus

- It is present inside the nucleus.
- It is the site of active ribosomal RNA synthesis.

Study of heredity and variation is called genetics.

- Term genetics was given by - Bateson.
- Father of genetics - Gregor Johann Mendel.
- Father of experimental genetics - Thomas Hunt Morgan.
- Father of human genetics - Archibald Garrod.

Some Terms in Genetics

Gene : It is segment of DNA. It is basic unit of heredity.

Back cross : It is cross which is performed between hybrid and one of its parents.

Test cross : Test cross is crossing of offspring with unknown dominant phenotype with the individual homozygous recessive for the trait.

Monohybrid cross : It is a cross between two organisms of a species which is made to study the inheritance of a single pair of alleles or factors of a character.

Monohybrid ratio : Monohybrid ratio is usually 3 : 1 (phenotypic ratio) or 1 : 2 : 1 (genotype ratio) in which 25% of the individuals carry the recessive trait, 25% pure dominant and 50% have hybrid dominant trait.

Dihybrid cross : It is a cross between two organisms of a species which is made to study the inheritance of two pairs of factors or alleles of two genes.

Dihybrid ratio : Dihybrid ratio is 9 : 3 : 3 : 1 (phenotypic ratio) where 9/16 first recessive and second dominant and 1/16 carry both the recessive traits.

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- M endel conducted cross hybridization experiments on Garden Pea plant (Pisum sativum). The first was the **Principle of segregation**, which claimed that each trait was specified by paired hereditary determinants (alleles of genes) that separate from each other during gamete formation. This law is also called **Law of purity of gametes or Law of splitting of hybrids.**
- **Gregor Mendel** was the first individual to apply a modern scientific approach to the study of heredity. Mendel proposed two basic principles of trasmission genetics.
- Mendel's second basic conclusion was the **Principle of independent assortment,** which stated that the segregation of one pair of genes-controlling a given trait - was not influenced by the segregation of other gene pairs. The chormosome theory provided a physical basis for the principle of independent assortment. Genes located on different chromosomes move to gametes independently of each other during meiosis.

Human Blood Groups and Multiple Allele

- The system of blood groups in humans was discovered by Karl Landsteiner in 1900s.
- There are four phenotypes of Blood namely **A**, **B**, **AB** and **O** produced by three different alleles I^A, I^B **and i** of a gene.
- The allele I^A and I^B are equally dominant and do not interfere with expression of each other hence the allele I^A I^B are said to be co-dominant because both are expressed in the phenotype **AB**.
- **Linkage** is the phenomenon of certain genes staying together during inheritance through generations without any change or separation due to their being present on the same chromosomes.
- Linkage in the genes can be identified by test cross.
- The rearrangements of linked genes due to crossing over is known as **recombination.** Recombination also occurs due to chance separation of chromosomes during gametogenesis and their random coming together during fertilization.

Sex Determination

- **Henking** discovered X body in spermatogenesis of few insects and it was given name of X chromosome. Due to involvment of X and Y chromosomes in determination of sex, they were called **sex chromosomes.**
- Rest of the chromosomes which determine other metabolic character of the body are called **autosomes**.

Mutation

- P henomenon that results in alteration of DNA sequence and consequently results in change in genotype and phenotype of an organism is called **mutation**.
- **Mutagens** are various chemical and physical factors that induce mutations, e.g., UV radiations, carcinogenic chemicals like nicotine, nitric oxide (NO).

Genetic Disorder

- A genetic disorder is a disease that is caused by an abnormality in an individual's DNA.

Haemophilia

- A protein involved in clotting of blood is affected in an affected individual; if person gets a cut, will result in non-stop bleeding.

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- Females are heterozygous and carriers of haemophilia.

Sickle Cell Anaemia

- It is due to inheritance of defective allele coding for β-globin. It results in the transformation of Hb^A into HbS in which glutamic acid is replaced by valine at 6th position in each of two β-chains of haemoglobin.
- It is an excellent example of single mutation.

Phenylketonuria

- Affected individual lacks enzyme phenylalanine hydroxylase that converts amino acid phenylalanine to tyrosine.
- It is characterized by severe mental retardation, hypopigmentation of skin & hair, eczema, etc.

PLANT PHYSIOLOGY

Photosynthesis

- Photosynthesis occurs in specialized cells called mesophyll cell which contain chloroplast.
- Photosynthesis follows two main step Light dependent reaction which occur in grana of the chloroplast and Light dependent reaction which occur in stroma region of the chloroplast.
- It is actually oxidation reduction process in which water is oxidized and CO_2 is reduced to carbohydrates.
- The reduction of CO_2 to carbohydrates needs assimilatory powers, ie., ATP and $NADPH_2$.

Respiration

- Carbohydrates are broken down through the process of oxidation and releasing of energy for cellular use, is called respiration. Respiration occurs in three steps as Glycolysis, Kreb's Cycle and Electron transport system.
  $C_6H_{12}O_6 + 6CO_2 \rightarrow 6CO_2 + 6H_20$ + energy
- Glycolysis occurs in the cytoplasm of the cell and the final product is pyruvate which is transported from the cytoplasm to mitochondria. Citric acid cycle/Kreb's cycle occur in mitochondrial matrix and $3NADH_2$, $1FADH_2$ and 1 GTP (ATP) produced by each turn of TCA cycle. In Electron transport system electron are passes in a downhill journey releasing energy at every step that is used in generating electrochemical proton gradient which help in synthesizing energy.

Transpiration

- Loss of water in the form of water vapour from plant through the small pore (stomata) present on leaves is called transpiration.

Nitrogen metabolism

- Plants obtain Nitrogen from the soil in the form of nitrites (NO_2^-), nitrates (NO_3^-) and ammonium $(NH_4)^+$ salts. Nitrogen assimilation is carried out by plants in three steps.
- **Ammonification:** It is the process of conversion of complex organic compounds like protein into ammonia in the presence of ammonifying bacteria.
- Proteins → Amino acids → Organic acids → Ammonia

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- N itrification: Ammonia is rapidly converted first to nitrite and then nitrates by the process of nitrification. Nitrification is brought about by nitrifying bacteria such as Nitrosomonas and Nitrobacter.
- 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.

Plant Growth Regulators

Some chemical molecules secreted by the plants which affect the growth of the plant known as Plant growth regulators.

- Auxin: It controls division in the vascular cambium and xylem differentiation. It Promotes flowering. It also causes the phenomenon of apical dominance.
- G ibberellines: It causes an increase in length of axis of the plant. It delay senescence and help in induction of seed germination.
- C ytokinins: It promotes cell division and growth of lateral branches by inhibiting apical dominance. It also promotes formation of adventitious shoot.
- Ethylene: It is synthesized in the tissue undergoing senescence and ripening of fruits. It promtes in ripening of fruits and accelerate the abscission of flower.
- Abscisic acid: It causes ageing and abscission of leaves and fruits. It also regulates bud and seed dormancy.

HUMAN PHYSIOLOGY

Digestion of Food

Name of the Digestive juice	Name of the enzymes	Substrate	End product
Saliva	Ptyalin (Salivary amylase)	Starch	Maltose
Pancreatic iuice	Amylopsin (pancreatic amylase)	Starch, Glycogen	Maltose and Glucose
Intestinal juice	Sucrase (invertase), Maltase, Lactase	Sucrose; Maltose, Lactose	Glucose and fructose, Glucose, Glucose and galactose
Gastric Juice	Pepsin, Rennin	Proteins, Casein	Proteoses and peptones, Calcium caseinate
Pancreatic Juice	Trypsin, Chymotrypsin, Carboxyl peptidases	Proteins, Proteins Peptides	Proteoses and peptides Peptides Amino acid.
Intestinal juice	Amino peptidase, Dipeptidase	Peptides	Amino acids, Amino acids

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Vitamin required by the body

Vitamin	Chemical Name	Function in Body	Deficiency Disease	Sources
B_1	Thiamine pyrophosphate	Part of coenzyme for respiration	**Beri-beri:** nerve and heart disorders	Found in whole grain cereals, legumes, beans, nuts, brewer's yeast, wheat germ, pork, ham, and liver.
B_2	Riboflavin	Part of coenzyme FAD needed for respiration	**Ariboflavinosis:** skin and eye disorders	Milk, yogurt, other dairy, meat, leafy greens, whole grains.
B_{12}	Cyanoco-balamin	Coenzyme needed for making red blood cells, bone, blood and nerve changes	**Pernicious anaemia**	Animal products (meat, fish, poultry, shellfish, eggs, cheese, milk).
B_5	Nicotinic acid ('niacin')	Part of coenzymes NAD, NADP used in respiration	**Pellagra:** skin, gut and nerve disorders	Widespread in foods.
C	Ascorbic acid	Not precisely known	**Scurvy:** degeneration of skin teeth and blood vessels.	
A	Retinol	Not fully known but forms part of visual pigment, rhodopsin	**Xeropthalmia:** 'dry eyes'	Milk, eggs, meat, fish liver oilsz: Green leafy vegetables - kale, spinach, broccoli Yellow Vegetables - carrots, sweet potatoes Fruits- mango, papaya and apricot

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D	Cholecalciferol	Stimulates calcium absorption by small intestine, needed for proper bone growth	**Rickets:** bone deformity	Formed in skin when exposed to sunlight. Also found in dairy products, egg yolk, fish liver oils, oysters, yeast.
E	Tocopherol	Not precisely known	**Infertility**	Found primarily in plant oils, green, leafy vegetables, wheat germ, whole grains, egg yolk, nuts, seeds, and liver.
K	Phylloquinone	Involved in blood clotting	**Possible haemorrage**	Bacterial synthesis in the digestive tract. Diet generally supplies remaining need. Green, leafy vegetables, cabbage-type vegetables and milk

Minerals	Source	Function
Sodium (Na)	Table salt large amounts is present in processed foods, small amounts in milk, breads, vegetables, and meats	Needed for proper fluid balance, nerve transmission, and muscle contraction
Chloride	Table salt, large amounts is present in processed foods, small amounts in milk, meats, breads, and vegetables	Needed for proper fluid balance, stomach acid
Potassium	Meats, milk, fresh fruits and vegetables, whole grains, legumes	Needed for proper fluid balance, nerve transmission, and muscle contraction

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Calcium	Milk and milk products, canned fish with bones (salmon, sardines), fortified tofu and fortified soy milk, greens (broccoli, mustard green), legumes	Important for healthy bones and teeth, helps muscles relax and contract, important in nerve functioning, blood clotting, blood pressure regulation, immune system health
Phosphorus	Meat, fish, poultry, eggs, milk, processed foods	Important for healthy bones and teeth, found in every cell, part of the system that maintains acid-base balance
Magnesium	Nuts and seeds; legumes, leafy, green vegetables, seafood, and chocolate	Found in bones, needed for making protein, muscle contraction, nerve transmission, immune system health
Sulfur	Occurs in foods as part of protein, meats, poultry, fish, eggs, milk, legumes, nuts	Found in protein molecules
Iron	Organ meats; red meats, fish, poultry, shellfish (especially clams), egg yolks, legumes; dried fruits dark, leafy greens, iron-enriched breads and cereals, and fortified cereals	Part of a molecule hemoglobin found in red blood cells that carries oxygen in the body, needed for energy metabolism
Iodine	Seafood, foods grown in iodine-rich soil, iodized salt, bread, dairy products	Found in thyroid hormone, which helps regulate growth, development, and metabolism

Inorganic Elements in the Human Diet

Element	Common ions	Functions in human body
Calcium	Ca^{2+}	Calcium ions are needed for stability of cell membranes, as cofactors for some enzymes and are involved in muscle contraction and blood clotting.
Phosphorus	H_2PO_4	Bones component of many organic molecules like DNA, RNA and ATP.
Potassium Sodium Chlorine	K^+ Na^+ Cl^-	These ions are important in determining the balance of electrical charges in body fluids.

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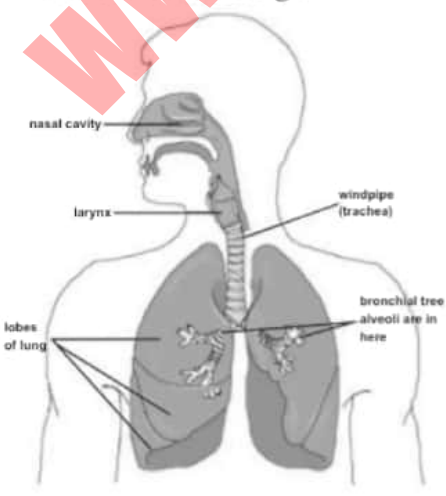
Iron	Fe^{2+}, Fe^{3+}	Component of haemoglobin and cytochrome molecules.
Iodine	I^-	Component of hormone thyroxin.
Copper Manganes Zinc	Cu^{2+} Mn^{2+} Zn^{2+}	Trace elements as enzyme cofactors, for example, Cu^{2+} is co-factor for cytochrome oxidase.

- Marasmus is produced by a simultaneous deficiency of proteins and calories. In Marasmus, protein deficiency impairs growth and replacement of tissue proteins; extreme emaciation of the body and thinning of limbs results, the skin becomes dry, thin and wrinkled. Growth rate and body weight decline considerably.
- Kwashiorkar is produced by protein deficiency unaccompanied by calorie deficiency. Like marasmus, kwashiorkor shows wasting of muscles, thinning of limbs, failure of growth and brain development.

Human Respiratory System

- Human respiratory system consists of external nostrils, nasal cavity, nasopharynx, larynx, trachea, bronchiole and lungs.



Transport of gases

- 97% of oxygen is transported from the lungs to the tissues in combination with haemoglobin ($Hb + O_2 \longrightarrow HbO_2$, oxyhaemoglobin). 3% is transported in dissolved condition by the plasma.

There are three ways of transport of CO_2.

- 5%–7% (approximately) of CO_2 is transported, being dissolved in the plasma of blood.
- CO_2 react with the water to form *carbonic acid* (H_2CO_3) by the enzyme carbonic anhydrase (present in RBC).
- CO_2 reacts with amine radicals (NH_2) of haemoglobin molecule and forms a carbamino – haemoglobin ($HbCO_2$) molecule. Nearly 23% of CO_2 is transported through this mode.

Circulatory Pathways

The circulatory patterns are of two types –

- **Open circulatory system** is present in arthropods and molluscs in which blood pumped by the heart passes through large vessels into open spaces or body cavities called sinuses. Annelids and chordates have a closed circulatory system in which the blood pumped by the heart is always circulated through a closed network of blood

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vessels. All vertebrates possess a muscular chambered heart. Fishes have a 2-chambered heart with an atrium and a ventricle. Amphibians and the reptiles (except crocodiles) have a 3-chambered heart with two atria and a single ventricle, whereas crocodiles, birds and mammals possess a 4-chambered heart with two artia and two ventricles.

Heart beat and pulse

- The human heart beats at the rate of about 72-80 per minute in the resting condition.

Electrocardiograph

- ECG is the graphic record of electronic current produced by the excitation of cardiac muscles.
- A normal electrocardiogram is composed of a p wave, QRS complex and T wave. P wave indicate the depolarisation of the atria. QRS complex expresses the ventricular depolarisation. T wave indicate an repolarisation of ventrcle.

Excretion

- T he process of excreting ammonia is -**Ammonotelism**. kidney plays a minor role in the elimination of ammonia e.g., teleost fishes, tadpoles, aquatic soft bodied invertebrates. Organism undergoing ammonotelism are called **ammonotelic**.
- The process of excreting urea is - **Ureotelism**. Examples are mammals, many terrestrial adult amphibians and cartilaginous fishes (shark).
- The process of elimination of uric acid is **Uricotelism** Examples are land snails, insects, birds and many reptiles.
- Each kidney has nearly one million complex tubular structures called **nephrons**, which are the functional units of kidney. These filter the blood to produce urine.

Skeletal System

Human Skeleton (comprising 206 bones)

divided into

- Axial Skeleton
  - made up of
    - Skull
    - Vertebral column
    - Sternum
    - Ribs
- Appendicular Skeleton
  - made up of
    - Girdles
    - Limbs

Axial Skeleton : Skeleton which occurs in the mid axial or longitudinal part of the body.

(i) **Skull** is made up of 29 bones. It is composed of

- **Cranium (8 bones) :** Frontal -1; Parietal-2; Occipital-1; Temporal - 2; Sphenoid - 1; Ethmoid - 1.
- **Facial bones (14 in number) :** Nasal-2; Maxillae - 2; Zygomatic -2; Lacrymals-2; Mandibles - 1; Inferior turbinals-2; Vomer-1; Palatines-2. Hyoid Tongue bone-1
- **Ear ossicles (6 bones) :** Malleus -2; Incus - 2; Stapes - 2.

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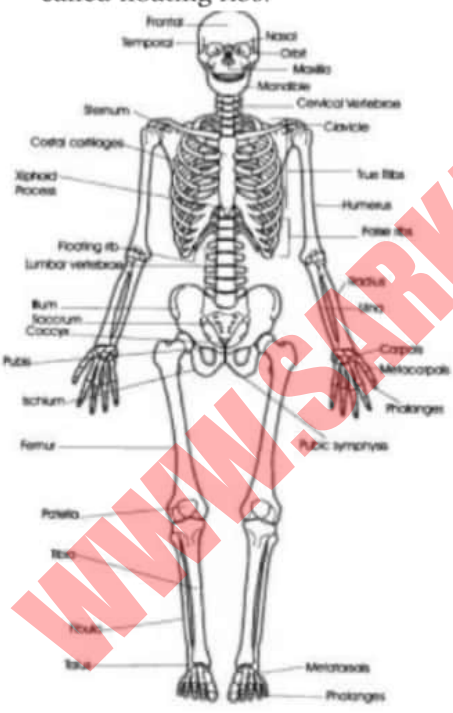
(ii) **Vertebral column :** 33 in babies, 26 in adults. Grouped into 5 categories :

- Cervical-7; Thoracic-12; Lumber-5; Sacral - 5; Coccygeal - 4 (fused in adults).

(iii) **Sternum :** Composed of 3 parts → Manubrium, body of sternum and xiphoid process .

(iv) **Ribs :** They are twelve pairs. First seven pairs are true ribs. The 8th, 9th and 10th ribs are called false ribs or vertebrochondrial ribs. The last 11th and 12th pairs are called floating ribs.



Appendicular Skeleton : Present laterally or attached to the axial skeleton.

(i) **Girdles :** 2 types - pectoral and pelvic.

Pectoral girdle : made of two parts - clavicle and scapula.

Pelvic girdle : made of three bones - ilium, pubis and ischium.

(ii) **Limb bones :** Hind limbs and fore limbs - both made up of 30 bones each.

Fore limbs : Humerus (1); Radius-Ulna (2); Carpals (8); Metacarpals (5); Phalanges (14); Phalanges formula = 2, 3, 3, 3,

(iii) **Hind limbs :** Femur (1); Tibia-Fibula (2); Patella (1); Tarsals (7); Metatarsals (5); Phalanges (14).

Joints

- A joint is a location at which two bones make contact and is essential for all types of movements, involving the bony parts of the body.

Synovial joints - Movable joints: They are characterised by the presence of a closed space or cavity between the bones.

- This kind of joint are classified into six major categories.
  - **Plane** (gliding joint) : Present between carpals. Only sliding motion in all direction is allowed.
  - **Hinge joint :** Present between Knee joint
  - **Pivot joint :** Present between atlas and axis
  - **Saddle joint :** Present between carpal and metacarpal
  - **Ball and Socket joint :** Present between humerus and pectoral girdle.

Neural Control and Coordination

- The neural sysem is the control system of the body which consists of highly specialized cells called neurons.
- A neuron consists of main cell body and cytoplasmic processes arising from it.

The human brain is divisible into three parts:

- **Forebrain :** It comprises the olfactory lobes, cerebrum and diencephalon.

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Cerebrum is the largest and complex part. It consists of the left and right hemispheres connected by a bundle of myelinated fibres, called corpus callosum. The outer layer of the cerebrum is called the cortex.

- **Diencephalon :** The main parts of the diencephalon are epithalamus, thalamus and hypothalamus.
  The hypothalamus is the highest centre of autonomic nervous system. It governs emotional reactions and exercise control over sleep mechanism.
- **Midbrain :** It is formed of corpora quadrigemina and cerebral peduncles. Cerebral penduncles are bundles of fibres connecting the cerebral cortex with other parts of brain and spinal cord.
- **Hind brain :** It comprises of :
  - Cerebellum : It controls the balance and posture of the body.
  - Pons varolii - The pons is concered with maintenance of normal rhythm of respiration.
  - Medulla oblongata - Medullary centres (reflex centres) are present for controlling the functions of important organs, e.g., cardiac centres (heart), respiratory centre, vasomotor centre (for regulating diameter of blood vessels) and reflex centres (for swallowing, vomiting, peristalsis, secretion and activity of alimentary canal, salivation, coughing etc.)

Chemical Coordination in Animal (Hormones)

Endocrine Gland	Hormone	Principal action	Disorders
Thyroid	Thyroxine (T_4) and Triiodothyronine (T_3)	Maintains calcium level normal in the body.	Cretinism, myxoedema goiter
	Calcitonin	Increases rate of metabolism in the body.	
Parathyroid	Parathormone (PTH)	Increases plasma calcium	Parathyroid tetany osteoporosis
"Adrenal gland (medulla)"	"Adrenaline and Noradrenaline"	Increases heart beat, blood sugar and also constricts blood vessel	
Adrenal cortex	"Mineralocorticoids (aldosterone)"	Increases reabsorption of sodium and excertion of potassium	"Addison's disease Adrenal virilism"
	Glucocorticoids (cortisol)	Increases blood sugar and affects carbohydrate, fat and protein metabolism	Cushing's syndrome
Hypothalamus	ARH	Regulates corticotropin secretion	
	TRH	Thyrotropin secretion	
	SRH	Stimulates secretion of gonadotropins	
	(Growth hormone releaing factor)	Regulates secretion of prolactin	

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	(Prolactir releasing hormone) and (Prolactin inhibitory hormone)	Control secretion of MSH	
Pituitary gland anterior lobe	Pituitary gland anterior lobe	Stimulates general growth	Pituitary dwarfism, gigantism, Acromegaly
	Prolactin	Stimulates milk production and secretion	
	(Follicle stimulating hormone)	Stimulates ovarian follicle and spermatogenesis	
	(Lutemizing hormone)	Stimulates corpus luteum and ovulation in females and interstitial cell in males	
	(Thyroid stimulating hormone)	Stimulates thyroid gland to secrete hormones	
	Adrenocorticotropic hormone	Stimulates adrenal cortex to secrete glucocorticoids	
Intermediate lobe	Melanocyte stimulating hormone	Growth and development of melanocyte	
Posterior lobe	Oxytocin	Contraction of uterine muscles and mammary gland cells	
	"Vasopressin (ADH)"	Promotes reabsorption of water from collecting ducts of kidneys	Diabetes insipidus

DIVERSITY IN LIVING ORGANISM

- **Biodiversity** refers number and types of wide variety of plants and animals present on earth.
- In 1773, Swedish botanist **Carolus Linnaeus** formulated the system of binomial nomenclature in his book 'Species plantarum'. In binomial system, each name is expressed in two parts *i.e.*, **generic** name and **specific** name.
- **Taxonomy** is the branch of biology that deals with the framing of laws and principles for classifying the organisms on the basis of their characteristics and evolutionary relationships.
- The hierarchial system of classification was introduced by **Linnaeus**.
  Kingdom → Phylum or Division → Class → Order→ Family → Genus → Species

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Basic Features of Whittaker's Five Kingdoms

Kingdom	Cellular Organisation	Movement	Nutrition	Reproduction
1. Monera (All Prokaryotes)	Unicellular, without nucleus or membranous organelle.	By flagella (tubulin-dynein system)	Absorptive or photosynthetic	Asexual
2. Protista (Protozoans, unicellular algae)	Unicellular, eukaryote with nucleus and membranous organelles.	By flagella, cillia, pseudopodia and mucilage propulsion	Absorptive, photosynthetic & holozoic	Both sexual and asexual
3. Fungi (Multicellular decomposers)	Multicellular eukaryote coenocytic, no plastids, cells wall of cellulose, chitin.	Non-motile	Heterotrophic (saprophytic/ parasitic)	Asexual and sexual both
4. Plantae (All plants)	Multicellular, higher organisation eukaryotes, cellulosic cell wall, plastids present.	Non-motile	Autotrophic or photosynthetic	Asexual and sexual both
5. Animalia (All animals)	Multicellular, higher organization, eukaryotes without cell wall and chlorophyll.	Highly motile with all type of motile machinery	Heterotrophic (holozoic or saprozoic)	Both sexual and asexual but in higher forms only sexual

Plant Kingdom

DIVISIONS OF ALGAE AND THEIR MAIN CHARACTERISTICS

Classes Name	Common	Major Pigments Food	Stored	Cell Wall	Flagellar Number and Position of Insertions	Habitat
Chlorophyceae	Green algae	Chlorophyll *a, b*	Starch	Cellulose	2-8, equal, apical	Fresh water, brackish and salt water.

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Phaeophyceae	Brown algae	Chlorophyll *a, c,* fucoxanthin	Mannitol, laminarin	Cellulose and algin	2, unequal, lateral	Fresh water (rare), brackish water, salt water
Rhodophyceae	Red algae	Chlorophyll *a, d,* phycoerythrin	Floridean starch	Cellulose	Absent	Fresh water (some), brackish water, salt water (most)

Bryophytes

- B ryophytes are also called **amphibians of the plant kingdom** because these plants can live in soil but are dependent on water for sexual reproduction. They usually occur in damp, humid and shaded localities.
- Species of *Sphagnum*, a moss, provide peat that have long been used as fuel, and because of their capacity to hold water as packing material for trans-shipment of living material.

Pteridophytes

- Evolutionarily, they are the first terrestrial plants to possess vascular tissues – xylem and phloem.
- The main plant body is a sporophyte which is differentiated into true root, stem and leaves. These organs possess well-differentiated vascular tissues. Examples are *Psilotum, Equisetum, Dryopteris, Marsilea*, etc.

Gymnosperms

- Gymnosperms are plants which bear naked seeds *i.e.*, the ovules and the seeds that develop from these ovules after fertilization are not enclosed in fruit wall.
- R oots in some genera have fungal association in the form of **mycorrhiza** (*Pinus*), while in some other (*Cycas*) small specialised roots called **coralloid roots** are associated with N_2–fixing cyanobacteria.

Angiosperms (Flowering Plants)

- Angiosperms are seed bearing, flowering vascular plants in which seeds are enclosed in fruits.
- T he flower is the most characteristic structure of the angiosperms. The male sex organ in a flower is the **stamen**. Each stamen consists of a slender **filament** with an **anther** at the tip. The anthers, following meiosis, produce pollen grains.
- The female sex organ in a flower is the **pistil** or the **carpel**. Pistil consists of an ovary enclosing one to many ovules. Within ovules are present highly reduced female gametophytes termed **embryo sacs**.

  Each embryo-sac has a seven-celled **egg apparatus** – one **egg cell** and two **synergids**, three **antipodal** cells and two **polar nuclei**. The polar nuclei eventually fuse to produce a diploid secondary nucleus.

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- Pollen grain, after dispersal from the anthers, are carried by wind or various other agencies to the stigma of a pistil. This is termed as **pollination**.
- The pollen tubes enter the embryo-sac where two male gametes are discharged. One of the male gametes fuses with the egg cell to form a zygote (**syngamy**). The other male gamete fuses with the diploid secondary nucleus to produce the **triploid primary endosperm nucleus (PEN)**. Because of the involvement of two fusions, this event is termed as **double fertilisation**, and event unique to angiosperms.

Animal Kingdom

- Animals are the most diverse groups of organisms. Multicellular, heterotrophs characterised by mobility, sensory and nervous systems.

Phylum-Porifera

- Sponges are aquatic, mostly marine, solitary or colonial and sessile.
- Examples of some sponges are : *Sycon* (scypha), Spongilla (fresh water sponge) and *Euspongia* (bath sponge).

Phylum-Coelenterata (Cnidaria)

- All are aquatic and are mostly marine (exception-Hydra are found in fresh-water), solitary or colonial, sessile, or free-swimming and radially symmetrical animals.
- Example-*Physalia* (Portuguese man of war), *Adamsia* (Sea anemone), *Pennatula* (Sea-pen), *Gorgonia* (Sea-fan) and *Meandrina* (Brain coral).

Phylum-Ctenophora

- These are diploblastic, radial symmetrical animals with tissue level of organization.
- Examples–*Hormiphora* (sea walnut), *Pleurobranchia* (sea gooseberry), *Cestum* (venus girdle), Beroe.

Phylum-Platyhelminthes

- These are mostly endoparasites, bilateral symmetrical, triploblastic and acoelomate animals with organ level of organisation.
- Examples– *Taenia* (Tape worm), *Fasciola* (liver fluke).

Phylum-Aschelminthes

- They may be free-living, aquatic and terrestrial or parasitic in plants and animals.
- Examples: *Ascaris* (Round worm), *Wuchereria* (filarial worm), *Ancylostoma* (Hook worm), *Enterobius* (Pin worm).

Phylum-Annelida

- It is characterised by metameric segmentation forming ring like segments.
- Example: *Neries, Pheretima* (Earthworm) and *Hirudinaria* (Blood sucking leech).

Phylum-Arthropoda

- They are bilateral symmetry, triploblastic animals, which have organ-system level of organisation.
- Example: *Apis* (Honey bee), *Bombyx* (Silkworm), *Laccifer* (Lac insect).

Phylum-Mollusca

- They are aquatic (marine or fresh water), or terrestrial having an organ-system level of organisation.
- Ex. *Pila*, *Octopus* (devil fish), *Loligo* (sea squid).

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Phylum-Echinodermata

- All existing echinoderms are marine, generally live at sea bottom.
- Ex. *Asterias* (star fish), *Cucumaria* (commonly called as sea cucumber), *Antedon* (water lily or feather star).

Phylum-Hemichordata

- They are bilaterally symmetrical, triploblastic, and entrocoelous animals.
- Ex. *Balanoglossus* (acorn worm or tongue worm), *Saccoglossus*.

Phylum-Chordata

- The fundamental four characters of phylum chordata are presence of notochord, a dorsal hollow nerve cord, paired pharyngeal gill slits and post anal tail either in the embryonic or adult stage.
- Examples: *Herdmania* (sea squirt), *Branchiostoma*.

Subphylum vertebrata is divided into two sections:

Section 1 Agnatha (The jawless vertebrates)

Class : Cyclostomata

- Mouth jawless suctorial and round.
- A ll living members are ectoparasites on some fishes.
- Ex. *Petromyzon* (lamprey), *Myxine* (hag fish).

Section 2 Gnathostomata (The jawed vertebrates)

Superclass : Pisces (Bear fins)

Class : Chondrichthyes

- They have a cartilagenous skeleton.
- Some of them possess electric organs e.g. Torpedo.
- Examples: *Scoliodon* (Dog fish), *Trygon* (Sting ray).

Class : Osteichthyes

- They have a bony skeleton.
- Examples : Marine – *Exocoetus* (Flying fish), *Hippocampus* (Sea horse), *Lophius* (Angler fish), Fresh water fishes – *Labeo* (Rohu), *Catla* (Katla).

Superclass : Tetrapoda (Bear Limbs)

Class : Amphibia

- Adapted for both water and land life.
- They are oviparous and development indirect through distinct larval stage called tadpole. Exambles : *Bufo* (Toad), *Rana* (Frog), *Hyla* (Tree frog), *Salamandra* (Salamander), *Ichthyophis* (Limbless amphibia).

Class: Reptilia

- The class name refers to their creeping or crawling mode of locomotion.
- They are oviparous ; Development direct.
  Examples: *Crocodilus* (Crocodile), *Bangarus* (Krait)

Class: Aves

- B irds are bipedal feathered animals.
- Endoskeleton is fully ossified (bony) and the long bones are hollow with air cavities (pneumatic). Examples : *Corvus* (crow), *Pavo* (Peacock).

Class: Mammalia

- T hese are warm blooded (homiothermous) animals having hair and mammary glands.
- They are viviparous with few exceptions and development is direct.
  Example : Oviparous – *Tachyglossus* = *Echidna* (spiny Anteater). Viviparous – *Pteropus* (Flying fox), *Camelus* (Camel), *Macaca* (Monkey).

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DISEASE AND DEFENCE MECHNANISM

Pratozoan diseases

Disease	Pathogen
1. Malaria	Plasmodium
2. Amoebiasis	Enta moeba histolylica
3. Giardiasis	Giardia Lambia
4. Sleeping Sickness	Trypanosoma
5. Leshmanis	Leishmania
6. Trichomoniasis	Trichomonas Vaginalis

Fungal diseases

Disease	Pathogen
1. Aspergillosis	Aspergillus fumigatuo
2. Candidiasis	Candida albicens
3. Ringworm	Trichoplyton
4. Blastomycosis	Blasto myces dermatitidis
5. Sporotnichosis	Sporothrix Schenckii

Bacteria Diseases

Disease	Pathogen
Dysentery	*Shigella*
Plague	*Pasteurellapestis*
Diphtheria	*Corynebacterium diphtheriae*
Cholera	*Vibrio cholerae*
Tuberculosis	*Mycobacterium tuberculosis*
Tetanus	*Clostridium tetani*
Whooping cough	*Bordetella pertussis*
Leprosy	*Mycobacterium leprae*
Anthrax	*Bacillus anthrasis*
Weil's disease	*Leptospira*

Viral Diseases

Disease	Pathogen
Rabies	Rabies virus
Dengue	Dengue virus
Influenza	Influenza virus
Measles	Rubeola virus
German measles	Rubella virus
Mumps	Mumps virus
Chicken pox	Varicella zoster
Small pox	Variola virus
Polio	Polio virus
Chikungunya	Chikungunya (CHIK) Virus
Avian flu	H5N1 virus
H1N1(Swine flu)	H1N1 virus

Select nutrient-deficiency diseases

Vitamin/ nutrients	Diseases	Symptoms	Food Sources
Vitamin A	xerophthalmia	blindness from chronic eye infections, poor growth, dryness and keratinization of epithelial tissues	liver, fortified milk, sweet potatoes, spinach, greens, carrots, cantaloupe, apricots
Vitamin D	rickets	weakened bones, bowed legs, other bone deformities	fortified milk, fish oils, sun exposure

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Thiamin	beriberi	nerve degeneration, altered muscle coordination, cardiovascular problems	pork, whole and enriched grains, dried beans, sunflower seeds
Niacin	pellagra	diarrhoea, skin inflammation, dementia	mushrooms, bran, tuna, chicken, beef, peanuts, whole and enriched grains
Vitamin C	scurvy	delayed wound healing, internal bleeding, abnormal formation of bones and teeth	citrus fruits, strawberries, broccoli
Iron	iron-deficiency anemia	decreased work output, reduced growth, increased health risk in pregnancy	meat, spinach, seafood, broccoli, peas, bran, whole-grain and enriched breads
Iodine	goitre	enlarged thyroid gland, poor growth in infancy and childhood, possible mental retardation, cretinism	iodized salt, saltwater fish

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Immunity

- The term **immunity** refers to the specific resistance exhibited by the host towards infections by micro-organisms (pathogens) and their products.

Innate or Natural Immunity

- Innate immunity is developed in an individual without having the disease or immunization, e.g., recreation of sweat glands contain certain chemical substances which prevent the entry of micro-organisms.
- It is present from birth.
- It is the general defence of body including the following four mechanism —

(i) Phagocytosis of invaders by leucocytes and macrophages (called cellular barrier).

(ii) Resistance of skin to invading micro-organisms (called physical barrier).

(iii) Destruction of micro-organisms swallowed with food by the HCl of gastric juice & by digestive enzymes and tear from eye (called physiological barriers).

(iv) Virus infected cells secrete proteins (called interferons) which protect non-infected cells from further viral infection (cytokine barriers)

Acquired Immunity

- It is a third line defence and developed by an animal in response to a disease caused by infections of microbes.
- The resistance against infectious disease that an individual acquires during life is known as acquired immunity.

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Antibody Mediated Immunity

- B cells produce specialized proteins called antibodies (immunoglobulin) which are glycoproteins.

Classification of Antibodies :

(a) **Ig A** – Protects from inhaled or ingested pathogens.
(b) **Ig D** – Present on lymphocyte surface as receptors, activation of B cells.
(c) **Ig E** – Mediator in allergic response.
(d) **Ig G** – Stimulation of phagocytes and complement system, passive immunity to foetus.
(e) **Ig M** – Activation of B cells.

MERS : Middle East Respiratory Syndrome (MERS) is new viral disease related to respiratory illness. It has been reported to World Health Organization (WHO) since 2012, first reported in Saudi Arabia. To date most of the affected countries is Middle East include Egypt, Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia and UAE. People affected with MERS-CoV developed severe acute respiratory illness including fever, cough and shortness of breath.

SARS : Severe Acute Respiratory Syndrome (SARS) is one of the severe and readily transmissible new disease emerged in the 21st Century. SARS is caused by coronavirus called, SARS-associated coronavirus (SARS-CoV). First time this disease was reported in November 2002 in Guangdong province, China. In general SARS begins with high fever headache an overall feeling of discomfort, and body aches. Some people also have mild respiratory symptoms at the outset.

Ebola: Ebola hemorrhagic fever (Ebola HF) is a severe, often-fatal disease in humans and nonhuman primates (monkeys, gorillas, and chimpanzees). The disease is caused by infection with Ebola virus, named after the Ebola River found in Democratic Republic of Congo (DRC). Ebola is spread through direct contact (through broken skin or unprotected mucous membranes in, for example, the eyes, nose, or mouth). The symptoms appears for Ebola HF from 2 to 21 days. Symptoms are characterized by fever, headache, joint and muscle aches, sore throat, and weakness, followed by diarrhea, vomiting, and stomach pain.

AIDS: Acquired Immune Deficiency Syndrome (AIDS) is caused by Human Deficiency Virus (HIV) which destroys the CD4 Cells that are essential for the body immune symptoms. HIV is transmitted (spread) through the blood, semen, genital fluids, or breast milk of a person infected with HIV. Unprotected sex and sharing of drug injection equipment with the person infected with HIV are the most common ways of HIV transmission. It takes many years to develop the HIV symptoms but the HIV infected person can spread the virus at any stage of HIV infection. 1st December is also remembered as World AIDS day globally people unite together to fight against HIV showing support to the people infected with HIV.

Rabies: Rabies is a viral disease which is endemic in most African and Asian countries and it affects the central nervous system of warm blooded animals, including human. This fatal zoonotic viral disease transmitted to human through contact (mainly bites and scratches)

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with infected animals both domestic and wild. Clinical signs of rabies in animals will vary depending on the effect of the virus on the brain. Typical signs include sudden behavioral changes and progressive paralysis leading to death.

Dengue: Dengue fever occurs through 1 to 4 types of dengue virus. It is spread by the bite of an infected dengue mosquito (*Aedes aegypti*). Dengue fever is more commonly seen in older children and adult. It is characterized by high fever lasting 3-7 days frontal headache pain behind the eyes and muscle and joint pain. There is no specific treatment for Dengue fever till now.

Chikungunya: Chikungunya fever (CF) is a viral illness caused by an arbovirus transmitted by the Aedes mosquitoes. Chikungunya disease does not often result in death, but the symptoms can be severe and disabling. Symptoms appear after 3-7 days after infected by the virus. Most common symptom is fever and joint pain. Other symptoms may include headache, muscle pain, joint swelling, or rash.

Common Heart diseases

- **Coronary artery disease or Arthrosclerosis:** In this disorder the deposition of calcium, fat, cholesterol and fibrous tissue occur in coronary arteries which makes the lumen of arteries narrower and thereby affect the blood supply.
- **Angina (angina pectoris):** Angina is an acute chest pain due to oxygen deficiency to heart muscles. It occurs due to oxygen deficiency to heart muscles. It occurs due to improper blood flow. It is common among middle-aged and elderly person.
- **Heart Failure (congestive heart failure):** It is the condition in which heart is not pumping blood enough to meet the need of the body. Congestion of the lung is the main symptom.
- Arteriosclerosis: It is the state of hardening of arteries and arterioles due to thickening of the fibrous tissue and consequent loss of elasticity. It leads to hypertension.

Common Lung diseases

- **Asthma:** It is a disease caused due to an allergic reaction to foreign substances that affect the respiratory tract. In people with asthma, the walls of these airways become inflamed (swollen) and oversensitive. The airways overreact to things like smoke, air pollution, mold, and many chemical sprays. Bronchioles can constrict (narrow) because of muscle spasms. Drugs called bronchodilators (inhalers). These devices help dilate (open up) the bronchioles.
- **Bronchitis (Inflammation of the Bronchi):** A condition where the bronchi and bronchioles get inflamed and their cavities become narrow so that air cannot pass in and out of lungs easily. The bronchial pathway gets blocked with the accumulation of mucus on the wall of bronchi due to which walls inflammation of the wall occur. Bronchitis occurs due to cough and cold smoking and exposure to air pollutant like carbon monoxide.

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Common Brain diseases

- Epilepsy: Epilepsy is a condition where a person has recurrent seizures, abnormal discharge of electrical activity in the brain cells which may give rise to abnormal behavior such as involuntary muscle movements, unusual perceptions and disturbed level of consciousness. Epilepsy can occur due to brain injury, brain tumor, chemical abnormalities and alcohol or drug effects.
- Loss of Consciousness: Faintness includes the sensation of dizziness lightheadedness and weakness. The majority of attack is due to altered reflex affecting cardiac rate, vascular tone and some time due to severe cardiac disturbances.

Cancer : Cancer is a complex genetical disease which occurs due to the environmental factors. Cancer causing agent (carcinogen) may be present in food and water, in air in sunlight and in chemicals. Since epithelial cells cover our body surface and internal organs also like respiratory organ and alimentary tract which are more exposed to the carcinogens and more than 90% of cancer occur in epithelia. Tumors are of two main types 'benign' and 'malignant'. Benign tumors are slow growing and are located at a place and compress the surrounding tissue by their expensive mass of cells. Whereas malignant tumors are rapidly growing, invading surrounding tissue and most significantly colonizing the distant organ. Five common types of cancer in India are breast cancer, stomach cancer, oral cancer and cervical cancer. Breast cancer is the most common malignancy type diagnosed in women in developed countries and the second most common type diagnosed in developing countries. In 2003, Indian Council of Medical Research (ICMR) reported that oral cancer is very common in India. There has been great increase in oral sub-mucous fibrosis especially in youngsters.

Rotavirus: Rotavirus is a double stranded RNA belongs to the family of Reoviridae. Rotavirus was first time identified as a cause of diarrhea in 1973. Virus get enter through mouth and its replication occur in the villous epithelium of the small intestine. The incubation period for rotavirus diarrhea is short, usually less than 48 hours. The confirmation of rotavirus infection is detection of rotavirus antigen in stool by enzyme-linked immunoassay (EIA). There are two live oral Rotavirus vaccine RV5 (RotaTeq) and RV1 (Rotarix).

Various Transplantation

Transplantation of Organ: Organ transplantation is technique in which surgical removal of an organ or tissue from donor to the recipient has been done. Most donated organs and tissues are from people who have died but living person can also donate the organ. Newborns as well as senior citizens have been organ donors.

Skull transplantation: Doctor of US has successfully performed the world's first partial scalp and skull transplantation of James Boysen. He also had the kidney and pancreas transplantation at the same time. Boyson was suffering from the leiomyosarcoma a rare form of cancer

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that affects the smooth muscles of his scalp. Radiation therapy for the cancer destroyed part of his head, immune suppression drugs kept his body from repairing the damage. Texas doctors have done the world's first partial skull and scalp transplant to make him free from cancer treatment. More than 50 doctors assisted or supported the surgery, including transplant surgeon, plastic surgeon, neurosurgeon and an anesthesiologist. This surgery is very complex as surgeons had to transplant the tissues utilizing microsurgery.

Kidney transplantation: Kidney transplantation is the treatment preferred for the patients who have developing end-stage renal disease or undergoing chronic dialysis therapy. Large number of patients of kidney failure and high success rates of transplantation is a result of ongoing research studies to advance transplantation technique. A successful kidney transplant may improve the patient blood count and energy level. It may also improve the bone strength, growth, and appetite. But still some risk are there as of blood transfusions, immunosupressions and wound healing.

Heart transplantation: In 1968, Dr. P. K. Sen carried out first heart transplantation in India. In Mumbai after 47 years first successful heart transplantation was done by Dr. Anvay Mulay. Recipient was 22 yrs who suffered a stroke because of cardiomayopathy and later his heart got failure. Donor was 42 year old woman declared brain dead in Pune after brain stroke. Donated organ flown from Pune was rushed 20 km to a Mulund hospital along a green corridor created during peak hours by the police in as little as one-fifth of the usual time. The operation took five hours and now the patient's new heart is beating and his kidney and liver that had got affected in the last few months after heart failure showed the signs of normalcy.

Liver transplantation: Liver transplantation is a very effective form of treatment for chronic liver disease as well as for acute liver failure. Living Related Liver Transplantation (LRLT) is an important advancement in liver transplantation. Generally liver transplantation is done in Cholestatic disorders and chronic parenchymal diseases. There are three types of liver transplantation viz., coventional liver transplantation, expanded criteria donor and living donor liver transplantation.

- **Conventional liver transplantation:** This type of liver transplantation is performed to replace the diseased liver with healthy liver from deceased person
- **Expanded Criteria donor:** In this type the donor are over the age of 60, or a donor over the age

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of 50 with two of the following: a history of high blood pressure, a creatinine (blood test to show kidney function). The term "expanded" is used because an expansion of the donor pool is considered to increase transplantation.

- **Living donor liver transplantation (LDLT):** In this type of liver transplantation healthy living person donates a portion of his liver to the recipient.

Lung Transplantation: Lung transplantation is a surgical procedure in which a patient's diseased lungs are partially or totally replaced by the donor's lung. Some of the diseases due to which lung transplantation favored are chronic obstructive pulmonary disease, Idiopathic pulmonary fibrosis, cystic fibrosis and idiopathic pulmonary hypertension. Generally there are three types of lung transplantation.

- **Single lung transplant:** Single donated lung comes from the brain dead donor.
- **Double lung transplant:** In this type both the lungs are transplanted especially in case of cystic fibrosis.
- **Heart-lung transplant:** In severe cardiac disease both heart and lungs have been transplanted.

BIOLOGY IN HUMAN WELFARE

Animal Husbandry

It deals with the care, breeding & management of domesticated animals that are useful to humans.

Poultary Farming

- P oultary is a rearing of domesticated fowls, ducks, geese turkeys guinea fowls and pigeons.
- Poultry birds exclusively grown for meat are called broilers, layers are for egg production, cockerel for young male fowls and rooster are mature male fowls.

Fisheries

- **Pisciculture** is the rearing, breeding and catching of fishes.
- **Aquaculture** is rearing and management of useful aquatic plants and animals like fishes, oysters, mussels and prawns etc.

Apiculture

- A piculture is rearing and breeding of honeybees for the production of honey. It also produces beeswax and bee pollen. Beeswax is used for the preparation of cosmetics and polishes of various kinds.
- T he commonest species of honeybee is Apis indica.

Animal Breeding

- Animal breeding is the production of new breeds of domesticated animals with improved traits. Breeding is the modification of genotype of an organism to make that organism more useful to human.
  - ➢ Inbreeding: Mating between the closely related animals of same breed.
  - ➢ Out-breeding: Mating between the animals which are not closely related.
  - ➢ Out-crossing: Mating between the animals of the same breed which do not have a common ancestor.

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- Cross-breeding: Mating between the superior animals of different breeds of the same species.

- M OET (Multiple Ovulation Embryo Transfer) technique is a programme which improves the chances of successful production of hybrids.

Plant Breeding

- **Plant breeding** refers to the modification and improvement of genetic material of plants resulting in the development of crops which are more beneficial to human beings.

Crop	Variety	Resistance to diseases
Wheat	Himgiri	Hill bunt & leaf and stripe rust
Cauliflower	Pusa snowball K-1 Pusa shubra	Blight black rot Black rot and curl
Brassica	Pusa Swarnim (Karan rai)	White rust
Cowpea	Pusa Komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and leaf curl.

Table : Crop varieties bred by hybridization and selection for disease resistance to fungi, bacteria and viral disease.

- Examples of insect pest resistance crops bred by hybridization are
  (i) **Pusa Gaurav** variety of Brassica is resistant to aphids.
  (ii) **Pusa Sawani and Pusa A-4** varieties of Okra (Bhindi) are resistant to shoot and fruit borer.
  (iii) **Pusa sem 2** and **Pusa sem 3** varieties of flat bean are resistance to aphids and fruit borer.

Biotechnology and its application

- It deals with large scale production and marketing of products and processes using living organism, cells or enzymes. This technology has application in agriculture, food processing industry, bioremediation, medicine diagnostics, waste treatment and energy production.
- Biotechnology deals with:
  - Microbe-mediated processes (making curd, bread, wine etc.)
  - In vitro fertilization ('test tube' baby programme)
  - Synthesis and using of gene
  - Preparation of a DNA vaccine
  - Correcting a defective gene

Genetically Modified Plants	
1. Golden Rice	It is a genetically modified variety of Rice, Oryza sativa which has been developed as fortified food for areas where there is shortage of dietary vitamin A.
2. Bt Cotton	Bacillus *thuringiensis* forms protein crystals during the particular phase of their growth. These crystals contain a toxic insecticidal protein. BT toxin gene were isolated from B. *thuringiensis* and genetically transferred to several crop plants such as cotton.

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3. Flavr savr variety of tomato	Flavr savr is the first genetically engineered crop in which tomatoes have longer shelf life.
Benefits of Transgenic Animals	
1. Transgenic animals are used to study gene regulation	Study of insulin-like growth factor helps to study the biological role of the factor in the body.
2. Biological products	(a) Human protein (α-1-antitrypsin) used to treat emphysema.
	(b) Protein for the treatment of Phenylketonuria (PKU) and cystic fibrosis etc.

DISCOVERIES IN BIOLOGY

- **Willaim Harvey** discovered the double circulatory system of blood also known as Systemic Circulation.
- **Marcello Malpighi** discovered the link between arteries and veins.
- **Louis Pasteur** and **Joseph Lister** discovered role of microorganism in causing infectious diseases.
- **Daniel Nathens** and **Hamilton Smith** discovered Restriction endonuclease enzyme used in Genetic engineering.
- **Hargovind Khorana** showed the order of nucleotides in nucleic acid and also shared Noble prize for Physiology or Medicine with Marshall **W. Nirenberg and Robert W. Holley**.
- Viroids were discovered by **T.O.Diener.**
- **Stanely Prusiner** did most of the work on Prions and was awarded Noble Prize in 1998.
- **Nerinberg** and **Philip Leder** discovered the triplet nature of the genetic code.
- **Edward Jenner** first time demonstrated the vaccination against the small pox in year 1798.
- **George Kohler and Cesar Milstein** discovered the monoclonal antibodies.
- **Francis Crick and James Watson** discovered the double helical structure of DNA molecule in year 1953.
- **Matthias Jacob Schleiden and Theodor Schwann** (1939) proposed the Cell theory.
- **Van Niel** postulates that in green plants, water is utilized in place of H_2S and O_2 evolved in place of sulphur and this discovery was confirmed by **Ruben and Kamen** in 1941 using Chlorella, a green alga.
- Brtish Scientist **Arthur Tansley** coined the term ecosystem which was later adopted by **Eugene Odum**.
- **Morgan** in 1910, showed that genes reside on specific chromosomes

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HEALTH GUIDE

CALORIE CHART

Food Categories	Measure	Calories
MILK & MILK PRODUCTS		
Milk (Cow)	90 ml	50
Milk (Buffallo)	45 ml	50
Cheese	15 gms	50
Butter	1 tbsp	50
Ghee	1 tbsp	50
FRUITS		
Apple	1 small	50-60
Banana	½ Medium	50-60
Grapes	20 small	50-60
Mango	1 small	50-60
Musambi	1 Medium	50-60
Orange	1 small	50-60
CEREAL		
Cooked Cereal	½ Cup	80
Rice Cooked	25 gms	80
Chapatti	1 Medium	80
STARCY VEGETABLES		
Potato	1 Medium	80
Dals	1 Large Katori	80
Mixed Vegetables	150 gms	80
PROTEIN / MEAT		
Fish	50 gms	55
Mutton	1 oz	75
Egg (Hen)	2 pieces	100
COOKED FOOD		
Biscuit (Sweet)	15 gms	70
Cake (Plain)	50 gms	135
Cake (Rich Chocloate)	50 gms	225
Dosa (Masala)	1 Medium	120
Pakoras	1 Medium	175
Puri	1 Large	85
Samosa	1 Piece	140
Vada (Medu)	1 Small	70
MAIN DISH		
Biryani (Mutton)	1 Cup	225
Biryani (veg.)	1 Cup	200
Curry (Chicken)	100 gms	225
Curry (Veg.)	100 gms	130
Fried Rice	85 gms	140
Pullao (Veg.)	100 gms	130
SWEET DISH		
Carrot Halwa	50 gms	300
Jalebi	20 gms	100
Kheer	100 gms	180
Rasgulla	150 gms	140
BEVERAGES		
Beer	12 Fl. oz	150
Cola	200 ml	90
Wine	3.5 Fl. oz	85

HEIGHT & WEIGHT CHART

Height Cms	Weight Kgs	Height Cms	Weight Kgs
+ Men		+ Women	
157.5	53.5-57.1	147.5	43.5-48.5
160.0	54.8-60.3	150.0	44.4-49.9
162.5	56.2-61.6	152.5	45.8-51.2
165.0	57.8-63.0	155.5	47.1-52.6
167.5	59.0-64.8	157.5	48.5-53.9
170.0	60.7-66.6	160.0	49.9-55.3
172.5	62.6-68.9	162.5	51.2-57.1
175.0	64.4-70.7	165.0	52.6-58.9
178.0	66.2-72.5	167.5	54.4-61.2
180.0	68.0-74.8	170.0	56.2-63.0
183.0	69.8-77.1	172.5	58.0-64.8
185.5	71.6-79.3	175.0	59.8-66.6
188.0	73.4-81.6	178.0	61.6-68.4
190.5	75.7-83.9	180.0	63.5-70.3
193.0	78.0-86.1	183.0	65.3-72.1

+For Medium Frame Persons

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Everyday Science

1. **Why does a ball bounce upon falling?**
When a ball falls, it is temporarily deformed. Because of elasticity, the ball tends to regain its original shape for which it presses the ground and bounces up (Newton's Third Law of Motion).

2. **Why is standing in boats or double decker buses not allowed, particularly in the upper deck of buses?**
On tilting the centre of gravity of the boat or bus is lowered and it is likely to overturn.If you stand in a boat, you change the center of gravity making the boat more likely to roll if struck by a wave and if you stand up on the second deck of a double decker bus (which has no roof) and are looking at where you've been, you probably won't see that low bridge ahead of you.

3. **Why is it recommended to add salt to water while boiling dal?**
By addition of salt, the boiled point of water gets raised which helps in cooking the dal sooner. Salt is added to improve the taste; also sodium is indispensable for the life.

4. **Why is the sky blue?**
A clear cloudless day-time sky is blue because molecules in the air scatter blue light from the sun more than they scatter red light. When we look towards the sun at sunset, we see red and orange colours because the blue light has been scattered out and away from the line of sight.

5. **On the moon, will the weight of a man be less or more than his weight on the earth?**
Since the moon is smaller than Earth, it has a weaker gravitational pull. In fact, the moon only has 1/6 the gravity that Earth does. This means you weigh six times less on the moon than you do on Earth!

6. **Why can we see ourselves in a mirror?**
We see objects when light rays from them reach our eyes. As mirrors have a shiny surface, the light rays are reflected back to us and enter our eyes.

7. **Why is cooking quicker in a pressure cooker?**
The trapped steam increases the atmospheric pressure inside the cooker by 15 pounds per square inch (psi), or 15 pounds above normal sea-level pressure. At that pressure, the boiling point of water is increased from 212°F to 250°F. This higher temperature is what cooks food faster. The trapped steam increases the atmospheric pressure inside the cooker by 15 pounds per square inch (psi), or 15 pounds above normal sea-level pressure. At that pressure, the boiling point of water is increased from 212°F to 250°F. This higher temperature is what cooks food faster.

8. **Ice wrapped in a blanket or saw dust does not melt quickly. Why?**

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Both wood and wool are bad conductors of heat. They do not permit heat rays to reach the ice easily.

9. **Why does a balloon filled with hydrogen rise in the air?**
Since the density of hydrogen is lower than that of the air, balloon will go up in the air

10. **Why does an electric bulb explode when it is broken?**
The bulb is a partial vacuum and as it breaks, air rapidly enters in resulting in a small explosion.

11. **Why do we lean forward while climbing a hill?**
We lean forward while climbing up a hill, so that the vertical line drawn through the center of the gravity of the body should fall within the base.

12. **Why does a man fall forward when he jumps out of a running train or bus?**
When the person is sitting inside a train, his complete body was in a state of motion with the train. The moment he jumps out of the moving train, his feet touches the ground, and the lower portion of his body comes to rest. But the upper portion remains in motion due to inertia of motion. That's why he falls in the direction of motion of the train.

13. **Why does an ordinary glass tumbler crack when very hot tea or milk is poured in it?**
The crack is caused by differential thermal expansion. The part of the glass that the boiling water touches first expands due to the heat, but the heat doesn't conduct through the glass quickly so there is stress between the expanded inside of the glass and unexpanded outside of the glass. This stress is sometimes too much and the glass cracks.

14. **Why is a compass used as an indicator of direction?**
The compass needle aligns with the Earth's magnetic field direction and points north-south.

15. **Why is water from a hand pump warm in winter and cold in summer?**
In winter the outside temperature is lower than that of water flowing out of the pump, and therefore , the water feels warm. Whereas in summer, the outside temperature is higher than the water of the pump, and therefore, it feels cold.

16. **Why does a swimming pool appear less deep than is actually is?**
The refraction of light at the surface of water makes ponds and swimming pools appear shallower than they really are.

17. **Why is one's breath visible in winter but not in summer?**
Absolute dew point in cold weather is lower than in warm weather. water from your breath condenses and freezes in cold weather.

18. **Why does water remain cold in an earthen pot?**
In an earthen pot, water gets evaporated quickly through the pores. Cooling is caused by evaporation

19. **Why do we place a wet cloth on the forehead of a patient suffering from high temperature?**
Water evaporating from the wet cloth produces a cooling effect and brings the temperature down.

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20. To prevent multiplication of mosquitoes, it is recommended to sprinkle oil in the ponds with stagnant water. Why?

Mosquitoes breed in stagnant water. The larvae of mosquitoes keep floating on the surface of water due to surface tension. However, when oil is sprinkled, the surface tension is lowered resulting in drowning and death of the larvae.

21. Why is it dangerous to sleep under trees at night?

Because plant on respiration gives CO_2, because the absence of light. So in nights if we sleep under big trees we do not have sufficient amount of oxygen.

22. Why is a new quilt warmer than an old one?

A quilt feels warm because the air trapped in the cotton or woolen batting acts as an insulator and does not allow the heat of the body to escape. However, when the quilt gets old - the cotton/wool gets compressed and the airspace are done away with. It does not remain as good an insulator to heat as it was earlier. Hence it feels less warm.

23. How do bats fly in dark?

In dark, bats' ears are more important than their eyes - they use a special sonar system called 'echolocation,' meaning they find things using echoes.

24. Water pipes often burst at hill stations on cold frosty nights. Why?

The temperature may fall below 0°C during cold frosty nights which converts the water inside the pipes into ice, resulting in an increase in volume. This exerts great force on the pipes and as a result, they burst.

25. Why are white clothes more comfortable in summer than dark or black ones?

White clothes are good reflectors and bad absorbers of heat, whereas dark or black clothes are good absorbers of heat. Therefore, white clothes are more comfortable because they do not absorb heat from the sun rays.

26. Why does a rose appear red grass green in daylight?

The rose absorbs all the other color light and reflects or gives out red so we see it in red color. Simliar is the condition with grass, Green grass absorbs blue and red light, but reflect green light. So it is the reflected light which gives color what we see.

27. If a highly pumped up bicycle tyre is left in the hot sunlight, it bursts. Why?

The air inside the tube increases in volume when heated up. As sufficient space for the expansion of the air is not available because the tube is already highly pumped, it may result in bursting of the tyre.

28. What will be the color of green in blue light?

Grass will appear dark in color because it absorbs all other colors of the light except its own green color. The blue light falling on grass will be absorbed by it, and hence, it will appear dark in color.

29. Why do two eyes give better vision than one?

Because two eyes do not form exactly similar images and the fusion of these two dissimilar images in the brain gives three dimensions of the stereoscopic vision.

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30. When a man fires a gun, he is pushed back slightly. Why?
Newton's 3rd law says 'Every action has an equal and opposite reaction'.. So when a man fires in forward direction, he is generating a force on the gun. As a result of that action the gun returns the force.. Or make a reaction in the backward direction..Hence, the man is pushed back slightly.

31. Why is a small gap left at the joint between two rails?
The gap in the joint between two rails is to compensate for the expansion of the material of rail during summer.

32. Who will possibly learn swimming faster—a fat person or a thin person?
The fat person displaces more water which will help him float much more freely compared to a thin person.

33. Why is a flash of lightening seen before thunder?
We see the lightning before we hear the thunder because light travels faster than sound. The light from the lightning travels to our eyes much quicker than the sound from the lightning. so we hear it later than we see it.

34. Why are ventilators in a room always made near the roof?
The hot air being lighter in weight tends to rise above and escape from the ventilators at the top. This allows the cool air to come in the room to take its place.

35. A burning candle gets extinguished when covered with a tumbler. Why ?
Fire needs oxygen to burn and when the tumbler covers the fire it uses up all the oxygen in the little space quickly and is extinguished.

36. A parachute enables a person to descend in safety in case of an accident to aircraft ?
A man falls to the earth because of the gravitational pull of the earth. The parachute offers considerable resistance to that gravity, thereby slowing down the speed of the descending man. The parachute thus enables a person to descend in safety.

37. Why does tea cool more rapidly in a saucer than in a cup ?
Cooling is caused by evaporation. In a saucer evaporation takes place more rapidly than in a cup.

38. It is advisable to work electric appliances when they are earthed suitably. Why ?
In case of short-circuiting, the current passess to the earth without harming the user, if an electrical appliance is properly earthed.

39. Explain why the planets do not twinkle.
Planets are much closer to earth as compared to stars. They are extended source of light. They behave like a number of point sources so that the average variation is zero. Thus, planets do not twinkle.

40. Why does the Sun appear reddish early in the morning?
In the morning, the sun is nearer to the horizon. Blue light have shorter wavelength, so, it scatters more. Therefore the red light which have longer wavelength reaches upto the eye of the observer and the sun appears reddish.

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41. Which is more elastic, rubber or steel?
Steel is more elastic for the same stress produced, compared to rubber.

42. Why do some liquids burn while others do not?
A liquid burns if its molecules can combine with oygen in the air with the production of heat. Hence, oil burns but water does not.

43. Why do we bring our hands close to the mouth while shouting across to someone far away?
By keeping hands colose to mouth the sound is not allowed to spread (phenomenon of diffraction of sound) in all directions but is directed to a particular direction and becomes louder.

44. Why does silver acquires a blackish tinge when exposed to air for a long time?
Silver on exposure to air acquires a blackish tinge due to the formation of silver sulphide.

45. In chilled winters the nose and ears turn red. Explain the advantage of this response?
In cold days, skin blood vessels of the ears and nose can dilate, bringing warm blood to the ears and nose, to prevent the tissue damage from cold. The increased blood flow makes the ears and nose appear red.

46. What would happen if the force of gravity were to disappear suddenly?
In the absence of the force of gravity all living objects on the earth will be practically in a floating condition. They will be thrown away because of the centrifugal force caused by the rotation of earth. Thus, one will not be able to eat, drink, move and continue to live.

47. When we drink soft drink through a straw, why does the liquid go up into our mouth?
When a person sucks air from the straw, the pressure of air inside the straw is reduced as compared to the atmospheric pressure acting on the surface of the liquid. Therefore, the soft drink rushes up into the straw and to the mouth.

48. Explain why it takes more time to cook meat and vegetables at hill stations.
The boiling point of water depends upon the pressure on its surface. It increases with the increase of pressure and decreases on lowering of pressure. At higher altitudes, the atmospheric pressure is low as compared to that in the plains, therefore, water boils below 100°C. Hence, sufficient heat is not supplied for cooking the meat and vegetables at hill stations. This difficulty may be overcome by using a pressure cooker. Water can be made to boil at any desired temperature with the help of this appliance.

49. Why does blotting paper absorb ink?
Blotting paper has fine pores which act like capillaries. When a portion of blotting paper is brought in contact with ink, ink enters the pores due to surface tension (capillary action of liquids) and is absorbed.

50. Why does kerosene float on water?
Because the density of kerosene is less than that of water.

51. Why is a metal tyre heated

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before it is fixed on wooden wheels?

On heating, the metal tyre expands by which its circumference also increases. This makes fixing the wheel easier and thereafter cooling down shrinks it ; thus fixing the tyre tightly.

52. Why is it easier to swim in the sea than in a river?

The density of sea water is higher; hence the upthrust is more than that of river water.

53. Why does oil rise on a cloth tape of an oil lamp?

The pores in the cloth tape suck oil due to the capillary action of oil.

54. Why are air–coolers less effective during the rainy season?

During the rainy reason the atmospheric air is saturated with moisture. Therefore, the process of evaporation of water from the moist pads of the cooler slows down thereby not cooling the air blown out from the cooler.

55. Why does grass gather more dew in nights than metallic objects such as stones?

Grass being a good radiator enables water vapour in the air to condense on it. Moreover, grass gives out water constantly (transpiration) which appears in the form of dew because the air near grass is saturated with water vapour and slows evaporation. Dew is formed on objects which are good radiators and bad conductors.

56. Why is it dangerous to have charcoal fire burning in a closed room?

When charcoal burns it produces carbon monoxide which is suffocating and can cause death.

57. Why does ENO's salt effervesce on addition of water?

It contains tartaric acid and sodium bicarbonate. On adding water, carbon dioxide is produced which when released into water causes effervescence.

58. Eskimos live in double-walled ice houses. Why?

Because the air in between two ice walls does not allow heat to pass.

59. Why is sunlight so hot and moonlight so cool?

The Sun is millions of times brighter than the Moon. All of the Moon's light is just scattered sunlight; it does not emit any light of its own. The fact that we can discern objects in moonlight is due to the remarkable capacity of our eyes to adjust to extremely low levels of light. Of course, moonlight differs from sunlight in its basic character as well; it also depends on the scattering properties of the Moon surface.

60. What is DNA finger printing? what are its uses?

The sequence of bases of DNA in each of our cells is the same, but differs from that of any other living thing except possibly an identical twin. This difference makes the DNA break at different places when certain proteins called enzymes are added to it, resulting in smaller DNA fragments of different sizes. These fragments migrate at different rates in an electric field, resulting in a unique pattern; this pattern is referred to as a DNA fingerprint. Our DNA is inherited from our

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parents. Some parts come from the father and some from the mother. DNA fingerprinting can help identify parentage, since a son or daughter would always exhibit a pattern identifiable as coming from both parents. DNA fingerprinting analysis is very useful in forensic science; from a single hair or a tiny sport of blood, it is possible to prove the innocence or guilt of a murder suspect. Similarly, it is also possible to identify human remains after violent accidents have caused disfigurement.

61. How does cooking happen in a microwave?

Passage of microwaves through food results in increased agitation of molecules. If we can increase the amplitude of the random movements of molecules, we are doing nothing but heating the food. But how do microwaves increase the agitation? At microwave frequencies, the alternating electric field of the radiation interacts with the electric dipole moment of water molecules, making them vibrate faster. The absorption length of the microwave energy is long, meaning that not all energy falling on a chunk of cooking food gets absorbed while traversing through it. It also means that for microwaves, in the simplest approximation, there is no inside or outside of the food chunk; heating occurs all through the body of the food. That is the reason you do not get a crisp surface on the outside, as you would in normal cooking where the heat has to travel inwards from outside.

62. If you press the upper lid of one of your eyes you see two images. Why?

The two eyes send independent image signals to the brain, which has the mechanism to combine them to give the sensation of a single 3D image. When we press on one eyelid, we are essentially tilting its lens, and therefore moving the image on the retina. The brain remains unaware and two visualised images are the result of improper superposition.

63. Why does an air conditioner "leak" water?

An air conditioner sucks in the outside air and passes it over fin-like projections, which have been cooled by the compressor. It cools the inside of a room while heating the outside. The outside air is not only hot but often it is also quite humid. When passed over the cold fins, the temperature of air drops below the dew point and excess moisture condenses out.

64. Why do stars twinkle and the planets do not?

Starlight passes through the atmosphere before reaching us. If the air above us were a passive, well-behaved and completely homogenous medium. we will not have any twinkling. Fortunately for us, our atmosphere is active and vibrant. Air masses are always on the move. It is natural, therefore, that there would be pockets of slightly higher density, and others of slightly lower density, flitting around. Starlight passing through these pockets is minutely deflected higher and thither.

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To an observer, the star will seem to come into view and then disappear, many times a second. We poetically refer to this phenomenon as twinkling.

On the other hand, planets are not point objects like stars. A spatially extant bundle of rays comes to us from various parts of the planet surface and there never is a time when all the rays are bent out of our eye. Therefore, where planets are concerned, we do not see any twinkling.

65. How is it possible for insects and spiders to walk on water or on the walls?

Tiny insects can walk on water because of the phenomenon of surface tension. The unbalanced intermolecular force makes the surface behave like a stretched membrane. The classical demonstration of the carrying capacity of this membrane is to gently lay flat a shaving blade (to ensure that the weight per unit area is kept low) upon the surface of still water; the blade does not sink. The blade is heavier than an equal volume of water and would surely sink if the force of surface tension were absent. Thus, one can easily understand why little insects and larvae can float on the surface of water.

As regards the ability of insects to walk on walls, several explanations are provided. The most popular is the hypothesis that such creatures have suction cups on their feet using which they can stick to walls and ceilings. Some recent investigations indicate a special construction of the feet; thousands upon thousands tiny, protruding hair-like projections stick to surfaces due to good old molecular forces.

66. What are the benefits of using GSLV to launch satellites into geostationary orbit?

Communication satellites are usually placed in a geo-stationary orbit. This is an orbit over the equator at a height such that the period of revolution of the satellite around the Earth is exactly the same as the period of rotation of the Earth - namely 24 hours. The advantage is that the satellite in such an orbit appears to be stationary with respect to the Earth. The communication antennas on the ground can then be pointed in a fixed direction without worrying about the rotation of the Earth. We already have several such satellites providing communication, including television broadcast and networking services. The demand for such services is continuously increasing. Therefore, we do need more satellite transponders in orbit. We also need to replace satellites that are close to the end of their lives.

So far, we have depended on European or American launchers to raise our satellites into the geo-stationary transfer orbit. However, we are now beginning to use our own launch vehicle. Some of the rocket stages and associated technologies already developed for putting satellites in polar orbits around the Earth (for remote sensing) were upgraded and modified for GSLV (Geo-stationary Satellite Launch Vehicle). A new rocket stage using liquid hydrogen and liquid oxygen was added, in

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addition to other modifications in the launch systems previously developed for polar launches.

67. What is the use of the glass sheet in a solar cooker?

To raise the temperature within, a solar cooker you have to allow maximum possible energy from sunlight to come in and lose the least amount through re-radiation to the environment. Most of the Sun's energy is concentrated in the visible range of radiation. A glass sheet is transparent in this range, so it allows a large fraction of the Sun's energy to enter the cooker. The temperature inside the cooker may rise to 100 degrees Celsius, at the most. At this temperature, most of the radiation is in the infrared range; in other wards, it is heat radiation. Glass is not very transparent at these wavelengths. This radiation is trapped inside the cooker, thus raising the temperature. Of course, ultimately, the energy going out must become equal to the energy coming in. This balance is achieved only after the cooker temperature has been elevated.

68. Is it true that body weight increases after death?

A dead body is heavier to carry, much like a person who is unconscious or drunk. The perception is probably due to the fact that a dead person does not cooperate in distributing his weight on to different parts of your body - for example, by putting an arm around your shoulder or clasping his legs around your middle. After a while, the remains of a dead body must weigh much less because much of the body degrades through the action of bacteria.

69. Water is colourless, water vapour is colourless, so why are clouds white or black and not colourless?

You must have noticed that clouds are not only white or black; at sunrise or sunset, they are also pink and red. This is because the colour of the cloud is dominated by the light that is scattered from the surface of a large number of tiny droplets. That colour is the same as that of the light falling on them. During the day when the sun is up, it is the scattered light that filters through; after many scatterings of water droplets. This makes the clouds white. When the sky is almost covered with thick clouds, little of the scattered light from the cloud comes down, and the dark colour of the clouds is due to absence of light.

70. Why does the Universe appear black to us?

From out in space, the Universe does look black except for the stars and galaxies with which it is studded. This is so because no visible light is scattered in our direction from positions and directions that do not have a star.

71. Why do we dream?

The phenomenon of dreams has been studied in detail by many experts. There are a large number of books on this subject.

It is clear that our body needs sleep; the brain and the central nervous system need rest. We also know that our brain, does not shut down while we are asleep. There is an enormous amount of delegation of power and autonomy. We do not stop breathing when we are sleeping. The heart rate might

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slow down a bit, yet it's beat keeps our blood flowing; our digestive system keeps working as well. Many of our senses are given a holiday and yet kept on alert should there be a need to take action. There are a lot of images and stories residing in some structures of the brain. When we are awake, these are under conscious control. On the other hand, when we fall asleep, they are still present but they are unsupervised and have some freedom to combine in odd ways, often responding to strong experiences - some very recent and others very old, fished out from the bottom of the storage file. The editing and serialisation of images and thoughts might seem random but even the randomness seems to have some logic. Those impulses that are suppressed while we are awake become free to operate and be experienced.

72. Why does hair stand on end on a chilly morning?

When it is cold the body reduce the loss of heat, particularly due to evaporation. This is due to closing of the pores on the skin tends to make the hair stand up like little poles.

73. Why does the rain fall in drops?

Rain is the result of condensation of vapour when the air is cooled below the dew point. All the vapour in a cloud cannot condense at the same time and turn into a large pool of water. Pockets of air move up independently and slowly cool till condensation begins and water droplets form. It is believed that most raindrops start out as tiny ice crystals - so tiny that they float down, slowly accreting more moisture on the way; at lower altitudes, the crystals melt into water droplets. In colder climates, the crystals reach the ground as snowflakes.

74. Is there a method of counting all the stars of the Universe?

We can't even see all the stars. Some are hidden by dust clouds, many more are in galaxies so far away that they cannot be resolved as separate entities even by the most powerful of telescopes. So how do we say that there might be a hundred billion stars in our galaxy and a hundred billion galaxies? Not by counting, but by estimating on the basis of sample counts in some small representative parts of the Universe. For example, for some parts of our own galaxy, we might count the stars in a tiny bit of an angle of view. Then it becomes a problem of repeating this exercise on selecting representative bits of the sky in all directions and doing the same. What remains then is to estimate the total volume in various representative bits.

75. Why do clouds look reddish-orange in the evening?

In the late evening, when it begins to get dark on the Earth's surface, the clouds can still catch the Sun's rays for a while longer, since they are high up. But, to reach the clouds, the rays of the Sun have to pass through the atmosphere almost tangentially. This distance travelled through air is therefore very large. You This long path through air leads to excessive molecular scattering. Orange and red light scatters away much less than the blue and green colours. Therefore, the clouds are illuminated by light that appears mainly orange-red.

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