GOVERNMENT OF TAMILNADU

STANDARD NINE

TERM - I

VOLUME 3

SCIENCE

Untouchability is Inhuman and a Crime

A publication under Free Textbook Programme of Government of Tamil Nadu

Department of School Education

Government of Tamil Nadu

First Edition - 2018

(Published under Uniform System of School Education Scheme in Trimester Pattern)

NOT FOR SALE

Content Creation

State Council of Educational Research and Training

Printing & Publishing

Tamil NaduTextbook and Educational Services Corporation

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PREFACE

This book is developed in a holistic approach which inculcates comprehending and analytical skills and also aimed to help students for better understanding of higher secondary science, and competitive exams in future. Textbook designed in learner centric way to trigger the thought process of students and to excel in learning science not by rote learning instead by activities.

HOW TO USE THE BOOK

- This term-1 science book has 9 units.
- Three units for every month, each unit has simple activities that can be done by the teacher as demonstration and also few group activities given for students alone under the guidance of the teacher.
- Infographics and info-bits are added to enrich the learner's scientific perception.
- The "Do you know?" and "More to know" placed in the units will be an eye opener.
- Glossary has been introduced to learn scientific terms.
- ICT corner and QR code introduced in each unit for the digital native generation.

How to get connected to QR Code?

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EJ38Y6

Assessment

B121_9_SCI_EM

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UNIT 1

Measurement and Measuring Instruments

Learning Objectives

EJC4ZT

To get exposed to:

- the rules to be followed while expressing physical quantities in SI units
- the derived units
- the usage of scientific notations
- the three characteristics of measuring instruments
- the usage of vernier caliper and screw gauge for small measurements
- to try and find the weight of an object using a spring balance
- the importance of accurate measurements

Introduction

Measurement is the basis of all important scientific study. It plays an important role in our daily life also. When finding your height, buying milk for your family, timing the race completed by your friend and so on, you need to be able to make measurements. Measurement answers questions like, how long, how heavy and how fast? Measurement is the assignment of a number to a characteristic of an object or event which can be compared with other objects or events. It is defined as the determination of the size or magnitude of something. In this lesson you will learn about units of measurements and the characteristics of measuring instruments.

1.1 Physical Quantities and Units

1.1.1 Physical quantities

Physical quantity is a quantity that can be measured. Physical quantities can be classified into two: fundamental quantities and derived quantities. Quantities which cannot be expressed in terms of any other physical quantities are called fundamental quantities. Example: Length, mass, time, temperature. Quantities like area, volume and density can be expressed in terms of some other quantities. They are called derived quantities.

Physical quantities have a numerical value (a number) and a unit of measurement (say, 3 kilogram). Suppose you are buying

3 kilograms of vegetable in a shop. Here, 3 is the numerical value and kilogram is the unit. Let us see about units now.

1.1.2 Unit

A unit is the standard quantity with which unknown quantities are compared. It is defined as a specific magnitude of a physical quantity that has been adopted by law or convention. For example, feet is the unit for measuring length. That means, 10 feet is equal to 10 times the definite predetermined length, called feet. Our forefathers used units like muzham, furlong (660 feet), mile (5280 feet) to measure length.

Many of the ancient systems of measurement were based on the dimensions of human body. As a result, unit of measurement varied from person to person and also from location to location. In earlier time, different unit systems were used by people from different countries. Some of the unit systems followed earlier are given below in Table 1.

Table - 1 Unit systems of earlier times

System	Length	Mass	Time
CGS	centimetre	gram	second
FPS	foot	pound	second
MKS	metre	kilogram	second

But, at the end of the Second World War there was a necessity to use worldwide system of measurement. Hence, SI (International System of Units) system of units was developed and recommended by General Conference on Weights and Measures in 1960 for international usage.

1.2 SI System of Units

SI system of units is the modernised and improved form of the previous system of units. It is accepted in almost all the countries of the world. It is based on a certain set of fundamental units from which derived units are obtained by multiplication or division. There are seven fundamental units in the SI system of units. They are also known as base units as in Table 2.

The units used to measure the fundamental quantities are called fundamental units and the units which are used to measure derived quantities are called derived units.

Table - 2 Fundamental physical quantities and their units

Fundamental quantities	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Luminous intensity	candela	cd
Amount of substance	mole	mol

With the help of these seven fundamental units, units for other derived quantities are obtained and their units are given below in Table-3.

Fortnight: A fortnight is two weeks or 14 days.

Moment: If you ask someone to wait for a moment, you know it is a short period of time. But, how short? It is 1/40 th of an hour or 1.5 minutes.

Table - 3 Derived quantities and their units

S.No	Physical quantity	Expression	Unit
1	Area	length × breadth	m^2
2	Volume	area × height	m^3
3	Density	mass/volume	Kgm^{-3}
4	Velocity	displacement/time	ms^{-1}
5	Momentum	mass × velocity	$kgms^{-1}$
6	Acceleration	velocity/time	ms^{-2}
7	Force	mass × acceleration	$kgms^{-2}$ or N
8	Pressure	force/area	Nm^{-2} or Pa
9	Energy (work)	force × distance	Nm or J
10	Surface tension	force/length	Nm^{-1}

Atomus: The smallest amount of time imaginable to us is a twinkling of the eye. This is called atomus. Do you know the value of this? It is 1/6.25 seconds or 160 milliseconds.

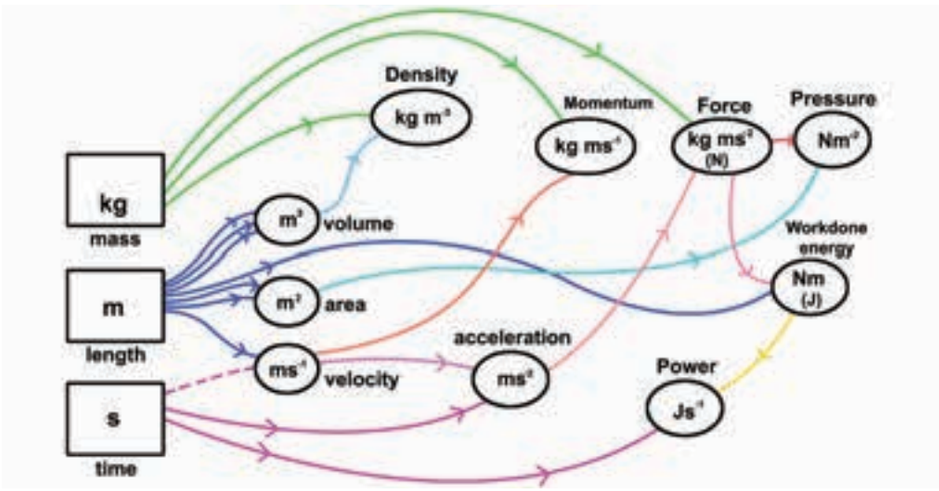
Donkey Power: You might have heard about horse power. But do you know donkey power? It is one third of a horse power. Its value is around 250 watt.

1.3 Fundamental Units of SI System

1.3.1 Length

Length is defined as the distance between two points. The SI unit of length is metre. One metre is the distance travelled by light through vacuum in 1/29,97,92,458 second.

In order to measure very large distance (distance of astronomical objects) we use the following units.



Flow chart for derived units

- Light year
- Astronomical unit
- Parsec

Light year: It is the distance travelled by light in one year in vacuum and it is equal to 9.46×10^{15} m.

Light travels 3×10^8 m in one second or 3 lakhs kilometre in one second. In one year we have 365 days. The total number of seconds in one year is equal to $365 \times 24 \times 60 \times 60 = 3.153 \times 10^7$ second.

1 light year = $(3.153 \times 10^7) \times (3 \times 10^8) = 9.46 \times 10^{15}$ m.

Astronomical unit (AU): It is the mean distance of the centre of the Sun from the centre of the earth. 1 AU = 1.496×10^{11} m Figure 1.

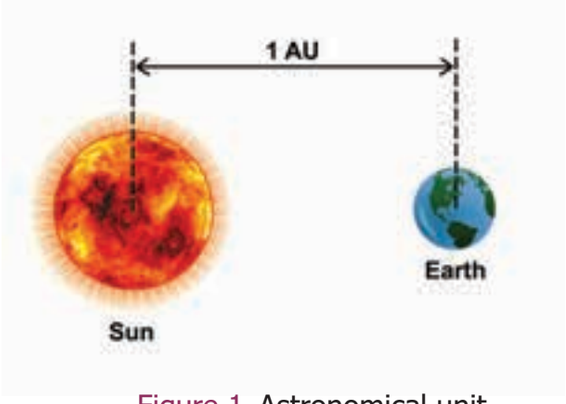


Figure 1 Astronomical unit

1 AU is equal to 14,95,97,871 km or approximately equal to 150 million km or 1,500 lakhs km.

Parsec: Parsec is the unit of distance used to measure astronomical objects outside the solar system.

1 parsec = 3.26 light year.

The nearest star alpha centauri is about 1.34 parsec from the sun. Most of the stars visible to the unaided eye in the night sky are within 500 parsec distance from the sun.

To measure small distances such as distance between two atoms in a molecule, the size of the nucleus and the wavelength, we use submultiples of ten. These quantities are measured in Angstrom unit (Table 4).

The total length of all the blood vessels in human body is 96,000 km.

When born, a baby giraffe is 1.8 m (6ft) tall.

A chameleons tongue is twice the length of its body.

Info bits

In Tamil Nadu, people still use some common length scales other than SI units. It is advisable to know the relationship between SI units with these length scales.

One feet = 30.4 cm, one meter =3.2 feet.

One inch = 2.54 cm, one meter is approximately equal to 40 inches.

These length scales are still used in hardware shops to measure house hold things like pipes, wood. Carpenters still use inch scale.

1.3.2 Mass

Mass is the quantity of matter contained in a body. The SI unit of mass is kilogram. One kilogram is the mass of a particular international

Table - 4 Smaller and larger units

Smaller units	In metre	Larger units	In metre
Fermi (f) *	10^{-15} m	Kilometre (km)	10^{3} m
Angstrom (Å)**	10^{-10} m	Astronomical unit (AU)	1.496×10^{11} m
Nanometre (nm)	10^{-9} m	Light year (ly)	9.46×10^{15} m
Micron (micrometre μ m)	10^{-6} m	Parsec (pc)	3.08×10^{16} m
Millimetre (mm)	10^{-3} m		
Centimetre (cm)	10^{-2} m		

* unit outside SI system and not accepted for use with it
** Non-SI unit accepted for use with it.

prototype cylinder made of platinum-iridium alloy, kept at the International Bureau of Weights and Measures at Sevres, France.

The related units in submultiples of 10 (1/10) are gram and milligram and in multiples of 10 are quintal and metric tonne.

1 quintal = 100 kg

1 metric tonne = 1000 kg = 10 quintal

1 solar mass = 2×10^{30} kg

Atomic mass unit (amu):

Mass of a proton, neutron and electron can be determined using atomic mass unit.

1 amu = 1/12th of the mass of carbon-12 atom.

More to Know

SI unit of volume is m^3 or cubic metre. Volume can also be measured in (l).

1 l = 1dm^3 = 1000 ml

1ml = 1cm^3

Mass of 1 ml of water = 1g

Mass of 1l of water = 1kg

Mass of the other liquids vary with their density.

DO YOU KNOW?

1 TMC is (thousand million cubic feet) hundred crore cubic feet.

1 TMC = 2.83×10^{10} litre.

1 TMC is approximately 3000 crore litres.

1.3.3 Time

Time is a measure of duration of events and the intervals between them. The SI unit of time is second. One second is the time required for the light to propagate 29,97,92,458 metres through vacuum. It is also defined as 1/86, 400th part of a mean solar day. Larger unit for measuring time is millennium. 1 millenium = 3.16×10^{9} s.

DO YOU KNOW?

In villages, people still use different time scales other than SI time units.

One hour = 2.5 Nazhikai (நாழிகை)

One day = 60 Nazhikai, Day time = 30 Nazhikai and Night time =30 Nazhikai.

In day time nazhikai starts at 6 am and ends at evening 6pm. Total nazhikai in

daytime= 12 hours × 2.5 Nazhikai = 30 Nazhikai. Similiarly in the night time the Nazhikai starts at 6 pm and ends next day at 6 am. Total nazhikai in night time =12 hours × 2.5 Nazhikai = 30 Nazhikai. For example, night 12 pm is equivalent to 15 Nazhikai (6 hours × 2.5 Nazhikai=15 nazhikai).

1.3.4 Temperature

Temperature is the measure of hotness. SI unit of temperature is kelvin(K). One kelvin is the fraction of 1/273.16 of the thermodynamic temperature of the triple point of water (The temperature at which saturated water vapour, pure water and melting ice are in equilibrium). Zero kelvin (0 K) is commonly known as absolute zero. The other units for measuring temperature are degree Celsius and Fahrenheit (Table 5). To convert temperature from one scale to another we use

$$C/100 = (F - 32)/180 = (K-273)/100$$

Example:

Convert (a) 300 K in to Celsius scale, (b) 104°F in to Celsius scale.

Solution

(a) Celsius = K-273 = 300-273 = 27°C

(b) Celsius = (F – 32) × 5/9 = (104-32) × 5/9 =72 × 5/9 = 40°C

Table - 5 Temperature conversion table

Units	Fahrenheit	Celsius	Kelvin
Fahrenheit (°F)	F	(F – 32) × 5/9	(F – 32) × 5/9 + 273
Celsius (°C)	(C × 9/5) + 32	C	C + 273
Kelvin (K)	(K – 273) × 9/5 + 32	K-273	K

1.4 Unit Prefixes

Unit prefixes are the symbols placed before the symbol of a unit to specify the order of magnitude of a quantity. They are useful to express very large or very small quantities. k(kilo) is the unit prefix in the unit, kilogram. A unit prefix stands for a specific positive or negative power of 10. k stands for 1000 or 10^3. Some unit prefixes are given in Table-6.

The physical quantities vary in different proportion like from 10^{-15} m being the diameter of nucleus to 10^{26} m being the distance between two stars and 9.11×10^{-31} kg being the electron mass to 2.2×10^{41} kg being the mass of the milky way galaxy.

Table – 6 Unit prefixes

Power of 10	Prefix	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m

Contd. on next page

Table – 6 Unit prefixes (*Contd*)

Power of 10	Prefix	Symbol
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

1.5 Rules and Conventions for Writing SI Units and their Symbols

1. The units named after scientists are not written with a capital initial letter. E.g. newton, henry, ampere and watt.
2. The symbols of the units named after scientists should be written by the initial capital letter. E.g. N for newton, H for henry, A for ampere and W for watt.
3. Small letters are used as symbols for units not derived from a proper noun. E.g. m for metre, kg for kilogram.
4. No full stop or other punctuation marks should be used within or at the end of symbols. E.g. 50 m and not as 50 m.
5. The symbols of the units are not expressed in plural form. E.g. 10 kg not as kgs.
6. When temperature is expressed in kelvin, the degree sign is omitted. E.g. 283 K not as 283° K (If expressed in Celsius scale, degree sign should be included e.g. 100° C not as 100 C, 108° F not as 108 F).
7. Use of solidus is recommended for indicating a division of one unit symbol by another unit symbol. Not more than one solidus is used. E.g. ms^{-1} or m/s. J/K/mol should be JK^{-1} mol^{-1}.
8. The number and units should be separated by a space. E.g. 15 $kgms^{-1}$ not as 15$kgms^{-1}$.
9. Accepted symbols alone should be used. E.g. ampere should not be written as amp and second should not be written as sec.
10. The numerical values of physical quantities should be written in scientific form. E.g. the density of mercury should be written as 1.36×10^4 kg m^{-3} not as 13600 kg m^{-3}.

1.6 Vernier Caliper and Screw Gauge

In our daily life, we use metre scale for measuring lengths. They are calibrated in cm and mm scales. The smallest length which can be measured by metre scale is called least count. Usually the least count of a scale is 1 mm. We can measure the length of objects up to mm accuracy using this scale. But this scale is not sufficient for measuring the size of small spherical objects. So, Vernier caliper and screw gauge are used.

Can you ask for milligram measures of groceries or gram measures of rice from the nearby shop? Can you ask for millimetre measure of cloth? What are the things that you could buy in smaller measures? Why?

1.6.1 Vernier scale

The diameters of spherical objects such as cricket ball and hollow objects such as a pen cap cannot be measured with a meter scale. For that we use an instrument named Vernier caliper which can measure the inner and outer diameters of objects.

Pierre Vernier (1580 – 1637) was a French government official. Vernier

was taught mathematics and science by his father who was a lawyer and engineer. He worked much of the time as an engineer, working on the fortifications of various cities. Like many other mathematicians and scientists of that period, Vernier worked on cartography and on surveying. His interest in surveying led him to develop instruments for surveying and this prompted the invention of a precise instrument called Vernier caliper.

1.6.2 Description of Vernier caliper

The Vernier caliper consists of a thin long steel bar graduated in cm and mm. This is the main scale. To the left end of the steel bar an upper and a lower jaw are fixed perpendicular to the bar. These are named as fixed jaws. To the right of the fixed jaws, a slider with an upper and a lower moveable jaw is fixed. The slider can be moved or fixed to any position using a screw. The Vernier scale is marked on the slider and moves along with the movable jaws and the slider. The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of objects. The thin bar attached to the right side of the Vernier scale is used to measure the depth of hollow objects.

1.6.3 Usage of Vernier caliper

The first step in using the Vernier caliper is to find out its least count, range and zero error.

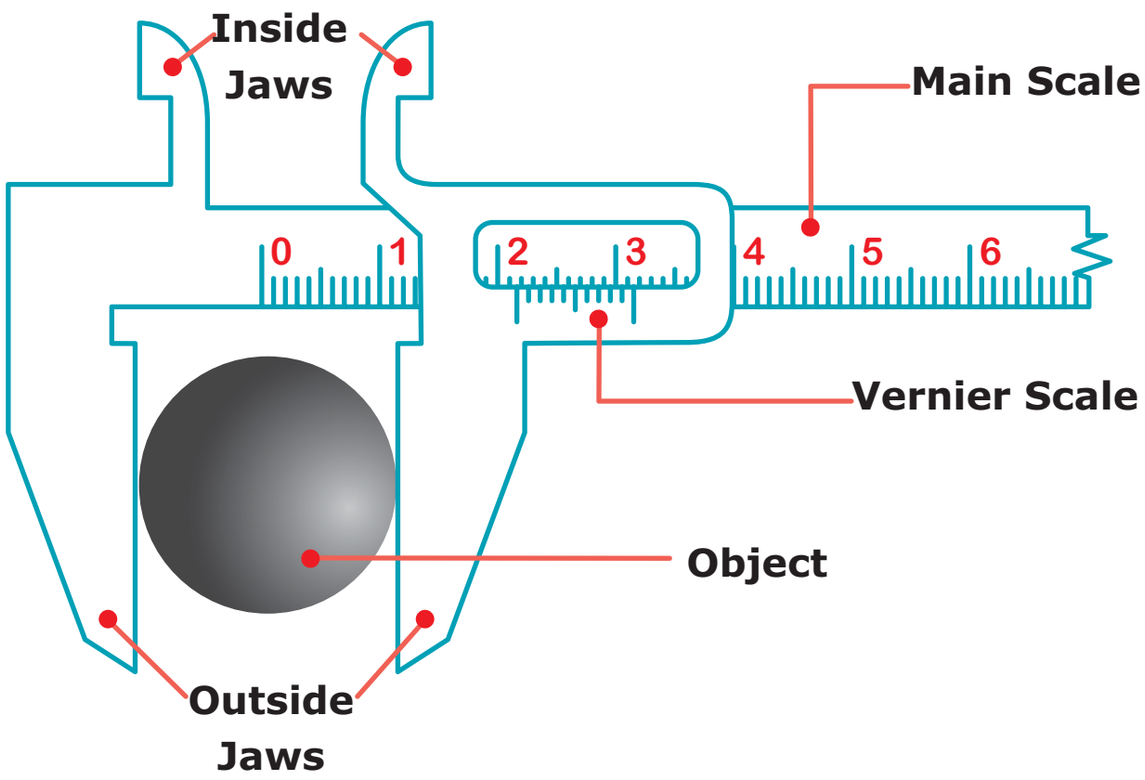


Figure 2 Vernier Caliper

Least count

$$\text{Least count of the instrument (L.C)} = \frac{\text{Value of one smallest main scale division}}{\text{Total number of vernier scale division}}$$

The main scale division can easily be obtained by inspecting the main scale. It will be in centimeter, further divided into millimetre. The value of the smallest main scale division is 1 mm. The Vernier scale division is obtained by counting number of division in it. In the Vernier scale there will be 10 divisions.

$$\text{L.C} = \frac{1\text{mm}}{10} = 0.1\text{mm} = 0.01\text{cm}$$

Zero error

Unscrew the slider and move it to the left, such that both the jaws touch each other. Check whether the zero marking of the main scale coincides with that of the Vernier scale. If they are not coinciding with each other, the instrument is said to posses zero error. Zero error may be positive or negative. If the zero mark of the Vernier is shifted to the right, it is called positive error. On the other hand, if the Vernier zero is shifted to the left of the main scale zero marking, then the error is negative.

Positive zero error

Figure 3(a) shows the positive zero error. From the figure you can see that zero of the vernier scale is shifted to the right of zero of the main scale. In this case the reading will be more than the actual reading. Hence, this error should be corrected. In order to correct this error, find out which vernier division is coinciding with any of the main scale divisions. Here, fifth vernier division is coinciding with a main scale division. So, positive zero error = +5 x LC = +5 x 0.01 = 0.05 cm.

(a)

(b)

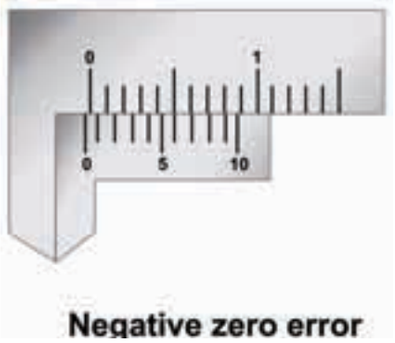


Figure 3 Positive zero error
Negative zero error

Negative zero error

Now look at the Figure 3(b). You can see that zero of the vernier scale is shifted to the left of the zero of the main scale. So, the obtained reading will be less than the actual reading. To correct this error we should first find which vernier division is coinciding with any of the main scale divisions, as we found in the previous case. In this case, you can see that sixth line is coinciding. But, to find the negative error, we can count backward (from 10). So, the fourth line is coinciding. Therefore, negative zero error = $-4 \times LC = -4 \times 0.01 = -0.04$ cm.

Example:

Calculate the positive and negative error from the given Figure 4.

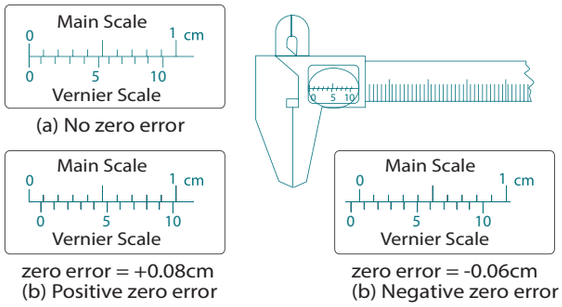


Figure 4 Zero error

Solution:

Case (a): Zero of the vernier scale and zero of the main scale are coinciding with each other. So there is no zero error.

Case (b): The zero of veriner scale is shifted to the right from the zero of the main scale. It is positive error. The 8th division of vernier scale coincides with one of the main scale divisions. So the positive error = (8×0.01cm) = 0.08 cm.

Case (c): The zero of veriner scale is shifted to the left from the zero of main scale. It is negative error. The 4th division of vernier scale (6^{th} from backward) coincides with one of the main scale divisions. So the negative zero error = −(6×0.01cm)= −0.06 cm.

Once you are able to calculate the zero error, you can get the correct reading using the formula:

The correct reading = Main scale reading + (VC × LC) ± (Zero correction)

Zero Correction:

If error is positive the we should subtract that error value. If error is negative, we should add that error value.

For example, let us calculate the correct reading, if the main scale reading is 8 cm, vernier coincidence is 4 and positive zero error is 0.05 cm,

The correct reading = 8 cm + (4 × 0.01cm) – 0.05 cm = 8 + 0.04 – 0.05 = 8 – 0.01 = 7.99 cm

Let us try another one. The main scale reading is 8 cm and vernier coincidence is 4 and negative zero error is 0.02 cm, then the correct reading:

= 8 cm+(4×0.01 cm)+(0.02 cm)

= 8+0.04+0.02 = 8.06 cm.

We can use Vernier caliper to find different dimensions of any familiar object. If the length, width and height of the object can be measured, volume can be calculated. For example, if we could measure the inner diameter of a beaker (using appropriate jaws) as well as its depth (using the depth probe) we can calculate its inner volume.

Example:

Calculate the diameter of the sphere which is shown in the Figure 5. Assume the scale has no zero error.

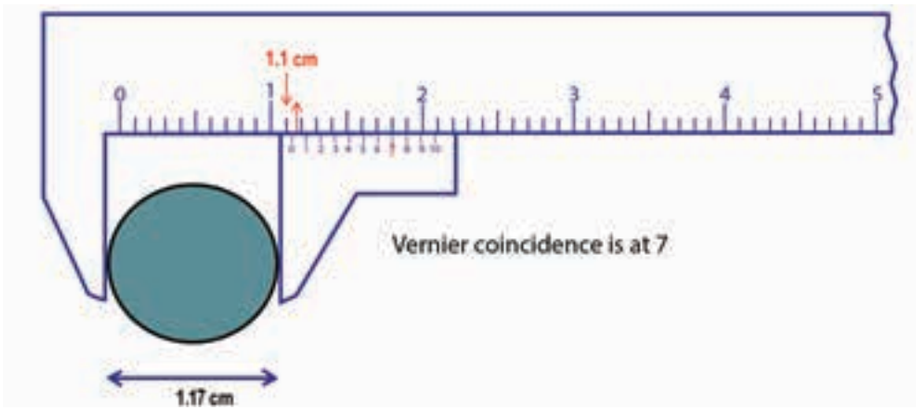


Figure 5 Measuring the diameter of a sphere

The diameter (D) of the sphere = Main scale reading (MSR) + (Vernier scale coincidence (VC) × least count (LC))± ZE. In this case the zero of the vernier scale is right after the main scale reading 1.1. So the main scale reading is 1.1 cm. The vernier scale coincidence is 7. The least count is 0.01 cm. The diameter of the sphere = 1.1 cm + (7 × 0.01cm)-0 = 1.1 + 0.07 = 1.17 cm.

1.6.4 Digital Vernier caliper

Today, we are living in a digital world and the digital version of the vernier callipers are available now. Digital Vernier caliper (Figure 6) has a digital display on the slider, which calculates and displays the measured value. The user need not manually calculate the least count, zero error etc.

Figure 6 Digital Vernier caliper

1.7 Screw Gauge

Measurements made with a Vernier caliper can be made in centimetre only. Hence to measure the length and thickness of very small objects we use a screw gauge. This instrument can measure the dimensions upto $1/100^{th}$ of a millimetre or 0.01 mm. With the screw gauge it is possible to measure the diameter of a thin wire and the thickness of thin metallic plates.

1.7.1 Description of screw gauge

The screw gauge consists of a U shaped metal frame. A hollow cylinder is attached to one end of the frame. Grooves are cut on the inner surface of the cylinder through which a screw passes (Figure 7).

Activity 1

Find the inner diameter and the depth of a tea cup with Vernier caliper. Record the observation in the table given below.

S.NO		Main Scale Reading MSR × 10^{-2} m	Vernier Scale coincidence	Observed reading OR = MSR + (LC × VC)	Corrected reading = OR ± ZC
Inner diameter	1				
	2				
	3				
	4				
				Average (D)	
depth r = D/2	1	$V = \pi r^2 h$			
	2				
	3				
	4				
				Average (h)	

On the cylinder parallel to the axis of the screw there is a scale which is graduated in millimetre called Pitch Scale (PS). One end of the screw is attached to a sleeve. The head of the sleeve (Thimble) is divided into 100 divisions called the Head scale.

The end of the screw has a plane surface (Spindle). A stud (Anvil) is attached to the other end of the frame, just opposite to the tip of the screw. The screw head is provided with a ratchat arrangement (safety device) to prevent the user from exerting undue pressure.

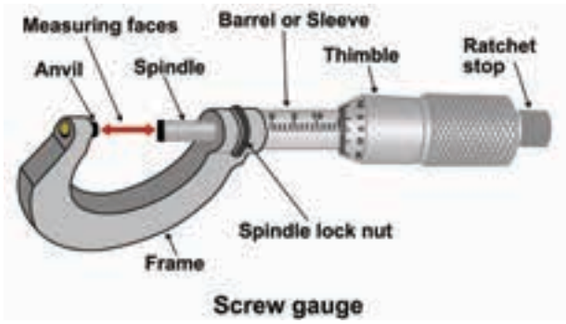


Figure 7 Screw gauge

1.7.2 Using the screw gauge

The screw gauge works on the principal that when a screw is rotated in a nut, the distance moved by the tip of the screw is directly proportional to the number of rotations.

Pitch of the screw

The pitch of the screw is the distance between two successive screw threads. It is also equal to the distance travelled by the tip of the screw for one complete rotation of the head. It is equal to 1 mm in typical screw gauges.

EJL12G

$$\text{Pitch of the screw} = \frac{\text{Distance moved by the Pitch}}{\text{No. of rotations by Head scale}}$$

Least count of a screw gauge

The distance moved by the tip of the screw for a rotation of one division on the head scale is called the least count of the screw gauge.

$$\text{Least count of the instrument (L.C.)} = \frac{\text{Value of one smallest pitch scale reading}}{\text{Total number of Head scale division}}$$

$$LC = \frac{1}{100} = 0.01 \text{ mm}$$

Zero Error of a screw gauge

When the plane surface of the screw and the opposite plane stud on the frame area brought into contact, if the zero of the head scale coincides with the pitch scale axis there is no zero error (Figure 8).

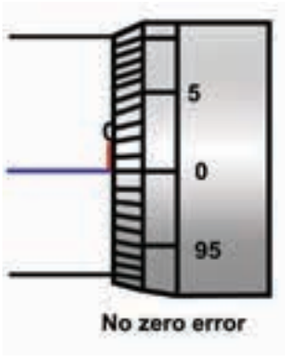


Figure 8 No Zero Error

Positive zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies below the pitch scale axis, the zero error is positive (Figure 9). For example, the 5th division of the head scale coincides with the pitch scale axis, then the zero error is positive and is given by

Z.E = + (n × LC) where 'n' is the head scale coincidence. In this case, Zero error = + (5 × 0.01) = 0.05mm. So the zero correction is – 0.05 mm.

Figure 9 Positive Zero Error

Negative zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies above the pitch scale axis, the zero error is negative (Figure 10). For example, the 95th division coincides with the pitch scale axis, then the zero error is negative and is given by

$$ZE = -(100 - n) \times LC$$
$$ZE = -(100 - 95) \times LC$$
$$= -5 \times 0.01$$
$$= -0.05 \text{ mm}$$

The zero correction is + 0.05mm.

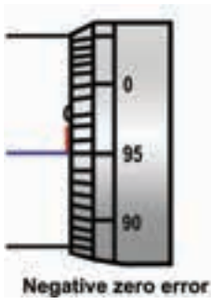


Figure 10 Negative Zero Error

1.7.3 To measure the thickness of a thin coin using a screw gauge

- Determine the pitch, the least count and the zero error of the screw gauge
- Place the coin between the two studs
- Rotate the head until the coin is held firmly but not tightly, with the help of the ratchat
- Note the reading of the pitch scale crossed by the head scale (PSR) and the head scale division that coincides with the pitch scale axis (HSC)
- The width of the coin is given by PSR + CHSR (Corrected HSR). Repeat the experiment for different positions of the coin
- Tabulate the readings
- The average of the last column readings gives the width of the coin

Activity 2

Using screw gauge or Vernier caliper find the outer diameter of your pen cap.

Activity-2

S.No	P.S.R (mm)	H.S.C (division)	CHSC = HSC ± ZC (Division)	CHSR = CHSC × LC (mm)	Total reading = PSR + CHSR (mm)
1					
2					
3					
					mean = mm

Width of the coin = mm

Activity 3

Can you determine the thickness of a single sheet of your science textbook? Justify the answer.

DO YOU KNOW?

The shell of an egg is 12% of its mass. A blue whale can weigh as much as 30 elephants and it is as long as 3 large tour buses.

1.8 Measuring Mass

We commonly use the term 'weight' which is actually the 'mass'. Many things are measured in terms of 'mass' in the commercial world. The SI unit of mass is kilogram. In any case, the units are based on the items purchased. For example, we buy gold in gram or milligram, medicines in milligram, provisions in gram and kilogram and express cargo in tonnes.

Can we use the same instrument for measuring the above listed items? Different measuring devices have to be used for items of smaller and larger masses. In this section we will study about some of the instruments used for measuring mass.

Common (beam) balance

A beam balance compares the sample mass with a standard reference mass. (Standard reference masses are 5g, 10g, 20g, 50g, 100g, 200g, 500g, 1kg, 2kg, 5kg). This balance can measure mass accurately up to 5g (Figure 11).

Figure 11 Common beam balance

Two pan balance

This type of balance is commonly used in provision and grocery shops (Figure 12). This balance compares the sample mass with the standard reference mass. The pans rest on top of the beam and can be conveniently placed on a table top. This balance can measure mass accurately upto 5 g.

Figure 12 Two pan balance

Physical balance

This balance is used in labs and is similar to the beam balance but it is a lot more sensitive and can measure mass of an object correct to a milligram (Figure 13).

The standard reference masses used in this physical balance are 10 mg, 20 mg, 50 mg, 100 mg, 200 mg, 500 mg, 1 g, 2g, 5 g, 10 g, 20 g, 50 g, 100g, and 200 g.

Figure 13 Physical balance

Activity 4

Visit a provision shop, grocery shop, jewellery shop, timber mart and a heavy vehicle weighing bridge with the guidance of your teacher. Observe the different devices used for measuring the accurate mass and the operating range of the device used in each case.

Digital balance

Nowadays for accurate measurements digital balances are used, which measures mass accurately even up to a few milligrams, the least value being 10 mg (Figure 14). This electrical device is easy to handle and commonly used in jewellery shops and labs.

Figure 14 Digital balance

Activity 5

With the resources available at home such as paper plates, tea cups, thread and sticks make a model of an ordinary balance. Using standard masses find the mass of some objects.

Spring balance

This balance helps us to find the weight of an object. It consists of a spring fixed at one end and a hook attached to a rod at the other end. It works by 'Hooke's law' which explains that the addition of weight produces a proportional increase in the length of the spring (Figure 15). A pointer is attached to the rod which slides over a graduated scale on the right. The spring extends according to the weight attached to the hook and the pointer reads the weight of the object on the scale.

Figure 15 Spring balance

Solve – The mass of 40 apples in a box is 10 kg. (i) Find the mass of a dozen of them (ii) Express the mass of one apple in gram.

1.8.1 Difference between mass and weight

Mass (m) is the quantity of matter contained in a body. Weight (w) is the normal force (N) exerted by the surface on the body to balance against gravitational pull on the object. In the case of spring scale the tension in the spring balances the gravitational pull on the object. When the man is standing on the surface of the earth or floor, the surface exerts a normal force on the body which is equivalent to gravitational force. The gravitational force acting on the object is given by 'mg'. Here m is mass of the object and 'g' is acceleration due to gravity.

If a man has a mass 50 kg on the earth, then what is his weight?

Weight (w) = mg
Mass of a man = 50 kg
His weight = 50 × 9.8
w = 490 newton

Mass	Weight
1. Fundamental quantity	Derived quantity
2. Has magnitude alone – scalar quantity	Has magnitude and direction – vector quantity
3. It is the amount of matter contained in a body	It is the normal force exerted by the surface on the object against gravitational pull
4. Remains the same	Varies from place to place

Mass	Weight
5. It is measured using physical balance	It is measured using spring balance
6. Its unit is kilogram	Its unit is newton

The pull of gravity on the Moon is 1/6 times weaker than that on the Earth. This causes the weight of the object on the Moon to be less than that on the Earth.

Acceleration due to gravity on the Moon = $1.63 m/s^2$

If the mass of a man is 70 kg then his weight on the Earth is 686 N and on the Moon is 114 N. But his mass is still 70 kg on the Moon.

1.9 Accuracy in Measurements

When measuring physical quantities, accuracy is important. Accuracy represents how close a measurement comes to a true value. Accuracy in measurement is center in engineering, physics and all branches of science. It is also important in our daily life. You might have seen in jewellery shops how accurately they measure gold. What will happen if little more salt is added to food while cooking? So, it is important to be accurate when taking measurements.

Faulty instruments and human error can lead to inaccurate values. In order to get accurate values of measurement, it is always important to check the correctness of the measuring instruments. Also, repeating the measurement and getting the average value can correct the errors and give us accurate value of the measured quantity.

Points to remember

- Length, mass, time, temperature, electric current, intensity and mole are the fundamental units in SI system
- To find the length or thickness of smaller dimensions Vernier caliper or screw gauge are used
- Austronomical unit is the mean distance of the sun from center of the earth $1AU=1.496 \times 10^{11}m$
- Light year is the distance travelled by light in one year in vacuum. 1 Light year = $9.46 \times 10^{15}m$
- Parsec is the unit distance used to measure astronomical objects outside the solar system
- 1 Angstrom (Å) = 10^{-10} m
- SI Unit of volume is cubic metre or m^3. Generally volume is represented in litre (l). $1ml=1cm^3$
- C/100 = (F -32)/180 = (K -273)/100
- Least count of screw gauge is 0.01 mm. Lease count of Vernier caliper is 0.01 cm
- Common balance can measure mass accurately upto 5 g
- Accuracy of physical balance is 10 mg

A-Z GLOSSARY

1. **Metre [m]** The metre is the basic unit of length. It is the distance light travels, in a vacuum, in $1/299792458^{th}$ of a second.
2. **Kilogram [kg]** The kilogram is the basic unit of mass. It is the mass of an international prototype in the form of a platinum-iridium cylinder kept at Sevres in France. It is now the only basic unit still defined in terms of a material object, and also the only one with a prefix [kilo] already in place.

3. **Second [s]** The second is the basic unit of time. It is the length of time taken for 9192631770 periods of vibration of the Caesium-133 atom to occur.
4. **Ampere [A]** The ampere is the basic unit of electric current. It is that current which produces a specified force between two parallel wires which are 1 metre apart in a vacuum.
5. **Kelvin [K]** The kelvin is the basic unit of temperature. It is $1/273.16^{th}$ of the thermodynamic temperature of the triple point of water.
6. **Mole [mol]** The mole is the basic unit of a substance. It is the amount of the substance that contains as many elementary units as there are atoms in 0.012 kg of carbon-12.
7. **Candela [cd]** The candela is the basic unit of luminous intensity. It is the intensity of a source of light of a specified frequency, which gives a specified amount of power in a given direction.
8. **Farad [F]** The farad is the SI unit of the capacitance of an electrical system, that is, its capacity to store electricity. It is rather a large unit as defined and is more often used as a microfarad.
9. **Joule [J]** The joule is the SI unit of work or energy. One joule is the amount of work done when an applied force of 1 newton moves through a distance of 1 metre in the direction of the force.
10. **Newton [N]** The newton is the SI unit of force. One newton is the force required to give a mass of 1 kilogram an acceleration of 1 metre per second^2.
11. **Ohm [Ω]** The ohm is the SI unit of resistance of an electrical conductor. Its symbol is the capital Greek letter 'omega'.
12. **Pascal [Pa]** The pascal is the SI unit of pressure. One pascal is the pressure generated by a force of 1 newton acting on an area of 1 square metre. It is rather a small unit as defined and is more often used as a kilopascal [kPa].
13. **Volt [V]** The volt is the SI unit of electric potential. One volt is the difference of potential between two points of an electical conductor when a current of 1 ampere flowing between those points dissipates a power of 1 watt.
14. **Watt [W]** The watt is used to measure power or the rate of doing work. One watt is a power of 1 joule per second. Electrical power V × I = W.

ICT CORNER

MEASUREMENT - VERNIER CALIPER

Vernier is a visual aid that helps the user to measure the internal and external diameter of the object.

This activity helps the students to understand the usage better

Step 1. Type the following URL in the browser or scan the QR code from your mobile. Youcan see"Vernier caliper" on the screen.

Step 2. The yellow colour scale is movable. Now you can drag and keep the blue colour cylinder in between. Now you can measure the dimension of the cylinder. Use the + symbol to drag cylinder and scale.

Step 3. Now go to the place where you can enter your answer. An audio gives you the feedback and you can see the answer on the screen also

B121_9_SCI_EM

https://play.google.com/store/apps/details?id=com.ionicframework.vernierapp777926

EXERCISE

EJUH44

I. Multiple Choice Questions

1. Choose the correct one
   a. mm< cm < m < km
   b. mm > cm > m > km
   c. km < m < cm < mm
   d. mm > m> cm> km
2. Rulers, measuring tapes and metre scales are used to measure
   a. Mass
   b. Weight
   c. Time
   d. Length
3. 1 metric ton is equal to
   a. 100 quintals b. 10 quintals
   c. 1/10 quintals d. 1/100 quintals
4. Distance between Chennai and Kanyakumari can be found in
   a. Kilometres b. Metres
   c. Centimetres d. Millimetres
5. Which among the following is not a device to measure mass?
   a. Spring balance
   b. Beam balance
   c. Physical balance
   d. Digital balance

II. Fill in the blanks

1. Metre is the unit of _____
2. 1 kg of rice is weighed by _____
3. The thickness of a cricket ball is measured by _____
4. The radius of a thin wire is measured by _____
5. A physical balance measures small differences in mass up to _____

III. True or False

1. The SI unit of electric current is kilogram
2. Kilometre is one of the SI units of measurement
3. In everyday life, we use the term weight instead of mass.
4. A physical balance is more sensitive than a beam balance as it can accurately measure even a very small mass, even milligram
5. One Celsius degree is an interval of 1K and zero degree Celsius is 273.15 K.

IV. Match the following

1.

Column I	Column II
Length	Kelvin
Mass	metre
Time	kilogram
Temperature	second

2.

Column I	Column II
Screw gauge	Vegetables
Vernier caliper	Coins
Beam balance	Gold ornaments
Digital balance	Cricket ball

3.

Column I	Column II
Temperature	Beam balance
Mass	Ruler
Length	Digital clock
Time	Thermometre

V. Assertion and reason type

1. Assertion (A): The SI systems of units is the improved system of units for measurement.

Reason (R): The SI unit of mass is kilogram

a. Both A and R are true but R is not the correct reason

b. Both A and R are true and R is the correct reason

c. A is true but R is false

d. A is false but R is true

2. Assertion (A): The skill of estimation is important for all of us in our daily life.

Reason (R): The skill of estimation reduces our consumption of time

a. Both A and R are true but R is not the correct reason

b. Both A and R are true and R is the correct reason

c. A is true but R is false

d. A is false but R is true

3. Assertion(A): The scientifically correct expression is " The mass of the bag is 10 kg"

Reason (R): In everyday life, we use the term weight instead of mass

a. Both A and R are true but R is not the correct reason

b. Both A and R are true and R is the correct reason

c. A is true but R is false

d. A is false but R is true

4. Assertion (A): 0 °C = 273.16 K. For our convenience we take it as 273 K after rounding off the decimal

Reason (R): To convert a temperature on the Celsius scale you have to add 273 to the given temperature

a. Both A and R are true but R is not the correct reason

b. Both A and R are true and R is the correct reason

c. A is true but R is false

d. A is false but R is true

5. Assertion (A): The distance between two celestial bodies is measured in the unit of light year

Reason (R): The distance travelled by the light in one year is one light year

a. Both A and R are true but R is not the correct reason

b. Both A and R are true and R is the correct reason

c. A is true but R is false

d. A is false but R is true

VI. Comprehensive type

Read the passage and answer the questions given below.

Mass is the amount of matter contained in an object. Measurement of mass helps us to distinguish between a lighter and a heavier body. Beam balance, spring balance and electronic balance are used to measure mass of different objects. The SI unit of mass is the kilogram (kg). But different units are used to measure the mass of different objects. E.g. weight (mass) of a tablet is measured in milligrams (mg), weight of a student is measured in kilogram (kg) and weight of a truck with goods is measured in metric tons. 1 metric ton is equal to 10 quintals and 1 quintal is equal to 100 kg. 1 gram is equal to 1000 mg.

1. The value of 1 metric ton is equal to

a. 1000 kg b. 10 quintals

c. 10,00,000 g d. 100 kg

2. How will you measure the weight of a tablet?

a. kg b. g

c. mg d. None of these

VII. Very short answer type

1. Define measurement.

2. Define standard unit.

3. What is the full form of SI system?

4. Define least count of any device.

5. What do you know about pitch of screw gauge?
6. Can you find the diameter of a thin wire of length 2 m using the ruler from your instrument box?

VIII. Short answer type

1. Write the rules that are followed in writing the symbols of units in SI system.
2. Write the need of a standard unit
3. Differentiate mass and weight
4. What is the measuring unit of the thickness of a plastic carry bag?
5. How will you measure the least count of vernier caliper?

IX. Numerical Problem

1. Inian and Ezhilan argue about the light year. Inian tells that it is 9.46×10^{15} m and Ezhilan argues that it is 9.46×10^{12} km. Who is right? Justify your answer.
2. The main scale reading while measuring the thickness of a rubber ball using Vernier caliper is 7 cm and the Vernier scale coincidence is 6. Find the radius of the ball.
3. Find the thickness of a five rupee coin with the screw gauge, if the pitch scale reading is 1 mm and its head scale coincidence is 68.
4. Find the mass of an object weighing 98 N.

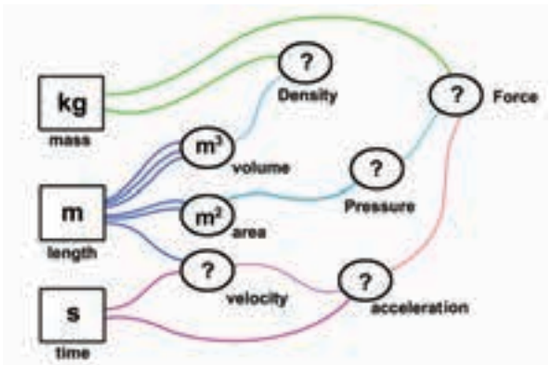
X. Long answer type

1. Explain a method to find the thickness of a hollow tea cup.
2. How will you find the thickness of a one rupee coin?
3. Find out any 'ten words' related to measurement from the grid.

A	C	C	U	R	A	T	E	V	B
N	U	O	P	I	E	R	R	E	E
A	B	N	I	S	N	I	R	R	A
L	I	S	T	C	D	A	O	N	M
O	T	T	C	R	F	L	R	I	B
G	Z	A	H	E	H	S	M	E	A
U	Y	N	E	W	T	O	N	R	L
E	G	T	R	A	I	L	E	R	L
L	E	A	S	T	C	O	U	N	T
K	E	L	V	I	N	O	T	E	C
X	B	E	A	M	B	A	N	C	E

XII. Activity - 6

Complete the flow chart



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1. Units and measurements – John Richards, S. Chand publishing, Ram nagar, New Delhi.
2. Units of Measurement - Past, Present and Future. International System of Units - Gupta, S. V. eBook ISBN 978-3-642-00738-5 DOI 10.1007/978-3-642-00738-5
3. Complete physics(IGCSE) - Oxford University press, New York
4. Practical physics – Jerry. D. Wilson – Saunders college publishing, USA

INTERNET RESOURCES

http://www.npl.co.uk/reference/measurement-units/

http://www.splung.com/content/sid/1/page/units

http://www.edinformatics.com/math_science/units.htm

https://www.unc.edu/~rowlett/units/dictA.html

https://study.com/academy/lesson/standard-units-of-measure.html

UNIT 2

Motion

Learning Objectives

EK4S5R

Students will be able to

- list the objects which are at rest and which are in motion around them
- understand distance and displacement
- determine the displacement and distance covered by an object describing a circular path
- classify the motion of vehicles as uniform motion and non-uniform motion
- distinguish between speed and velocity
- relate accelerated and unaccelerated motion
- deduce the equations of motion of an object from velocity – time graph
- write the equations of motion for a freely falling body
- understand the nature of circular motion
- identify centripetal force and centrifugal force in day to day life

Introduction

Every object undergoes motion, even stationary objects move along with the speed of earth.

Hence it becomes necessary to study the state of an object at any instant of time. An object under the influence of forces may either be at rest or in motion.

2.1 State of Rest and Motion

Activity 1

Look around you! What do you see? Many things, a row of houses, large trees, small plants, flying birds, running cars and buses and many more

- List the objects which remain fixed at their position, and do not change their position and
- List the objects which keep on changing their position

In physics, the objects which do not change their position are said to be at rest, while those which change their position are said to be in motion. Example: A book lying on a table, the walls of a room (at rest) Cars and buses running on the road, birds and aeroplanes flying in air (in motion). Motion is a relative phenomenon. This means that an object appearing to be in motion to one person can appear to be at rest as viewed

by another person. For example, trees on roadside would appear to move backward for a person travelling in a car while the same tree would appear to be at rest for a person standing on road side.

2.2 Types of Motion

Activity 2

Have you ever gone to an amusement park? Have you seen the motion of a giant wheel? List various types of motion of the play machines like children train, dragula ride, etc.

In physics, motion can be classified under the following types for ease of understanding.

Linear motion – where the object moves along a straight line.

Circular motion – where the object moves along a circular path.

Oscillatory motion – where an object describes a repetitive to and fro movement retracing its original path.

Uniform motion – where an object travels equal distance in equal intervals of time.

Random motion – where the motion of the object does not fall in any of the above categories.

2.3 Distance and Displacement

2.3.1 Distance

The actual length of the path travelled by a moving body irrespective of the direction is called the distance travelled by the body. It is measured in metre in SI system. It is a scalar quantity having magnitude only.

2.3.2 Displacement

It is defined as the change in position of a moving body in a particular direction. It is vector quantity having both magnitude and direction. It is also measured in metre in SI system.

Activity 3

Observe the motion of a car as shown in the Figure 1.

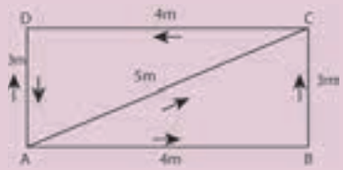


Figure 1 Motion of a car

Now answer the following questions:

1. How much distance is covered by the car through the path ABC and AC and compare the values? From this what do you observe?
2. Which path gives the shortest distance to reach D from A? Either the path ABCD or the path ACD or the path AD. Think!
3. What is the total distance covered by the car when it travels the path ABCDA and where does it finally reach? From this what do you understand? How much distance it covers? What is its displacement?

Activity 4

Tabulate the differences between distance and displacement.

2.4 Uniform and Non Uniform Motion

Activity 5

Tabulate the distance covered by a bus in a heavy traffic road in equal intervals of time and do the same for a train which is not in an accelerated motion. From this table what do you understand?

The bus covers unequal distance in equal intervals of time but the train covers equal distances in equal intervals of time.

2.4.1 Uniform motion

An object is said to be in uniform motion if it covers equal distances in equal intervals of time how so ever big or small these time intervals may be.

For example, suppose a car covers 60 km in first hour, another 60 km in second hour, and again 60 km in the third hour and so on. The motion of the car is uniform. Let us now understand the meaning of the words "how so ever small the time interval may be" used in the definition. In this example, the car travels a distance of 60 km in each hour. In the striker sense, the car should travel 30 km in each half an hour, 15 km in every 15 minutes, 10 km in every 10 minutes, 5 km in every 5 minutes and 1 km in every 1 minute. Only then the motion of the car can be said to be uniform.

2.4.2 Non uniform motion

An object is said to be in non uniform motion if it covers unequal distances in equal intervals of time.

EKDN7E

Consider a bus starting from one stop. It proceeds slowly when it passes crowded area of the road. Suppose, it manages to travel merely 100 m in 5 minutes due to heavy traffic, when it gets out and the road is clear, it speeds up and is able to travel about 2 km in 5 minutes.

We say, the motion of the bus is non uniform i.e. it travels unequal distances in equal intervals of time.

2.5 Speed, Velocity and Acceleration

2.5.1 Speed

Speed is the rate of change of distance or the distance travelled in unit time. It is a scalar quantity. The SI unit of speed is ms^{-1}. Thus,

Speed = Distance travelled / time taken

2.5.2 Velocity

EKMJ92

Velocity is the rate of change of displacement. It is the displacement in unit time. It is a vector quantity. The SI unit of velocity is ms^{-1}. Thus,

Velocity = Displacement / time taken

2.5.3 Acceleration

Acceleration is the rate of change of velocity or it is the change of velocity in unit time. It is a vector quantity. The SI unit of acceleration is ms^{-2}.

Acceleration = Change in velocity/time
= (Final velocity – initial velocity)/time
$a = (v-u)/t$

Consider a situation in which a body moves in a straight line without reversing its direction.

Case 1: From the above equation if $v > u$, i.e. if final velocity is greater than

Compare speed and velocity

Speed	Velocity
It is the rate of change of distance	It is the rate of change of displacement
It is a scalar quantity having magnitude only	It is a vector quantity having both magnitude and direction
It is measured in ms^{-1} in SI system	It is also measured in ms^{-1} in SI system
Speed in any direction would be a positive quantity, since the distance in any direction is a positive quantity.	Velocity can have both positive and negative values. If velocity in one direction is assumed to be positive then the velocity in the opposite direction would be a negative quantity. Velocity can have zero value also, even for an object under motion.

initial velocity, the velocity increases with time and the value of acceleration is positive.

Case 2: If v < u, i.e. if final velocity is less than initial velocity, the velocity decreases with time and the value of acceleration is negative. It is called negative acceleration.

Note

Negative acceleration is called retardation or deceleration.

If the acceleration has a value of $-2\ ms^{-2}$ when we say that the retardation is $2\ ms^{-2}$ or deceleration is $2\ ms^{-2}$.

Case 3: If v = u, then a = 0. This means that the acceleration is zero when the final velocity is equal to initial velocity

2.6 Graphical Representation of Motion along a Straight Line

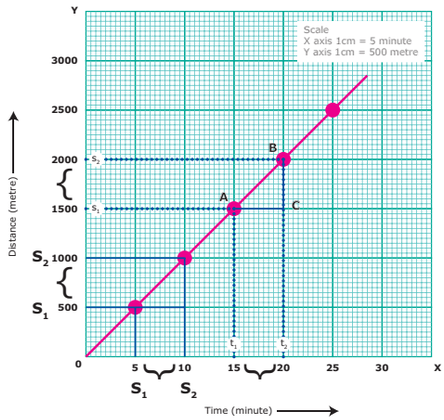
Plotting the distance/displacement or speed/velocity on a graph helps us visually understand certain things about time and position.

2.6.1 The distance – time graph for uniform motion

The following Table shows the distance walked by Surya at different times.

Time (minute)	Distance (metre)
0	0
5	500
10	1000
15	1500
20	2000
25	2500

A graph is drawn by taking time along X-axis and distance along Y-axis. The graph is known as distance – time graph. When we look at the distance – time graph of Surya's walk, we notice certain things. First, it is a straight line. We also notice that Surya covers equal distances in



equal intervals of time. We can therefore conclude that Surya walked at a constant speed. Can you find the speed at which Surya walked, from the graph? Yes, you can. The parameter is referred to as the slope of the line.

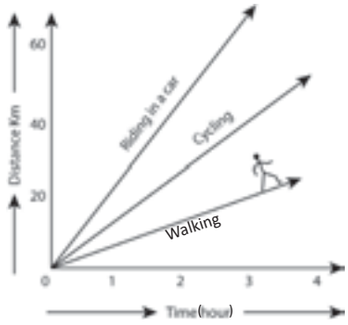
Speed at which Surya walked = distance covered / time taken = BC/AC (From the graph)

= slope of the straight line

= 500 / 5 = 100 ms^{-1}

Steeper the slope (in other words the larger value) the greater is the speed.

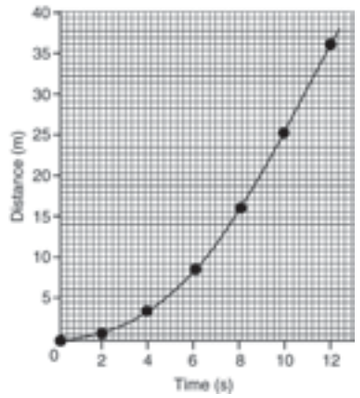
Let us take a look at the distance – time graphs of three different people – Surya walking, Monica cycling and Hari going in a car, along the same path. We know that cycling can be faster than walking and a car can go faster than a cycle. The distance – time graph of the three would be as given in the following graph. The slope of the line on the distance – time graph becomes steeper and steeper as the speed increases.



2.6.2 The distance time graph for non uniform motion

We can also plot the distance – time graph for accelerated motion (non uniform motion). Table given below shows the distance travelled by a car in a time interval of two second.

Time (second)	Distance (metre)
0	0
2	1
4	4
6	9
8	16
10	25
12	36

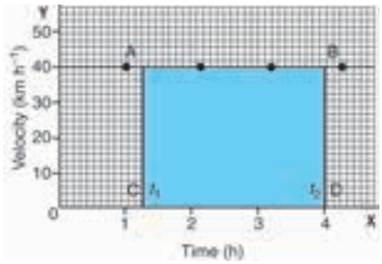


Note that the graph is not a straight line as we got in the case of uniform motion. This nature of the graph shows non – linear variation of the distance travelled by the car with time. Thus, the graph represents motion with non uniform speed.

2.6.3 Velocity – Time graph

The variation in velocity of an object with time can be represented by velocity – time graph. In the graph, time is represented along the X – axis and the velocity is represented along the Y – axis. If the object moves at uniform velocity, a straight line parallel to

X-axis is obtained. This Graph shows the velocity – time graph for a car moving with uniform velocity of 40 km/hour.



We know that the product of velocity and time gives displacement of an object moving with uniform velocity.

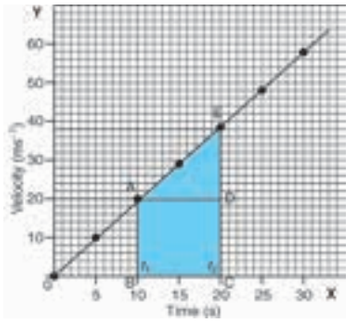
The area under the velocity – time graph is equal to the magnitude of the displacement.

So the distance (displacement) S covered by the car in a time interval of t can be expressed as

S = AC × CD
S = Area of the rectangle ABCD (shaded portion in the graph)

We can also study about uniformly accelerated motion by plotting its velocity – time graph. Consider a car being driven along a straight road for testing its engine. Suppose a person sitting next to the driver records its velocity for every 5 seconds from the speedometer of the car. The velocity of the car in ms^{-1} at different instants of time is shown in the Table below.

Time (Second)	Velocity of the Car (ms^{-1})
0	0
5	9
10	18
15	27
20	36
25	45
30	54



In this case, the velocity – time graph for the motion of the car is shown in graph (straight line). The nature of the graph shows that the velocity changes by equal amounts in equal intervals of time. Thus, for all uniformly accelerated motion, the velocity – time graph is a straight line.

One can also determine the distance moved by the car from its velocity – time graph. The area under the velocity – time graph gives the distance (magnitude of displacement) moved by the car in a given interval of time.

Since the magnitude of the velocity of the car is changing due to acceleration, the distance S travelled by the car will be given by the area ABCDE under the velocity – time graph. That is

S = area ABCDE
= area of the rectangle ABCD + area of the triangle ADE

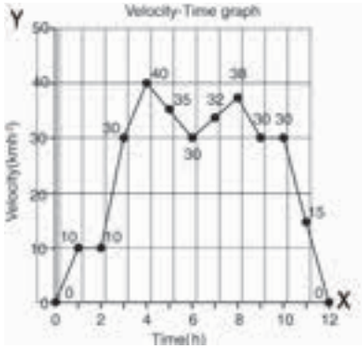
S = (AB × BC) + ½ (AD × DE)

The area ABCDE can also be calculated by considering the shape as trapezium. Area of the quadrangle ABCDE can also be calculated by calculating the area of trapezium ABCDE. It means

S = area of trapezium ABCDE
= ½ × sum of length of parallel sides × distance between parallel sides

S = ½ × (AB + CE) × BC

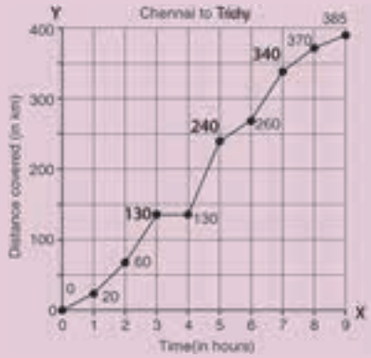
In the case of non uniformly accelerated motion, distance – time graph, velocity – time graphs can have any shape as shown in Figure below:



Study the velocity – time graph of the car and answer the following questions:

- *What was the maximum value of velocity during the journey?*
- *Was the velocity constant during any part of the journey? If so, when was it?*
- *What was the maximum value of acceleration during the journey? When did it occur?*
- *When did the car slow down?*
- *What was the value of acceleration during the period between 10^{th} and 12^{th} hour?*

Activity 6



The whole class can divide themselves into small groups, study the distance-time graph of the bus travelling from Chennai to Trichy and discuss the questions given below:

- *What is the total distance between Chennai and Trichy?*
- *How long did the bus take for the full journey?*
- *Was the speed of the bus constant?*
- *Did the bus halt for a while during the journey?*
- *If it halted, how long was the halt?*
- *Simply, by looking at the inclination of the graph line, can you tell when the speed was the greatest?*
- *What was the maximum speed that the bus attained during the journey?*

The magnitude of instantaneous velocity is equal to the instantaneous speed at the given instant. The speedometer of an automobile measures the instantaneous speed of the automobile. In a uniform motion in one dimension, the average velocity = instantaneous velocity. Instantaneous velocity is also called velocity and instantaneous speed also called simply speed.

2.7 Equations of Motion

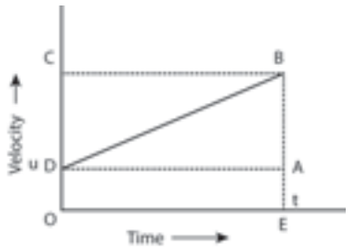
Newton studied the motion of an object and gave a set of three equations of motion. These equations relate the displacement, velocity, acceleration and time of an object under motion. An object is in motion with initial velocity u attains a final velocity v in time t due to acceleration a, with displacement s.

The three equations of motion can be written as,

$$v = u + at$$
$$s = ut + \tfrac{1}{2} a t^2$$
$$v^2 = u^2 + 2as$$

Let us try to derive these equations by graphical method.

Equations of motion from velocity – time graph:



Graph shows the change in velocity with time for an uniformly accelerated object. The object starts from the point D in the graph with velocity u. Its velocity keeps increasing and after time t it reaches the point B on the graph.

The initial velocity of the object = u = OD = EA

The final velocity of the object = v = OC = EB

Time = t = OE = DA

Also from the graph we know that, AB = DC

2.7.1 First equation of motion

By definition, acceleration = change in velocity / time

= (final velocity – initial velocity)/ time

= (OC – OD) / OE

= DC / OE

$a = DC / t$

$DC = AB = at$

From the graph EB = EA + AB

$$v = u + at \qquad (1)$$

This is first equation of motion.

2.7.2 Second equation of motion

From the graph the distance covered by the object during time t is given by the area of quadrangle DOEB

s = area of the quadrangle DOEB

= area of the rectangle DOEA + area of the triangle DAB

= (AE × OE) + (1/2 × AB × DA)

$$s = ut + \tfrac{1}{2} at^2 \qquad (2)$$

This is second equation of motion.

2.7.3 Third equation of motion

From the graph the distance covered by the object during time t is given by the area of the quadrangle DOEB. Here DOEB is a trapezium. Then

S = area of trapezium DOEB

= ½ × sum of length of parallel side × distance between parallel sides

= ½ × (OD + BE) × OE

$S = \tfrac{1}{2} \times (u + v) \times t$

since $a = (v - u) / t$ or $t = (v - u)/a$

Therefore $s = \tfrac{1}{2} \times (v + u) \times (v - u)/a$

$2as = v^2 - u^2$

$$v^2 = u^2 + 2as \qquad (3)$$

This is third equation of motion.

Motion of objects under the influence of gravitational force of the earth – Freely falling body:

Activity 7

Take a large stone and a small eraser. Stand on the top of a table and drop them simultaneously from the same height? What do you observe?

Activity 8

Take a small eraser and a sheet of paper. Stand on the top of a table and drop them simultaneously from the same height? What do you observe?

Activity 9

Take two sheets of paper having same mass. Now, crumple one of the sheets into a ball and drop the sheet and the ball from the same height. What do you observe?

In activity 7, both the stone and the eraser have reached the surface of the earth almost at the same time but in activity 8, the eraser reaches first, the sheet of paper reaches later. In activity 9, the paper crumpled into a ball reaches ground first and plain sheet of paper reaches later, although they have equal mass. Do you know the reason? When all these objects are dropped in the absence of air medium (vacuum), all would have reached the ground at the same time. In air medium, due to friction, air offers resistance to the motion of free falling objects. The resistance offered by air is negligibly small when compared to the gravitational pull acting on the stone and rubber (in activity 7). Hence, they reach the ground at the same time. But, in activity 8, the air resistance exerted on the sheet of paper is much higher than that on the eraser. Again in activity 9, the air resistance offered to the plain sheet of paper is much higher than that offered to the paper ball. This is because the magnitude of air resistance depends on the area of objects exposed to air. If we do experiment in a tall glass jar from which air has been sucked out, both the paper and the eraser would fall at the same rate. Galileo dropped different objects from the top of the Leaning Tower of Pisa in Italy to prove the same. We know that an object experiences acceleration during free fall. This acceleration experienced by an object is independent of mass. This means that all objects hollow or solid, big or small, should fall at the same rate.

DO YOU KNOW?

Can a body have zero velocity and finite acceleration?

Yes, when a body is thrown vertically upwards in space, then at the highest point, the body has zero velocity and acceleration equal to the acceleration due to the gravity.

The equation of motion for a freely falling body can be obtained by replacing 'a' in equations 1 to 3 with g, the acceleration due to gravity. For an object falling freely, its initial velocity u = 0. Thus we get the following equations

$$v = gt,\ s = \tfrac{1}{2}\, gt^2,\ v^2 = 2gh$$

when we through an object vertically upwards, it moves against the acceleration due to gravity. Hence g is taken to be –g in such cases.

Uniform circular motion

Activity 10

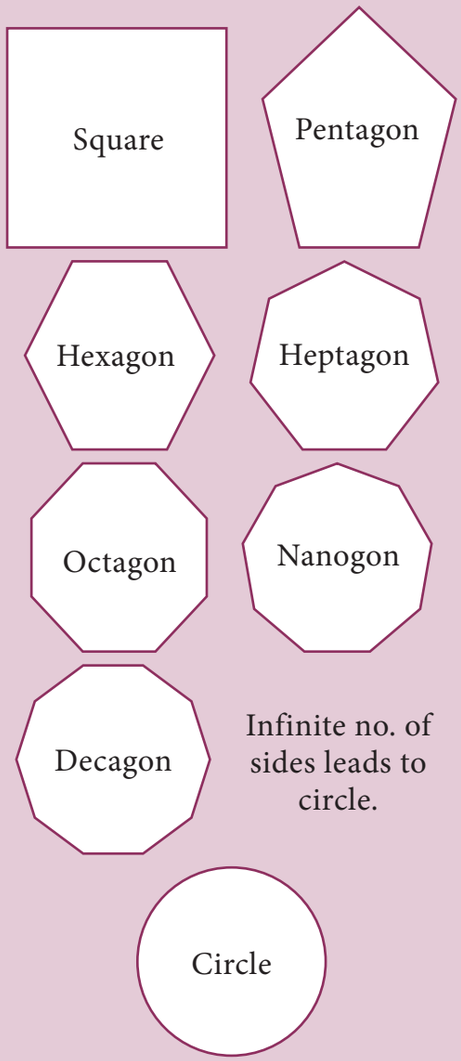
1. Draw a square path as shown in following Figure.
2. Place the tip of your pencil on the middle of any side of the square path.
3. Note how many times you have to change the direction while tracing the complete path.

4. Now repeat this action for a pentagon, hexagon, octagon and note the number of times one changes the direction to complete the path.

   This shows that as we increase the number of sides, we have to keep changing direction more and more times.

5. If you increase the number of sides of the polygon and make it infinite, how many times will you have to change the direction? What will be the shape of the path?

   And when we increase the number of sides to infinity, the polygon becomes a circle.



Activity 11

1. Take a piece of thread and tie a small piece of stone at one of its ends. Rotate the stone to describe a circular path with constant speed by holding the thread at the other end as shown in Figure below.
2. Now, release the thread and let the stone go.
3. Can you tell the direction in which the stone moves after it is released?
4. Repeat the activity for a few times, and releasing the stone at different positions of the circular path. Check whether the direction in which the stone moves remains the same or not.

If you carefully observe, on being released the stone moves along a straight line tangential to the circular path. This is because once the stone is released, it continues to move along the direction it has been moving at that instant. This shows that the direction of motion changed at every point when the stone was moving along the circular path. When an object moves with constant speed along a circular path, the motion is called uniform circular motion. When an object is moving with a constant speed along a circular path, the velocity changes due to the change in direction. Hence it is an accelerated motion.

Examples of uniform circular motion.

1. Revolution of earth around the sun.
2. Revolution of moon around the earth.
3. The tip of the second's hand of a clock.

If an object, moving along a circular path of radius r, takes time T to come back to its starting position, the speed v is given by,

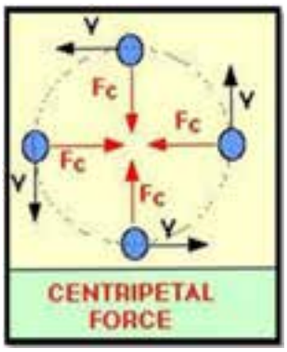
Speed = circumference/time taken

$$V = 2\pi r/T$$

Giant Wheel moves in a vertical circular path.

2.8 Centripetal Acceleration and Centripetal Force

A body is said to be accelerated, if the velocity of the body changes either in magnitude or in direction. Hence the motion of a stone in circular path with constant speed and continious changes of direction is an accelerated motion. There must be an acceleration acting along the string directed inwards, which makes the stone to move in circular path.



This acceleration is known as centripetal acceleration and the force is known as centripetal force. Since the centripetal acceleration is directed radially towards the centre of the circle, the centripetal force must act on the object radially towards the centre.

Let us consider an object of mass m, moving along a circular path of radius r, with a velocity v, its centripetal acceleration is given by

$$a = v^2/r$$

Hence, the magnitude of centripetal force is given by,

F = mass × centripetal acceleration

$$F = mv^2/r$$

Note

Any force like gravitational force, frictional force, magnetic force, electrostatic force etc., may act as a centripetal force.

Activity 12

Take a piece of rope and tie a small stone at one end. Hold the other end of the rope and rotate it such that the stone follows a circular path. Will you experience any pull or push in your hand? What do you infer?

In this activity, a pulling force that acts away from the centre is experienced. This is called as centrifugal force.

2.9 Centrifugal Force

Force acting on a body away from the centre of circular path is called centrifugal force. Thus centrifugal force is in a direction opposite to the direction of centripetal force. Its magnitude is same as that of centripetal force. The dryer in a washing machine is an example for the application of centrifugal force.

How do we separate cream from milk?

A separator is a high speed spinner. It acts on the same principle of centrifuge machines. The bowl spins at very high speed causing the heavier contents of milk to move outward in the bowl pushing the lighter contents inward towards the spinning axis. Cream is lighter than other components in milk. Therefore, skimmed milk which is denser than cream is collected at outer wall of the bowl. The lighter part of cream is pushed towards the centre from where it is collected through pipe.

Spin dryer – centrifugal force

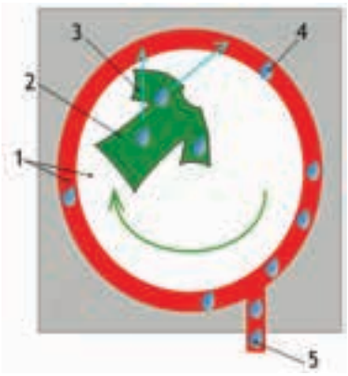
1-rotating metal drum

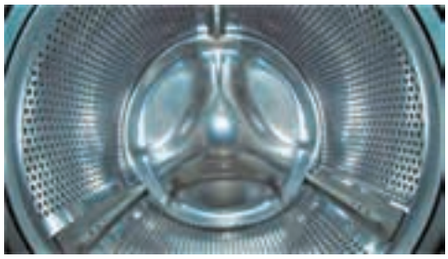
2&3 - wet cloth

When you go for a ride in a merry-go-round in amusement parks, what force do you experience? We experience an outward pull as merry-go round rotates about vertical axis. This is due to centrifugal force.

4-water droplet

5-let out of droplets





A spin dryer removes excess water from clothing by rotating a perforated drum at high speed. The water is thrown out through the holes. The clothes keep moving in a circle because the contact force of the drum provides centrifugal force.

2.10 Summary

- Motion is a change of position, which can be described in terms of the distance moved or the displacement.
- The motion of an object could be uniform or non-uniform depending on its velocity.
- The speed of an object is the distance covered per unit time and velocity is the displacement per unit time.
- The acceleration of an object is the change in velocity per unit time.
- Uniform and non-uniform motion of object can be shown through graphs.

The motion of an object at uniform acceleration can be described with the help of three equations, namely

$$v = u + at$$

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

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

where u is initial velocity of the object, v is its final velocity, s is the distance travelled in time t, a is the acceleration.

For a freely falling body the acceleration a is replaced by g.

An object under uniform circular motion experiences centripetal force.

A-Z GLOSSARY

1. **Motion** an object's change in position
2. **Distance** is a scalar quantity that refers to "how much length an object has covered" during its motion
3. **Displacement** is an object's change in position, only measuring from its starting position to the final position
4. **Speed** the rate of motion at which the object moves (distance/time)
5. **Velocity** the speed of an object in a particular direction
6. **Acceleration** change in velocity either magnitude or direction
7. **Circular motion** circular motion is a movement of an object along the circumference of a circle or rotation along a circular path
8. **Centripetal force** a force which acts on a body moving in a circular path and is directed towards the centre
9. **Centrifugal force** a force, arising from the body's inertia, which appears to act on a body moving in a circular path and is directed away from the centre
10. **Gravity** a force of attraction between object and the centre of Earth, due to their masses

ICT CORNER

FORCE AND MOTION

Newton's second law says a force acting on the object either change it's direction or acceleration or both. F=ma

This activity proves that:

Step 1. Type the following URL in the browser or scan the QR code from your mobile.Youcan see a wheel barrow full of load on the screen. Below that you can see two sets of people also.

Step 2. Place different number of peoples on both the side of the rope. Click go. According to the force given by the people the wheel barrow moves to anyone of the side. If the number of people is equal on both the sides the load will not move.

Step 3. By changing the number of people you can see the force and motion.

https://phet.colorado.edu/en/simulation/forces-and-motion-basics

B121_9_SCI_EM

EXERCISE

EKWFAP

I. Solved Examples

1. An object travels 16m in 4s and then another 16m in 2 s. What is the average speed of the object?

Sol: Total distance travelled by the object = 16 m + 16 m = 32m
Total time taken = 4s + 2s = 6s

Average speed =

$$\frac{\text{Total distance travelled}}{\text{total time taken}} = \frac{32m}{6s} = \frac{32}{6} = 5.33 ms^{-1}$$

Therefore, the average speed of the object is $5.33 ms^{-1}$

2. The brakes applied to a car produce an acceleration of 6 ms^{-2} in the opposite direction to the motion. If the car takes 2s to stop after the application of brakes. Calculate the distance it travels during this time.

Sol: We have been given a = −6 ms^{-2}, t = 2s and v = 0

From the equation of motion v = u + at

$0 = u + (-6 \times 2)$

$0 = u - 12$

$u = 12\ ms^{-1}$

$s = ut + ½\ at^2$

$= (12 \times 2) + ½\ (-6 \times 2 \times 2)$

$= 24 - 12$

$s = 12m$

Thus, the car will move 12m before it stops after the application of brakes.

3. Surya swims in a 90 m long pool. He covers 180 m in 60 s by swimming from one end to the other and back along the same straight path. Find the average speed and the average velocity of Surya.

Sol: Average speed = $\frac{\text{Distance covered}}{\text{time taken}} = \frac{180m}{60s} = 3 ms^{-1}$

Average velocity = $\frac{\text{Displacement}}{\text{time taken}} = \frac{0m}{60s} = 0$

The average speed of Surya is 3 ms^{-1} and his average velocity is 0

4. A 100 m long train crossed a bridge of length 200 m in 50 s with constant velocity. Find the velocity of the train.

Sol: Distance travelled by the train = length of the train + length of the bridge

= 100 m + 200 m

= 300 m

Velocity of the train =

$$\frac{\text{Distance travelled by the train}}{\text{time taken}} = \frac{300}{50}$$

= 6 ms^{-1}

5. A sound is heard 5 s later than the lightning is seen in the sky on a rainy day. Find the distance of location of lightning? Given the speed of sound = 346 ms^{-1}

$$\text{Speed} = \frac{\text{Distance}}{\text{time}}$$

Distance = speed × time = 346 × 5 = 1730m

Thus, the distance of location of lightning = 1730 m

6. A 900 kg car moving at 10 m s^{-1} takes a turn around a circle with a radius of 25 m. Determine the acceleration

and the net force acting upon the car.

When the car turns around circle, it experiences centripetal acceleration

$a = \frac{v^2}{r}$

The solution is as follows: $a = \frac{(10)^2}{25}$

$a = \frac{100}{25}$

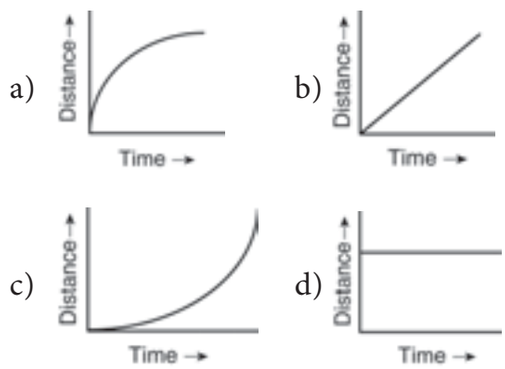
$a = 4\ m\ s^{-2}$

To determine the net force acting upon the car, use the equation F = m a.

F = m a F = 900 × 4 F = 3600 N

II. Multiple Choice Questions

1. Slope of the velocity - time graph gives
   a) speed b) displacement
   c) distance d) acceleration
2. Which of the following graph represents uniform motion of a moving particle?



3. A body moving with an initial velocity $5ms^{-1}$ and accelerates at $2ms^{-2}$. Its velocity after 10s is
   a) $20ms^{-1}$ b) $25ms^{-1}$
   c) $5ms^{-1}$ d) $22.55ms^{-1}$
4. In a 100 m race, the winner takes 10s to reach the finishing point. The average speed of the winner is
   a) $5ms^{-1}$ b) $20ms^{-1}$
   c) $40\ ms^{-1}$ d) $10\ ms^{-1}$
5. The area under velocity – time graph represents
   a) velocity of the moving object
   b) displacement covered by the moving object
   c) speed of the moving object
   d) acceleration of the moving object
6. A car is being driven at a speed of 20 ms^{-1} when brakes are applied to bring it to rest in 5 s. The deceleration produced in this case will be
   a) $+4\ ms^{-2}$ b) $-4\ ms^{-2}$
   c) $-0.25\ ms^{-2}$ d) $+0.25\ ms^{-2}$
7. Unit of acceleration is
   a) ms^{-1} b) ms^{-2}
   c) ms d) ms^2
8. Which one of the following is most likely not a case of uniform circular motion?
   a) Motion of the Earth around the Sun.
   b) Motion of a toy train on a circular track.
   c) Motion of a racing car on a circular track.
   d) Motion of hours' hand on the dial of the clock.
9. The force responsible for drying of clothes in a washing machine is ....
   a) Centripetal force
   b) Centrifugal force
   c) Gravitational force
   d) Electro static force
10. The centrifugal force is ….
    a) Real force
    b) The force of reaction of centripetal force
    c) Virtual force
    d) Directed towards the centre of the circular path.

III. Fill in the Blanks

1. Speed is a _____ quantity whereas velocity is a _____ quantity
2. The slope of the distance – time graph at any point gives _____
3. Consider an object is rest at position x = 20m. Then its displacement – time graph will be straight line to _____ the axis.
4. Negative acceleration is called _____
5. Area under velocity – time graph shows _____

IV. True or False

1. The motion of a city bus in a heavy traffic road is an example for uniform motion.
2. Acceleration can get negative value also.
3. Distance covered by a particle never becomes zero between any interval of time but displacement becomes zero.
4. The velocity – time graph of a particle falling freely under gravity would be straight line parallel to the x axis.
5. If the velocity – time graph of a particle is a straight line inclined to time axis then its displacement – time graph will be a straight line?

V. Assertion and Reason Type Question

Mark the correct choice as:

a. If both assertion and reason are true and reason is the correct explanation of assertion.

b. If both assertion and reason are true but reason is not the correct explanation of assertion.

c. If assertion is true but reason is false.

d. If assertion is false but reason is true.

1. Assertion: The accelerated motion of an object may be due to change in magnitude of velocity or direction or both of them.

   Reason: Acceleration can be produced only by change in magnitude of the velocity it does not depend the direction.

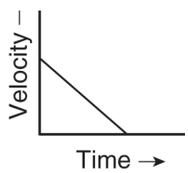
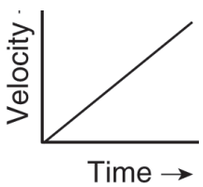
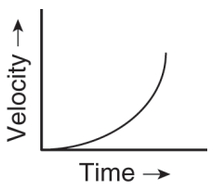
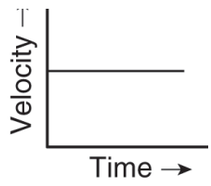
2. Assertion: The Speedometer of a car or a motor-cycle measures the average speed of it.

   Reason: Average velocity is equal to total displacement divided by total time taken.

3. Assertion: Displacement of a body may be zero when distance travelled by it is not zero.

   Reason: The displacement is the shortest distance between initial and final position.

VI. Match the Following

List I	List II
Motion of a body covering equal distances in equal interval of time	 A
Motion with non uniform acceleration	 B
Constant retardation	 C
Uniform acceleration	 D

VII. Short Answer Questions

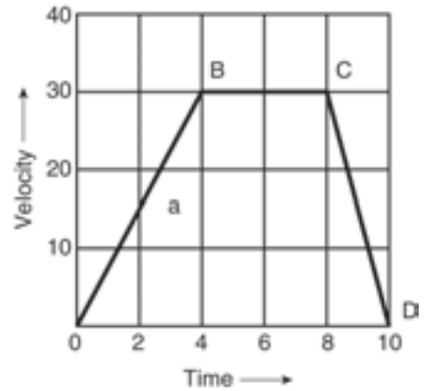
1. Define velocity?
2. Distinguish distance and displacement?
3. What do you mean by uniform motion?
4. Compare speed and velocity?
5. What do you understand about negative acceleration?
6. What remains constant in uniform circular motion? And What Changes continuously in uniform circular motion?
7. Is the uniform circular motion accelerated? Give reasons for your answer?
8. What is meant by uniform circular motion? Give two examples of uniform circular motion.

VIII. Paragraph Questions

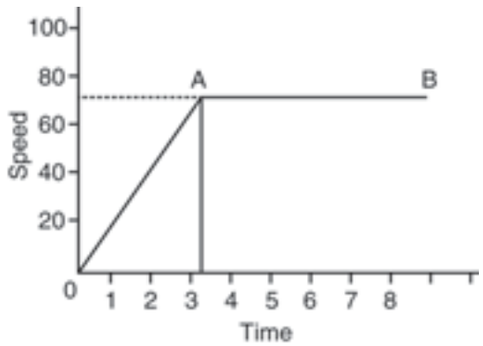
1. Derive equations of motion by graphical method.

IX. Exercise Problems

1. During an experiment, a signal from a spaceship reached the ground station in five seconds. What was the distance of the spaceship from the ground station? The signal travels at the speed of light that is 3×10^8 ms^{-1}
2. A ball is gently dropped from a height of 20m. If its velocity increases uniformly at the rate of 10 ms^{-2} with what velocity will it strike the ground? After what time will it strike the ground?
3. An Athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 m and 20 s?
4. A racing car has a uniform acceleration of 4 ms^{-2}. What distance it covers in 10 s after start?
5. A train travelling at a speed of 90 kmph. Brakes are applied so as to produce a uniform acceleration of -0.5 ms^{-2}. Find how far the train will go before it is brought to rest?
6. The adjacent diagram shows the velocity time graph of a body. During what time interval is the motion of the body accelerated. Find the acceleration in the time interval mentioned in part 'a'. What is the distance travelled by the body in the time interval mentioned in part a?



7. The following graph shows the motion of a car. What do you infer from the graph along OA and AB? What is the speed of the car along AB and what time it reached this speed



8. From the following Table, check the shape of the graph

Time (s)	0	2	4	6	8	10	12
Velocity(ms^{-1})	0	20	40	40	40	20	0

QUESTION PAPER - I

I. Choose the best answer

1. The area under velocity time graph represents
   a. Velocity of the moving object
   b. Displacement covered by the moving object
   c. Speed of the moving object

2. Unit of acceleration is
   a. Ms^{-1} b. ms^{-2}
   c. ms d. ms^2

3. When a body starts from rest, the acceleration of the body after 2second in _____ of its displacement
   a. Half b. Twice
   c. Four times d. One fourth

II. Short answer Questions

1. A bus travel, a distance of 20km from Chennai central airport in 45 minutes. What is the average speed?
2. Why did the actual speed differ from average speed!
3. Mention the uses of velocity–time graph
4. The speed of a particle is constant. Will it have acceleration? Justify with an example
5. Distinguish distance and displacement of a moving object

III. Answer the following Question briefly

Derive the three equations of motion by graphical method.

QUESTION PAPER - II

I. Choose the best answer

1. In a 100 m race, the winner takes 10s to reach the finishing point. The average speed of the winner is _____ ms^{-1}
   a) 5 b) 10
   c) 20 d) 40

2. Force involved in uniform circular motion is given by _____
   a) $f = \frac{mv^2}{r}$ b) f = mvr
   c) $f = \frac{mr^2}{v}$ d) $f = \frac{v^2}{r}$

II. Choose correct statement

1. Action and reaction forces act on same object

   Action and reaction forces act on different objects

   Both (a) and (b) are possible

   Neither (a) nor (b) is correct

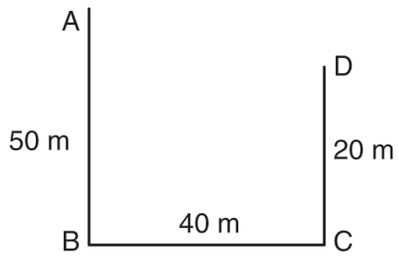
III. Short answer Questions

1. A motorcycle travelling at $20ms^{-1}$ has an acceleration of $4ms^{-2}$. What does it explains about the velocity of the motorcycle.

2. Complete of following sentences
   a. The acceleration of the body that moves with a uniform velocity will be _____
   b. A train travels from A to station B with a velocity of 100 km/h and returns from station B to station A with a velocity of 80km/h. Its average velocity during the whole journey in _____ and its average speed is _____
3. Distinguish speed and velocity.
4. What is meant by negative acceleration?

IV. Answer the following Question

A boy moves along the path ABCD. What is the total distance Covered by the boy? What is his net displacement?



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1. Advanced Physics by: M. Nelkon and P. Parker, C.B.S publications, Chennai
2. College Physics by: R.L.Weber, K.V. Manning, Tata McGraw Hill, New Delhi.
3. Principles of Physics (Extended) - Halliday, Resnick & Walker, Wiley publication, New Delhi.

INTERNET RESOURCES

http://www.ducksters.com/science/physics/motion_glossary_and_terms.php

http://www.physicsclassroom.com/mmedia/circmot/ucm.cfm

http://www.physicsclassroom.com/Class/1DKin/U1L1d.cfm

http://www.physicsclassroom.com/Class/1DKin/U1L1e.cfm

https://brilliant.org/wiki/uniform-circular-motion-easy/

Centrifugal force

https://www.youtube.com/watch?v=Rv4pnUlf0PQ

UNIT 3

Light

Learning Objectives

EL6BCC

At the end of this unit the students will be able to

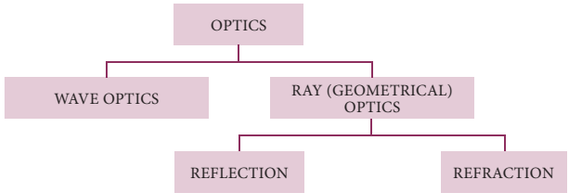
- describe the nature of images formed by plane mirrors
- explain why lateral inversion takes place
- apply the laws of reflection for plane mirrors and spherical mirrors
- draw ray diagrams to find the position and size of the image for spherical mirrors
- distinguish between real and virtual images
- apply the mirror equation to calculate position, size and nature of images and focal lengths for spherical mirrors
- identify situations in which refraction will occur
- identify the direction of bending when light passes from one medium to another
- solve problems using Snell's law
- predict whether light will be refracted or undergo total internal reflection
- recognize atmospheric conditions that cause refraction

Introduction

In our day to day life we use number of optical instruments. Microscopes are inevitable in physics laboratory, biology laboratory and in medical laboratories. Also telescopes, binoculars, cameras and projectors are used in educational, scientific and entertainment fields. Do you know the basic components or parts used in these instruments? Mirrors and lenses! You can name some more optical instruments you have seen. Also, in our daily life we come across many optical illusions like mirage, rainbow, apparent bending of objects placed in liquids.

In this chapter, you will learn about the properties of plane mirror and spherical mirrors (concave and convex). Also you will learn about the properties of light, namely reflection and refraction and their applications.

Light is a form of energy and it travels in the form of electromagnetic waves. The branch of physics that deals with the properties and applications of light is called *optics*. The branch of optics that treats light as rays is named *ray optics* or *geometrical optics* and the branch of optics where the wave nature of light is considered is called *wave optics*.



3.1 Reflection of Light

You know that light is a form of energy. This energy travels from a source in all direction and the direction along which it travels is called a ray of light. Observe a bulb in your house, slightly closing your eye lids. You can see the light in the form of yellow lines. One such a line is called a ray. A bundle of such rays constitute a beam of light.

Light falling on any polished surface such as a mirror, is reflected. This reflection of light on polished surfaces follows certain laws and you might have studied about them in your lower classes. Let us study about them little elaborately.

3.1.1 Laws of reflection

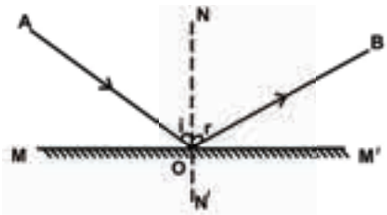


Figure 1 Plane mirror

Consider a plane mirror MM′ as shown in Figure 1. Let AO be the light ray incident on the plane mirror at O. The ray AO is called incident ray. The plane mirror reflects the incident ray along OB. The ray OB is called reflected ray. Draw a line ON at O perpendicular to MM′. This line ON is called **normal.**

The angle made by the incident ray with the normal (i = *angle* AON) is called angle of incidence. The reflected ray OB makes an angle (r = angle NOB) with the normal and this is called angle of reflection. From the figure you can observe that the angle of incidence is equal to the angle of reflection. (i.e) $\angle i = \angle r$. Also, the incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane. These are called the laws of reflection.

Laws of reflection:

- The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.
- The angle of incidence is equal to angle of reflection.

Activity 1

The most common modern usage of mirror writing can be found on the front of ambulances, where the word "AMBULANCE" is often written in very large mirrored text, find out why it is written in such a way?

Reflection of light has many interesting facts. Let us look at some of them here.

How tall does a mirror have to be to fit your entire body?

Can you see your entire body in a make-up mirror? Now, stand before the mirror in your dressing table or the mirror fixed in a steel almirah. Do you see your whole body now? What do you know from this? To see your entire body in a mirror, the

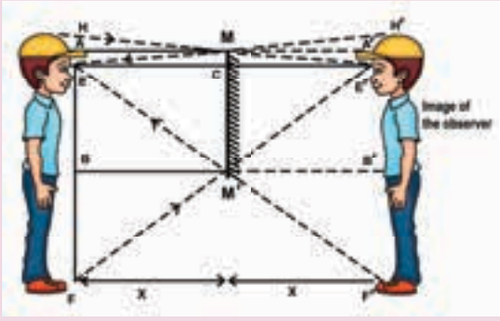
mirror should be atleast half of your height. Height of the mirror= Your height/2

Find out

Using a metre scale, measure your height in centimetre. Now find out the height of the mirror to see your entire body.

More to Know

Let an observer *HF* stand at a distance '*x*' in front of a plane mirror *MM*′. The image *H*′*F*′ of the observer is formed at the same distance '*x*' behind the plane mirror. The image *H*′*F*′ of this observer will be of the same size as that of the observer.



A ray from the person's feet FM′, gets reflected as M′E. He observes this as virtual image at F'. Based on Law of reflection (2) and on the geometry of the triangles Δ FM′B and Δ BM′E,

the height of the person from feet to eye = FE
this is double that of EB (or) EB = $\frac{FE}{2}$.

Also EB = CM′ (1)

Similarly, a ray from the person's head HM, gets reflected as ME. He observes this as virtual image at H'. Based on the same law and geometry of the triangles Δ HMA and Δ H′MA′,

the height of the person from head to eye = HE
this is double that of AE (or) AE = $\frac{HE}{2}$.

Also AE = MC (2)

From the above figure,

total height of the person = HF = HE + EF (3)

total height of his image = H′F′ = H′E′ + E′F′ (4)

These two heights are the *same*. (Can you prove it?)

Moreover, from (1) and (2),

Height of mirror = CM′ + CM = $\frac{FE}{2}$ + $\frac{EH}{2}$ = $\frac{HF}{2}$. i.e., half of his height

Note: The requirement remains the same regardless of the distance *x* of the observer from the mirror.

3.1.2 Lateral inversion

You might have heard about inversion. But what is lateral inversion?The word lateral comes from the Latin word *latus* which means side. Lateral inversion means sidewise inversion; it is the apparent inversion of left and right that occurs in a plane mirror.

Why do plane mirrors reverse left and right, but they do not reverse up and down?

Well the answer is surprising. Mirrors do not actually reverse left and right and they do not reverse up and down also. What actually mirrors do is reverse inside out.

Look at the image below and observe the arrows, which indicate the light ray from the object falling on the mirror. The arrow from object's head is directed towards the top of the mirror and the arrow from the feet is directed towards the bottom. The arrow from left hand goes to the left side of the mirror and the arrow from the right hand goes to the right side of the mirror. Here, you can see that there is no switching. It is an optical illusion.

The apparent lateral inversion we observe is not caused by the mirror but the result of our perception.

Note: You can try this activity with pencil or pen. What do you observe?

3.2 Curved Mirrors

We studied about laws of reflection. These laws are applicable to all types of reflecting surfaces including curved surfaces. Let us learn about image formation in curved surfaces in this part.

In your earlier classes, you have studied that there are many types of curved mirrors, such as spherical and parabolic mirrors. The most commonly used type of curved mirror is spherical mirror. The curved surfaces of a shining spoon could also be considered as a curved mirror.

Take a hemispherical spoon. It has an inner and outer surface like the inside and outside of the ball. See your face on these surfaces? How do they look?

Move the spoon slowly away from your face. Observe the image. How does it change? Reverse the spoon and repeat the activity. How does the image look like now?

3.2.1 Spherical mirrors

In curved mirrors, the reflecting surface can be considered to form a part of the surface of a sphere. Such mirrors whose reflecting surfaces are spherical are called spherical mirrors.

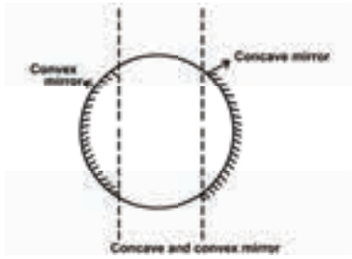


Figure 2 Concave and Convex mirror

In some spherical mirrors the reflecting surface is curved inwards, that is, it faces towards the centre of the sphere. It is called concave mirror. In some other mirrors, the reflecting surface is curved outward. It is called convex mirror and are shown in Figure 2.

In order to understand reflection of light at curved surfaces, we need to know the following.

Centre of curvature (C): The centre of the hollow sphere of which the spherical mirror forms a part.

Pole (P): The geometrical centre of the spherical mirror.

Principal axis (PC)**:** The perpendicular line joining the pole and the centre of curvature of the mirror.

Radius of curvature(R): The distance between the pole and the centre of curvature of the spherical mirror.

Principal focus (F): The point on the principal axis of the spherical mirror where the rays of light parallel to the principal axis meet or appear to meet after reflection from the spherical mirror.

Focal length(f): The distance between the pole and the principal focus.

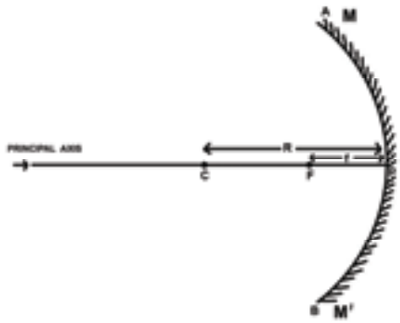


Figure 3 Concave mirror

Radius of curvature and focal length are related to each other by the formula: R=2f. All these are depicted in Figure 3.

Check yourself:

ELF7DZ

1. Focal length of a concave mirror is 5 cm. Find its radius of curvature.
2. For a concave mirror the distance between P and C is 10 cm. Calculate it's the focal length.
3. A concave mirror has radius of curvature 20 cm. Find the focal length of the mirror.

3.3 Image Formed by Curved Mirrors

Activity 2

Hold a concave mirror in your hand (or placed in a stand). Direct its reflecting surface towards the sun. Direct the light reflected by the mirror onto a sheet of paper held not very far from the mirror. Move the sheet of paper back and forth gradually until you find a bright, sharp spot of light on the paper. [**Do this activity only under adult supervision**]. Position the mirror and the paper at the same location for few moments. What do you observe? Why does the paper catches fire?

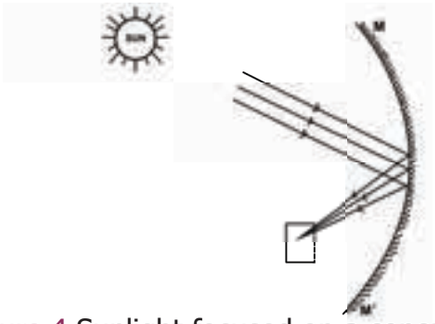


Figure 4 Sunlight focused on a concave mirror

We have seen that the parallel rays of sun light (Figure 4) could be focused at a point using a concave mirror. Now let us place a lighted candle and a white screen in front of the concave mirror. Adjust the position of the screen. Move the screen front and back. Note the size of the image and its shape. Is it inverted? Is it small?

Next, slowly bring the candle closer to the mirror. What do you observe? As you bring the object closer to the mirror the image becomes bigger. Try to locate the image when you bring the candle very close to the mirror. Are you able to see an image on the screen? Now look inside the mirror. What do you see? An erect magnified image of the candle is seen. In some positions of the object an image is obtained on the screen. However at some position of the object no image is obtained. It is clear that the behaviour of the concave mirror is much more complicated than the plane mirror.

However, with the use of geometrical technique we can simplify and understand the behaviour of the image formed by a concave mirror. In the earlier case of plane mirror, we used only two rays to understand how to get full image of a person. But for understanding the nature of image formed

by a concave mirror we need to look at four specific rules.

3.3.1 Rules for the construction of image formed by spherical mirrors

From each point of an object, number of rays travel in all directions. To find the position and nature of the image formed by a concave mirror, we need to know the following rules.

Rule 1: A ray passing through the centre of curvature is reflected back along its own path (Figure 5).

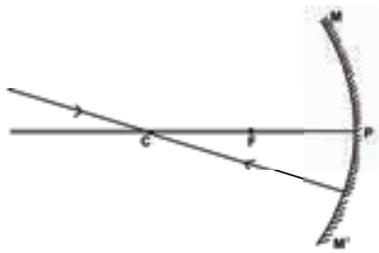


Figure 5 Ray passing centre of curvature

Rule 2: A ray parallel to the principal axis passes through the principal focus after reflection (Figure 6).

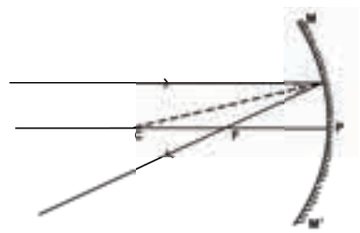


Figure 6 Ray parallel to prinicpal axis

Rule 3: A ray passing through the focus gets reflected and travels parallel to the principal axis (Figure 7).

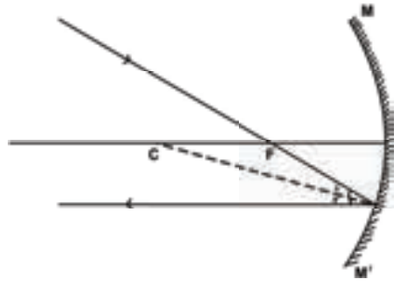


Figure 7 Ray travelling through the principal focus

Rule 4: A ray incident at the pole of the mirror gets reflected along a path such that the angle of incidence (APC) is equal to the angle of reflection (BPC) (Figure 8).

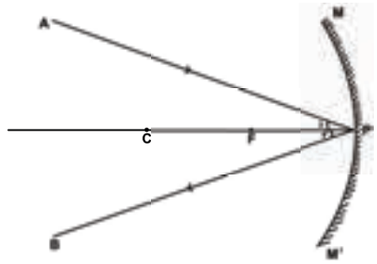


Figure 8 Angle of incidence equal to angle of reflection

3.4 Real and Virtual Image

If the light rays coming from an object actually meet, after reflection, the image formed will be a real image and it is always inverted. A real image can be produced on a screen. When the light rays coming from an object do not actually meet, but appear to meet when produced backwards,that image will be virtual image. The virtual image is always erect and cannot be caught on a screen (Figure 9).

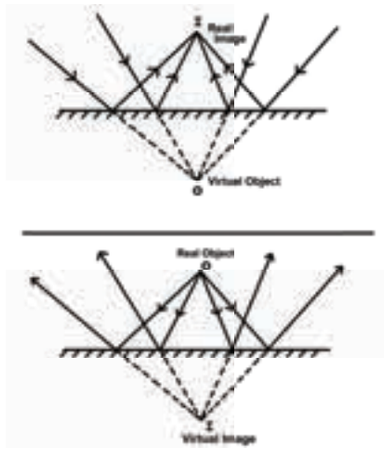


Figure 9 Real and virtual image

Activity 3

Keep a lighted candle between the principal focus (F) and pole (P) of a

concave mirror. Can you see an enlarged image of the candle on the mirror? Now keep the candle away from P, beyond C. You can obtain an image of the candle on a screen.

What is the type of image formed by a plane mirror? Can you catch that image on a screen?

3.5 Concave Mirror

3.5.1 Ray diagrams for the formation of images

We shall now find the position, size and nature of image by drawing the ray diagram for a small linear object placed on the principal axis of a concave mirror at different positions.

Case–I: When the object is far away (at infinity), the rays of light reaching the concave mirror are parallel to each other (Figure 10).

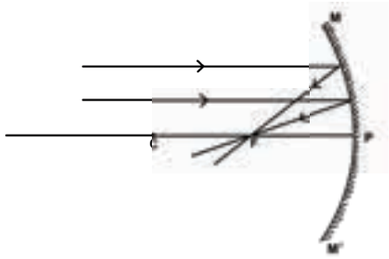


Figure 10 Object at inifinity

Position of the Image: The image is at the principal focus F.

Nature of the Image: It is (i) real, (ii) inverted and (iii) highly diminished in size.

Case–II: When the object is beyond the centre of curvature (Figure 11).

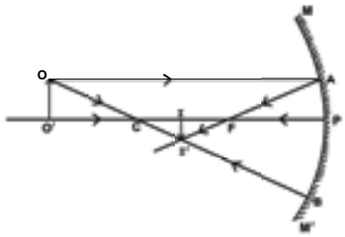


Figure 11 Object beyond the centre of curvature

Position of the image: Between the principal focus F and centre of curvature C.

Nature of the image: Real, inverted and smaller than object.

Case – III: When the object is at the centre of curvature (Figure 12).

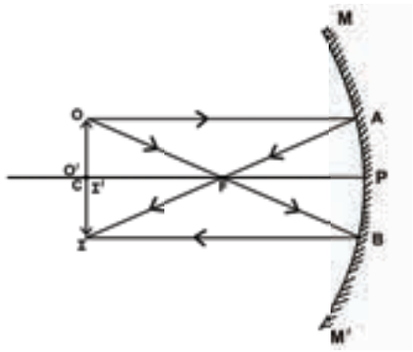


Figure 12 Object at the centre of curvature

Position of the image: The image is at the centre of curvature itself.

Nature of the image: It is i) Real, ii) inverted and iii) same size as the object.

Case – IV: When the object is in between the centre of curvature C and principal focus F (Figure 13).

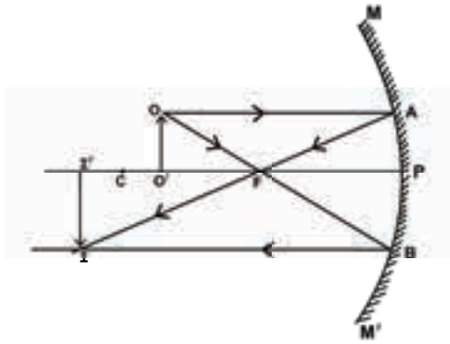


Figure 13 Object in between centre of curvature and principal focus

Position of the image: The image is beyond C

Nature of the image: It is i)Real ii) inverted and iii) magnified.

Case – V: When the object is at the principal focus F (Figure 14).

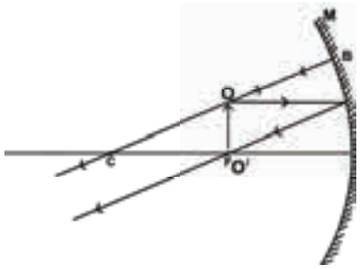


Figure 14 Object at principal focus

Position of the image: Theoretically, the image is at infinity.

Nature of the image: No image can be captured on a screen nor any virtual image can be seen.

Case – VI: When the object is in between the focus F and the pole P (Figure 15).

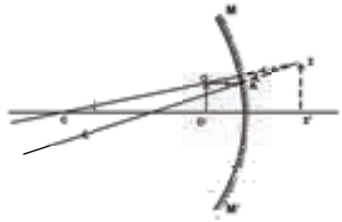
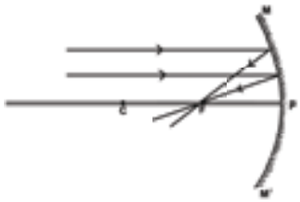
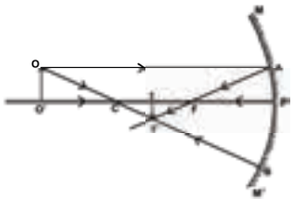
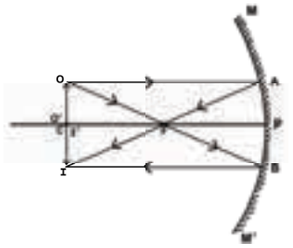
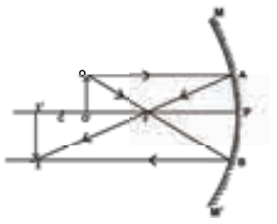
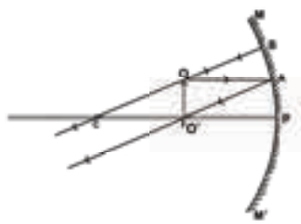
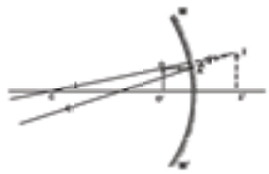


Figure 15 Object in between principal focus and pole

Position of the image: The image is behind the mirror.

Nature of the image: It is virtual,erect and magnified.

Sl. No.	Position of Object	Ray Diagram	Position of Image	Size of Image	Nature of Image
1.	At infinity		At the principal focus	Point size	Real and Inverted
2.	Beyond the Centre of Curvature C		Between F and C	Smaller than the object	Real and Inverted
3.	At the Centre of Curvature C		At C	Same size	Real and Inverted
4.	Between C and F		Beyond C	Magnified	Real and inverted

Sl. No.	Position of Object	Ray Diagram	Position of Image	Size of Image	Nature of Image
5.	At the principal focus F		At infinity	infinitely large	Real and Inverted
6.	Between the principal focus F and the pole P of the mirror		Behind the mirror	Magnified	Virtual and Erect

3.5.2 Sign convention for measurement of distances

We follow a set of sign conventions called the cartesian sign convention. In this convention the pole (P) of the mirror is taken as the origin. The principal axis is taken as the x axis of the coordinate system (Figure 16).

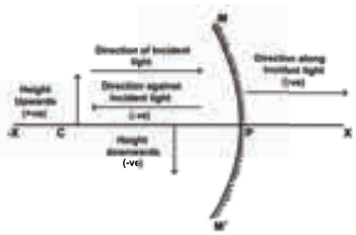


Figure 16 Sign convention for spherical mirrors

- The object is always placed on the left side of the mirror.
- All distances are measured from the pole of the mirror.
- Distances measured in the direction of incident light are taken as positive and those measured in the opposite direction are taken as negative.
- All distances measured perpendicular to and above the principal axis are considered to be positive.
- All distances measured perpendicular to and below the principal axis are considered to be negative.

3.5.3 Mirror equation

The expression relating the distance of the object u, distance of image v and focal length f of a spherical mirror is called the mirror equation. It is given as:

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

Type of mirror	u	v		f	R	Height of the Object	Height of the Image	
		real	virtual				real	virtual
Concave mirror	-	-	+	-	-	+	-	+
Convex mirror	-	No real image	+	+	+	+	No real image	+

Sign convention for measurement of distances

3.5.4 Linear magnification (m)

Magnification produced by a spherical mirror gives the how many times the image of an object is magnified with respect to the object size.

It can be defined as the ratio of the height of the image (h_i) to the height of the object (h_o).

$$m = \frac{h_i}{h_o}$$

The magnification can be related to object distance (u) and the image distance (v)

$$m = -\frac{v}{u}$$

$$\therefore m = \frac{h_i}{h_o} = -\frac{v}{u}$$

Note: A negative sign in the value of magnification indicates that the image is real. A positive sign in the value of magnification indicates that the virtual image.

Sample Problem 1

Find the size, nature and position of image formed when an object of size 1 cm is placed at a distance of 15 cm from a concave mirror of focal length 10 cm.

1. Position of image

Object distance u = – 15 cm (to the left of mirror)

Image distance v =?

Focal length f = – 10 cm (concave mirror)

Using mirror formula

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

$$\frac{1}{v} + \frac{1}{-15} = \frac{1}{-10}$$

$$\frac{1}{v} - \frac{1}{15} = \frac{-1}{10}$$

$$\frac{1}{v} = \frac{-1}{10} + \frac{1}{15}$$

$$= \frac{-3+2}{30}$$

$$\frac{1}{v} = \frac{-1}{30}$$

∴ Image distance v = −30cm (negative sign indicates that the image is on the left side of the mirror)

∴ Position of image is 30 cm in front of the mirror

2. Nature of image: Since the image is in front of the mirror it is real and inverted.

3. Size of image: To find the size of the image, we have to calculate the magnification.

$$m = \frac{-v}{u}$$

Object distance u = – 15cm

Image distance v = – 30 cm

$$m = \frac{-(-30)}{(-15)}$$

$$m = -2$$

We know that, $m = \frac{h_2}{h_1}$

Here, height of the object h_1 = 1 cm

$$-2 = \frac{h_2}{1}$$

$$h_2 = -2 \times 1$$

$$= -2 \text{ cm}$$

The height of image is 2 cm (negative sign shows that the image is formed below the principal axis).

Sample Problem 2

An object 2 cm high is placed at a distance of 16 cm from a concave mirror which produces a real image 3 cm high. Find the position of the image.

Calculation of position of image

Height of object $h_1 = 2$ cm

Height of real image $h_2 = -3$ cm

Magnification $m = \frac{h_2}{h_1}$

$= \frac{-3}{2}$

$= -1.5$

We know that, $m = \frac{-v}{u}$

here, object distance $u = -16$ cm

Substituting the value, we get

$$-1.5 = -\frac{v}{(-16)}$$

$$-1.5 = \frac{v}{16}$$

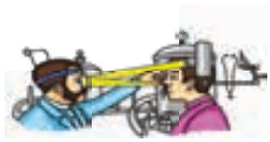
$$v = 16 \times (-1.5)$$

$$v = -24 \text{ cm}$$

The position of image is 24 cm in front of the mirror (negative sign indicates that the image is on the left side of the mirror).

3.5.5 Uses of concave mirror

As a dentist's head mirror: You would have seen a circular mirror attached to a band tied to the forehead of the dentist/ENT specialist. A parallel beam of light is made to fall on the concave mirror;this mirror focuses the light beam on a small area of the body (such as teeth, throat etc.).



As a make-up mirror: When a concave mirror is held near the face (between the pole and principal focus of the mirror), an upright and magnified image is seen. Here, our face will be seen magnified.

Other applications: Concave mirrors are also used as reflectors in torches, head lights in vehicles and search lights to get powerful beams of light. Concave reflectors are also used in room heaters. Large concave mirrors are used in solar heaters.

Think

Stellar objects are at an infinite distance; therefore the image formed by a concave mirror would be diminished, and inverted. Yet, why do astronomical telescopes use concave mirror?

3.6 Convex Mirror

3.6.1 Rules for the construction of image formed by spherical mirrors

We have studied the image formation by a concave mirror. Similarly, we can trace the path of light rays reflected by the convex mirrors using four 'rules'.

Rule 1: A ray of light which is parallel to the principal axis of a convex mirror appears to be coming from its principal focus, after reflection from the mirror (Figure 17).

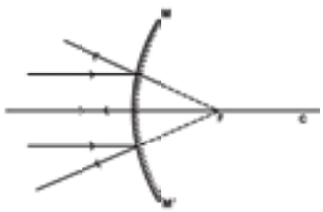


Figure 17 Rule 1

Rule 2: A ray of light going towards the centre of curvature is reflected back along the same path (Figure 18).

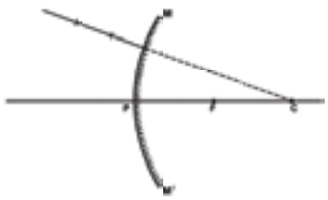


Figure 18 Rule 2

Rule 3: A ray of light going towards the principal focus of a convex mirror becomes parallel to the principal axis after reflection (Figure 19).

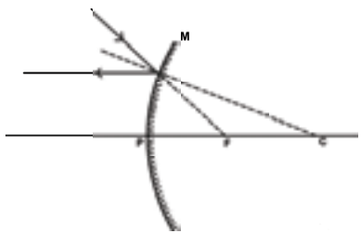


Figure 19 Rule 3

Rule 4: A ray of light which is incident at the pole of a convex mirror is reflected back making the same angle with the principal axis (Figure 20).

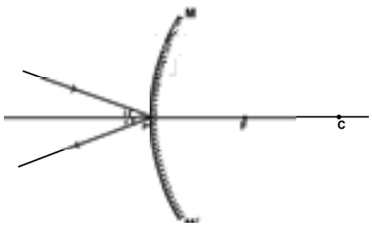


Figure 20 Rule 4

3.6.2 Image formation in a convex mirror

Any two rays can be chosen to draw the position of the image in a convex mirror (Figure 21).

1st ray: the ray that is parallel to the principal axis (rule 1) and

2nd ray : the ray that appears to pass through the centre of curvature (rule 2).

Note: All rays behind the convex mirror shall be shown with dotted lines.

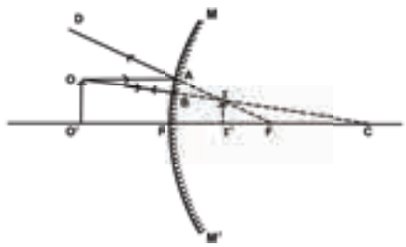


Figure 21 Image formation in a convex mirror

The ray OA parallel to the principal axis is reflected along AD. The ray OB retraces its path. The two reflected rays diverge but they appear to intersect at I when produced backwards. Thus II′ is the virtual image of the object OO′. It is virtual, erect and smaller than the object.

Activity 4

Draw a ray diagram with the object at different positions in front of the convex mirror. Observe the size, nature and positions of image in each case. What do you conclude?

Activity 5

Take a convex mirror. Hold it in one hand. Hold a pencil close to the mirror in the upright position in the other hand. Observe the image of the pencil in the mirror. Is the image erect or inverted? Is it diminished or enlarged? Move the pencil slowly away from the mirror. Does the image become smaller or larger? What do you observe?

ELP3FM

Sample Problem 3

A car is fitted with a convex mirror of focal length 20 cm. Another car is 6 m away from the first car.

a) Find the position of the second car as seen in the mirror of the first

b) What is the size of the image if the second car is 2 m broad and 1.6 m high?

Focal length = 20 cm (convex mirror)

Object distance = −6m
= −600 cm

Image distance v =?

Calculation for position of image using mirror equation

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

$$\frac{1}{20}=\frac{1}{-600}+\frac{1}{v}$$

$$\frac{1}{v}=\frac{1}{20}-\frac{1}{-600}$$

$$=\frac{1}{20}+\frac{1}{600}$$

$$\frac{1}{v}=\frac{30+1}{600}=\frac{31}{600}$$

$$v=\frac{600}{31}$$

$$= 19.35 \text{ cm}$$

b) Size of the image

$$m = \frac{-v}{u}$$

$$= -\frac{v}{(-u)} = \frac{-600}{31} \times \frac{1}{-600}$$

$$m = \frac{1}{31}$$

Breadth of image = $\frac{1}{31}$ x 200 cm = 6.45 cm

Height of image = $\frac{1}{31}$ x 160 cm = 5.16 cm

3.6.3 Uses of convex mirrors

Convex mirrors are used as rear-view mirrors in vehicles. It always forms a virtual, erect, small-sized image of the object. As the vehicles approach the driver from behind the size of the image increases. When the vehicles are moving away from the driver, then image size decreases. A convex mirror provides a much wider field of view* compared to plane mirror.

(* field of view – it is the observable area as seen through eye / any optical device such as mirror)

DO YOU KNOW?

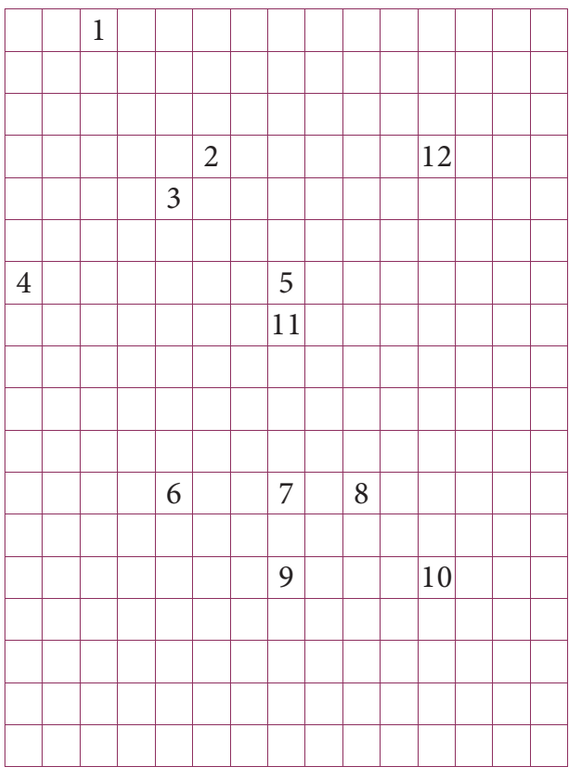
Convex mirrors are installed on public roads as traffic safety device. They are used in acute bends of narrow roads such as hairpin bends in mountain passes where direct view of oncoming vehicles is restricted. It is also used in blind spots in shops.

More to know by observation

1) Have you ever seen the dish antenna used at your home? What is the shape of the antenna? Is it convex or concave? Why?
2) Look around your environment. Observe all the spherical objects (having reflecting surfaces) and record your observation (for example soap bubble).

In the rear view mirror, the following sentence is written."Objects in the mirror are closer than they appear" Why?

Crossword puzzle



Across

3. Kind of image formed when rays from the mirror converge.

4. Rays from an object at infinity.

6. Converging mirror.

9. Line perpendicular to the surface at the point of incidence.

11. Diameter of circular rim of spherical mirror.

Down

1. Reflection of light into many directions by rough objects.

2. The turning back of light at the shining surface of substance.

5. _____ of reflection: angle of incidence (i) = angle of reflection (r).

7. Centre of curvature is on the side opposite to the reflecting surface of mirror.

8. Image of an object in a plane mirror.

10. _____ of reflection angle between the reflected ray and the normal at thepoint of contact.

12. Nature of image formed by convex mirror.

3.7 Speed of light

In early seventeenth century, the Italian scientist Galileo Galilee (1564-1642) tried to measure the speed of light as it travelled from a lantern on a hill top about a mile (1.6 km) away from where he stood. His attempt was bound to fail, because he had no accurate clocks or timing instruments.

In 1665 the Danish astronomer Ole Roemer first estimated the speed of light by observing one of the twelve moons of the planet Jupiter. As these moons travel around the planet, at a set speed, it would take 42 hours to revolve around Jupiter. Roemer made a time schedule of the eclipses for the whole year. He made first observation in June and second observation in December. Roemer estimated the speed of light to be about 220,000 km per second.

In 1849 the first land based estimate was made by Armand Fizeau. Today the speed of light in vacuum is known to be almost exactly 300,000 km per second.

3.7.1 Refraction of light

Activity 6

Refraction of light at air – water interface

a) Coin in a cup

Put a small coin, for example a five-rupee coin at the nearside of the cup and keep it at a distance so you/or your friend cannot see the coin; now gently pour water in the cup (without disturbing the coin). At some point, the coin comes in sight.

b) The bent pencil

Put a straight pencil into a tank of water or beaker of water at an angle of 45° and look at it from one side and above. How does the pencil look now? The pencil appears to be bent at the surface of water.

Both the above activities are the result of refraction of light. The bending of light rays when they pass obliquely from one medium to another medium is called refraction of light.

3.7.2 Cause of refraction

Light rays get deviated from their original path while entering from one transparent medium to another medium of different optical density. This deviation (change in direction) in the path of light is due to the change in velocity of light in the different medium. The velocity of light depends on the nature of the medium in which it travels. Velocity of light in a rarer medium (low optical density) is more than in a denser medium (high optical density).

3.7.3 Refraction of light from a plane transparent surface

When a ray of light travels from optically rarer medium to optically denser medium, it bends towards the normal. (Figure 22)

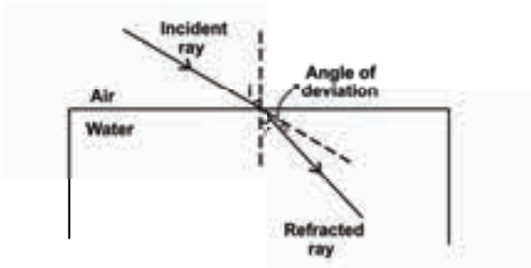


Figure 22 Light ray travelling from rarer to denser medium

When a ray of light travels from an optically denser medium to an optically rarer medium it bends away from the normal. (Figure 23)

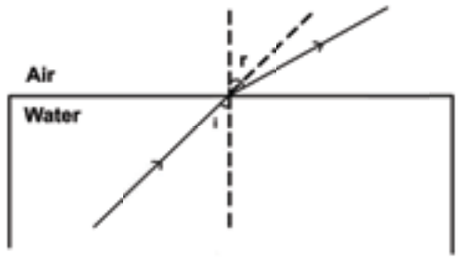


Figure 23 Light ray travelling from denser to rarer medium

A ray of light incident normally on a denser medium, goes without any deviation. (Figure 24).

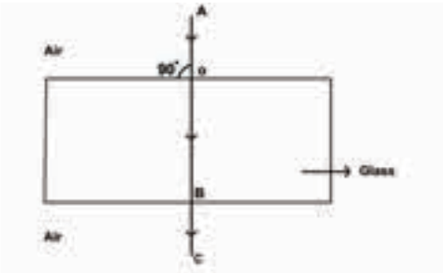


Figure 24 Incident of light ray in denser medium

3.7.4 The laws of refraction of light

The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction.

If i is the angle of incidence and r is the angle of refraction, then

$$\frac{\sin i}{\sin r} = \text{constant}$$

This constant is called the refractive index of the second medium with respect to the first medium. It is generally represented by the Greek letter, ${}_1\mu_2$ (mew)

Note: The refractive index has no unit as it is the ratio of two similar quantities

3.7.5 Verification of laws of refraction

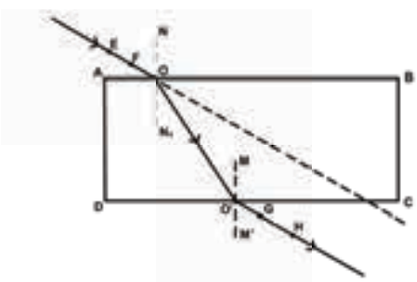


Figure 25 Verification of laws of refraction

Activity 7

Fix a sheet of white paper on a drawing board using drawing pins.

Place a rectangular glass slab over the sheet in the middle

Draw the outline of the slab with a pencil. Let us name the outline as ABCD

Take four identical pins.

Fix two pins. Say E and F, vertically such that the line joining the pins is inclined to the edge AB.

Look for the images of the pins E and F through the opposite edge. Fix two other pins, say G and H, such that these pins and the images of E and F lie on a straight line.

Remove the pins and the slab.

Join the prints of the pins E and F and let it meet AB at O. Let EF meet AB at O. Similarly, join the prints of the pins G and H and Let it meet HG at O′. Join O and O′. Also produce EF as shown by a dotted line in Figure 25.

Draw a perpendicular NN′ to AB at O and another perpendicular MM′ to CD at O′. In this activity, you will note that, the light ray has changed its direction at points O and O′. Note that both the points O and O′ lie on surfaces separating two transparent media. The light ray has entered from air to glass and has bent towards the normal that is from a rarer to denser medium.

The light ray has emerged from glass to air that is from a denser medium to a rarer medium. The light here has bent away from the normal. Compare the angle of incidence with the angle of refraction at both refracting surfaces AB and CD.

In Figure 25 EO is the incident ray OO′ the refracted ray and O′H the

emergent ray. You may observe that the emergent ray is parallel to the direction of the incident ray. Why does it happen so? The extent of bending of the ray of light at the opposite parallel faces AB (air-glass interface) and CD (glass-air-interface) of the rectangular glass slab is equal and opposite. This is why the ray emerges parallel to the incident ray. However, the light ray is shifted sideward slightly. What happens when a light ray is incident normally to the interface of two media? Try and find out.

Refraction through Rectangular glass slab:

http://www.freezeray.com/flashFiles/Refraction2.htm

3.7.6 Speed of light in different media

Light has the maximum speed in vacuum and it travels with different speeds in different media. The speed of light in some media is given below.

Substance	Speed of light(ms^{-1})	Refractive index(μ)
Water	2.25×10^8	1.33
glass	2×10^8	1.5
diamond	1.25×10^8	2.41
Air	3×10^8	1.00

Note: The refractive index of a medium is also defined in terms of speed of light in different media

$$\mu = \frac{\text{speed of light in vacuum or air } (c)}{\text{speed of light in the medium } (v)}$$

In general $_1\mu_2 = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}}$

Sample problem 4

The speed of light in air is $3 \times 10^8 ms^{-1}$ and in glass it is $2 \times 10^8 ms^{-1}$ what is the refractive index of glass.

$$_a\mu_g = \frac{3 \times 10^8}{2 \times 10^8} = \frac{3}{2} = 1.5$$

Sample problem 5

Light travels from a rarer medium to a denser medium. The angles of incidence and refraction are respectively 45° and 30°. Calculate the refractive index of the second medium with respect to the first medium.

Angle of incidence i = 45°

Angle of refraction r = 30°

$$_1\mu_2 = \frac{\sin i}{\sin r}$$

$$_1\mu_2 = \frac{\sin 45^\circ}{\sin 30^\circ}$$

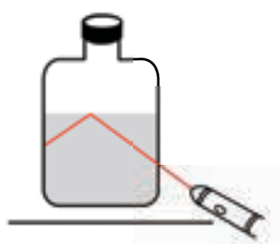
$$= \frac{1/\sqrt{2}}{1/2} = \sqrt{2}$$

$$_1\mu_2 = 1.414$$

3.8 Total Internal Reflection

A demonstration for total internal reflection

Apparatus: Small transparent bottle, Few drops of Dettol (or some salt); Pointer laser



- Take some water in a bottle; add a few drops of Dettol or some salt.

- Point the laser pointer at different angles and note its path
- At some angle, you will see that the light gets reflected within the water itself. This is called total internal reflection.

Total internal reflection: https://www.youtube.com/watch?v=axwDkA9PrgI

3.8.1 When does total internal reflection takes place?

When light travels from denser medium into a rarer medium, it gets refracted away from the normal. We know this. While the angle of incidence in the denser medium increases the angle of refraction also increases and it reaches a maximum value of r = 90° for a particular angle of incidence value. This angle of incidence is called critical angle (Figure 26). Now the refracted ray grazes the surface of separation between the two media.

The angle of incidence at which the angle of refraction is 90° is called the critical angle.

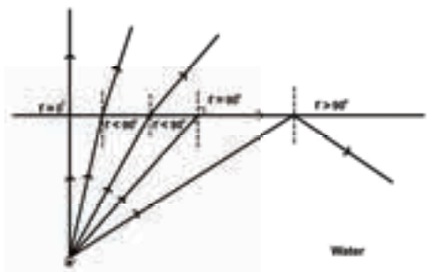


Figure 26 Critical angle

When the angle of incidence exceeds the value of critical angle, the refracted ray is not possible, since r > 90° the ray is totally reflected back to the same medium. This is called as total internal reflection.

3.8.2 Conditions to achieve total internal reflection

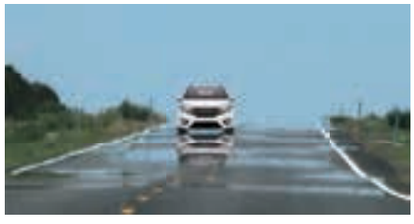
- Light must travel from denser medium to rarer medium. Example from water to air.
- The angle of incidence inside the denser medium must be greater than that of the critical angle.

Recall

1. Write the relation between the angle of incidence and the angle of refraction.
2. What is the unit of refractive index?
3. Which has higher refractive index: water or glass?
4. When does refraction take place?
5. When does total internal reflection take place?

3.8.3 Total internal reflection in nature

Mirage: On hot summer days, when you are travelling on a straight road have you seen the patch of water on the road which keeps moving ahead as you approach it? This is an illusion sometimes in the desert or over hot roads. Especially in summer, the air near the ground becomes hotter than the air at higher levels. The refractive index of air increases with its density. Hotter air is less dense, and has smaller refractive index than the cooler air. If the air currents are small, that is, the air is still, the optical density of different layers of air increases with height. As a result, light from an object such as a car (See Photo), passes through a medium whose refractive index decreases towards the ground. Thus, a ray of light from such an object successively bends away from the normal and undergoes total internal reflection, if the angle of incidence for the air near the ground exceeds the critical angle.



Diamond: Diamonds are known for their spectacular brilliance. Do you know the reason for their brilliance? It is mainly due to the total internal reflection of light inside them. The critical angle for diamond – air interface (θ_c =24.4°) is very small; therefore once light enters a diamond, it is very likely to undergo total internal reflection inside it. Diamonds faces in nature rarely exhibit the brilliance for which they are known. It is the technical skill of a diamond cutter which makes diamonds to sparkle so brilliantly. By cutting the diamond suitably, multiple total internal reflections can be made to occur.

Why do stars twinkle?

Stars are very far away from us (so appear as point-like objects); light from the star passes through our atmosphere before it reaches our eyes. This light bends (refracts) due to the varying densities and temperature of atmosphere. Moreover, the atmosphere is not stable; it is very turbulent. Therefore, the light which reaches us appears to come from different points. This gives the impression that stars are twinkling. If you go above the atmosphere and see(!), stars do not twinkle. Can you find why do planets not twinkle?

Optical fibres

Optical fibres are bundles of high-quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core is higher than that of the cladding. Optical fibres work on the phenomenon of total internal reflection. When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflection along the length of the fibre and finally comes out at the other end.

Optical fibres are extensively used for transmitting audio and video signals through long distances. Moreover, due to their flexible nature, optical fibers enable physicians to look and work inside the body through tiny incisions without having to perform surgery.

DO YOU KNOW?

We must be proud that an Indian-born physicist **Narinder Kapany** is regarded as the *Father of Fibre Optics*. Kapany used optical fibres to transmit and get back good images. In addition, Kapany's work is now used in lasers, biomedical instrumentation, solar energy and pollution monitoring. He is the one to have coined the name Fibre Optics.

Optical Fiber You tube Video: https://www.youtube.com/watch?v=llI8Mf_faVo

Recall

1. What are the examples of total internal reflection in nature?
2. What are the uses of total internal reflection?

Key words

Spherical mirror
Concave mirror
Convex mirror
Centre of curvature
Radius of curvature
Pole
Principal axis
Principal focus
Focal length
Magnification
Refraction of light
Laws of refraction
Total internal reflection

A-Z GLOSSARY

1. **Light** Light is a form of energy which produces the sensation of sight
2. **Ray of Light** Line drawn in the direction of propagation of light
3. **Laws of reflection**
   i) Angle of incidence is equal to the angle of reflection
   ii) The incident ray, the normal to the point of incidence and the reflected ray, all lie in the same plane
4. **Plane Mirror** Mirror with a flat (planar) reflective surface
5. **Spherical Mirror** A reflecting surface which is a part of a sphere whose inner or outer surface is reflecting
6. **Concave Mirror** Part of a hollow sphere whose outer part is silvered and/or inner part is the reflecting surface
7. **Convex Mirror** Part of the hollow sphere whose inner part is silvered and/or outer part is the reflecting surface
8. **Centre of curvature** The centre of the hollow sphere of which the spherical mirror forms a part is called centre of curvature
9. **Radius of curvature** The radius of the hollow sphere of which the spherical mirror forms a part is called radius of curvature
10. **Pole** The midpoint of the spherical mirror is called the pole
11. **Aperture** The diameter of the circular rim of the mirror is called the aperture of the mirror
12. **Principal axis** The normal to the centre of the mirror is called the principal axis
13. **Principal focus** The point on the principal axis of the spherical mirror where the rays of light parallel to the principal axis meet or appear to meet after reflection from the spherical mirror
14. **Focal length** The distance between the pole and the principal focus of the spherical mirror is called focal length. $f = \frac{R}{2}$; Where R is the radius of curvature of the mirror

15. **Mirror equation** The relation between u, v and f of a spherical mirror is known as mirror formula $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$

16. **Magnification** $m = \frac{\text{height of the image } h_2}{\text{height of the object } h_1}$

$$= \frac{-\text{image distance } v}{\text{object distance } u}$$

$$\text{so } m = \frac{h_2}{h_1} = \frac{-v}{u}$$

17. **Refraction of light** the bending of light when it passes obliquely from transparent medium to another is called refraction

18. **Laws of refraction**

The incident ray, the refracted ray and the normal to the surface separating two medium lie in the same plane

The ratio of the sine of the incident angle ($\angle$i) to the sine of the refracted angle ($\angle$r) is constant

i.e. $\mu = \frac{\sin i}{\sin r}$ = constant

19. **Total internal reflection** When the angle of incidence exceeds the value of critical angle the refracted ray is impossible, since r > 90° refraction is impossible the ray is totally reflected back to the same medium (denser medium). This is called as total internal reflection

ICT CORNER

LIGHT - REFRACTION

Refraction is bending of light when travel from one medium to another

This activity enable the students to learn about the different mediums and its role in refraction of light

B121_9_SCI_EM

Step 1. Type the following URL in the browser or scan the QR code from your mobile. Youcan see"**Bending light**" on the screen. Click intro

Step 2. Now you can see light beam from the torch. Options are there in the four corners. Select options of your choice and then press the button in the torch. You can see the phenomeno of refraction. The angles of refraction differ for different medium. You can check it with the protractor

Step 3. Next select prism. Now explore with given tools and different mediums and come out with different results

https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html

EXERCISE

ELXYHA

I. Multiple Choice Questions

1. The field of view * is maximum for _____

a) plane mirror

b) concave mirror

c) convex mirror

(*FOV is the extent of the observable area that is seen at any given instant)

2. When a ray of light passes from one medium to another medium, refraction takes place when angle of incidence is

a) 0° b) 45° c) 90°

3. _____ is used as reflectors in torchlight

a) concave mirror

b) convex mirror

c) plane mirror

4. We can create enlarged, virtual images with

a) concave mirror

b) convex mirror

c) plane mirror

5. When the reflecting surface is curved outwards the mirror formed will be

a) concave mirror

b) convex mirror

c) plane mirror

6. The focal length of a concave mirror is 5cm. Its radius of curvature is

a) 5 cm b) 10 cm c) 2.5 cm

7. When a beam of white light passes through a prism it gets

a) Reflected

b) deviated and dispersed

c) only deviated

8. The speed of light is maximum in

a) vacuum

b) glass

c) diamond

9. A real and enlarged image can be obtained by using a

a) convex mirror

b) plane mirror

c) concave mirror

10. Which of the following statements about total internal reflection is true?

a) angle of incidence should be greater than critical angle

b) light must travel from a medium of higher refractive index to a medium of lower refractive index

c) both (a) and (b)

II. True or False – If false give the correct answer

1. The angle of deviation depends on the refractive index of the glass.

2. If a ray of light passes obliquely from one medium to another, it does not suffer any deviation.

3. If the object is at infinity in front of a convex mirror the image is formed at infinity.

4. An object is placed at distance of 3 cm from a plane mirror. The distance of the object and image is 3 cm.

5. The convex mirror always produces a virtual, diminished and erect image of the object.
6. The distance from centre of curvature of the mirror to the pole is called the focal length of the mirror.
7. When an object is at the centre of curvature of concave mirror the image formed will be virtual and erect.
8. Light is one of the slowest travelling energy with a speed of 3×10^{-8} ms^{-1}
9. The angle of incidence at which the angle of refraction is 0^o is called the critical angle.
10. The reason for brilliance of diamonds is mainly due to total internal reflection of light.

III. Fill in the blanks / complete the Sentence

1. In going from a rarer to denser medium, the ray of light bends _____.
2. The ratio of sine of the angle of incidence to the sine of _____ is a constant.
3. The mirror used in search light is _____.
4. The angle of deviation of light ray in a prism depends on the angle of _____.
5. The radius of curvature of a concave mirror whose focal length is 5cm is _____.
6. A spherical mirror whose reflecting surface is curved outwards is called _____ mirror
7. Large _____ mirrors are used to concentrate sunlight to produce heat in solar furnaces
8. All distances parallel to the principal axis are measured from the _____ of the mirror
9. A negative sign in the value of magnification indicates that the image is _____
10. Light is refracted or bent while going from one medium to another because its _____ changes.

IV. Match the following

i) List I	List II
1. Ratio of height of image to height of object.	1. concave mirror
2. Used in hairpin bends in mountains	2. total internal reflection
3. Coin inside water appearing slightly raised	3. magnification
4. Mirage	4. convex mirror
5. Used as Dentist's mirror	5. refraction

ii) Position of object	Position of image	Size and nature of image
1. Within focus	a) Between F and C	A) Magnified , Real, inverted
2. At focus F	b) At C	B) Magnified, virtual, erect
3. Between F and C	c) Behind the mirror	C) Diminished, Real, inverted
4. At C	d) Infinity	D) Highly Diminished, Real, inverted
5. Beyond C	e) At F	E) Highly Magnified , Real, inverted
6. At infinity	f) Beyond C	F) Same size, Real, inverted

V. Assertion & Reason

In the following questions, the statement of assertion is followed by a reason. Mark the correct choice as:

a) If both assertion and reason are true and reason is the correct explanation

b) If assertion is true but reason is false.

c) If assertion is false but reason is true.

1. Assertion: For observing the traffic at a hairpin bend in mountain paths a plane mirror is preferred over convex mirror and concave mirror.

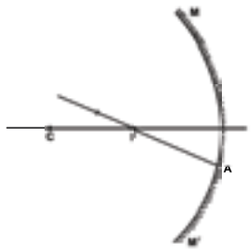
   Reason: A convex mirror has a much larger field of view than a plane mirror or a concave mirror.

2. Assertion: Incident ray is directed towards the centre of curvature of spherical mirror. After reflection it retraces its path.

   Reason: Angle of incidence i = Angle of reflection $r = 0^o$.

VI. Very short answer type

1. Give two examples of transparent medium that are denser than air.
2. According to cartesion sign convention, which mirror and which lens has negative focal length?
3. A coin in a glass beaker appears to rise as the beaker is slowly filled with water, why?
4. Name the mirror(s) that can give (i) an erect and enlarged image, (ii) same sized, inverted image
5. Name the spherical mirror(s) that has/have
   i) Virtual principal focus
   ii) Real principal focus
6. If an object is placed at the focus of a concave mirror, where is the image formed?
7. Copy this figure in your answer book and show the direction of the light ray after reflection

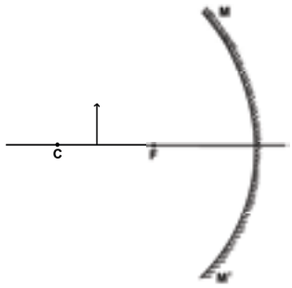


8. Why does a ray of light bend when it travels from one medium to another?
9. What is speed of light in vacuum? Who first measured the speed of light?
10. Concave mirrors are used by dentists to examine teeth. Why?

VII. Short answer type

1. a) Complete the diagram to show how a concave mirror forms the image of the object.

   b) What is the nature of the image?



2. Pick out the concave and convex mirrors from the following and tabulate them

   Rear-view mirror, Dentist's mirror, Torch-light mirror, Mirrors in shopping malls, Make-up mirror.

3. State the direction of incident ray which after reflection from a spherical mirror retraces its path. Give reason for your answer.

4. What is meant by magnification? Write its expression. What is its sign for the

   a) real image b) virtual image

5. Write the spherical mirror formula and explain the meaning of each symbol used in it.

VIII. Long answer type

1. a) Draw ray diagrams to show how the image is formed, using a concave mirror when the position of object is i) at C ii) between C and F iii) between F and P of the mirror.

   b) Mention in the diagram the position and nature of image in each case.

2. Explain with diagrams how refraction of incident light takes place from

   a) rarer to denser medium b) denser to rarer medium c) normal to the surface separating the two media.

3. State and verify laws of refraction using a glass slab.

4. Draw a ray diagram to show the formation of image by a concave mirror for an object placed between its pole and Principal focus and state three characteristics of the image.

IX. Numerical problems

1. The radius of curvature of a convex mirror is 40 cm. Find its focal length (Ans: 20 cm)

2. An object of height 2 cm is placed at a distance 20 cm in front of a concave mirror of focal length 12 cm. Find the position, size and nature of the image.

   (Ans: 30 cm in front of the mirror 3 cm high, real, inverted and magnified)

3. A concave mirror produces three times magnified real image of an object placed at 7 cm in front of it. Where is the image located?

   (Ans: 21 cm in front of the mirror)

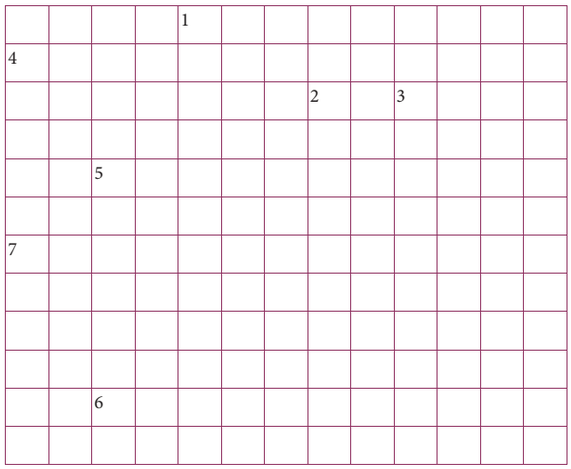
4. Light enters from air into a glass plate having refractive index 1.5. What is the speed of light in glass?(Speed of light in vacuum is 3×10^8 ms^{-1})

   (Ans: 2×10^8 ms^{-1})

5. The speed of light in water is 2.25×10^8 ms^{-1}. If the speed of light in vacuum is 3×10^8 ms^{-1}, calculate the refractive index of water.

   (Ans:1.33)

X. Cross word puzzle



Across

2. Optical illusion due to refraction
4. A type of mirror that diverge the light rays
6. The nature of image formed when object is near the pole of concave mirror
7. Electromagnetic radiation visible to us

Down

1. The light ray sent back from a surface into the same medium
3. When magnification is negative, the nature of the image is _____
5. For concave mirror u and f are always _____

HOTS

1. Light ray emerges from water into air. Draw a ray diagram indicating the change in its path in water.
2. When a ray of light passes from air into glass, is the angle of refraction greater than or less than the angle of incidence?
3. What do you conclude about the speed of light in diamond if you are told that the refractive index of diamond is 2.41?

Amazing fact

Did you know that some organisms can make their own light too? This ability is called bioluminescence. Worms, fish, squid, starfish and some other organisms that live in the dark sea habitat glow or flash light to scare off predators.

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2. Optics – Ajay GhotakDharyaganj Publishing circle, New Delhi
3. Physics for entertainment – book 2 Yakov Perelman, Mir Publishers

INTERNET RESOURCES

I. www.Physics.org
II. https://elearning.cpp.edu/learning-objects/optics/spherical-mirrors/
III. https://www.geogebra.org/m/aJuUDA9Z
IV. https://www.edumedia-sciences.com/en/media/362-concave-mirror
V. http://www.animations.physics.unsw.edu.au/light/geometrical-optics/
VI. https://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html
VII. http://www.splung.com/content/sid/4/page/snellslaw
VIII. http://interactagram.com/physics/optics/refraction/
IX. https://faraday.physics.utoronto.ca/PVB/Harrison/Flash/Optics/Refraction/Refraction.html

UNIT 4

Matter Around Us

Learning Objectives

EM7UIX

At the end of the lesson you will be able to

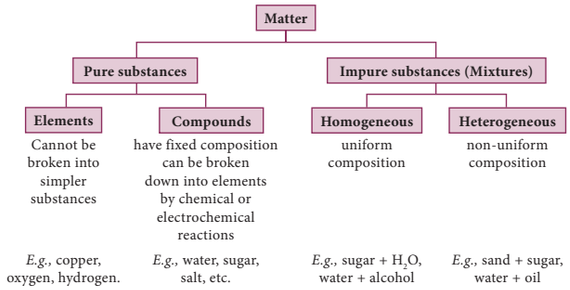
- understand the particle's nature of matter
- use particle-model to describe solids, liquids and gases
- list out the characteristics of particles of different states
- discuss about diffusion
- explain the force of attraction between the particles of matter
- explain change of state on the basis of particle model of matter
- explain the effect of temperature on changes of state
- introduced to microscopic models of particles through reasoning based on careful observation of macroscopic behaviour of particles
- inter convert Celsius & Kelvin scales of temperature
- classify substances as elements, compounds and mixtures based on chemical composition
- group mixtures as homogeneous and heterogeneous
- classify solutions based on the size of the solute particles and compare the true solutions, colloids and suspensions based on their properties
- differentiate colloids based on the nature of dispersed phase and dispersion medium
- compare o/w and w/o emulsions
- discuss some important examples and uses of colloids

Introduction

As we look-at our surroundings we see a variety of things made of different materials of different shapes, size, textures and colours.

The air we breathe, the food we eat, clouds, stones, plants, animals, a drop of water or a grain of sand everything is matter. As you will recall, from a tiniest bacteria to a giant planet anything which has mass and occupies space (volume) is matter.

From very early days, human beings have been trying to understand their surroundings. Early Indian philosophers classified matter in the form of five basic elements. Tolkāppiyam says "the world is the mixture of five elements – land,



fire, water, air and space. According to it everything, living and non living, was made up of these five basic elements. Ancient Greek philosophers had arrived at a similar classification of matter. Presently matter is classified based on its physical and chemical properties.

4.1 Is Matter Particulate or Continuous?

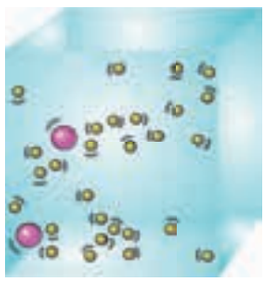
Some people thought that matter is made up of separate tiny particles and is discontinuous, like sands on a beach while some others thought it is continuous like a sea.

You already know that matter is made up of particles. Let us verify this first through some real life experiences and then by simple experiments.

Though **in 1803 John Dalton** proposed his atomic theory, no one could prove that matter was made up of separate particles since they were too small to see. In 1827, a Scottish botanist Robert Brown noticed, Pollen grains jiggling in water. He used a microscope to look at pollen grains moving randomly in water. Initially he thought that these pollen grains were to be some sort of unknown organisms. He repeated the experiment with non-living substances like fine rock dust. To his surprise he saw the same strange dance of the particles in the surface of the water. They were non-living, but they were constantly moving, as if something was making each of them to move. What could be there to make them move? At this point, he could not explain why this occurred.

One possible explanation was that very small particles in water were actually randomly moving all the time and were striking the pollen particles from all sides, to make them move randomly. This erratic movement of pollen grains later came to be known as **Brownian motion.**

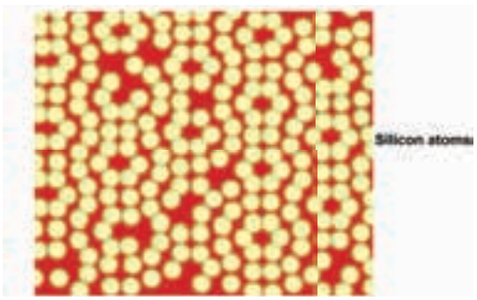
Movement



Brownian motion – Named after the botanist Robert Brown

In 1905, physicist **Albert Einstein** explained that the pollen grains were being moved by individual water particles or molecules. This confirmed that atoms and molecules did exist, and provided evidence for particle theory as well as they were on continuous motion. Particles in both liquids and gases (collectively called fluids) move randomly. They do this because they were bombarded by the other moving particles in the fluid. Larger particles can be moved by light, fast-moving molecules. It was only in 1908, observations backed with calculations had confirmed that atoms were real.

Today we are very convinced that atoms and molecules are not mere speculations. Using very sophisticated methods like Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), has actually made it possible to see atoms, like in the picture below.

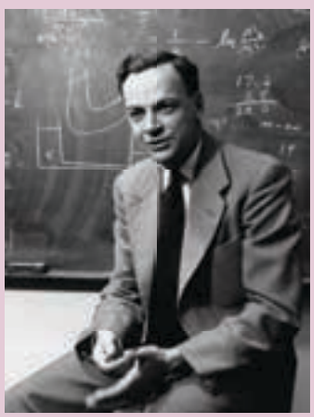


Silicon atoms on a surface via Scanning Electron Microscopy, SEM.

The atomic fact is: "***All things are made of atoms – tiny little particles moving around continuously, attracting each other when they are a short distance apart, but repelling when they are squeezed very close.***"

The Most Important Discovery

Richard Feynman, a very famous and extraordinary scientist (1918-1988) had said: The most important scientific discovery of the last ten thousand years is the **Atomic Fact!**



Activity 1

Identify the matters from the given data

Items for identification	Matters	Non-matters
Flower, bee, cloud, rainbow, leaf, fire, baby, torch light, sky, smoke, heat coming from glowing coals, fog, sound coming from a drum, laser beam		

Have you ever seen dust particles 'dancing' when a narrow beam of light enters a dark room?

This is yet another example of Brownian motion. Air is made of tiny particles that move around. These moving particles bump into dust particles making them move irregularly or dance. Air particles are tiny to be seen. Hence, we can see only dust particles.

These observations led to the kinetic particle theory of matter. According to this theory all matter is made up of tiny particles and these particles are in constant motion, which possesses kinetic energy.

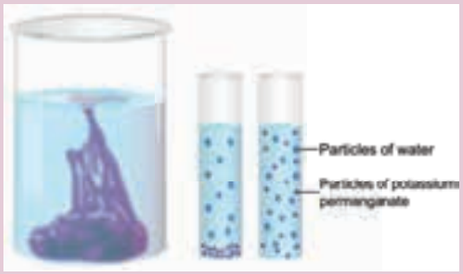
'Kinetic' means motion, based on this we are going to describe the differences in the properties of solids, liquids and gases and the changes in states of matter.

4.2 Evidence for Existence of Particles?

Activity 2

Let us place one or two crystals of Potassium Permanganate in a beaker of

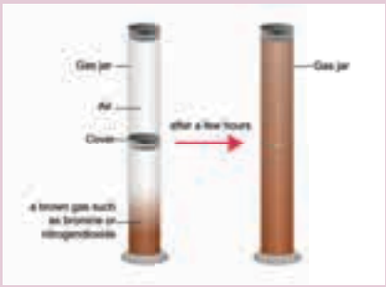
water. Leave it undisturbed for a while. What will we observe?



The pink colour spreads throughout the beaker. The colour spreads because the particles of permanganate leave the crystal and mix through the water particles. This process of dissolving is known as dissolution.

Let us see another experiment

Let us place an open gas jar of air upside down on another jar containing some bromine vapours or any other coloured gas. After some time we can see the colour spreads upwards due to the movement of the bromine particles which mixes with air.



In each of the above cases we can see that particles are in motion and they are colliding with each other and bounce off in all directions. This process is called diffusion. This couldn't have happened if particles didn't exist!

DO YOU KNOW?

A grain of common salt contains 1.2×10^{18}. Particles- half of which are sodium particles and half of which are chlorine particles

4.3 Kinetic Particle Theory of Three States of Matter- Solid, Liquid and Gas

The table below summarises the arrangement and movement of the particles in solid, liquid and gas and show schematic diagrams for the arrangement of these particles.

4.4 Solids

4.4.1 Why do solids have fixed shape?

According to the kinetic particle theory of matter the particles in solids

1. Are tightly packed in an orderly manner;
2. Are held together by strong attractive forces;
3. Have just enough kinetic energy to vibrate or rotate about their fixed positions
4. Cannot move freely

4.4.2 Why do solids have fixed volume?

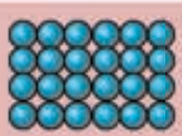
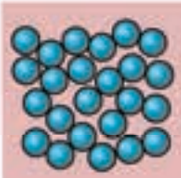
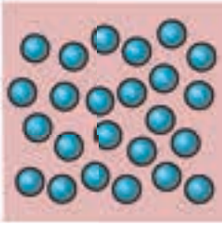
Solids cannot be compressed as there is very little space between the particles; they are packed close to each other. The distance between the particle is minimum. Hence they have fixed volume.

4.5 Liquids

4.5.1 Why do liquids not have fixed shape?

According to the kinetic particle theory of matter the particles in liquids

1. Are not arranged in an orderly manner;

Physical states	Solid	Liquid	Gas
Arrangement of particles	Tightly packed Regular pattern	Loosely packed Low random arrangement	Far apart High random arrangement
Movement of particles	Vibrate on the spot	Move around each other	Move quickly in all directions
Diagram			

2. Are held together by weak forces of attraction;
3. Have more kinetic energy than the particles of solids;
4. Are free to move throughout the medium by colliding over each other.

4.5.2 Why do liquids have fixed volume?

The particles in liquids are slightly away from each other compared to solids. They are packed quite closer to each other. Moreover the forces of attraction between them help to stay together. Thus liquids cannot be compressed and they have fixed volume.

4.6 Gases

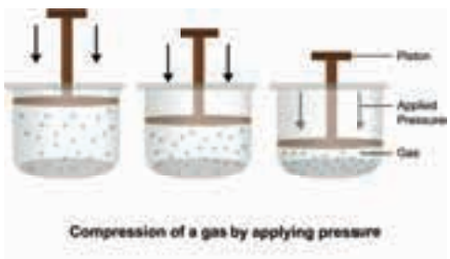
4.6.1 Why do gases not have fixed shape?

According to the kinetic theory of matter the particles in gases

1. Are not close to each other but are spread far apart from each other;
2. Are not held in any fixed positions;
3. Have very weak forces of attraction between each other, lesser than liquids;
4. Have a lot of kinetic energy and can move freely in all directions.

4.6.2 Why do gases not have fixed volume?

Since the particles in gases are far apart there is a lot of space between them. Therefore, they can be forced to get closer or in other words can easily be compressed.



Compression of a gas by applying pressure

By applying pressure, the particles in a gas can be brought closer. Gases are easily compressible.

Light, sound, heat etc. are not matter. They are different forms of Energy.

4.7 Effect of Temperature on Movement of Particles

Activity 3

Look at the image given below and give reasons to justify why they are not matter

Activity 4

1. Let us take two glass tumblers and fill one with cold water and the other with hot water.
2. Now add a drop of red ink into each of the glasses but do not stir. Observe.
3. In which glass does water turn red faster?
4. Does the rate of mixing change with temperature? What do you conclude?

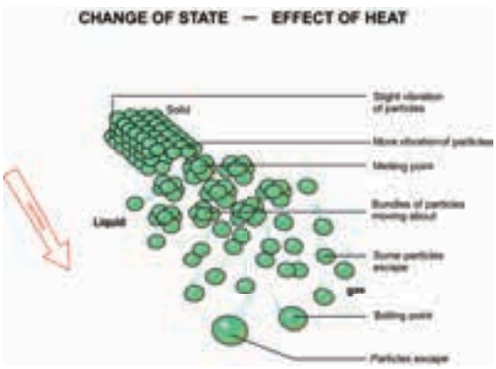
Ink diffuses faster in hot water than in cold water because with increase in temperature kinetic energy of the particles increases. The particles gain energy on heating and they move faster. Faster they move faster will be the mixing of ink in water. Rate of diffusion increases with increase in temperature.

DO YOU KNOW?

Why do liquids like water, mercury etc. form drops? The tendency for particles of water or mercury to stick together (cohesive forces) causes spheres or drops.

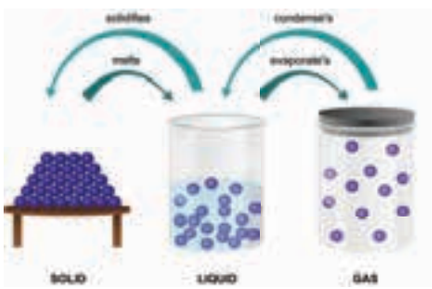
4.8 Changes in States of Matter and the Kinetic Particle Theory

Change of state



Matter can change from one state to another. When you taste an ice cream it changes from solid to liquid state due to the transfer of heat energy from your body to the ice cream. According to kinetic particle theory, particles of matter are in constant motion as they possess kinetic energy. As we discussed earlier, gases have more kinetic energy than the liquids and solids. Solids have the least kinetic energy.

When matter is either heated or cooled, heat energy is either absorbed or given out. This causes change in the energy of the particles leading to change of state. These changes are reversible physical changes.



Changes of states

- solid **melts** into liquid
- liquid **vaporises** into gas
- gas condenses into liquids
- liquid **freezes** or solidifies into solid

DO YOU KNOW?

The heat from our hand is enough to change solid metal Gallium into liquid.

According to first law of thermodynamics energy can be neither created nor destroyed but it can be converted from one form to another. During a change of state of matter, heat energy is converted into kinetic energy of the particles.

4.9 Melting

A substance absorbs heat energy and it melts. The temperature at which a substance melts is called as melting point. Different substances have different melting points. Hard substance such as diamond also melts.

Melting points of a few substances

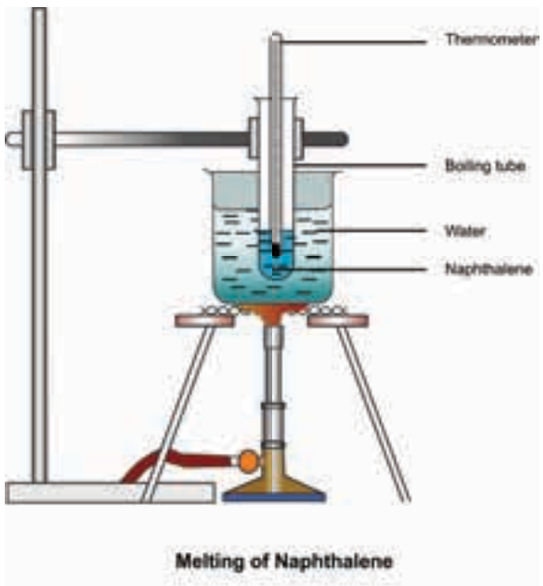
Substance	Melting point/°C
Oxygen	-219
Sodium	98
Iron	1540
Diamond	3550

4.9.1 What happens when a solid is heated until it melts?

Effect of heat on the particles of a solid

How temperature of a solid does varies on heating?

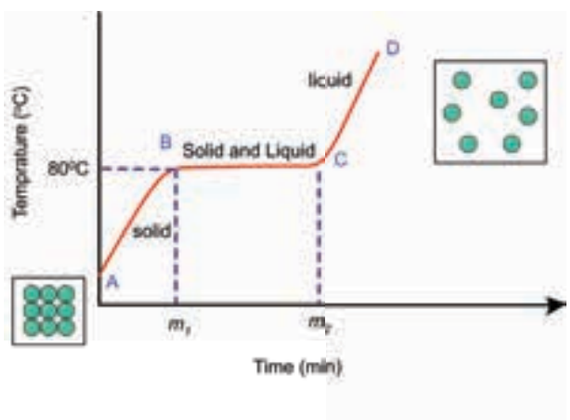
Melting point apparatus set up is as shown below. We can study the melting of solid naphthalene by varying the temperature with time.



Melting of Naphthalene

Let us observe the variation of temperature of the solid while it is heated at regular intervals of time. We can continue heating till entire solid melts and a little beyond. If we plot a graph of temperature versus time, we get a melting curve as shown below.

Melting Curve



From the graph what conclusions can we get?

Let us try to answer the following questions.

At what temperature does the solid start melting?

At what temperature does it melt completely?

What is the melting point of Naphthalene?

What does $m_1 - m_2$ represent?

Let us now analyse the curve.

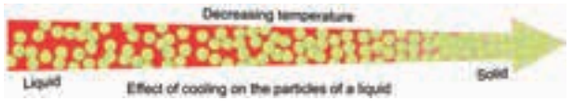
Between A → B	Between B → C	Between C → D
Solid gets heated up	Solid melts	Liquid gets heated up
Temperature steadily Increases till B which is the melting point and the solid begins to melt. Melting point 80°C	Solid continues to melt but there is no change in temperature, though heating is continued. A mixture of both solid and liquid naphthalene exists at this stage.	At C, entire solid is melted. Naphthalene is in liquid state now. There is gradual increase in temperature as heating is continued.

Why the temperature remains constant between B – C?

The entire heat energy absorbed is used to overcome the attractive forces between the solid particles, which are held in fixed positions. Hence, there is no increase in temperature. This hidden energy is called latent heat of fusion, which is exclusively used for change of state from solid to liquid.

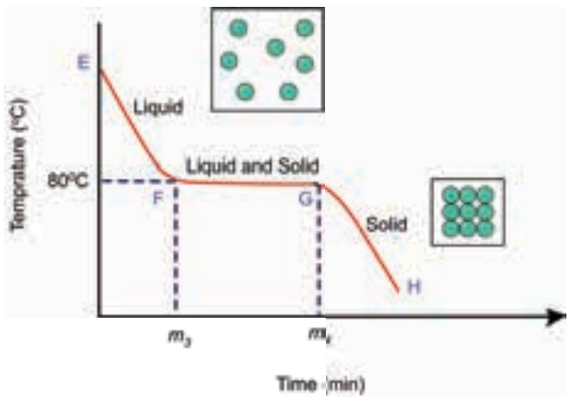
4.10 Freezing

Let us now try to reverse the process. Let us start with the liquid and cool it slowly. What happens?



How does the temperature of a liquid vary when it is cooled till it freezes?

Now let us start with the liquid naphthalene that we got from the previous experiment. Let us allow it to cool while observing the temperatures at regular intervals of time till the liquid completely freezes or solidifies. Let us plot a graph of temperature versus time. This curve is called the cooling curve. This shows that how the temperature of a pure solid changes as it is cooled to its freezing point and beyond.



Cooling Curve

From the graph what conclusions can we get?

At what temperature does the liquid begins to freeze?

At what temperature does it freeze completely?

What is the freezing point of Naphthalene?

Is the freezing point same as the melting point?

What does $m_3 - m_4$ represent?

Let us now analyse the curve.

Between E → F	Between F → G	Between G → H
Liquid gets cooled	Liquid freezes	Solid cools
Temperature gradually decreases till F, which is the freezing point and the liquid begins to freeze. Freezing point is 80°C	Liquid continues to freeze but there is no change in temperature, though cooling is continued. A mixture of both solid and liquid naphthalene exists at this stage.	At G, entire liquid is frozen. Naphthalene is in solid state now. The temperature of the solid naphthalene gradually decreases as the cooling continues.

Why the temperature remains a constant between F – G?

The entire heat energy is given out at this stage as the particles of the liquid get attracted to each other. This released energy is absorbed by the surroundings. Hence there is no increase in temperature for naphthalene. Both liquid and solid states co-exist at this stage. This hidden energy is called latent heat of freezing which is the same as latent heat of fusion, This latent heat is released when there is a change of state from liquid to solid.

4.11 Boiling

Boiling refers to the process by which a substance changes from the liquid state to the gaseous state at its boiling point. Different liquids have different boiling points.

Boiling points of a few substances

Substance	Boiling point/°C
Oxygen	–183
Sodium	890
Iron	2900
Diamond	4832

What happens when a liquid is heated?

Effect of heat on the particles of a liquid

More to Know

Boiling Point

Atmospheric pressure = prevailing pressure of the system

When a liquid is heated, it eventually reaches a temperature at which the vapour pressure is large enough that bubbles form inside the body of the liquid. This temperature is called the **boiling point**. Once the liquid starts to boil, the temperature remains constant until entire liquid has been converted to a gas.

The normal boiling point of water is 100°C at NTP. But if you try to boil an egg while camping in the Rocky Mountains at an elevation of 10,000 feet, you will find that it takes longer time for the egg to cook because water boils only at 90°C in this altitude. In theory, it is impossible to heat a liquid to temperatures above its normal boiling point.

Before microwave ovens became popular, however, pressure cookers were used to decrease the

amount of time it took to cook food. In a typical pressure cooker, water can remain a liquid at temperatures as high as 120°C, and food cooks in as little as one-third the normal time. To explain why water boils at 90°C in the mountains and 120°C in a pressure cooker, even though the normal boiling point of water is 100°C, we have to understand why a liquid boils. By definition, a liquid boils when the vapour pressure of the gas escaping from the liquid is equal to the pressure exerted on the liquid by its surroundings.

The normal boiling point of water is 100°C because this is the temperature at which the vapour pressure of water is 760 mmHg, or 1 atm. Under normal conditions, when the pressure of the atmosphere is approximately 760 mmHg, water boils at 100°C. At 10,000 feet above sea level, the pressure of the atmosphere is only 526 mmHg. At these elevations, water boils when its vapour pressure is 526 mmHg, which occurs at a temperature of 90°C.

Pressure cookers are equipped with a valve that lets gas escape when the pressure inside the pot exceeds some fixed value.

This valve is often set at 15 psi, which means that the water vapour inside the pot must reach a pressure of 2 atm before it can escape. Because water doesn't reach a vapour pressure of 2 atm until the temperature is 120°C, it boils in this container at 120°C. Since the temperature of water is higher, cooking is done faster. The concept of the above facts can be understood by the Gay-Lusaac's law.

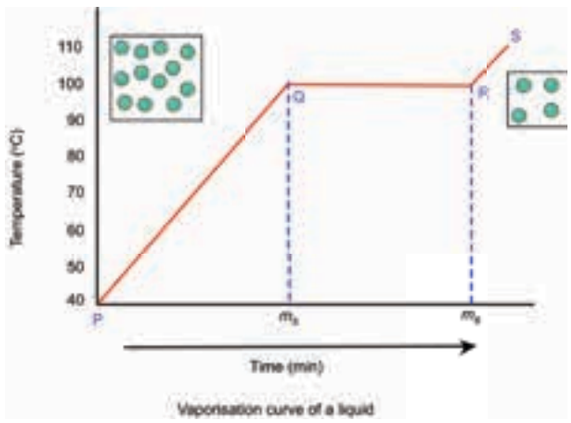
Heating curves and cooling curves

A heating curve is a graph showing the temperature of a substance plotted against the amount of energy it has absorbed. You may also see a cooling curve, which is obtained when a substance cools down and changes state.

How does the temperature of a liquid change when it is heated to its boiling point?

Let us take a liquid say water and heat it slowly till it boils while observing the temperature at regular intervals of time. If we plot a graph of temperature against time we will get one curve similar to the one shown below.

Vaporisation curve of a liquid



Vaporisation curve of a liquid

From the graph what conclusions can we get?

At what temperature does the liquid start boiling?

At what temperature does it boil off completely?

What is the boiling point of the liquid?

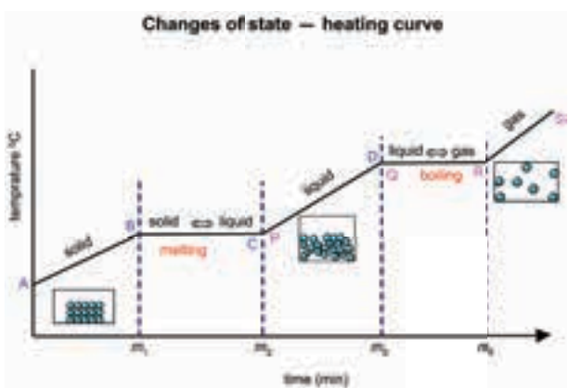
Let us now analyse the curve.

Between P → Q	Between Q → R	Between R → S
Liquid gets heated up	Liquid melts	Gas gets heated up
Temperature gradually increases till Q which is the boiling point and the liquid begins to boil.	Liquid continues to boil but there is no change in temperature, though heating is continued. A mixture of both liquid and gas exists at this stage.	At R, entire liquid is boiled. The liquid is changed into gas (vapour). There is a gradual increase in temperature of the gas as heating is continued.

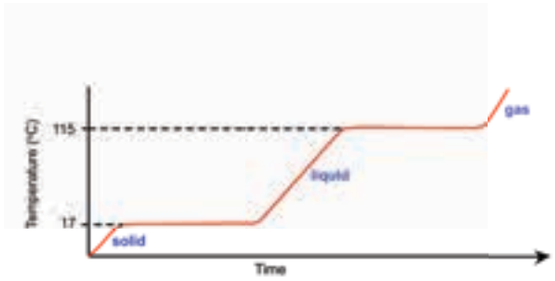
Why the temperature remains a constant between Q-R?

Entire heat energy is absorbed at this stage is used to overcome the attractive forces between the liquid particles which are intact. The particles start moving faster as their kinetic energy increases. Hence there is no increase in temperature. This hidden energy is called latent heat of vaporisation. The heat energy that is absorbed at this stage is exclusively used for change of state from liquid to vapour.

The following curve sums up what we have been discussed so far



Heating Curve



What is the melting point of this substance?

What is the boiling point of this substance?

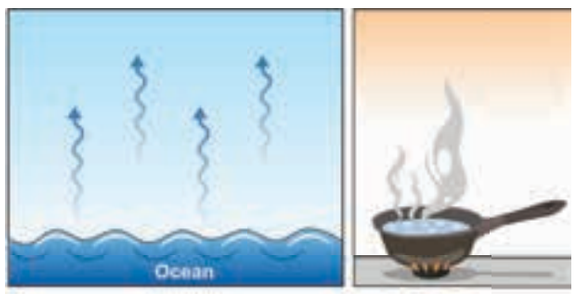
What is the state of the substance at room temperature (21^0C)

Test Yourself

1. Draw a cooling curve when a hot gas is cooled and condensed to its liquid form.
2. When you boil water you see bubbles.

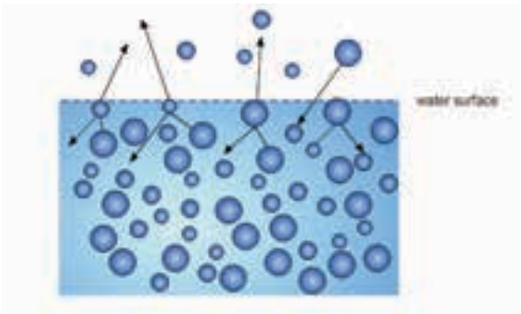
What are these bubbles? How are they formed?

Evaporation and Boiling



Vaporization is a process of phase transition (change of state) in which a substance, change its state from liquid to vapour. It can take place in two ways, i.e. evaporation and boiling. The process of evaporation involves phase transition at a temperature below the boiling temperature. On the other hand, boiling of a substance takes place at boiling point, which may vary with the change in the atmospheric pressure.

4.12 Evaporation



Evaporation takes place at the surface of a liquid, where molecules with the highest kinetic energy are able to escape.

When this happens, the average kinetic energy of the liquid is lowered, and its temperature decreases.

Test Yourself

1. Why do clothes dry faster on a hot day?
2. Name two factors other than temperature which will affect the rate of evaporation, taking examples from our daily life experiences.

4.13 Sublimation

Have you noticed that the moth balls which we place in our cloth cupboards disappear after a few days? But you may still get the smell of those naphthalene balls even after they 'disappear'. What has happened?

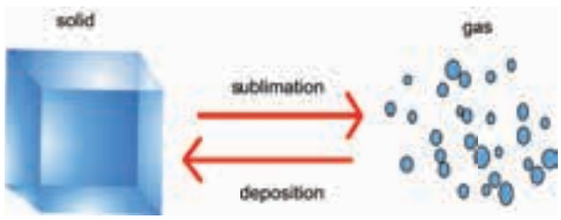
Certain solids change directly to gas without passing through the liquid state. The direct change of a state from solid to gas is called sublimation. On cooling these vapours come back to its original (or) actual state.

Comparison of boiling and evaporation

Basis For Comparison	Boiling	Evaporation
Meaning	Boiling implies a vaporization process that turns liquid into gas, when heated. It is a fast process.	Evaporation is a natural process, wherein the liquid changes its form to gas even without heating. It is a slow process.
Phenomenon	Bulk	Surface
Temperature	Occurs only at boiling point.	Occurs at any temperature.
Appearance	It forms bubbles	It does not forms bubbles.
Energy	Source of energy is required.	Energy is supplied by the surrounding.
Temperature of liquid	Remains constant	Decreases

More to Know

The air freshners are used in toilets. The solid slowly sublimes and releases the pleasant smell in the toilet over a certain period of time. Moth balls, made of naphthalene are used to drive away moths and some other insects. These also sublime over time. Camphor, is a substance used in Indian household. It sublimes to give a pleasant smell and is sometimes used as a freshner.



For example, dry ice (frozen CO_2), naphthalene, ammonium chloride and iodine sublime. The energy required for this change of state can be derived either from the surrounding or from the heat supplied. Inverse of this process is called deposition, in which gas particles lose heat and change their phase to solid.

DO YOU KNOW?

Dry ice, sometimes referred to as "cardice" is used primarily as a cooling agent. It is widely used for industrial refrigeration and transporting frozen food. It can maintain a temperature even lower than ice and it does not leave any liquid behind as it directly changes to gas.

4.14 Effect of Pressure on Gases

When you are blowing air into a balloon, you fill it with air particles moving with high speed. These particles colloide at the sides of the balloon and the applied pressure on it keeps the balloon inflated.

In a similar way all gases exert pressure. The pressure depends on the temperature of the gas and the volume it occupies.

Higher the temperature, higher will be the kinetic energy of the particles and faster will be the motion of the gas particles. They start hitting harder and more often on the walls of the container and pressure increases. Similarly when the volume decreases the gas gets compressed. The particles of the gas have only lesser space to move around. Therefore they start hitting on the walls of the container more and pressure increases.

BOYLE's law

The pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature.

https://www.thoughtco.com/definition-of-boyles-law-604842

DO YOU KNOW?

The temperature of gases can be expressed in Kelvin Scale also.

Kelvin is the SI unit of temperature.

The Kelvin scale is named after the Belfast-born, Glasgow University engineer and physicist William Lord Kelvin (1824–1907), who wrote of the need for an "absolute thermometric scale".

For conversion of temperature scale remember:

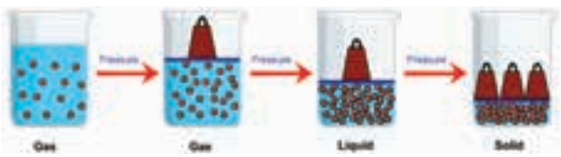
0 ^{0}C = 273.16 K (273 K for convenience)

Test Yourself

Complete the following table

CELSIUS	KELVIN
90 ^{0}C	363 K
?	283 K
63 ^{0}C	?
25 ^{0} C	?
?	303 K

We have seen that in gases the particles are apart and there is only very weak forces of attraction between them. If pressure is applied on a gas the particles are brought in close contact with each other. The attractive forces eventually become strong enough to hold the particles close together, and the gas condenses to the liquid state.



If the pressure is increased still further, the particles are brought in very close to each other that the attractive forces are strong enough to hold them in place in a three-dimensional arrangement. The liquid then becomes a solid.

More to Know

Gas cylinder

LPG – Liquefied Petroleum Gas

It is highly inflammable hydrocarbon gas. It contains mixture of butane and propane gases. LPG, liquefied through pressurisation, is used for heating, cooking, auto fuel etc.

But, increase in pressure alone cannot bring about change of states from gas to liquid to solid. Apart from high pressure, low temperature is also necessary for a gas to be converted into liquid. You may learn more about this in higher classes.

To Summarise

PROPERTY	SOLIDS	LIQUIDS	GASES
VOLUME	Have definite volume	Have definite volume	Not have definite volume
SHAPE	Have definite shape	Not have definite shape	Not have definite shape

PROPERTY	SOLIDS	LIQUIDS	GASES
COMPRESSIBILITY	Cannot be compressed	Can be compressed to some extent	Can be compressed easily
DENSITY	Have high density	Have less density	Have least density
FLUIDITY	Do not flow	Can flow, particles slide over each other	Easily move throughout the available space
PACKING OF PARTICLES	Tightly packed	Loosely Packed	Particles much farther apart when compared to solids and liquids
DIFFUSION	Do not diffuse, vibrate in its fixed positions	Can be diffused	Diffused very easily
ATTRACTIVE FORCES	Strong attractive forces	Attractive forces are not so strong as in solids	Weak or negligible attractive forces
KINETIC ENERGY	Possess low kinetic energy	High kinetic energy	Very high kinetic energy

So far we have been discussing the classification of matter on the basis of their physical states. Now let us see how we can classify matter on the basis of chemical composition.

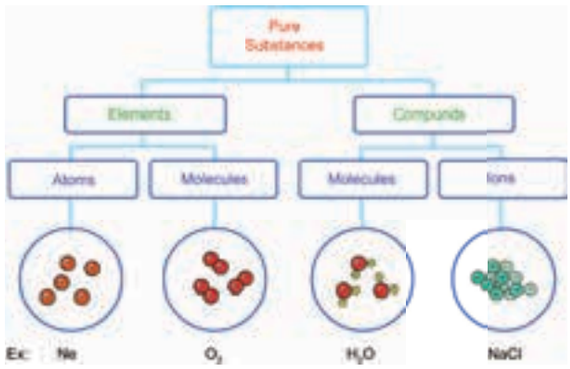
4.15 Classification of Matter Based on Composition

EMGQKK

As we know already, the matter is classified into pure substances and mixtures. From the chemistry point of view, pure substances are those which contain only one kind of particles whereas impure substances contain more than one kind of particles. While elements and compounds are considered to be pure substances, mixtures are considered as impure substances.

Let us look at a few examples.

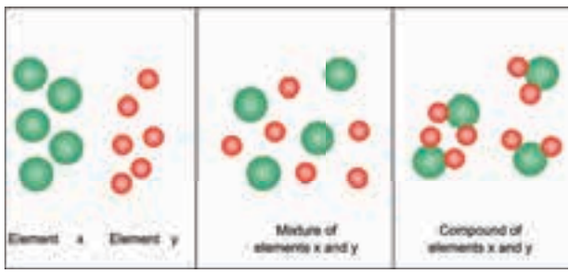
	SOLID	LIQUID	GAS
ELEMENT	Sodium	Bromine	Hydrogen
COMPOUND	Sodium chloride	Water	Carbon dioxide



Let us now try to recall our idea of elements and compounds.

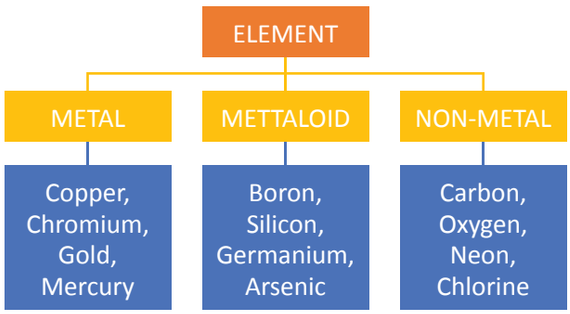
4.16 Element

An element contains atoms of the same kind. It cannot be further broken into simpler particles of matter by chemical methods of action, heat, light or electricity. Elements combine chemically to form compounds. When they are mixed physically they form mixtures.



DO YOU KNOW?

In modern periodic table there are 118 elements known to us, 92 of which are naturally occurring while the remaining 26 have been artificially created. But from these 118 elements, billions of compounds are formed- some naturally occurring and some artificial. Isn't that amazing?



4.17 Compound

A compound is made of two or more of elements combined in a fixed ratio by mass. For example water is made up of two elements, hydrogen and oxygen. Similarly, cane sugar is made up of three elements carbon, hydrogen and oxygen. A compound has a definite formula. Examples - water is H_2O, cane sugar is $C_{12}H_{22}O_{11}$.

The properties of a compound are entirely different from their constituent elements. For e.g. Iron Sulphide does not show the properties of neither sulphur nor iron. Try waving a magnet over Iron Sulphide? Does it get attracted to the magnet? No.

Compare and Contrast

ELEMENTS	COMPOUNDS
Contains only one kind of atoms	Contains more than one kind of atoms
It is a pure substance	It is not a pure substance
Cannot be broken down further in to simpler substances by chemical methods	Can be broken down further in to simpler substances by chemical methods
Has definite physical and chemical properties	Has definite physical and chemical properties

We can classify matter as pure and impure substances

Characteristics of Pure Substances

1. Made up of only one kind of atom or molecule.
2. The ratio of the components of a pure substance is fixed.
3. Have characteristic set of properties. Physical properties like boiling point, melting point, density etc. are fixed. Such properties will vary with the proportions of constituents present in the mixture.
4. Has the same composition throughout i.e. it is homogenous in nature.

Mixtures contain more than one substances. These are made by physically mixing two or more elements or compounds in any random proportion by mass or volume. For example Gunpowder is a mixture of sulphur, potassium nitrate and charcoal. Here individually each component by itself is a pure substance.

You will be able to find several examples of mixtures that we come across and use in our daily life.

Characteristics of Mixtures

1. The constituents of a mixture are loosely held together without any chemical force between the constituents and in such a case the constituents retain their individual properties.
2. A mixture can be prepared by mixing the constituents in any proportion i.e. mixtures do not have any fixed amount of its constituents.
3. Formation of mixtures does not involve any exchange of energy.
4. Mixtures do not have any characteristic set of properties. Physical properties of mixtures like boiling point, melting point etc. are not fixed. Such properties will vary with the proportions of constituents present in the mixture.
5. Components of a mixture can be separated by Physical methods.

Do it yourself: Collect various labels of food products, medicines, juices, etc. and discuss the ingredients present in them and tabulate it.

Have you come across the word "carat"? It describes purity of gold and weight of diamond.

Let us see the differences between mixtures and compounds.

4.18 Differences between Mixtures and Compounds

S.No	Mixtures	Compounds
1	A mixture can be separated into its constituents by physical processes like filtration, evaporation, sublimation, magnetic separation, solvent extraction.	A compound cannot be separated into its constituents by physical processes but can be only separated by chemical process
2	A mixture retains or shows the properties of its constituents	The properties of a compound are entirely different from those of its constituents
3	Energy (in the form of heat, light etc.) is neither given out nor absorbed in the preparation of a mixture	Energy (in the form of heat, light etc.) is given out or absorbed during the preparation of a compound
4	The composition or proportion is variable in a mixture does not have a definite formula	The composition of a compound is fixed. The constituents are present in a fixed ratio by mass. Compound has a definite formula
5	A mixture does not have fixed boiling point or melting point	A compound has a fixed boiling point or melting point

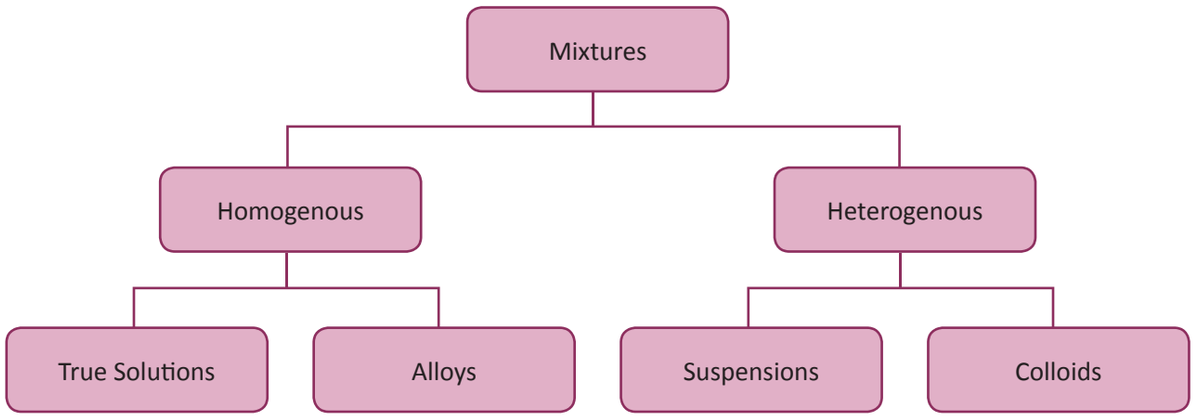
Most of the substances that we use in our daily life are mixtures. In some we will be able to see the components with our naked eyes but in most others the different components are not visible. They appear to have uniform composition. Based on this mixtures can be classified as below.

Activity 5

Test Yourself

1. Is air a pure substance or Mixture? Justify
2. You must have seen brass statues in museums and places of worship. Brass is an alloy made up of approx. 30% zinc and 70% copper. Is Brass a pure substance or a mixture or compound?

4.19 Types of Mixtures



4.19.1 Homogenous and heterogeneous mixtures

Let us try to differentiate a homogenous mixture from a heterogeneous mixture

In a homogeneous mixture the components are uniformly mixed and it will have single phase.

In heterogeneous mixture are not mixed thoroughly or uniformly, and it will have more than single phase.

Mix some Iron filings and common salt in a glass plate. Observe.

Are the constituents distinguishable? Can you see them separately despite mixing?

Now wave a magnet over the mixture. What do you observe?

Next take a pinch of salt and dissolve in water.

What do you get? Can you see the salt particles?

Record all your observations.

Conclusion – The mixture of iron filing and salt is **heterogeneous**. While the salt solution is **homogenous.**

Let us now try to differentiate a true solution from colloidal solution and suspension.

Let us go to the kitchen shelf and pick up bottles containing sugar, oil and rice or wheat flour.

Now let us add one tea spoon full of each one to a glass of water and stir well. Leave it aside for about ten minutes. Let us observe and enter

our observations in the table below.

Observations

	Water + sugar	Water + oil	Water + flour
Mixture- Clear/ cloudy/ turbid			
Particles-not seen/seen			
Particles settle down/ did not settle down			

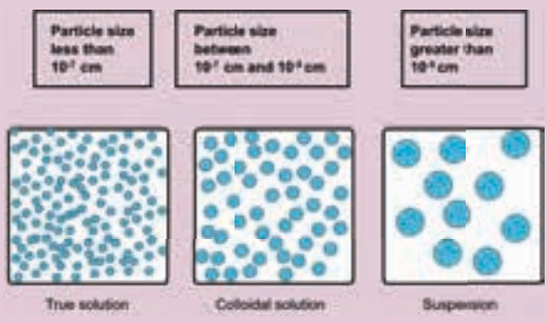
We can see that in the case of sugar we get a clear solution and the particles never settle down. In the case of oil and water we first get a cloudy mixture which separates into layers after a while. In the case of flour mixed with water we get a very turbid mixture and fine particles slowly settle down at the bottom after some time. We can call the first mixture as homogeneous mixture and a true solution. The second one was apparently homogeneous for a while but separated into layers, leaving behind some cloudiness. This is called a colloidal solution. The third one is heterogeneous and is called a suspension in which the particles settle down at the bottom.

4.19.2 Differences between homogenous and heterogeneous mixtures

Homogeneous mixtures	Heterogeneous mixtures
Components are uniformly mixed and it will have single phase, E.g. Alloys, salt solution, lemonade, petrol etc.	Components are not uniformly mixed and it will have more than single phase. Are called suspensions. E.g. chalk in water, petrol in water, sand in water, etc.
No boundaries of separation between the components. Has single phase.	There are visible boundaries between the components. Have two or more distinct phases.
Components are invisible to naked eye.	Components are visible to naked eye.
They will be in solid, liquid or in the gaseous phase.	Can be a solid-liquid or solid-gas or liquid- gas or solid-solid, or liquid-liquid mixtures.

What are the differences between True solutions, suspensions and colloids?

The major difference is the particle size. In fact interconversions of these mixtures are possible by varying the particle sizes by certain chemical and physical methods.



The following table summarises the differences between the three types of mixtures

Differences between Suspension, colloidal solution

Property	Suspension	Colloidal sol.	Solution
Particle size	>100nm	1 to100nm	<100nm
Filtration separation	Possible	Impossible	Impossible
Settling of particles	Settle on their own	Settle on centrifugation	Do not settle
Appearance	Opaque	Translucent (or) Semi transparent	Transparent
Tyndall effect	Shows	Shows	Does not show
Diffusion of particles	Do not diffuse	Diffuse slowly	Diffuse rapidly
Brownian movement	May show	Shows	May or may not show
Nature	Heterogeneous	Heterogeneous	Homogeneous

DO YOU KNOW?

1 nanometre (nm) = 10^{-9} m
or
1 meter = 10^{9} nanometres

Try this on your own

The longest wavelength of red light (almost infrared) that most people can see is 7.5×10^{-7} meters. What is this in nanometres?

Length in nm = (length in m) × (10^{9} nm/m)

More to Know

The Headlights of vehicles work on the principle of Tyndall effect. Blue colour of sky is also a Tyndall effect.

4.20 Colloidal Solutions

A colloidal solution is a heterogeneous system consisting of the dispersed phase and the dispersion medium.

Dispersed Phase	Dispersion Medium
Component present in smaller proportion	Component present in larger proportion
Analogous to solute of a true solution	Analogous to solvent of a true solution

Classification of colloids based on physical state of dispersed phase and dispersion medium

Dispersed phase or the dispersion medium can be a solid, or liquid or gas. There are eight different combinations possible (The combination in which both the dispersed phase and dispersion medium are gases which are completely miscible and can never give rise to a colloidal solution). Because gas in gas formed a true solution.

We can see that the particle size in a colloidal solution is in between that of a true solution and suspension. Because of this particular range in size colloidal solutions show certain special properties like Brownian movement and Tyndall effect. You are already familiar with the Brownian movement and the particle nature of matter is explained on that.

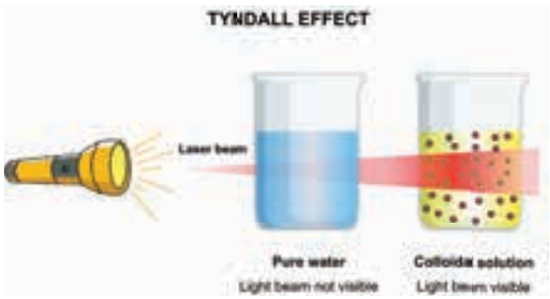
S.No	Dispersed Phase	Dispersion Medium	Name	Examples
1	Solid	Solid	Solid sol	Alloys, gems, coloured glass
2	Solid	Liquid	Sol	Paints, inks, egg white
3	Solid	Gas	Aerosol	Smoke, dust
4	Liquid	Solid	Gel	Curd, Cheese, jelly
5	Liquid	Liquid	Emulsion	Milk, butter, oil in water
6	Liquid	Gas	Aerosol	Mist, fog, clouds
7	Gas	Solid	Solid foam	Cake, bread
8	Gas	Liquid	Foam	Soap lather, Aerated water

4.20.1 Brownian movement

It is a kinetic property. When colloidal solution are viewed under powerful microscope, it can be seen that colloidal particles are moving constantly and rapidly in zig-zag directions. The Brownian movement of particles is due to the unbalanced bombardment of the particles by the molecules of dispersion medium.

4.20.2 Tyndall effect

Tyndall Effect: Tyndall (1869) observed that when a strong beam of light is focused on a colloidal solution the path of the beam becomes visible. This phenomenon is known as **Tyndall effect** and the illuminated path is called **Tyndall cone.** This phenomenon is not observed in case of true solution.



Cause for Tyndall effect

This phenomenon is due to scattering of light by colloidal particles. The colloidal particles become self-luminous due to absorption of light energy which is then scattered from their surface. The maximum scattered intensity in the plane is at right angle to the path of the light and thus the path becomes visible when observed from the sides. The intensity of scattered light depends on the type of colloidal solution and the size of the colloidal particles.

Think and answer

1. Why whole milk is white?
2. Why ocean is blue?
3. Why sun looks yellow when it is really not?

Some Important Types of Colloids

4.20.3 Gels

Gels are colloidal solutions with liquid dispersed in solid. A gel is a semi-solid substance which can flow but not as freely as a liquid. Within a gel the solid (dispersion medium) makes a kind of network which traps the dispersed liquid and makes it unable to flow freely.

Hair creams that are used to keep hair in place are gels that contain water and an oil.

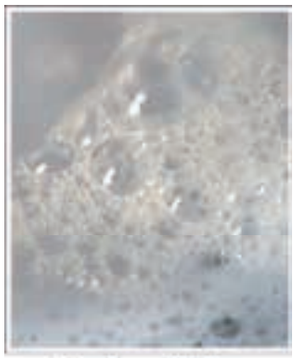
Petroleum gel used to hydrate skin

Hair gel used to style hair

Tooth paste - a gel

Foam and Solid foams: when gas dispersed in a liquid is called a foam. E.g. soap bubbles, carbonated beverages etc.

When the gases are dispersed in a solid structure is called solid foam. E.g. Bread, mattresses.



Soap foam bubbles

Solid foam

Emulsions - a special kind of colloids

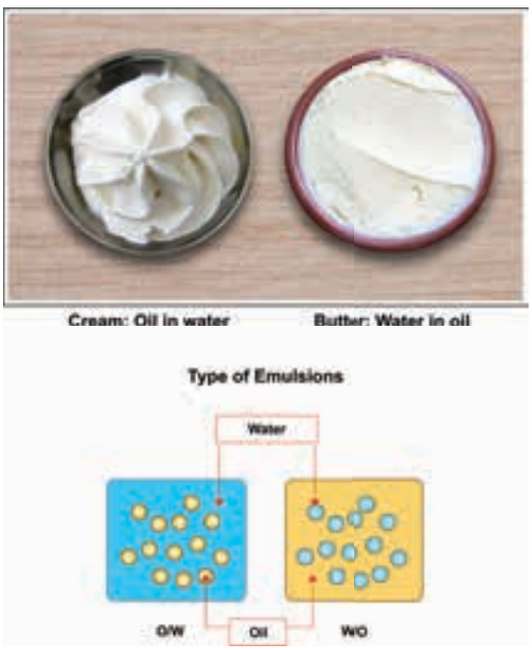
An emulsion is a colloid of two or more immiscible liquids where one liquid is dispersed in another liquid. This means one type of liquid particles get scattered in another liquid. In other words, an emulsion is a special type of mixture made by combining two liquids that normally don't mix. The word emulsion comes from the Latin word meaning "to milk" (milk is one example of an emulsion of fat and water). The process of turning a liquid mixture into an emulsion is called emulsification.

Examples of emulsions

Milk, butter, cream, egg yolk, paints, cough syrups, facial creams, pesticides etc. are some common examples of emulsions.

Types of emulsions

The two liquids mixed can form different types of emulsions. For example, oil and water can form an oil in water emulsion, where the oil droplets are dispersed in water, or they can form a water in oil emulsion, with water dispersed in oil.



Emulsions find wide applications in food processing, pharmaceuticals, metallurgy and many other important industries.


Cosmetology


Food industry

Pharmacology

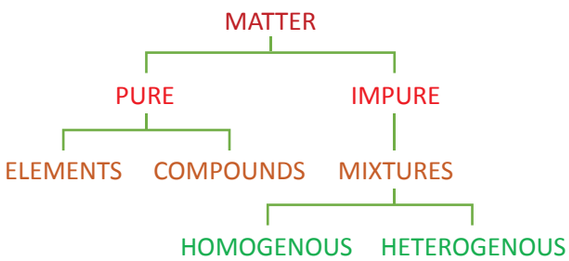
More to Know

Have you seen colourful rainbow patches on a wet road? When oil drops in water on road, it floats over water and forms a rainbow. Find out why.


Have you seen colourful rainbow patches on a wet Road?

Classification of matter based on composition – summary

Flow chart



4.21 Separation of Mixtures

At the end of the lesson you will be able to

- define key terms such as solute, solvent, solution, filtration, filtrate,

distillation, distillate, centrifugation, and chromatography

- analyse and select appropriate methods for separating a given mixture, based on certain difference in physical properties
- describe appropriate methods of separating a given mixture
- perform simple experiments involving separation of mixtures
- identify and assemble the suitable set of apparatus used for separating the components of a given mixture
- explain the basic principles involved in filtration, centrifugation, distillation and chromatography
- gather information about the industrial applications of the different techniques of separation

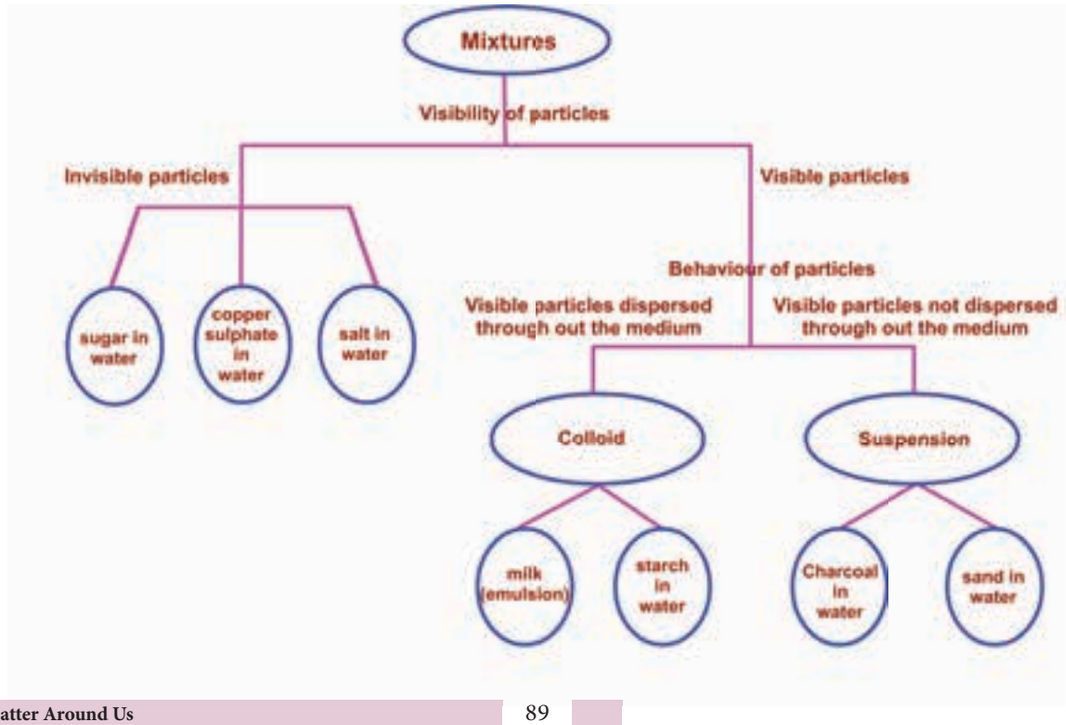
4.21.1 Introduction

A mixture as you know contains more than one substance in which the components can either be elements or compounds or both. We separate the components of a mixture very often as they contain useful substances mixed with harmful or unwanted substances which have to be removed. The choice of a particular method to separate components of a mixture will depend on the properties of the components of the mixture as well as their physical states.

4.21.2 Separation of solid – liquid mixtures

Before we talk about the separation methods let us recall briefly some aspects of solubility of solid and liquid. When a solid is added to a liquid, either the solid will dissolve in the liquid or not.

- When the solid dissolves in the liquid, it is said to be soluble i.e. Solid (solute) + Liquid (solvent) → Solution.
- When the solid does not dissolve in the liquid, it is said to be insoluble.



Separation of insoluble solids from liquids

Filtration and Decantation: You are already familiar with these methods. The illustrations given below will help you to recall these important techniques.

Activity 6

Identify whether the given substance is mixture or compound and justify your answer.

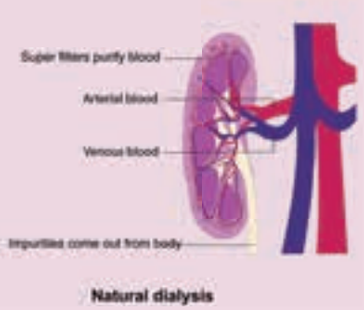
S. No.	Substance	Mixture/ compound
1	Sand and water	
2	Sand and iron filings	
3	Concrete	
4	Water and oil	
5	Salad	
6	Water	
7	Carbon dioxide	
8	Cement	
9	Alcohol	

Centrifugation: This is used to separate very fine and tiny particles of solid which do not settle down easily in a liquid. The mixture taken in a centrifuge tube is centrifuged (by rotation) in a centrifuging machine, so that the solid gets deposited at the bottom of the tube and the clear liquid (supernatant) is decanted. E.g. this is used to separate plasma (the liquid) from blood.

More to Know

Filters

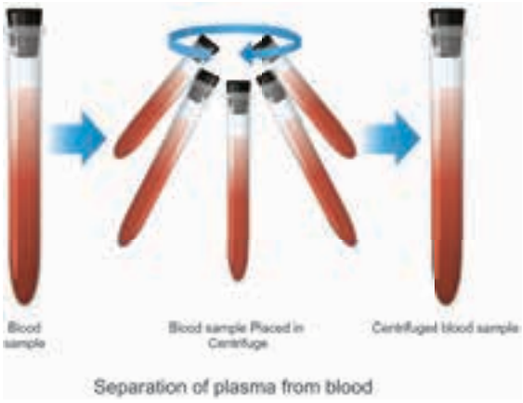
There are several types of filters: water filters, air - conditioning filters, automobile filters and carbon filters. In the case of colloids, special filter papers are used. They are called as ultra-filters, which have micro pores than ordinary filter papers and will allow only tiny impurities to pass through them and not the colloidal particles. Dialysis is an important method of filtration for purifying colloids.



Natural dialysis

Centrifugation technique is used in cream separator in diaries, in removing fat from

milk to produce skimmed milk and in separation of blood components & urine components in forensic science. Medium sized centrifuges are used in washing machine to wring water out of fabrics



Separation of plasma from blood

Separation of soluble solids from liquids

Evaporation and crystallisation: This is used to separate the dissolved solute from the solution. The solution is heated slowly so that the liquid (solvent) evaporates leaving behind the solid as crystals. E.g. Separation of salt from sea water (by solar evaporation in saltern).

Salterns in Tuticorin of Tamil Nadu

Simple distillation: This method is used to separate two liquids whose boiling points differ by more than 25 K. Also by this method, brackish water can be distilled.

Procedure: A distillation flask is fixed with a water condenser. A thermometer is introduced into the distillation flask through a one-holed stopper. The bulb of the thermometer should be slightly below the side tube.

The brackish water (sea water) to be distilled is taken in the distillation flask and heated for boiling. The pure water vapour passes through the inner tube of the condenser. The vapours on cooling condense into pure water (distillate) and are collected in a receiver. The salt are left behind in the flask as a residue.

4.21.3 Separation of liquid – liquid mixtures

a) Type I – Miscible liquids

Fractional distillation: To separate two or more miscible liquids which do not differ much in their boiling points (difference in boiling points is less than 25 K) fractional distillation is employed.

Example: Refining of petroleum product by fractional distillation.

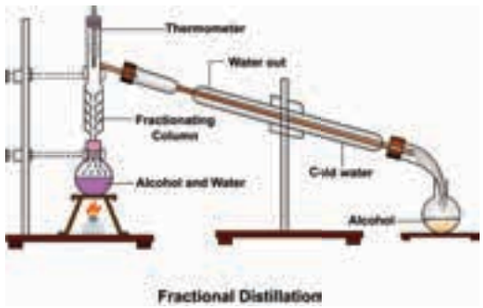

Saltern in Tuticorin of Tamil nadu

Activity 7

Make the students to collect various petroleum products and arrange them according to their boiling points.

Applications of fractional distillation

Fractional distillation is used in petrochemical industry to obtain different fractions of petroleum, to separate the different gases from air, to distil alcohols etc.

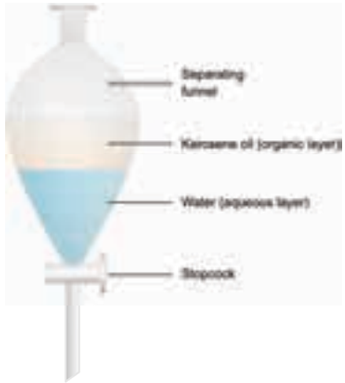


Fractional Distillation

b) Type II: Immiscible liquids

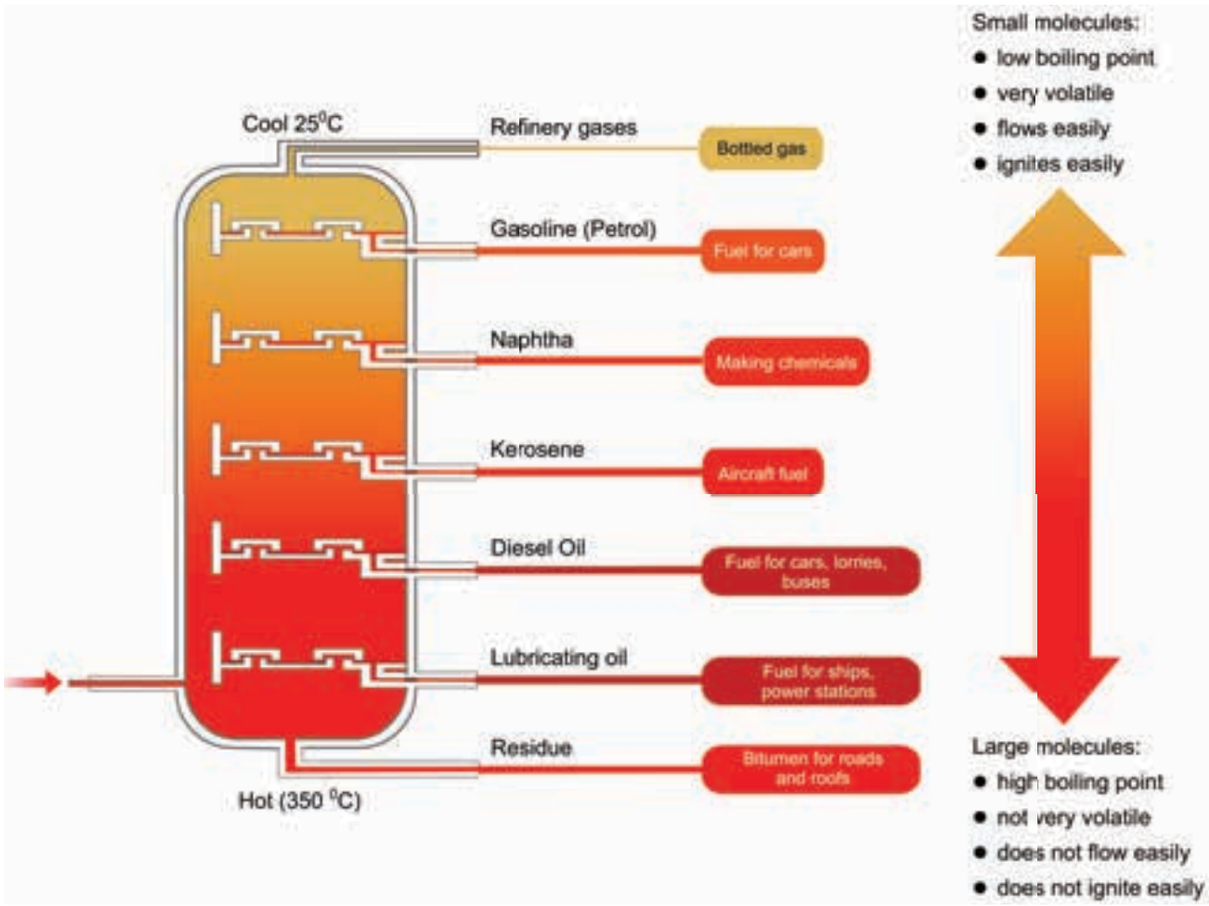
Mixtures of two immiscible liquids are separated by using a separating funnel.

Examples: Mixture of water and oil, Mixture of water and kerosene.



Two immiscible liquids can be separated by solvent extraction method, which is also called as liquid – liquid extraction method. This method works on the basis of difference in solubility of two immiscible liquids in a suitable solvent. Solvent extraction method is used in soap, pharmaceutical and petroleum industries.

Paradip refinery



Fractionating column

DO YOU KNOW?

Solvent extraction is an old practice done for years. It is the main process in perfume development and it is also used to obtain dyes from various sources.

Oil Spill

Oil containers are being washed and huge volume of oil-wastages are disposed into river and sea. Oil spill happens by accidents involving tankers, ships and refineries, etc. oil spills also caused by disposal of oil into water bodies. Oil spills affect marine organisms and they may be poisoned or even killed depending on what kind of oil is spilled. Oil spill can take several years to clean-up water bodies depending on location and area located.

Activity 8

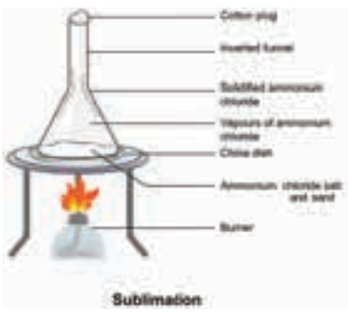
Pair activity: To separate a mixture of oil and water

Take separating funnel. Open the lid and pour the mixture of water and kerosene shake well. Then leave it for 5 minutes. Observe what happens? Water as bottom layer and kerosene floats as upper layer why?

Open the stopcock and collect the water and oil in a separate container.

Separation of mixture containing volatile and non-volatile solids

(i) Sublimation: Certain solid substances when heated change directly from solid to gaseous state without attaining liquid state. The vapours when cooled give back the solid substance. This process is known as sublimation. Examples: (a) Iodine (violet vapours) (b) Camphor, (c) Ammonium chloride etc.



Sublimation

The powdered mixture of Ammonium chloride and sand is taken in a china dish and covered with a perforated asbestos sheet. An inverted funnel is placed over the asbestos sheet as shown in the figure. The open end of the stem of the funnel is closed using cotton wool and the china dish is carefully heated. The pure vapours of the volatile solid pass through the holes in the asbestos sheet and condense on the inner sides of the funnel. The non-volatile impurities remain in the china dish.

Separation of mixture containing volatile and non-volatile solids

Before we discuss the technique we will take a look at two important terms that chromatography involves: Absorption and Adsorption.

Absorption is the process in which the substance is dissolved throughout the bulk of another substance. For example a paper (absorbent) soaks up or absorbs water.

Adsorption is the process in which particles of a substance (it could be gas, liquid or dissolved solid) adhere to a surface of another substance.

For example: charcoal adsorbs gases on its surface. Charcoal is called the adsorbent and the gas is called the adsorbate.

Chromatography is a separation technique. It is used to separate different components of a mixture based upon their different solubilities in the same solvent.

There are several types of chromatography; based on the above basic principles. It involves separation of mixtures by allowing the constituents of the mixture to move between two phases namely

I. Mobile phase
II. Stationary phase

The simplest type is paper chromatography. Here, the stationary phase is the chromatography paper and the

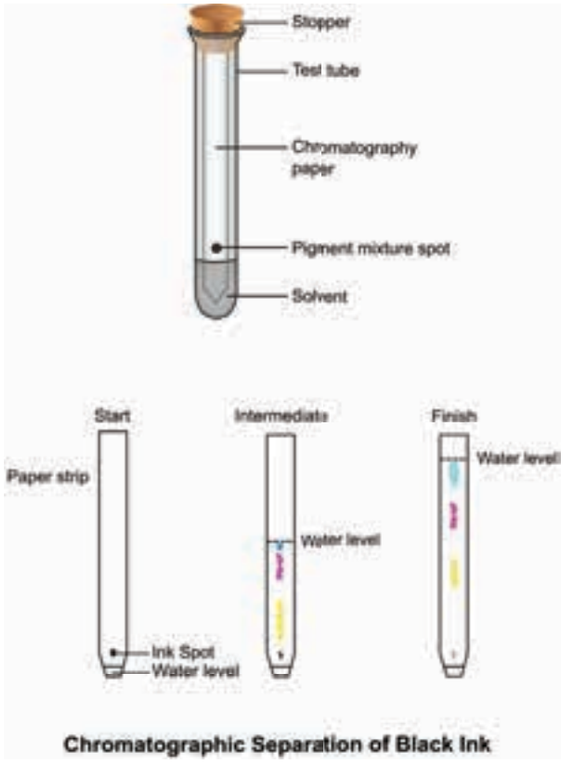
mobile phase is the solvent. For example, to separate the different-coloured dyes in a sample of ink, a spot of the ink (e.g. black ink) is put on to a piece of chromatography paper. This paper is then set in a suitable solvent as shown in Figure. The black ink separates into its constituent dyes. As the solvent moves up the paper, the dyes are carried with it and begin to separate. They separate because they have different solubility in the solvent and are adsorbed to different extents by the chromatography paper. The chromatogram shows that the black ink contains three dyes.

We can also draw important inferences from a numerical measurement called Rf (Retention factor) values using the obtained chromatograms. Rf value is defined as the ratio of the distance travelled by the solute spots to the distance travelled by the solvent.

$$Rf = \frac{\text{Distance travelled by the solute}}{\text{Distance travelled by the solvent}}$$

Applications

Chromatography is used extensively in medical research and forensic science laboratories to separate a variety of mixtures. For example, protein samples are separated by electrophoresis in medical research laboratories.



Chromatographic Separation of Black Ink

More to Know

The substances to be separated need not be coloured. Colourless substances can be made visible by spraying the chromatogram with a 'locating agent'. The 'locating agent' will react with the colourless substances to form a coloured product. In other situations the position of the substances on the chromatogram may be located using ultraviolet light.

EMQLM8

Key words

Matter	Boiling point	Pure substance
Volume	Kinetic energy	Mixture
Diffusion	Inter particle attraction	Homogenous
Force	Inter particle distance	Heterogeneous
Pressure	Change of state	True solution
Latent heat	Melting point	Suspension
Vaporisation	Sublimation	Colloid emulsions

Brownian motion	Emulsion	Adsorbate
Tyndall effect	Centrifugation	Chromatography
Solute	Distillation	Mobile phase
Solvent	Fractional Distillation	Stationary phase
True solution	Solvent Extraction	Dispersed phase / medium
Decantation	Absorption	Retention factor (Rf)
Supernatant liquid	Adsorption	Crystallization
Suspension	Adsorbent	Desalination

Points to Remember

- Matter is made of small particles- atoms in elements and molecules in compounds
- Matter around us exists in three physical states solid, liquid and gas
- The forces of attraction between particles are maximum in solids, intermediate in liquids and minimum in gases and this is responsible for the different properties of the three states of matter
- Matter changes states either by absorbing energy or releasing energy
- Heating and cooling curves describe the changes in temperature with time when a substance is heated or cooled
- Latent heat refers to the hidden heat energy which is utilised for change of state
- Depending upon the chemical composition, matter is classified into elements, compounds and mixtures
- Elements and compounds are considered to be pure substances as they contain only one kind of particles whereas mixtures contain more than one type of particles and they are considered impure substances
- The ratio of the components of a compound is fixed and their components cannot be separated by physical methods
- A mixture contains two or more kinds of particles which are mixed together in any ratio. The components can be separated by physical methods
- In a homogenous mixture (true solution) is the components are uniformly mixed and it will have single phase
- An alloy is a homogenous solution of two or more elements
- A heterogeneous mixture are not mixed thoroughly or uniformly and it will have more than single phase
- Based on particle size heterogeneous mixtures can be classified as colloidal solutions and suspensions
- The properties of colloidal solution are in between that of true solutions and suspensions
- Gels and emulsions are special kind of colloidal solutions which find wide applications in our daily life

GLOSSARY

1. **Celsius Scale** a scale of temperature in which 0° represents the melting point of ice and 100° represents the boiling point of water.
2. **Colloid** A system in which finely divided particles, which are approximately 1 to 1,000 millimicrons in size, are dispersed within a continuous medium in a manner that prevents them from being filtered easily or settled rapidly.
3. **Compounds** A pure, macroscopically homogeneous substance consisting of atoms or ions of two or more different elements in definite proportions that cannot be separated by physical means. A compound usually has properties unlike those of its constituent elements.
4. **Elements** A substance composed of atoms having an identical number of protons in each nucleus. Elements cannot be reduced to simpler substances by normal chemical means.
5. **Emulsion** a colloid in which both phases are liquids: an oil-in-water emulsion.
6. **Fahrenheit Scale** a scale of temperatures in which 32° represents the melting point of ice and 212° represents the boiling point of pure water under standard atmospheric pressure. Compare Celsius scale.
7. **Force of attraction** The first force that causes attraction is the gravitational force. According to Newton's Universal Law of Gravitation every object in the universe attracts every other object in the universe. Gravity is an attractive force since any object with mass will experience a force of attraction from other objects with mass.
8. **Gas** an air-like fluid substance which expands freely to fill any space available, irrespective of its quantity.
9. **Kelvin Scale** a thermodynamic temperature scale based upon the efficiencies of ideal heat engines. The zero of the scale is absolute zero. Originally the degree was equal to that on the Celsius scale but it is now defined so that the triple point of water is exactly 273.16 kelvins.
10. **Liquid** a substance that flows freely but is of constant volume, having a consistency like that of water or oil.
11. **Matter** physical substance which occupies space and possesses rest mass, especially as distinct from energy.
12. **Mixtures** A composition of two or more substances that are not chemically combined with each other and are capable of being separated.
13. **Solid** Solid is one of the four fundamental states of matter (the others being liquid, gas, and plasma). In solids molecules are closely packed. It is characterized by structural rigidity and resistance to changes of shape or volume.
14. **Absorption** is the process by which atoms, molecules, or ions enter a bulk phase (liquid, gas, solid). Absorption differs from adsorption, since the atoms/molecules/ions are taken up by the volume, not by surface. Examples: absorption of carbon dioxide by sodium hydroxide.
15. **Adsorption** is the adhesion of atoms, ions or molecules from a gas, liquid or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent.

16. **Centrifugation** is sedimentation of particles under the influence of the centrifugal force and it is used for separation of superfine suspensions. At centrifuging forces up to 10 000 times greater than gravity force are used, and at ultracentrifuge up to 600 000 times as great.

17. **Distillation** the separation of the constituents of a liquid by boiling it and then condensing the vapor that results. Distillation can be used to purify water or other substances, or to remove one component from a complex mixture, as when gasoline is distilled from crude oil or alcohol from a mash.

18. **Filtration** is any of various mechanical, physical or biological operations that separate solids from fluids (liquids or gases) by adding a medium through which only the fluid can pass. The fluid that passes through is called the filtrate.

19. **Retention factor** The Rf value is defined as the ratio of the distance moved by the solute (i.e. the dye or pigment under test) and the distance moved by the solvent (known as the Solvent front).

20. **Solution** a solution is a homogeneous mixture composed of two or more substances.

21. **Solute** a solute is a substance dissolved in another substance, known as a solvent.

22. **Supernatant** denoting the liquid lying above a solid residue after crystallization, precipitation, centrifugation, or other process.

23. **Suspension** A suspension is a heterogeneous mixture in which solute-like particles settle out of a solvent-like phase sometime after their introduction. We use the terms 'solute-like' and 'solvent-like' because we are dealing with a heterogeneous mixture, while the terms solute and solvent refer to homogeneous solutions.

EXERCISE 1

EVQDGD

I. Choose the correct answer

1. The physical state of water at 373 K is _____
   a) Solid b) liquid
   c) vapour d) plasma
2. Among the following _____ is a mixture
   a) Common Salt b) Juice
   c) Carbon dioxide d) Pure Silver
3. When we mix a drop of ink in water we get a _____
   a) Heterogeneous Mixture
   b) Homogeneous Mixture
   c) Compound
   d) Suspension
4. The constituents that form a mixture are also called
   a) Elements b) Compounds
   c) Alloys d) Components
5. _____ has the same properties throughout the sample
   a) Pure substance b) Mixture
   c) Colloid d) Suspension

II. State whether the following statements are true or false. If false give the correct statement

a) Liquids expand more than gases on heating.

b) A compound cannot be broken into simpler substances chemically.

c) Water has a definite boiling point and freezing point.

d) Buttermilk is an example of heterogeneous mixture.

e) Aspirin is composed of 60% Carbon, 4.5% Hydrogen and 35.5% Oxygen by mass. Aspirin is a mixture.

III. Match the following

S.No	A	B
i	Element	Settles down on standing
ii	Compound	Impure substance
iii	Colloid	Made up of molecules
iv	Suspension	Pure substance
v	Mixture	Made up of atoms

IV. Fill in the blanks

1. Evaporation is always accompanied by_____ in temperature
2. 150°C =_____ K
3. A _____mixture has no distinguishable boundary between its components.
4. An example of a substance that sublimes is _____
5. Latent heat is the energy used for _____.

V. Very Short answer

1. Why is it possible to row a boat in water but not pass through a wooden fence?
2. How gaseous pressure arises?
3. Define Sublimation.
4. Which state of matter has the highest kinetic energy?
5. A few drops of 'Dettol' when added to water the mixture turns turbid. Why?

VI. Short answer

1. Why are gases easily compressible whereas solids are incompressible?
2. Hold a 'smiley ball' and squeeze it. Can you compress it? Justify your answer?
3. Which of the following are pure substances? Ice, Milk, Iron, Hydrochloric acid, Mercury, Brick and Water.
4. Oxygen is very essential for us to live. It forms 21% of air by volume. Is it an element or compound?
5. You have just won a medal made of 22-carat gold. Have you just procured a pure substance or impure substance?

VII. Long Answer

1. Write the differences between elements and compounds and give an example for each.
2. Explain Tyndall effect and Brownian movement with suitable diagram.
3. How are homogenous solutions different from heterogeneous solution? Explain with examples.

VIII. Get together and do

1. **Project**

   Make a model to demonstrate any characteristic property of particles in a solid, liquid and gas.

IX. Get Connected

With Biology

The protoplasm that makes up our cells is a complex colloid that comprises a dispersed phase of protein, fat and other complex molecules in a continuous aqueous phase.

With History

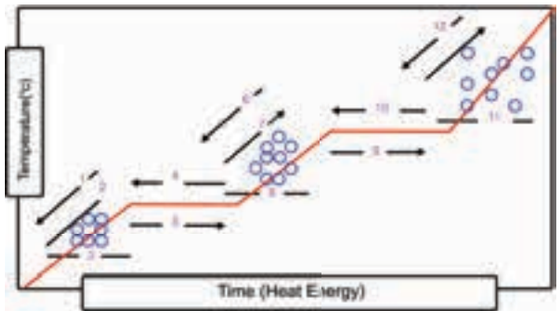
Alloys are mixtures of metals. The art of alloying was known to early man and this forms an important part of history and rise and fall of civilisations. The copper age followed the Bronze Age and later Iron Age. Read up more on these different ages.

With Home

List out three things you may do to dry your wet T -Shirt quickly.

HOTS

1. Fill in the numbered blanks to make the heating curve meaningful.



1. 'Shake well before use'. This is the instruction on a bottle of medicine. What kind of a mixture is contained in the bottle? Give reason.
2. What produces more severe burns, boiling water or steam? Why?

EXERCISE 2

I. Choose the correct answer

1. Difference in _____ is the principle used in fractional distillation
   a) solubility b) melting point
   c) boiling point d) adsorption
2. The separation of denser particles from lighter particles done by rotation at high speed is called _____
   a) Filtration b) sedimentation
   c) decantation d) centrifugation
3. _____ is essential to perform separation by solvent extraction method.
   a) Separating funnel
   b) centrifuge machine
   c) filter paper
   d) sieve
4. Filtration method is effective in separating _____ mixture
   a) Solid-solid b) solid-liquid
   c) liquid-liquid d) liquid-gas
5. For a simple distillation process we need to have
   a) an evaporating dish.
   b) a separating funnel.
   c) a filter with filter paper.
   d) a Liebig condenser.

II. State whether the following statements are true or false. If false give the correct statement

1. Butter from curd can be separated by centrifugation.
2. Oil and water are immiscible in each other.

3) Sublimation is the property of a substance to directly change from liquid to solid state.

4) Liquid – liquid colloids are called gels.

5) Fractional distillation is used when the boiling point of the components have large difference

III. Match the following

	A	B	C
i	Sand and camphor	Ink	Distillation
ii	Acetone and water	Miscible liquids	Chromatography
iii	Pigments	Immiscible liquids	Separating funnel
iv	Salt and water	Mixture of two solids	Fractional distillation
v	Water and kerosene	Soluble	Sublimation

IV. Fill in the blanks

1. Alcohol can be separated from water by _____
2. Sand is removed from naphthalene by _____ method.
3. In petroleum refining, the method of separation used is _____
4. Chromatography is based on the principle of _____
5. The solubility of solid in water _____ with an increase in temperature

V. Very Short answer

1. Name the method you would adopt to separate a mixture of ammonium chloride and common salt.
2. Define a solute and a solvent.
3. Name the sublimate that you will be getting when you heat a mixture of
   i. Iodine and sand
   ii. Sodium chloride and ammonium chloride.
4. What is meant by desalination of sea water?

VI. Short answer

1. What is an adsorbate and adsorbent?
2. What is meant by Rf value?
3. Differentiate between filtrate and distillate.
4. Name the apparatus that you will use to separate the components of mixtures containing two, i. miscible liquids, ii. immiscible liquids.
5. How will you separate a mixture containing saw dust, naphthalene and iron filings?

VII. Long Answer

How is a mixture of common salt, oil and water separated? You can use a combination of different methods.

1. Group activity (group of four): Use your research skills (including the Internet) to find out what is forensic science and obtain information about the use of chromatography in forensic science.

2. Field Trip: Visit a milk dairy and note down the at least two separating techniques used there.

Connect with Environmental Science:

November 2017 - BREAKING NEWS

…There's no fresh air in the Indian capital right now. Pollution in Delhi, which spikes during winter, hit almost 30 times the World Health Organisation's (WHO) safe limits with the concentration of harmful PM 2.5 particles topping 700 micrograms per cubic metre (mpcm). Smog in the capital (November 2017) Read up on the cause and hazardous effects of smog.

Pollution in Delhi

Connect with Geography

Formation of delta: A river delta is a landform that is formed when river water meets the sea water. Clay particles and constituents of sea water 'coagulate' leading to the deposition of sediment which is called the delta. Read more on deltas of India especially -The Sundarbans!

HOTS

1.

Two immiscible liquids are taken in the above funnel for separation. Which is denser, X or Y? Suggest any one example for X and one for Y. A third liquid Z which is soluble only in Y is added to the mixture and contents in the funnel are shaken well. How many layers will you observe now? How will you separate the three liquids? Boiling point of X is 98° C, that of Y is 43° C and that of Z is 75° C.

2. The most appropriate labelling of X and Y in a filtration set up are

	X	Y
a.	precipitate	solvent
b.	solvent	solute
c.	residue	filtrate.
d.	filtrate	residue

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UNIT 5

Atomic Structure

Learning Objectives

EVZ9I1

At the end of this unit you will be able to

- state and illustrate the laws of multiple proportion, reciprocal proportion and law of combining volumes
- solve simple numerical problems based on the above laws
- to understand Rutherford's gold foil experiment
- conclude the presence of nucleus in an atom.
- to identify the limitations of Rutherford's model
- compare the charge and mass of sub-atomic particles
- calculate number of protons, neutrons and electrons in a given atomic number and mass number of an element
- differentiate isotopes, isobars and isotones
- explain the main postulates of Bohr's atomic model
- draw the atomic structure of first 20 elements
- recognize the significance of quantum numbers.
- assign valency of various elements based on the number of valence electrons

Introduction

We already know that anything that has definite mass and occupies space is known as matter.

Let us quickly recall
What is matter?
What are the different states of matter?
Is matter continuous or particulate in nature?

If somehow we could go on dividing any piece of matter we will get smaller and smaller particles until we reach the smallest particle of it which cannot be divided further. These smallest particles can be atoms, molecules or ions.

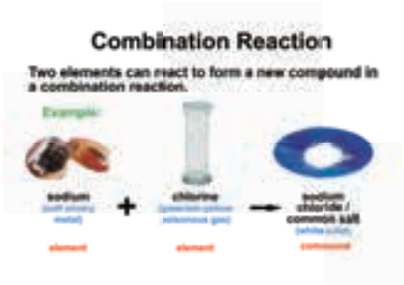
Atoms are the building blocks of matter. Every substance is made up of atoms in one form or other. Different kinds of atoms have different properties (both physical and chemical).

You already know that atoms combine together to form molecules. This combination is called a chemical reaction which can be represented symbolically by balanced chemical equations.

Now look at the following equation. What do you understand?

We can say that Sodium and Chlorine combine to form Sodium Chloride.

$$2Na + Cl_2 \longrightarrow 2NaCl$$



What is a combination reaction?

Combination reaction is a reaction where two or more substances combine to form a single substance. The combination of different elements to form a compound is governed by certain basic rules. These rules are known as Laws of chemical combination.

5.1 Laws of Chemical combination

Out of these five laws you already know the first two laws. Let us see the next three laws in detail in this chapter.

More to Know

- Kanada, the Indian philosopher of 6th century put forward the theory that everything in the universe was made of minute particles called "Paramanu"
- In fourth century BC, the Greek philosophers Leucippus and Democritus suggested that the universe was formed by very tiny particles named atoms.
- Ancient Indian philosophers said that Universe is formed from five basic elements, air, water, fire, soil, and space. Greek philosopher Plato argued that the Universe is formed of four elements soil, air, water & fire.

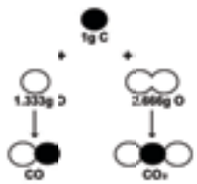
5.1.1 Law of multiple proportions

This law was proposed by **John Dalton in 1804**.

When two elements A and B combine together to form more than one compound, then masses of A which separately combines with a fixed mass of B are in simple ratio.

To illustrate the law let us consider the following example.

Carbon combines with oxygen to form two different oxides, carbon monoxide(CO) and carbon dioxide (CO_2).



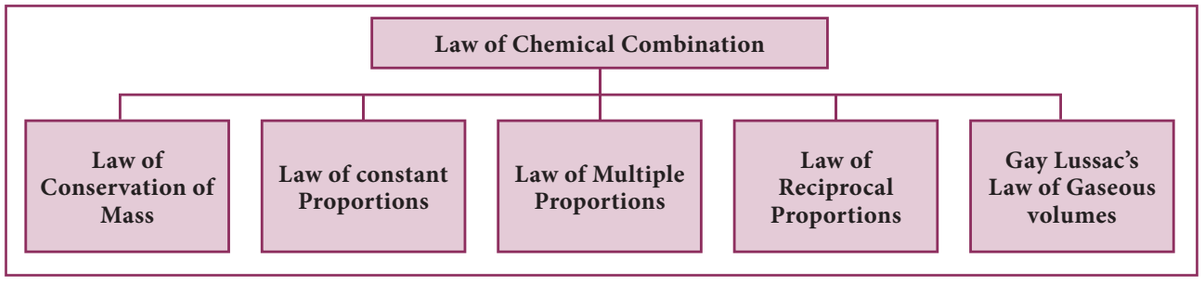
The ratio of masses of oxygen in CO and CO_2 for fixed mass of carbon is 1: 2. Isn't this a simple ratio? Let us take one more example. Sulphur combines with oxygen to form sulphur dioxide and sulphur trioxide. The ratio of masses of oxygen in SO_2 and SO_3 for fixed mass of Sulphur is 2:3.

Test Yourself

Tabulate the composition by mass of oxides of nitrogen with the fixed weight of nitrogen in the following table

What do you conclude?

Compound	N_2O	NO_2	N_2O_4	N_2O_5
Ratio of the molar masses N : O				



S. No	Compound	No. of atoms/g of carbon	No atoms/g of Oxygen	Ratio of masses C : O
1.	CO	One -12g	One-16g	12:16 or 1: 1.333g
2.	CO_2	One-12g	Two- 32g	12:32 or 1: 2.666g

Compound	N_2O	NO_2	N_2O_4	N_2O_5
Grams of oxygen combining with 1 gm of Nitrogen				
Simple O : N ratio				

Sample Problem(Solved)

Iron forms two different chlorides, namely ferrous and ferric chlorides. Each of these chlorides was prepared from 2 gram of iron. It was found that 4.538 gram ferrous chloride and 5.804 gram ferric chloride were produced. Show that these observations are according to the law of multiple proportions.

Solution:

Here iron is forms different chlorides. The weight of iron taken in both cases is the same. i.e. 2.0 g. Therefore, we have

	Ferrous chloride (A)	Ferric chloride (B)
Weight of chloride	4.538 g	5.804 g

	Ferrous chloride (A)	Ferric chloride (B)
Weight of iron	2.000 g	2.000 g
Weight of chlorine	2.538 g	3.804 g

The proportion of chlorine in this compound is

Ferrous chloride	:	Ferric chloride
2.538	:	3.804
1	:	1.5 or 2: 3

The proportion by weight of chlorine is indicated by a simple ratio. Thus Law of multiple proportions is verified

Activity 1

Lead forms three oxides A, B and C. The quantity of oxygen in each of the oxides A, B and C is 7.143%, 10.345% and 13.133% respectively. Show that the law of multiple proportions is obeyed.

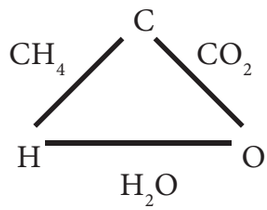
5.2 Law of Reciprocal Proportions

The **law of reciprocal proportions** was proposed by Jeremias Ritcher in 1792.

Jeremias Ritcher

It states that, "If two different elements combine separately with the same weight of a third element, the ratios of the masses in which they do so are either the same or a simple multiple of the mass ratio in which they combine."

Let us study the following example Here carbon combines with hydrogen and oxygen to form Methane (CH_4) and CO_2 (carbon dioxide) respectively. Hydrogen and oxygen combine to form water.



Sr. No	Compounds	Combining elements		Combining weights	
1	CH_4	C	H	12	4
2	CO_2	C	O	12	32

It is seen that in CH_4 the ratio of masses C : H = 3:1

In CO_2 the ratio of masses of C : O = 3:8

Here hydrogen and oxygen combine with the same mass of carbon. They also combine with each other to form water (H_2O)

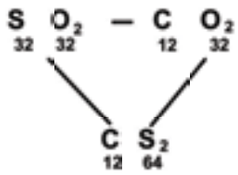
What is the ratio of masses of H and O in H_2O?

It is 2: 16 or 1:8 which is same as 4:32, which is the ratio of the different masses of hydrogen and oxygen combining with the same mass of carbon.

This illustrates the law of reciprocal proportions.

Let us consider one more example.

Sulphur combines with oxygen to form sulphur dioxide, carbon combines with oxygen to form carbon dioxide and carbon combines with sulphur to form carbon disulphide



The ratio of masses of carbon and sulphur which combine with fixed mass (32 parts) of oxygen is

12:32 or 3:8 …(1)

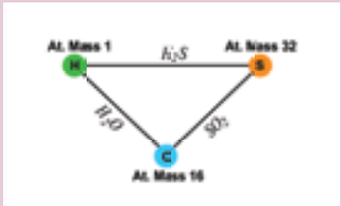
In CS_2 ratio of masses of carbon and sulphur is in the ratio

12:64 or 3:16 …(2)

The two ratios (1) and (2) are related to each other by $\frac{3}{8} : \frac{3}{16}$ or **2:1**

Activity 2

Illustrate the given diagram of law of reciprocal proportion



Solved problem

Hydrogen sulphide (H_2S) contains 94.11% sulphur, water (H_2O) contains 11.11% hydrogen and sulphur dioxide (SO_2) contains 50% of oxygen. Show that the results are in agreement with the law of reciprocal proportions.

Solution

In 100g of water, the weight of hydrogen	=	11.11 g
The weight of oxygen	=	100 – 11.11 = 88.89 g
In 100g of sulphur dioxide, the weight of sulphur	=	50 g
Weight of oxygen	=	100 – 50 = 50 g

The ratio between the weight of oxygen and Hydrogen is 88.89:11.11 i.e. 8:1 (1)

In hydrogen sulphide, the weight of sulphur = 94.11 g

The weight of hydrogen = 100 – 94.11 = 5.89 g

The ratio between the weight of sulphur and hydrogen is 94.11: 5.89 ie. 16: 1 … (2)

The two ratios 1 and 2 are related as 8/1: 16/1 (or) **1 : 2**

These are simple multiples of each other. The ratio between the weight of sulphur (32) and oxygen (16) which combine separately with the weight of Hydrogen (2) supports **the law of reciprocal proportions.**

Activity 3

1 gram of hydrogen combines with 15.88 gram of sulphur. 1 gram of hydrogen combines with 7.92 gram of oxygen. 8 gram of sulphur combines with 7.92 gram of oxygen. Show that these data illustrate the law of reciprocal proportions.

5.2.1 Gay Lussac's law of Combining Volumes

Whenever gases react together, the volumes of the reacting gases as well as the products bear a simple whole number ratio, provided all the volumes are measured under similar conditions of temperature and pressure

Step 1: Hydrogen combines with oxygen to form water (word equation)

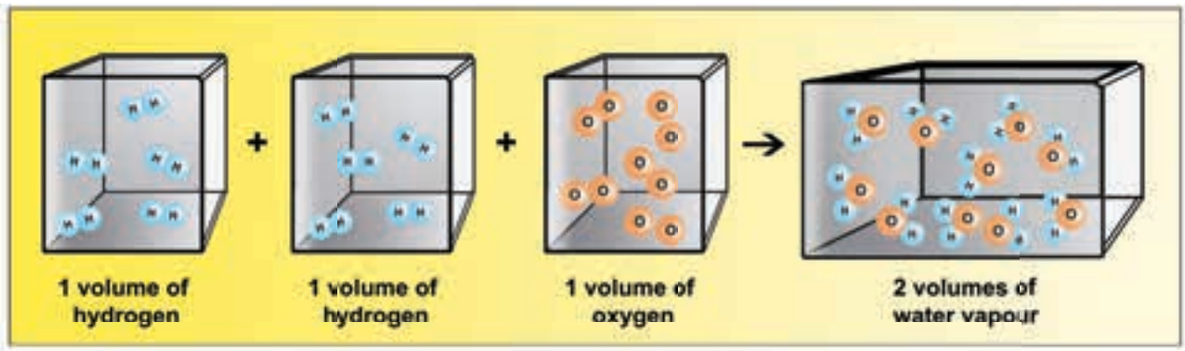
Step2: $H_2 + ½ O_2 \rightarrow H_2O$ (skeletal equation)

Step3: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_20$ (g) (balanced equation)

(2 Volumes) + (1 Volume)→(2 Volumes) **(2:1:2)**

i.e. two volumes of hydrogen react with 1 volume of oxygen to form two volumes of water vapour. i.e. the ratio by volume which gases bears is **2:1:2** which is a simple whole number ratio.

It follows that at a given temperature and pressure the volumes of all gaseous reactants and products bear a simple whole number ratio to each other.



Two volumes of hydrogen react with One volume of oxygen to give Two volumes of water vapour

Let us consider one more example:

Step 1: Hydrogen combines with chlorine to form hydrogen chloride

Step2: $H_2 + Cl_2 \rightarrow 2HCl$

Step 3: $\underset{1\text{volume}}{H_{2(g)}} + \underset{1\text{volume}}{Cl_{2(g)}} \rightarrow \underset{2\text{volumes}}{2HCl_{(g)}}$

[1 : 1 : 2]

i.e. one volume of hydrogen reacts with one volume of chlorine to form two volumes of HCl gas. i.e. the ratio by volume which gases bears is **1:1:2** which is a simple whole number ratio.

Activity 4

Nitrogen combines with hydrogen to form ammonia (NH_3). Illustrate Gay Lussac's law using this example.

Solved Problem

Methane burns in oxygen to form carbon dioxide and water vapour as given by the equation

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)+} 2H_2O_{(g)}$$

Calculate: (i) the volume of oxygen needed to burn completely 50 cm^3 of methane and (ii) the volume of carbon dioxide formed in this case.

Solution:

$CH_{4(g)}$	$+2O_{2(g)}$	$\rightarrow CO_{2(g)}$	$+2H_2O_{(g)}$
1 volume	2 volumes	1 volume	2 volumes
1 x 50 cm^3	2 x 50 cm^3	1 x 50 cm^3	2 x 50 cm^3
50 cm^3	100 cm^3	50 cm^3	100 cm^3

Volume of oxygen used = 100 cm^3

Volume of carbondioxide formed = 50 cm^3

Activity 5

100 cm^3 of propane (C_3H_8) was burnt in excess oxygen to form carbon dioxide and water. Calculate (i) the volume of oxygen used up (ii) the volume of carbon dioxide formed.

[Hint: $C_3H_8(g) + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O(l)$]

More about of structure of atoms

Know your Scientist

John Dalton FRS was an English chemist, physicist, and meteorologist. He is best known for proposing the modern atomic theory and for his research into colour blindness, sometimes referred to as Daltonism in his honour.

You already have a basic idea of Dalton's atomic theory, J. J. Thomson's Cathode ray experiments, and limitations of Thomson's model of atom.

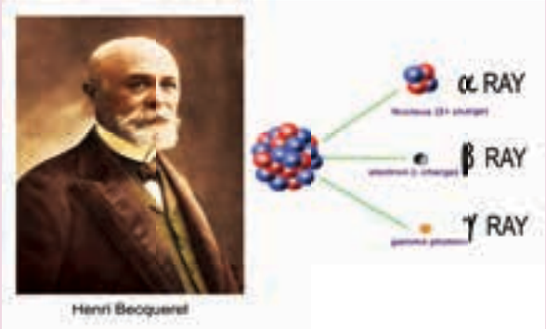
Let us recall:

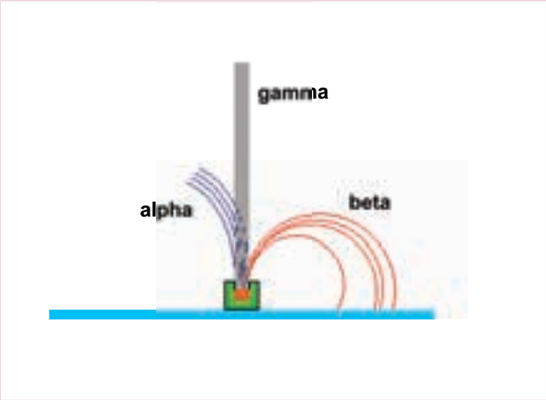
According to John Dalton: Matter consists of very small and indivisible particles called atoms.Atoms can neither be created nor be destroyed.The atoms of an element are alike in all respects but they differ from the atoms of other elements. Atoms of an element combine in small whole numbers to form molecules.

J J Thomson said that like plums in pudding the negatively charged electrons are dotted here and there in a positively charged sphere. According to this 'plum pudding' model, an atom is considered to be a sphere of uniform positive charge and electrons are embedded into it.

MORE TO KNOW: RADIOACTIVITY

In 1896, Henri Becquerel arranged in his cupboard, a packet of uranium salt beside an unexposed photographic plate. Several days later, he took out the plate and developed it. To his surprise, he noticed that the photographic plate had been exposed without having been exposed to the light. Having repeated this experiment, he concluded that some stream of particles came out from Uranium. Today we call them as alpha particle.





Alpha (α), beta (β) and gamma(γ) rays are emitted during the radioactive decay of an atom. The alpha and beta rays consist of actual matter form, while *gamma rays* are electromagnetic waves. The alpha particles which are the main constituent of the alpha radiation are made up of two protons and two neutrons. An alpha particle is identical with a Helium nucleus. Hence it is positively charged and has mass equal to a Helium atom.(He^{2+}). Beta particle is negatively charged and is identical with electron. Gamma rays have no charge. Rutherford used a stream of alpha particles for his experiment which is discussed below.

5.3 Discovery of Nucleus

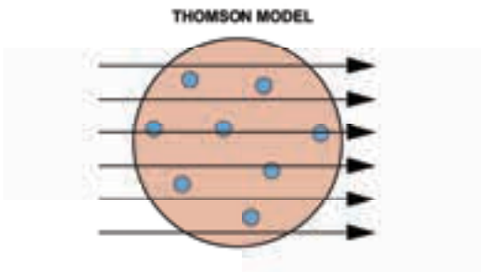
Know your Scientist

E. Rutherford (1871-1937) was born at Spring Grove on 30th August 1871. He was the 'Father' of nuclear physics. He is famous for his work on radioactivity and the discovery of the nucleus of an atom with the gold foil experiment. He got the Nobel Prize in chemistry in 1908. He was the first to produce Tritium in 1934.

Thomson's model of atoms is a conceptual representation like many other models in science. Scientists test scientific models by doing experiments to find out if they were wrong. The model proposed by Thomson was conceptual. Scientists were eager to test it by doing an experiment. How would you test if the model is correct or wrong? They are so small that even a powerful microscope is useless in peering inside an atom.

In 1905, Ernest Rutherford along with his scholars Hans Geiger and Ernest Marsden came up with an interesting idea to test the Thomson's model. In Thomson's model recall that the charges are symmetrically distributed. Suppose you shoot a highly energetic positively charged particle smaller than an atom, to collide at an atom, what do you expect? As the incoming particle is positive, it should be repelled by the positive atom. This is because you know that "like charges repel each other." If according to plum pudding model, the positive charge of atoms is evenly distributed; it should be very small at each point inside the atom. But as the energy of the incoming particle is higher than the repulsion at the point of contact, the particle should overcome the repulsion and penetrate the atom.

Once it is inside the atom, the positively charged particle is repulsed on all sides with the same force. Assuming that atom is a uniformly positively charged mass with random moving electrons, the particle should come out of the other end of the atom almost undeflected. Some of the electrons inside the atom could attract the positively charged particle and make small change in the path. Therefore it can be predicted that deviation if any, be less than a small fraction of a degree and is negligible.

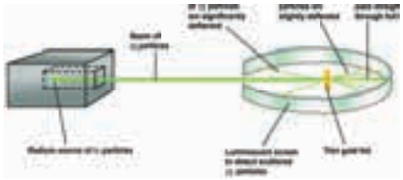


5.3.1 Rutherford's α–ray scattering experiment

Alpha particles are positively charged it possess adequate energy to overcome the repulsive force of positive charge, if the charge is evenly distributed in an atom. As you probably know, according to Coulomb's law, the less concentrated a sphere of electric charge is, the weaker is its electric field at its surface.

Atoms are so small that you cannot pick them one by one to be kept as a target and shoot alpha particles. Gold as you may know is a highly malleable metal and can be made in to a very thin layer.

They arranged an experimental set up. A natural radioactive source that emitted highly energetic alpha particles was chosen. The source was kept inside a lead box with a small hole in it. Alpha particles came out of the source in all directions. Those particles which hit the walls of the box were absorbed by it. Only those alpha particles that were emitted in the direction of the hole could escape. These rays of alpha particles followed a straight line.



A thin gold foil, about 400 atoms thick, was kept on the path of the alpha particle. They also kept a circular screen coated with zinc sulphide surrounding the foil. When an alpha particle hit the screen, it would produce fluorescence glow in the point where they struck the screen. From the point on the screen, one can infer the path taken by the alpha particle after penetrating the gold foil. The whole set up was kept inside a vacuum glass chamber, to avoid alpha particles from interacting and getting scattered by air molecules.

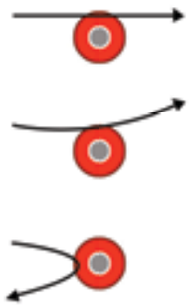
The experiments were repeated for reproducibility. Each time when the experiment was conducted, they

computed and tabulated the angle of the rays of alpha particle after it hits the gold foil. They observed the following.

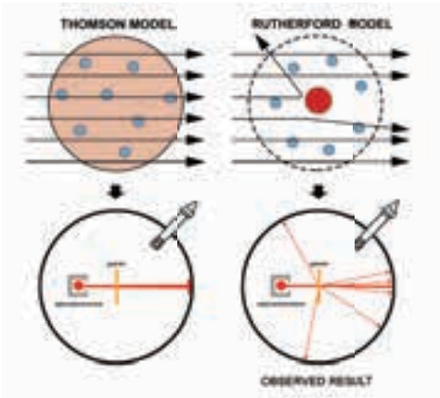
(i) Most of the fast moving α-particles passed straight through the gold foil.

(ii) Some α particles were deflected by small angles and a few by large angles.

(iii) Surprisingly very few α particles completely rebounded.



The experiments showed that most of the alpha particles behaved as expected, but there was a small discrepancy. Out of every 2000 particles that got scattered, just one was deflected by a full 180°. That is, they simply retraced their path after hitting the gold foil. You know that change of direction is possible only if a strong enough force acted against the direction of the motion of the particle.



Based on the plum pudding model of the atom, it was assumed that there was nothing dense or heavy enough inside the gold atoms to deflect the massive alpha particles from their paths. However, what Rutherford actually observed did not match his prediction. These observations indicated that a new model is needed to account for the evidences gathered in the experiment.

Rebound of alpha particle was impossible under the Thomson model. The alpha particle could have been deflected at 180° only if the positive charge was concentrated at a point rather than dispersed throughout the atom. If all the positive charge of the atom was concentrated at a small area inside the atom, only then, the electrostatic repulsion would be strong enough to bounce them back at 180°.

Now two observational evidence were before Rutherford and his team

1) Most of the particles passed are not deviated as there was no obstruction to their path: This should imply that most part of the atom is empty

2) Some alpha particle was deflected right back; implying that the positive charge should be concentrated at the centre of atom.

To be sure that their findings were really correct, the team performed the same type of experiments with many other materials including gases between the period 1908 and 1913.

Based upon these evidences, Rutherford rejected the Thomson's idea and proposed that all the positive charges are concentrated in the central region of the atom called 'nucleus', and electrons orbit the nucleus at a distance. Further he stated that in between the nucleus and electron inside an atom there existed a void. This came to be called as planetary model of atom.

5.3.2 Rutherford's model of an atom- salient features

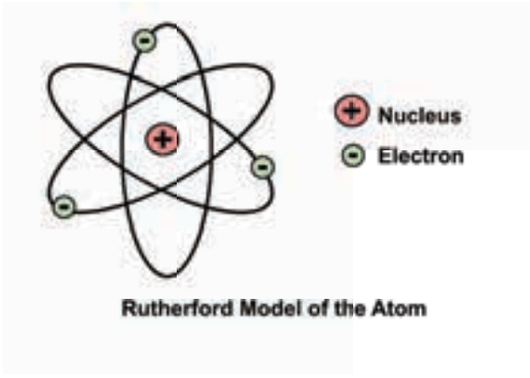
(i) Atom has a very small nucleus at the centre.

(ii) There is large empty space around the nucleus.

(iii) Entire mass of an atom is concentrated in a very small positively charged region which is called the nucleus.

(iv) Electrons are distributed in the vacant space around the nucleus.

(v) The electrons move in circular paths around the nucleus.

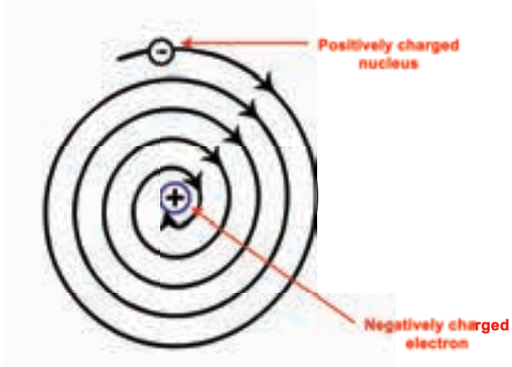


Rutherford Model of the Atom

5.3.3 Limitations in Rutherford's model

Although the model suggested by Rutherford went beyond the one by Thomson and explained the behaviour of alpha particles, it also left a few questions unanswered. Planets can go around the Sun under the gravitational attraction. But negatively charged electron should be attracted by the positively charged nucleus, since opposite charges attract. But it does not happen that way.

It was shown by Clark Maxwell that a charged body moving under the influence of attractive force loses energy continuously in the form of electromagnetic radiation. Thus unlike a planet the electron is a charged body and it emits radiations while revolving around the nucleus. As a result, the electron should lose energy at every turn and move closer and closer to the nucleus following a spiral path consequently the orbit will become smaller and smaller and finally the electron will fall into the nucleus. In other words, the atom should collapse. However, this never happens and atoms are stable.



Thus the stability of the atom could not be explained by Rutherford Model. There were also a few more objections to his model. This led on to more research and evolving better models of atomic structure.

5.3.4 Bohr's model of an atom

Know your Scientist


Niels Bohr

Niels Bohr was born on October 7, 1885 in Copenhagen, Denmark. He was also an outstanding soccer player. He worked with Rutherford at the university of Manchester. Bohr received the Nobel Prize for Physics in 1922.

A new model of atom was needed because Rutherford model could not explain the stability of atom. Neils Bohr developed a successful model of hydrogen atom. In order to justify the stability of an atom Neils Bohr made some improvements on Rutherford's model. The main postulates are:

i. In atoms, electrons revolve around the nucleus in certain special or permissible orbits known as discrete orbits or shells or energy levels

ii. While revolving in these discrete orbits the electrons do not radiate energy.

iii. The circular orbits are numbered as 1, 2, 3, 4,… or designated as K, L, M, N, shells. These numbers are referred to as principal quantum numbers (n).

iv. K shell (n=1) is closest to the nucleus and is associated with lowest energy.

L, M, N, …. etc are the next higher energy levels. As the distance from the nucleus increases the energy of the shells also increases.

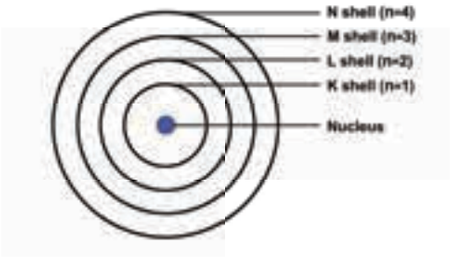
v. The energy of each orbit or shell is a fixed quantity and the energy is quantized.

vi. As the distance from the nucleus increases, the size of the orbits also increases.

vii. Maximum number of electrons that can be accommodated in an energy level is given by $2n^2$ where n is the principal quantum number of the orbit.

viii. When an electron absorbs energy, it jumps from lower energy level to higher energy level.

ix. When an electron returns from higher energy level to lower energy level, it gives off energy.



DO YOU KNOW?

How big are atoms?

Very small! An average atom is 0.000,000,001 metre. (one millionth of 1 mm) across. Blow up a balloon, It seems to contain nothing and weight almost nothing. But it contains about one hundred billion billion atoms which make up the gases in the air.

5.3.5 Limitations of Bohr's model

Many arguments were raised against Bohr's model of an atom. One main limitation was that his model was applicable only to Hydrogen. It could not be extended to multi electron atoms. Hence more research and deeper study of atoms became necessary. A detailed study of these aspects will be done in higher classes.

Orbit or shell:

Orbit is defined as the path by which electrons revolve around the nucleus.

Illustration:

The number of electrons in the first orbit (K)(n = 1);2 x 1^2 = 2

The number of electrons in the second orbit (L) (n = 2); 2 x 2^2 = 8

Activity 6

Calculate the number of electrons present in the third (M) and fourth orbits (N)

5.4 Discovery of Neutrons

In 1932 James Chadwick observed when Beryllium was exposed to alpha particles, particles with about the same mass as protons were emitted.

DO YOU KNOW?

In 1920 Rutherford predicted the presence of another particle in the nucleus as neutral. James Chadwick, the inventor of neutron was student of Rutherford

$_4Be^8 + \alpha$ rays $\longrightarrow$ $_6C^{12}$ + Neutron (n)
Beryllium + Alpha rays $\longrightarrow$ carbon + neutron

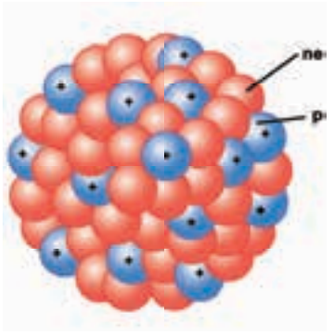
These emitted particles carried no electrical charges. They were called as neutrons. Neutrons present in the nuclei of all the atoms except of hydrogen. The mass of a neutron is almost equal to the mass of proton. Neutron is represented by n.

5.4.1 Composition of nucleus

Electrons have a negligible mass; hence the mass of the atom mainly depends on the mass of the nucleus. Nucleus of an atom consists of two components, they are protons and neutrons.

Protons are positively charged. Protons repel each other because of their like charges. Hence more than one proton cannot be packed in a small volume to form a stable nucleus, unless neutrons are present.

Neutrons reduce the repulsive force between the positively charged protons and contribute to the force that holds the particles in the nucleus together.



DO YOU KNOW?

The strong force that binds proton and neutron is more powerful than gravity.

5.4.2 Nucleons

The elementary particles such as protons and neutrons are collectively called as Nucleons. Why are atoms neutral? Because an atom contains the same number of protons and electrons and hence it's neutral.

Characteristics of fundamental particles

The physical and chemical properties of elements and their compounds can be

Particles	Mass	Charge		Location	Mass relative to Hydrogen atom
		Unit	Coulomb		
Electron	9.108 x 10^{-28}g	–1	-1.602×10^{-19}	Orbit	1/1837
Proton	1.672 x 10^{-24}g	+1	1.602×10^{-19}	Nucleus	1
Neutron	1.674×10^{-24} g	0	-	Nucleus	1

Activity 7

Complete the following table:

Particles	Mass	Charge	Location	Scientist who discovered
Electron	?	–1	?	J.J. Thomson
Proton	1.672 x 10^{-24}gm	?	Nucleus	?
Neutron	?	0	?	James Chadwick

explained by the fundamental particles of an atom. The fundamental particles are proton, neutron and electron.

DO YOU KNOW?

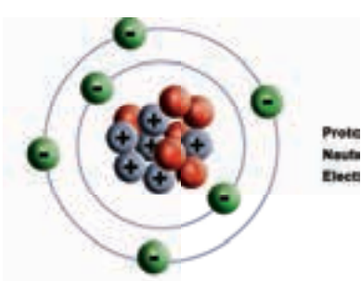
Besides the fundamental particles like protons, electrons and neutrons some more particles are discovered in the nucleus of an atom. They include mesons, neutrino, antineutrino, positrons etc.

Terminology

Atomic Number (Z)

The figure shown here represents an atom.

Using the colour code given below



	Proton	?
	Neutron	6
	Electron	?

Count the number of protons, electrons and complete the table. Are the number of protons and electrons the same?

An atom of an element has its own characteristic number of protons in its nucleus, which distinguishes it from the atoms of other elements. Hence proton is considered to be the finger print of an atom.

This characteristic number (Number of protons) is called the atomic number of the element. Atomic number is denoted by Z.

What is the Atomic number of the above element?

Since there are 6 protons, the atomic number = 6.

The number of electrons = 6, which is the same as the atomic number.

Atomic number of an atom is therefore equal to the number of protons and it is also equal to the number of electrons present.

In a neutral atom

Atomic Number = Number of protons = Number of electrons

Illustration:

An atom has 11 protons, 11 electrons and 12 neutrons. What is the atomic number and the name of the element?

Atomic number = Number of protons = Number of electrons

Number of protons = Number of electrons = 11

∴ Atomic number = 11

Name of the element is Sodium.

Test Yourself

An atom 'A' has 7 protons, 7 neutrons and 7 electrons. Atom 'B' has 9 protons, 9 electrons and 10 neutrons. Identify the Atomic number and names of A and B

Mass Number:(A)

From Rutherford's experiment it was clear that the mass of the atom is concentrated in the nucleus. This means that mass of an atom is practically due to protons and neutrons which are present in the nucleus. Protons and neutrons together are also called nucleons.

Mass number of the element is the total number of protons and neutrons present in the nucleus.

Mass number is denoted by A

Mass number = Number of protons + Number of neutrons

For example if an atom has 3 protons, 3 electrons and 4 neutrons, then its mass number will be equal to 7 (3 protons+ 4 neutrons)

Test Yourself

An atom has 15 protons, 15 electrons and 16 neutrons. What is the mass number?

Symbolic representation of an atom using Atomic Number and Mass Number

An atom can be represented by its symbol with atomic number as subscript and mass number as superscript.

Mass Number A

Symbol of element X

Atomic Number Z

For example, nitrogen is written as $^{14}_{7}N$

Here **7** is its atomic number and **14** is its mass number.

Activity 8

Symbolically represent the following atoms using atomic number and mass number.

a) Carbon b) Oxygen c) Silicon d) Beryllium

Relationship between Mass Number and Atomic Number:

Mass Number (A) = Atomic Number (z) + Number of Neutrons(n)

Atomic Number (Z) = Number of Protons or Number of Electrons

$$A = Z + n$$

DO YOU KNOW?

Atomic number designated as Z why?

Z stands for Zahl, which means NUMBER in German.

Z can be called Atomzahl or atomic number

A is the symbol recommened in the ACS style guide instead of M (massenzahl in German)

Sample Problem (solved):

Calculate the atomic number of an element whose mass number is 39 and number of neutrons is 20. Also find the name of the element.

Solution:

Mass Number = Atomic Number + Number of neutrons

Atomic Number = Mass Number – Number of neutrons

= 39 – 20

Atomic Number = 19

Element having Atomic Number 19 is Potassium (K)

Complete the following table: Pair work

Elements	Atomic Number	Mass number	No. of protons	No. of electrons	No. of Neutrons
Beryllium	?	9	4	4	?
Oxygen	8	?	?	8	8
Magnesium	12	24	?	?	12
Aluminum	?	27	13	?	?

Do It Yourself

Calculate the atomic number of the element whose mass number 31 number of neutron is 16 and find the name of the element.

Chlorine got from natural resources (Sea water) has fractional atomic mass. Why is it so?

This is due to the presence of isotopes.

An atom can have a fractional atomic mass (Relative atomic mass) For example:

Chlorine has fractional atomic mass.

Chlorine – 35 exists by 75% Chlorine – 37 exists by 25%

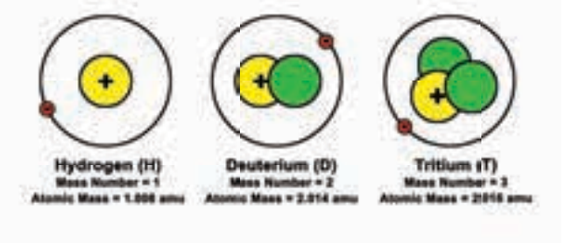
$$35 \times \frac{75}{100} + 37 \times \frac{25}{100} = 35.5 \text{ amu}$$

Fractional atomic mass of Chlorine is [(75/100)x 35] + [(25/100)x37] = 35.5

5.5 Isotopes (Iso – same, topo – place, Isotope – same place

5.5.1 ISOTOPES

Find below three different atoms. Count the different subatomic particles and fill in the table.



More to Know

Thumb rule for isotopes and isobars. Remember **t** for top and **b** for bottom.
Isotope: Top value changes – atomic mass
Isobars: Bottom value changes – atomic number

What do you observe in the above atoms?

Which is same and what is different in them?

All of them have the same number of protons and electrons but different number of neutrons.

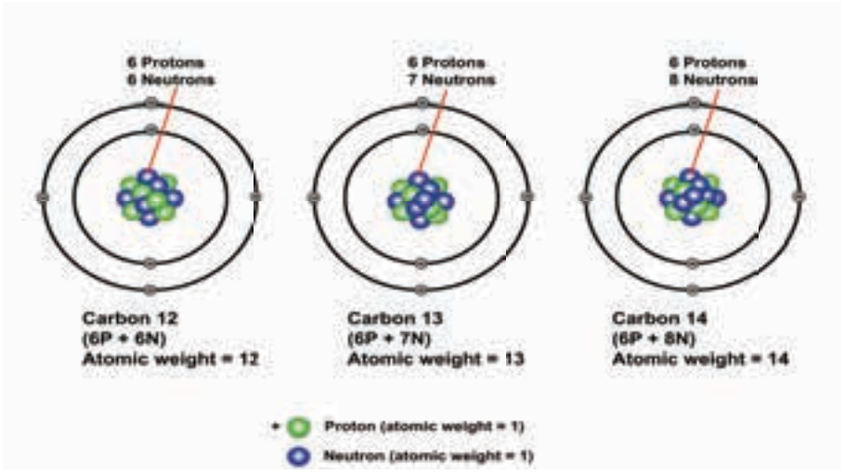
What will they have in common?

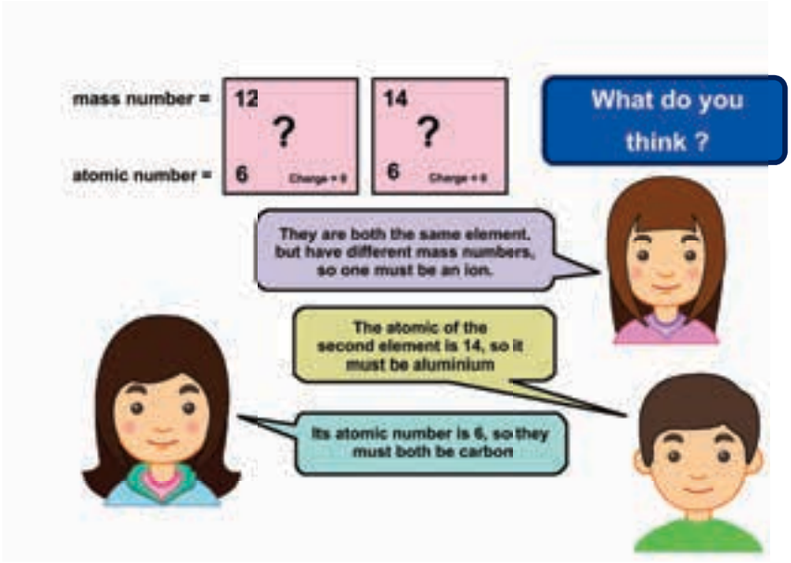
All the three structures have same atomic number but different mass numbers. They have the same number of electrons also. Such atoms of the same element are called isotopes.

Isotopes are atoms of the same element having same atomic number but different mass numbers.

This is due to the difference in the number of neutrons in the nucleus. Isotopes differ in few physical properties such as density, boiling point etc. Physical properties depend upon mass number. Isotopes have different mass numbers. So they differ in physical properties.

Lightning can trigger nuclear reaction, creating rare atomic isotopes.





Example: Isotopes of carbon

Activity 9

Draw the structures of the isotopes of oxygen O^{16} and O^{18}

Atomic number of oxygen = 8

Why do some isotopes show radioactivity?

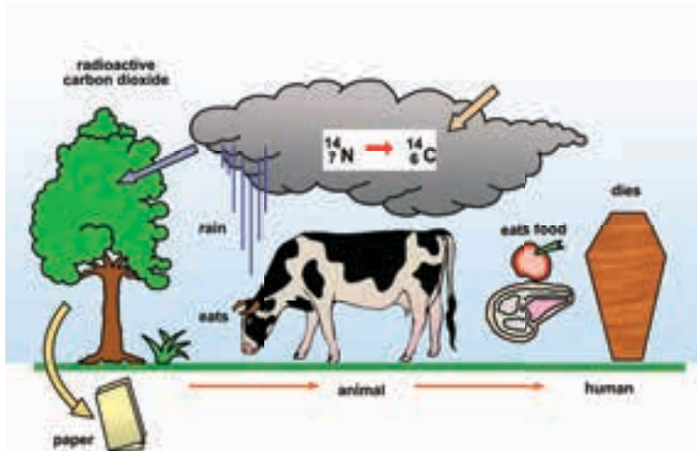
When the number of neutrons exceeds the number of protons in the nucleus of atoms, some nuclei become unstable. These unstable nuclei break up spontaneously emitting certain type of radiations. They are known as radioactive isotopes. Examples: $H^3$and C^{14}

Many elements have isotopes of which some of them are radioactive isotopes.

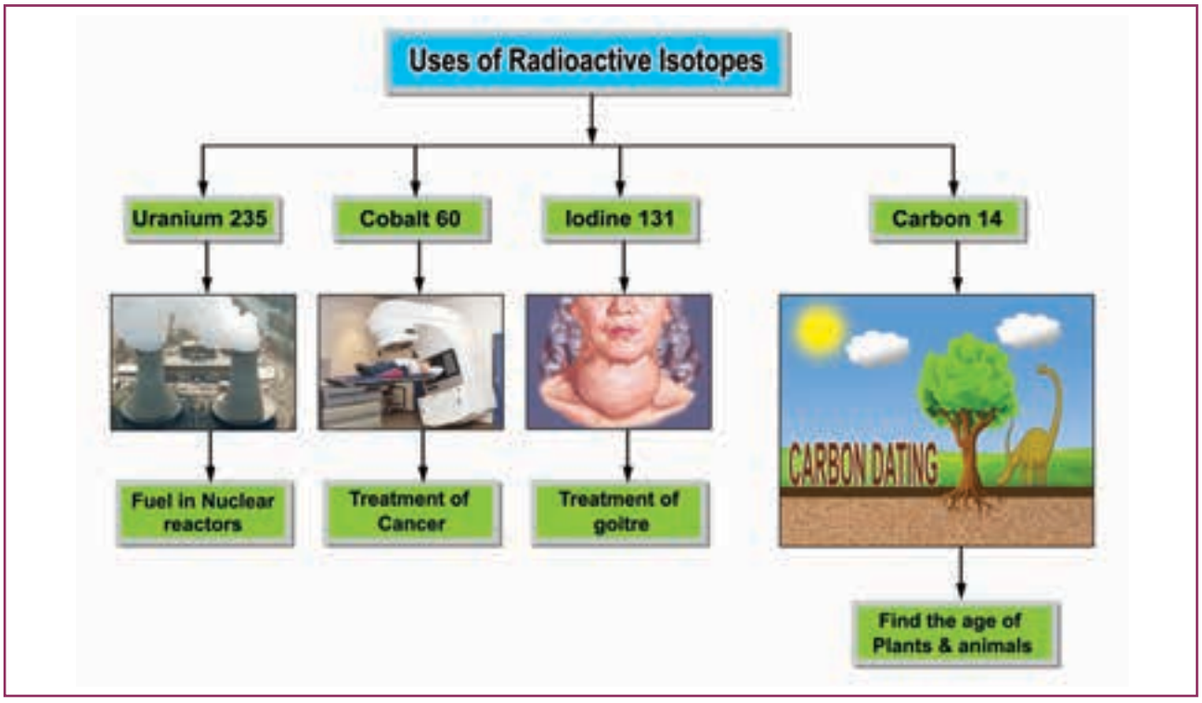
Uses of radioactive isotopes

Radioactivity prevails around us. The food we eat, the air we breathe, the buildings we live in, all contain small amounts of radioactive materials. This radiation will be present always.

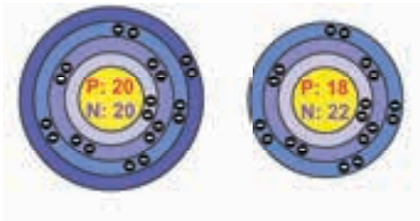
Thus there are a lot of low level natural radioactivity around us. For example, our bodies contain radioisotopes, such as potassium-40, which continuously emit radiation, but the level is so low that this does not harm us.The picture below shows us how radioactive carbon(C^{14}) is all around us.



But the special properties of radioactive isotopes make them useful to us in various fields.



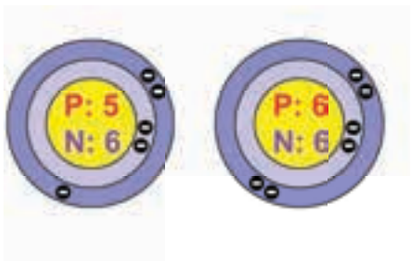
5.5.2 Isobars



What is the difference between these two atoms?

The above two elements calcium and argon have atomic number 20 and atomic number 18 respectively. This means they have different number of protons and electrons. But the mass number of both these elements is 40. It follows that the total number of nucleons in both of them are the same. Atoms of different elements with different atomic numbers, which have the same mass number, are known as isobars.

5.5.3 Isotones



The above pair of elements Boron and Carbon has the same number of neutrons but different number of protons and hence different atomic numbers. Atoms of different elements with different atomic numbers and different mass numbers, but with the same number of neutrons are called isotones.

Activity 10

Draw the model of the following pairs of isotones:

Fluorine & Neon (ii) Sodium & Magnesium (iii) Aluminum and Silicon

How are electrons arranged around the nucleus in an atom?

So far we have been discussing about the nucleus of an atom and the protons and neutrons which constitute the nucleus. We also saw that electrons are extra nuclear particles and they revolve around the nucleus in fixed trajectories or orbits. Let us now see how electrons are arranged in different orbits. The systematic arrangement of electrons in various shells or orbits in an atom is called the electronic configuration.

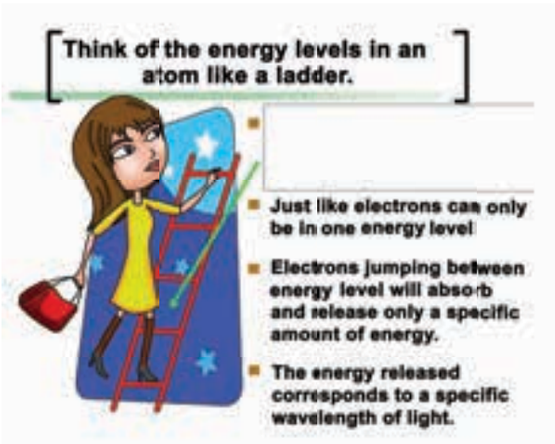
Electronic configuration of atoms:

You already know that electrons occupy different energy levels called orbits or shells.The distribution of electrons in these orbits of an atom is governed by certain rules or conditions. These are known as **Bohr and Bury Rules of electronic configuration.**

Bohr and Bury simultaneously proposed the following rules for the distribution of electrons in different shells.

- **Rule 1:** The maximum number of electrons that can be accommodated in a shell is equal to $2n^2$ where 'n' is the quantum number of the shell (i.e., the serial number of the shell from the nucleus).

Shell	Value of (n)	Maximum number of electrons ($2n^2$)
K	1	$2 \times 1^2 = 2$
L	2	$2 \times 2^2 = 8$
M	3	$2 \times 3^2 = 18$
N	4	$2 \times 4^2 = 32$



- **Rule 2:** Shells are filled in a **stepwise manner** in the increasing order of energy.
- **Rule 3:** The outermost shell cannot have more than 8 electrons and the next inner, i.e., the penultimate shell cannot have more than 18 electrons.

Illustration:

Structure of Aluminium atom: (13 electrons)
K shell = 2 electron, L shell = 8, M Shell – 3
So its electronic configuration is 2, 8, 3

DO YOU KNOW?

Atoms are so tiny their mass number cannot be expressed in grams but expressed in amu (atomic mass unit). New unit is U Size of an atom can be measured in nano metre ($1nm=10^{-9m}$)Even though atom is an invisible tiny particle now-a-days atoms can be viewed through SEM that is Scanning Electron Microscope.

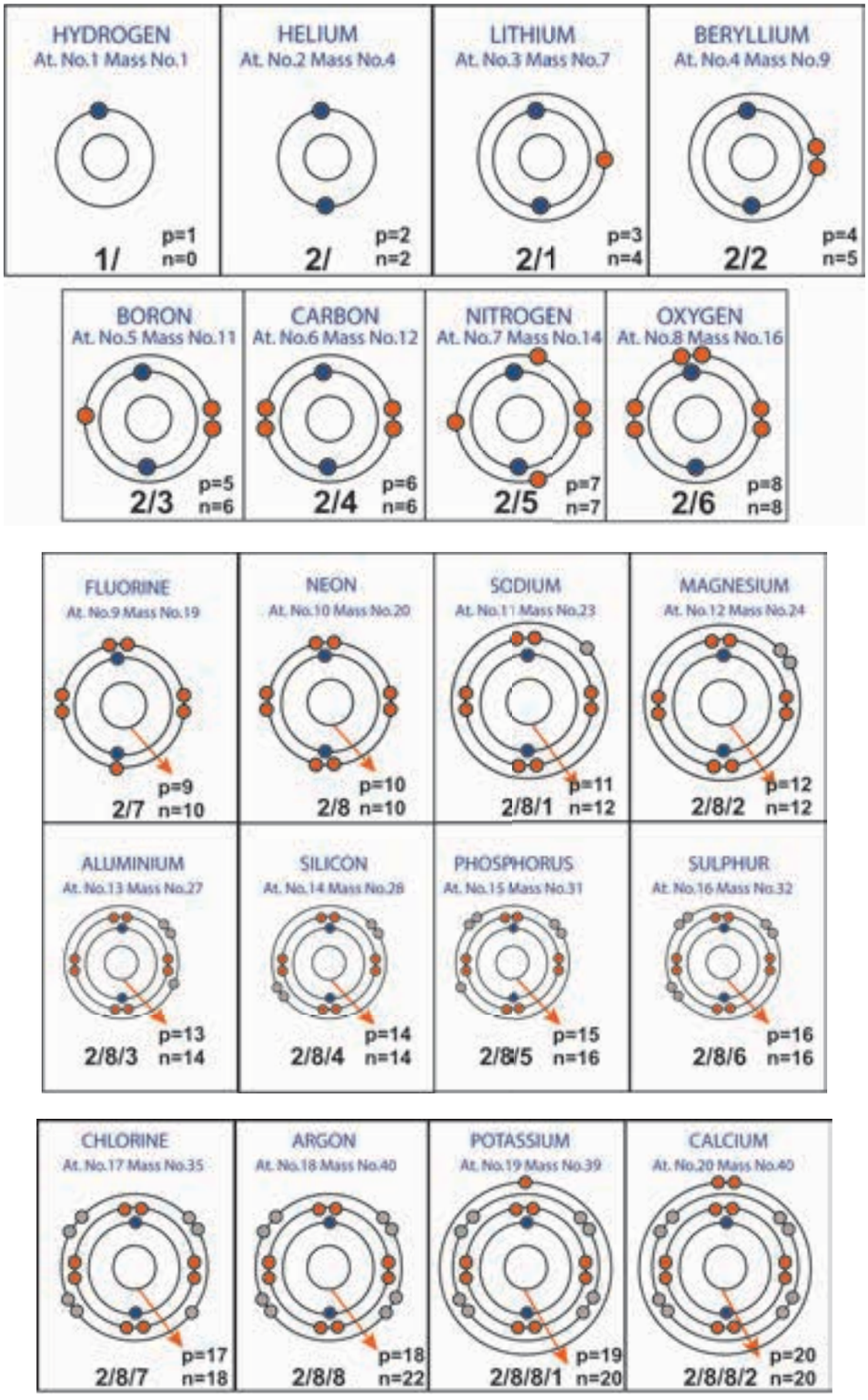
EW95JN

Electronic configuration of first 20 elements

Element	Symbol	Atomic Number	Electronic configuration or Electron distribution			
			K	L	M	N
Hydrogen	H	1	1			
Helium	He	2	2			
Lithium	Li	3	2	1		
Beryllium	Be	4	2	2		
Boron	B	5	2	3		
Carbon	C	6	2	4		
Nitrogen	N	7	2	5		
Fluorine	F	9	2	7		
Neon	Ne	10	2	8		
Sodium	Na	11	2	8	1	
Magnesium	Mg	12	2	8	2	
Aluminium	Al	13	2	8	3	
Silicon	Si	14	2	8	4	
Phosphorus	P	15	2	8	5	
Sulphur	S	16	2	8	6	
Chlorine	Cl	17	2	8	7	
Argon	Ar	18	2	8	8	
Potassium	K	19	2	8	8	1
Calcium	Ca	20	2	8	8	2

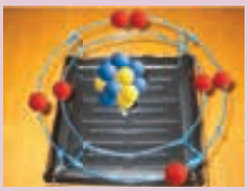
For getting a basic idea about the electron distribution around the nucleus we can draw schematic diagrams as shown below. As you learn more about atomic structure you will come to know that the real picture of electron distribution is entirely different from what we have shown here.

Schematic diagrams for Atomic Structure of Elements (first 20)



Activity 11

Look at the model given below. Make groups of five. Each group can make models of 4 elements by using available materials like balls, beads, string etc.



Activity 12

Electronic configuration of some elements are given below. Elements follow the sequence of their atomic numbers.

Complete the blank spaces.

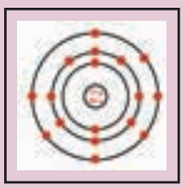
?

Aluminium

Silicon

?

Sulphur



?

Argon

Potassium

5.5.4 Valence electrons

How many electrons are in the outermost shell? 5

The outermost shell of an atom is called its valence shell and the electrons present in the valence shell are known as valence electrons.

Hydrogen atom has only one electron in its valence shell. Hence it has **one** valence electron. Similarly carbon has 4 electrons in the outermost shell and so it has **4 valence electrons.**

The chemical properties of elements are decided by these valence electrons, since they are the ones that take part in chemical reaction.

The elements with same number of electrons in the valence shell show similar properties and those with different number of valence electrons show different chemical properties. Elements, which have valence electrons 1 or 2 or 3 (except Hydrogen) are **metals.**

These elements can lose electrons to form ions which are positively charged and are called **cations**.

Eg: $Na - e^- \rightarrow Na^+$
2, 8, 1 2, 8

Elements with 4 to 7 electrons in their valence shells are **non-metals.**

These elements can gain electrons to form ions which are negatively charged and are called **anions**.

Eg: $Cl + e^- \rightarrow Cl^-$ (Chlorine has valence electrons 7)
2, 8, 7 2,8,8

5.5.5 Valency

Valency of an element is the combining capacity of the element with other elements and is equal to the number of electrons that take part in a chemical reaction. Valency of the elements having valence electrons 1, 2, 3, 4 is 1, 2, 3, 4 respectively.

While valency of an element with 5, 6 &7 valence electrons is 3, 2 and 1 (8–valence electrons) respectively, where 8 is the number of electrons required by an element to attain stable electronic configuration. Elements having completely filled outermost shell show **Zero valency**.

For example: The electronic configuration of Neon is 2,8 (completely filled). So valency is **0**.

Illustration:

Assign the valency of Magnesium & Sulphur

Electronic configuration of magnesium is 2, 8, 2. So valency is 2.

Electronic configuration of sulphur is 2, 8, 6. So valency is 2 i.e.(8 – 6)

Activity 13

Assign the valency for Phosphorus, Chlorine, Silicon and Argon

Introduction to Quantum Numbers

We have learnt to designate orbits (shells) by K,L,M, N …., and orbitals (sub shells) as s, p, d and f. We have seen that electrons are filled in to these orbitals according to certain rules. Can we now designate an electron in an atom in a manner in which it gets a unique identity? Each electron inside of an atom has its own 'identity' which is given by **four quantum numbers** that communicate a great deal of information about that electron.

The numbers which designate and distinguish various atomic orbitals and electrons present in an atom are called quantum numbers.

How would you describe to someone exactly where you live? I guess you would start with your address. (similar to the identity fo an electron).

When you specify the location of a building, you usually list which country it is in, which state and city it is in that country, then the area and the street and the door number.

Just like no two buildings have the exact same address, no two electrons can have the same set of **quantum numbers**.

A **quantum number** describes a specific aspect of an electron. Just like we have four ways of defining the location of a building (country, state, city, and street address), we have four ways of defining the properties of an electron, i.e.**four quantum numbers.**

These quantum numbers tell us

- how far is the electron from the nucleus,- **(Principal Quantum number)**
- which orbital does it occupy and what is its shape **(Azimuthal Quantum number)**
- how this orbital is oriented in space **(Magnetic Quantum number)**
- what kind of spin the electron has. **(Spin Quantum number)**:

Quantum Number	Symbol	Information conveyed
Principal quantum number	*n*	Main energy level
Azimuthal quantum number	*l*	Sub shell/ shape of orbital
Magnetic quantum number	*m*	Orientation of orbitals
Spin quantum number	*s*	Spin of the electron

You will learn more details about this in higher classes.

Key words

Atomic number	Isobars	Valency
Mass number	Isotones	Orbit
Nucleons	Electronic configuration	Orbital
Isotopes	Valence electrons	Quantum numbers

Points to Remember

- Rutherford's alpha-particle scattering experiment led to the discovery of the atomic nucleus.
- Rutherford's Planetary model of an atom proposed that nucleus of an atom is in the centre and electrons revolve around this nucleus.
- Neils Bohr's atomic model explained the stability of an atom.
- J.Chadwick discovered presence of neutrons in the nucleus.
- The atomic number of an element is the number of protons or electrons in an atom.
- Mass number of an element is the total number of protons & neutrons.
- Valence electrons are the electrons in the outermost orbit.
- Valency is the combining capacity of an atom.
- Isotopes are atoms of the same element, which have same atomic number but different mass numbers.
- Isobars are the atoms of the different element of same mass number but different atomic number.
- Isotones are the different element having same number of neutron but different atomic number and mass number.
- Simple diagrammatic representation may be used to depict electronic configuration of various elements.
- Quantum numbers designate an electron in an orbital.

A-Z GLOSSARY

1. **Atom** the smallest component of an element, and is also a nucleus with neutrons, protons and electrons.
2. **Atomic mass** the mass of an atom of a chemical element expressed in atomic mass units. It is approximately equivalent to the number of protons and neutrons in the atom (the mass number) or to the average number allowing for the relative abundances of different isotopes.
3. **Atomic number** the number of protons in the nucleus of an atom, which is characteristic of a chemical element and determines its place in the periodic table.
4. **Electron** a stable subatomic particle with a charge of negative electricity, found in all atoms and acting as the primary carrier of electricity in solids.

5. **Isotope** each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; "some elements have only one stable radioactive isotope".
6. **Isobar** each of two or more isotopes of different elements, with the same atomic weight.
7. **Isotone** one of two or more atoms having an equal number of neutrons but different atomic numbers.
8. **Mass number** the total number of protons and neutrons in a nucleus.
9. **Neutron** a subatomic particle of about the same mass as a proton but without an electric charge, present in all atomic nuclei except those of ordinary hydrogen.
10. **Orbitals** Atomic orbitals are regions of space around the nucleus of an atom where an electron is likely to be found. Atomic orbitals allow atoms to make covalent bonds. The most commonly filled orbitals are s, p, d, and f.
11. **Proton** a stable subatomic particle occurring in all atomic nuclei, with a positive electric charge equal in magnitude to that of an electron.
12. **Quantum number** a number which occurs in the theoretical expression for the value of some quantized property of a subatomic particle, atom, or molecule and can only have certain integral or half-integral values.
13. **Radical** molecule that contains at least one unpaired electron. Most molecules contain even numbers of electrons, and the covalent chemical bonds holding the atoms together within a molecule normally consist of pairs of electrons jointly shared by the atoms.
14. **Valency**: the property of an element that determines the number of other atoms with which an atom of that element can combine.

ICT CORNER

ATOMIC STRUCTURE

Atoms are building blocks. They are made of neutrons, protons and electrons.

This activity help the students to explore more about atoms and its components.

Step 1. Type the following URL in the browser or scan the QR code from your mobile.You can see on the screen. Click that.

Step 2. Select atom. Atomic orbit you can see with multiple options. Select protons, neutrons and electrons to their respective places. According to their numbers name of the elements appear on the periodic table. You can also find out whether the selected element is neutral or charged(ions)

Step 3. click"**symbol**"now. When you arrange electrons, neutrons and protons on the orbits you can see the name of the element, it's atomic number, atomic mass and number of electrons.

Step 4. Third option is games. It's an evaluation one to test your understanding

https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html

B121_9_SCI_EM

EXERCISE

EWI1LB

I. Multiple Choice Questions

1. Among the following the odd pair is
   a) $^{18}_{8}O$, $^{37}_{17}Cl$ b) $^{40}_{18}Ar$, $^{14}_{7}N$
   c) $^{30}_{14}Si$, $^{31}_{15}P$ d) $^{54}_{24}Cr$, $^{39}_{19}K$
2. Change in the number of neutrons in an atom changes it to
   a) an ion. b) an isotope.
   c) an isobar. d) another element.
3. The term nucleons refer to
   a) Protons and electrons
   b) only Neutrons
   c) electrons and neutrons
   d) Protons and neutrons
4. The number of protons, neutrons and electrons present respectively in $^{80}_{35}Br$
   a) 80, 80, 35 b) 35, 55,80
   c) 35, 35, 80 d) 35, 45, 35
5. The correct electronic configuration of potassium is
   a) 2,8,9 b) 2,8,1
   c) 2,8,8,1 d) 2,8,8,3

II. True or false/if false give the correct answer

1. In an atom, electrons revolve around the nucleus in fixed orbits
2. Isotopes of an element have the different atomic numbers
3. Electrons have negligible mass and charge.
4. Smaller the size of the orbit, lower is the energy of the orbit.
5. The maximum number of electron in L Shell is 10

III. Fill in the Blanks:-

1. Calcium and Argon are examples of a pair of _____
2. Total Number of electrons that can be accommodated in an orbit is given by _____
3. _____ isotope is used in the treatment of goiter
4. The number of neutrons present in $^{7}_{3}Li$ is _____
5. The valency of Argon is _____

IV. Match the following

i)

a) Dalton	1. Hydrogen atom model
b) Thomson	2. Planetary model
c) Rutherford	3. First atomic theory
d) Neils Bohr	4. Plum pudding model
	5. Discovery of neutrons

ii)

a) Mass of proton	1) 1.6×10^{-19} C
b) Mass of electron	2) -1.6×10^{-19} C
c) Charge of electron	3) 9.31×10^{-28} g
d) Charge of proton	4) 1.67×10^{-24} g

V. Complete the following table

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Name of the Element
9	-	10	-	-	-
16	-	16	-	-	-
-	24	-	-	12	Magnesium
-	2	-	1	-	-
-	1	0	1	1	-

VI. Arrange the following in the increasing order of atomic number

Calcium, Silicon, Boron, Magnesium, Oxygen, Helium, Neon, Sulphur, Fluorine and Sodium

4. One or two electrons in the outermost shell of atoms of elements are called as _____ electrons.
5. $^{14}_{6}C$ is used for carbon dating
6. Discovery of neutron

VII. (a) Cross word puzzle

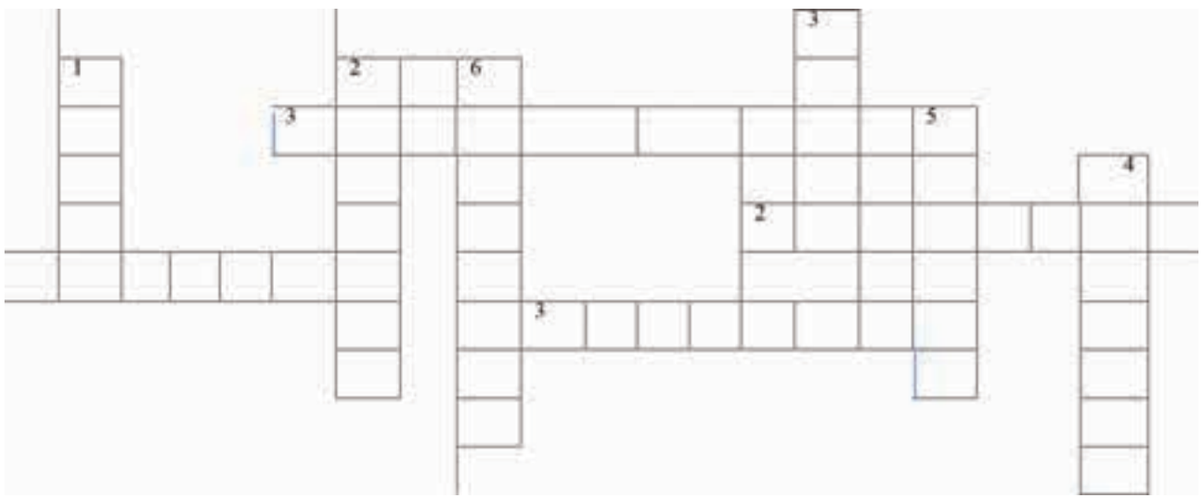
Clues:

Down:

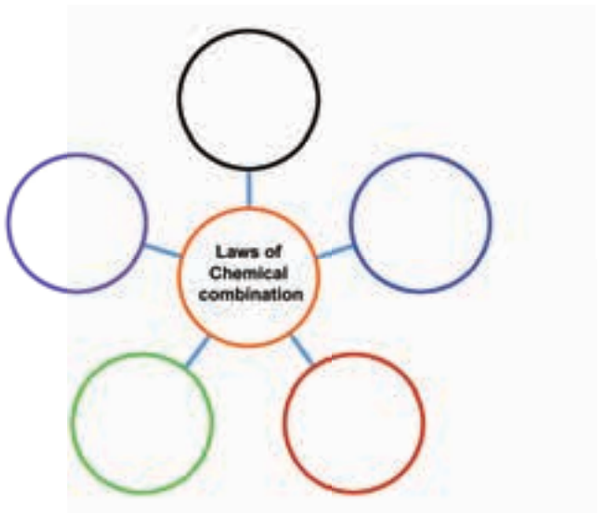
1. Helium Nuclei (Particle)
2. Positive Charge mass at the core of the atom
3. An atom whose valency is zero

Across:

1. Electrons present in the outermost shell
2. This pair of atoms $^{40}_{20}Ca$, $^{40}_{18}Ar$ are ____
3. An atom that does not have neutron
4. Scattering of α particles in the gold foil experiment



b) Copy the following and write the names of the laws and their simple definitions in the space provided.



VIII. Very short answer

1. Name an element which has the same number of electrons in its first and second shell.
2. Write the electronic configuration of K^+ and Cl^-
3. Compare the charge and mass of protons and electrons.
4. For an atom 'X', K, L and M shells are completely filled. How many electrons will be present in it?
5. Ca^{2+} has completely filled outer shell. Justify your answer.

IX. Short answer

1. State the law of multiple proportion.
2. List the uses of isotopes?
3. What is isotone? Give an example
4. Draw the structure of oxygen and sulphur atoms.
5. Calculate the number of neutrons, protons and electrons (i) atomic number 3 and mass number 7 (ii)atomic number 92 and mass number238

X. Numerical problem

1. Calculate the volume of oxygen required for the complete combustion of 20 cm^3 of methane[$CH_{4(g)} + 2O_2 \rightarrow CO_{2(g)} + 2H_2O_{(g)}$]
2. A metal combines with oxygen to form two oxides having the following composition

   i) 0.398 gram of metal oxide I contains 0.318 gram of metal

   ii) 0.716 gram of metal oxide II contains 0.636 gram of metal. So that the above data agrees with the law of multiple proportions.
3. Calculate the mass of a proton, given its charge = $+ 1.60 \times 10^{-19}$ C

   charge / mass = 9.58×10^7 C kg^{-1}

XI. Long answer

1. What conclusions were made from the observations of Gold foil experiment?
2. Explain the postulates of Bohr's atomic model.

3. State the Gay Lussac's law of combining volumes, explain with an illustration.

XII. Get connected

Health

1. Discuss the uses of radio-active isotopes in Medicine.

Art

1. Make the model of different atoms by using the materials like card boards, colour beads and strings.
2. Draw the time line of history of atomic model

Language

1.Write (in about 200 words) about Homi J Bhabha who was the father of **Indian Nuclear programme**

XIII. Get Together and Do

1. Prepare a science magazine including photos, profiles and contribution of philosophers and scientists related to the history of atom
2. Prepare a display board chart illustrating the electronic configuration and valency of elements with atomic number 1 – 20.

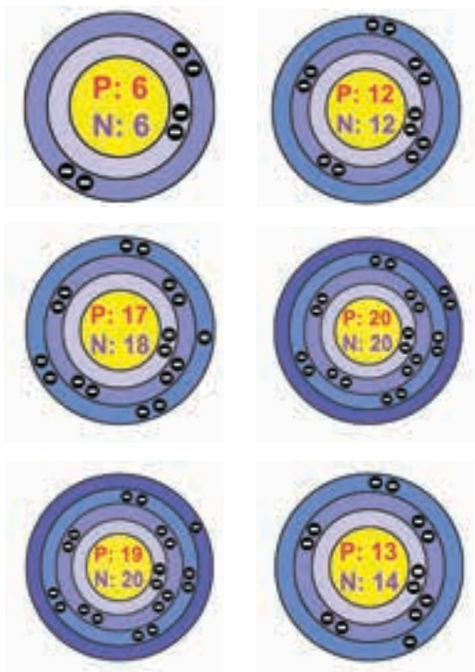
XIV. Unlock

1.

The particles represented above are

	1	2	3
a.	electrons	protons	neutrons.
b.	protons	electrons	neutrons
c.	neutrons.	protons	electrons
d.	electrons	neutrons.	protons

2. From the structures given below, Tabulate the following:
   1. Valence electron
   2. Valency
   3. Atomic Number
   4. Mass number
   5. Electronic configuration



3. The correct numbers of protons and neutrons present in $^{23}_{11}Na^{+}$ are

	protons	neutrons
a.	11	23
b.	10	12
c.	11	12
d.	11	22

REFERENCE

1. Atomic Structure Rebecca L. Johnson Twenty-First Century Books ISBN-13: 978-0-8225-6602-1.
2. Atomic structure and Periodicity Jack Barrett. Royal Society of Chemistry. ISBN 0-85404-657-7.
3. Chemistry for Degree Students (B.Sc. Sem.-I, As per CBCS) R L Madan ISBN: 9789352533039. S. Chand Publishing

INTERNET RESOURCES

Electronic configuration

https://www.youtube.com/watch?v=t4xgvlNFQ3c

https://www.youtube.com/watch?v=P6DMEgE8CK8

https://www.youtube.com/watch?v=YURReI6OJsg

UNIT 6

Living World of Plants - Plant Physiology

Learning Objectives

At the end of this unit the students will be able to understand,

- that Plants too have certain autonomic movements
- how do plants produce their food through the process of photosynthesis?
- that Plants are the primary producers that feed the rest of the living organisms

Introduction

Animals move in search of food, shelter and for reproduction, even microorganisms show movement.

Do plants show such movement?

We see a branch of a tree shaking in heavy thunder storm; and leaves dancing in gentle wind. These movements are caused by an external agency.

6.1 Do they Move on their own Accord?

In short, do plants have spontaneous movements without external agency? Do they breathe? In this chapter we will study some of the biological functions of plants.

6.2 Do Plants Move?

The leaves of *Mimosa pudica* (touch-me-not plant) closes on touching, and in like manner, the stalk of *Helianthus annuus* (sunflower) follows the path of the sun from dawn to dusk, (from east to west) and during night it moves from west to east. The dance of *Desmodium gyrans* (Indian telegraph plant) leaf is mesmerizing.

Mimosa pudica

Helianthus annuus

Desmodium gyrans

These movements are triggered by an external stimuli. Unlike animals, plants may not move on their own from one location to another, but can move their body parts for getting sunlight, water and nutrients and are sensitive to external factors like light, gravity, temperature etc.

More to Know

In *Desmodium gyrans* (Indian telegraph plant), the compound leaf shows three leaflets, one terminal large leaflet and two very small lateral opposite leaflets. The two lateral leaflets move up, move back and then move down and finally back to the original position showing rhythmic movement. *Desmodium gyrans* is also called the dancing plant. This plant was used by Indian scientist Jagadish Chandra Bose for his experiment.

DO YOU KNOW?

Mimosa pudica is called as *Thotta surungi* and *Desmodium gyrans* is called as *Thozhu kanni* in Tamil.

Activity 1

Roots grow down and shoots grow up

You can do this experiment with some of your friends.

Step -1

It is easy and fun. Take four or five earthen cups or small pots and fill them with soil from a field. Add a little cow dung to the soil. Make sure the cups have a hole at the bottom. Label them as A, B, and C. Put some seeds of green gram in all the cups, water them daily. As soon as the seeds sprout, select a shoot of same height from each of the cups. Remove all the other shoots from the cups.

Step-2

You will need a rectangular box with a small window in one of its sides. A shoe box would be ideal. Cut a 1 × 1 cm window in one side. When the shoots are 10 cm long, cover the plants in all the cups except cup A with the rectangular box. When covering the cups, place the box such that opening in each of them face different directions. Keep all the cups including 'A' in open sun light.

Step-3

Wait for three to four days. Remove the box and look at the plants again. Are the plants tilted? To which side are the plants tilted? With opening facing different direction, did all the plants tilt the same direction?

Compile the results and discuss with your friends.

Perhaps you have done such experiments in earlier classes and have found that plants do grow towards the sunlight.

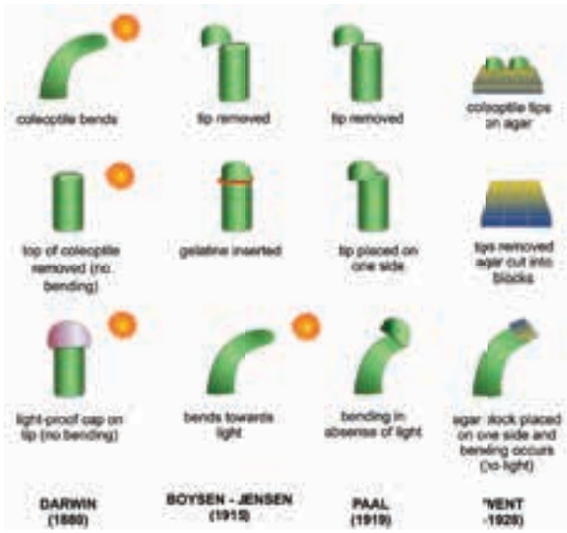
6.3 Do Plants Actually Sense Light?

You would have studied in earlier classes about seed germination. In monocot plants like grass, there is only one first leaf (called cotyledon). Once germinated, the embryo sends a primary root downward into the soil and pushes the primary shoot to the soil surface. The tip of the embryonic shoot (plumule) is covered by a protective sheath called coleoptile. It is the coleoptile covered embryonic shoot that grows above the ground.

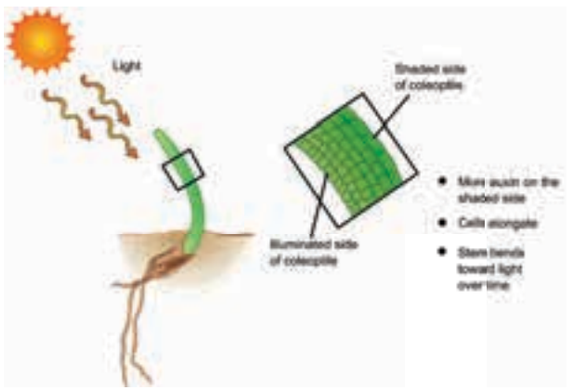
In one of the experiments initially Darwin noticed that germinated seeds also grow towards light. If, in a dark room light is placed in one end, the growing seedlings bend towards the light. In the next experiment, he carefully removed the tip from growing seedlings. The shoot did not bend towards the light. When he covered the tip (Coleoptile) with foil, preventing light from entering, the shoot did not bend. In the next step, he covered the elongating part of the shoot, but left the tip open. Now the bending could be noticed. Covering the elongating part of the shoot did not affect the response to light at all! Darwin concluded "some **'influence'** is transmitted from the tip to the more basal regions of the shoot thereby regulating growth and inducing curvature". This demonstrated clearly that something within the tip of the coleoptile controlled growth of the plant.

Charles Darwin Peter Boysen-Jensen

What is this **influence**? In 1913 Peter Boysen-Jensen, a Danish Botanist further developed Darwin's experiments. He found that if he removed the coleoptiles, plant growth stopped. Then he inserted a piece of agar and then placed the coleptile on top of it the plant again was able to curve towards the light. Hence this chemical was predicted to be water soluble. He reasoned that chemicals that controlled the light sensitive movement (phototropism) moved through agar.



In his next experiment he replaced the agar block with butter. The above mentioned water soluble chemical did not dissolve in butter, as expected the chemical did not pass through butter. This water soluble "influence" was later identified as the plant hormone **Auxin**. In response to light, auxin elongates the cells on the dark side of a stem so that the plant literally bends towards the light source.



Bending of the stem towards light

6.4 Types of Tropisms in Plants

Tropism is a growth movement, the direction of which is determined by the direction of the stimuli. Unidirectional movement of plant part to light stimulus is called **Phototropism**. Heliotropism or motion of plant parts like flowers or leaves in response to the direction of the sun is a kind of phototropism. The plant may also respond to gravity and it is termed **Geotropism** or **Gravitropism**. The response to water is called **Hydrotropism**. Climbing vines have to find a suitable support shortly after germination. Once the shoot touches a suitable support, it grows towards the surface it is touching. This is called **Thigmotropism**. Growth or movement of a plant in response to chemical stimuli is called **Chemotropism**. During fertilization, pollen tube grows down the style in response to the sugars in the style is an example of chemotropism.

EX1SPL

Phototropism

Info bits

- Tropism allows plant to get the best conditions for its survival.
- Tropic movements are slow, directional movements towards or away from the stimulus and it depends on growth.
- Nastic movement is an immediate action.

Tropism is generally termed "positive" if growth is towards the signal and "negative", if it is away from the signal. While the shoot in a plant moves towards the light, the roots move away in the opposite direction. Thus the shoots are said to have **positive phototropism,** while the roots have **negative phototropism**. Can you think of an example of a negative hydrotropism?

Positive phototropism (negatively geotropic)

Negative phototropism (positively geotropic)

Activity 2

Experiment to demonstrate phototropism

i) Take pea seeds soaked in water overnight.

ii) Wait for the pea seeds to germinate.

iii) Once the seedling has grown put it in a box with an opening for light on one side.

iv) After sometime, you can clearly see how the stem has bent and grown towards the light.

Info bits

Some halophytes produce negatively geotropic roots (E.g. *Rhizophora*). These roots turn 180° upright for respiration.

Water or gravity?

When a seed germinates the primary shoot, (plumule) goes up while the primary root, (radicle) goes down. What stimulus is making the primary root to go down? Is it gravity or water that is principally responsible for the direction of the growth of a primary root? We can do an interesting experiment to find out for ourselves.

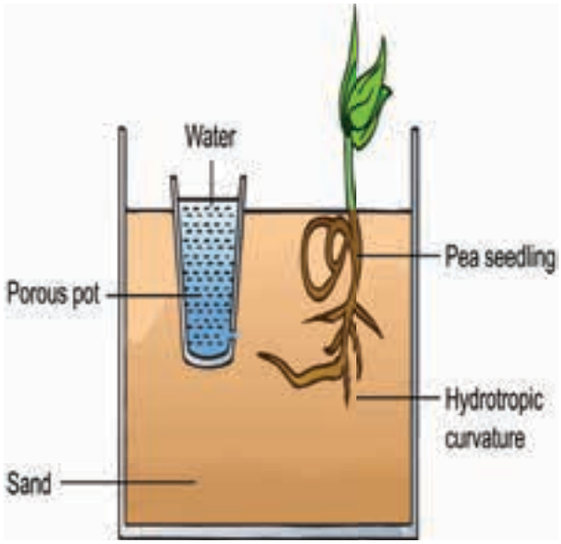
What do you need? Glass trough, sand, flower pot, plugged at the bottom, pea or bean seeds and water.

How to do?

1. A glass trough is taken and is filled with sand. A flower pot containing water, plugged at the bottom is kept at the centre of the glass trough.
2. Soaked pea or bean seeds are placed around the pot in the sand, what do we observe after 6 or 7 days?

What do you observe? It will be observed that radicle has grown towards the pot and moisture instead of growing vertically downward.

What do you conclude? It proves that primary root is positively hydrotropic and that hydrotropism is stronger than geotropism in this case.



Activity 3

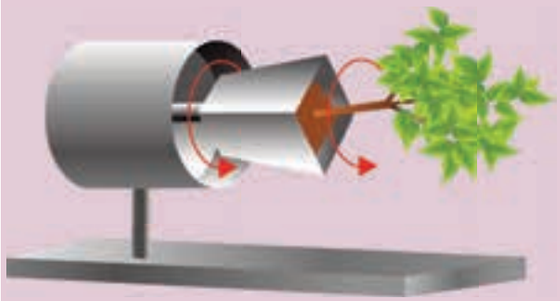
Experiment to demonstrate Geotropism

i) Two Clinostats are taken and a potted plant on each is fixed on a horizontal position.

ii) One Clinostat is rotated and the other is kept stationary.

Observations made after sometime will show that the shoot of the plant fixed on the stationary clinostat bends upwards showing negative geotropism and the root bends downwards showing positive geotropism.

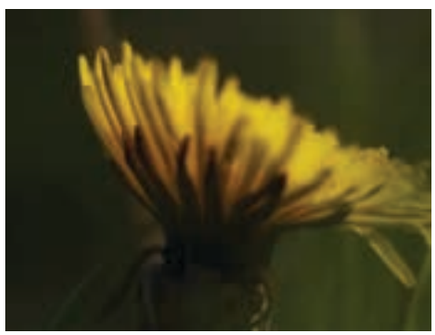
But there is no bending in the root and shoot of the plant fixed on the rotating clinostat. This is due to the fact that gravitational stimulus is not unilateral as it affects the sides of the rotating organs equally.



6.5 More to Movement than Growth

The flower of ***Taraxacum officinale*** (common Dandelion) blooms in the morning and evening it closes (**Photonasty**). ***Ipomoea alba*** (Moon flower) does exactly the opposite. They open in the night and hence the name moon flower and closes in the day time. Just a casual touch is enough to make the ***Mimosa pudica*** (Touch-me-not) leaves fold up and droop (**Seismonasty or thigmonasty**).

Day



Night

Photonasty in Dandelion

Day

Night

Photonasty in Moon flower

The root and shoot move towards the direction of the stimuli, whereas the movement of the opening and closing of the flowers are not directed towards stimuli. Such movements in plants are called as **Nastic movements**. Unlike tropic movement, nastic movements are independent of the stimuli direction and may or may not be growth movement.

Some plants feed on insects and small animals, even a frog. (Example: *Nepenthes, Drosera* and Venus flytrap). The Venus Flytrap (*Dionaea muscipula*) presents a spectacular example of thigmonasty. It exhibits one of the fastest known nastic movements.

Types of Nastic movements

1. Thigmonasty or Seismonasty – touch - Example: *Brunnichia ovata* and *Mimosa pudica*

2. Nictinasty – darkness - Example *Leucaena leucocephala*

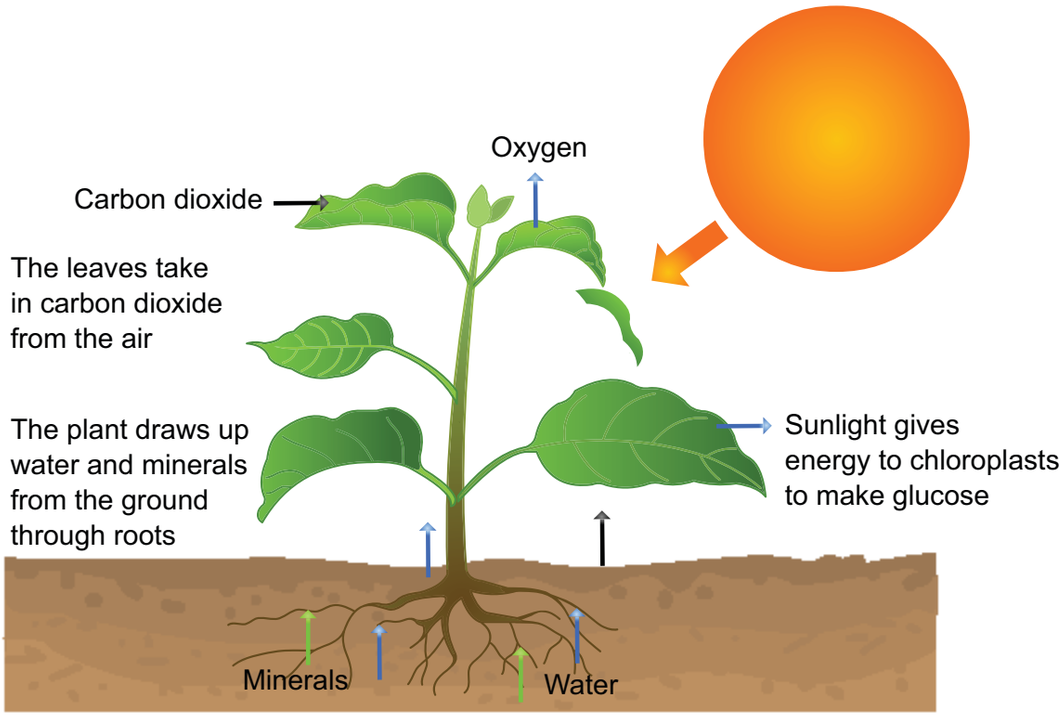
3. Thermonasty – temperature Example: *Tulipa sp*

4. Photonasty – changes in light intensity - *Samanea saman*

Plant parts move as they have clear adaptive advantages. Roots going down are more likely to find water and minerals they need. Stem growing up and towards light is more likely to get sunlight for photosynthesis and display its flowers prominently for pollinators to arrive. It also has better chance of spreading its seeds (Table 1).

Table 1 Differences between tropic and nastic movements

Tropic movements	Nastic movements
Unidirectional response to the stimulus	Non-directional response to the stimulus
Growth dependent movements	Growth independent movements
More or less permanent and irreversible	Temporary and reversible
Found in all plants	Found only in a few specialized plants
Slow action	Immediate action



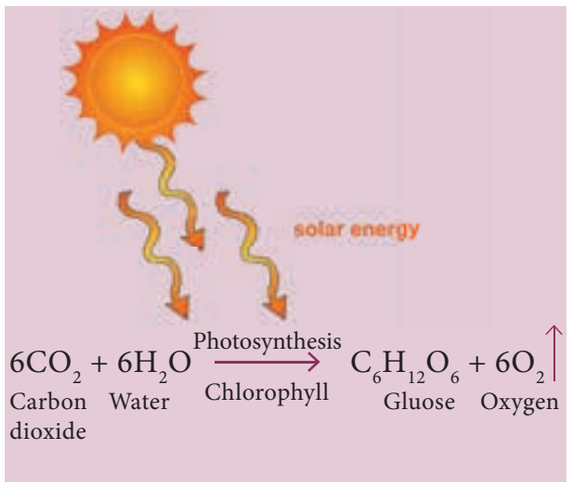
6.6 What is Photosynthesis?

'Photo' means **'light'** and **'synthesis'** means **'to build'** thus photosynthesis literally means **"building up with the help of light"**. During this process, the light energy is converted into chemical energy. Green plants are autotrophic in their mode of nutrition because they prepare their food materials through a process called photosynthesis.

Info bits

Only plants can photosynthesize and release oxygen (O_2). This is converted into ozone (O_3), which protects our mother Earth.

The overall equation of photosynthesis can be given as follows:



The end product of photosynthesis is glucose which will be converted into starch and stored. Plants take in carbon dioxide for photosynthesis; but for its living, plants also need oxygen to carry on cellular respiration.

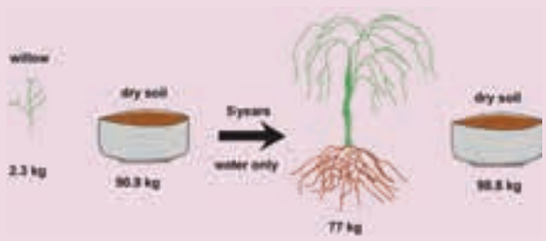
$$\underset{\text{Glucose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{Starch}}{(C_6H_{12}O_6)_n}$$

More to Know

Look at a gigantic banyan tree. Many years ago it would have been just a sapling. It has grown into a huge tree. How did it gain the mass? Whether it is from soil/water/air? A Belgian scientist, Jan Baptist van Helmont was intrigued by this question and performed an experiment in 1648 to test how much the plant gains from extracting materials out of soil. He devised an interesting experiment to find out.

He took soil and heated it to make it dry. He then measured the weight of the soil. It was 90.9 kg. Can you guess why he first dried the soil? He placed this soil in a container which can transport water through its pores but without soil. He took a small sapling of willow tree, cleaned it and measured its weight. The tree weighed 2.3 kg. He closed the container with a lid having number of holes permitting free movement of air and light, but not dust. The experiment went on for five years, and he added only water to the pot. After five years the sapling grew into a small tree. He uprooted the tree carefully, cleaned it and measured its weight. Now the tree weighed 77.0 kg. Once again he dried the soil in the container and measured its weight. Soil weighed 90.8 kg.

Jan Baptist van Helmont



He was able to see that the plant gained 74.7 kg (77.0 – 2.3 = 74.7) in five years, but the soil had lost only 0.1 kg (90.9 – 90.8 = 0.1 kg) in five years. So, we can see that soil is not the major contributor to the gaining of the mass of the plant. Perhaps like vitamins in Humans, soil may supply vital elements and crucial, but that is not how plants make their food is clear. Van Helmont thought water alone was the cause of the increase in weight. Do you agree? Can you think of any other factor that could have added mass to the growing tree? The next step in our understanding is the process by which plants produce food came from the experiments of Joseph Priestley.

Priestley devised an extraordinary experiment in 1771. First he burned a candle inside a jar and converted all the oxygen into carbon dioxide. (How can you be sure that all the oxygen inside the jar has been converted into carbon dioxide?) Now he placed a sprig of mint inside the jar, without outside air mixing with the gases inside the jar. He waited for ten days. Using a lens he re-lit the candle from outside. (Why he did not use a matchstick?) The candle burned. This means that oxygen was once again inside the jar. Priestley concluded that sprig of mint had absorbed the carbon dioxide and released oxygen. That is why, he said, the candle was lit again. Priestley concluded that the plant was converting the carbon dioxide back into oxygen.

Joseph Priestley

6.6.1 What else is needed for photosynthesis?

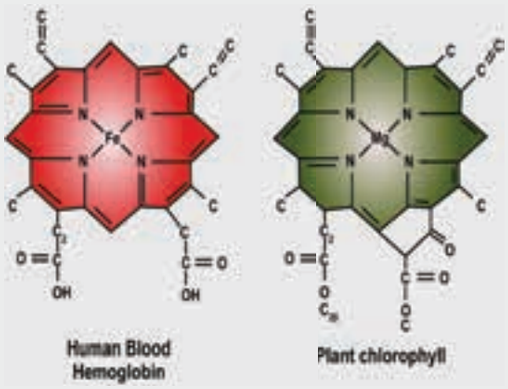
Photosynthesis is the process by which plants make their food. A small speck of seed grows and gains weight into a giant tree, due to photosynthesis. Almost all the other organisms rely on plants for their food directly or indirectly. Even a carnivore depends ultimately upon plants for its food, how? Can you highlight? Four important things needed by plants for photosynthesis:

1) Chlorophyll - Green pigment present in leaves
2) Water
3) Carbon dioxide (from air)
4) Light

Let us examine two of these factors

Info bits

Structurally chlorophyll resemble haemoglobin but differ with the central molecule.



Chlorophyll

Aim: To show that chlorophyll is essential for photosynthesis.

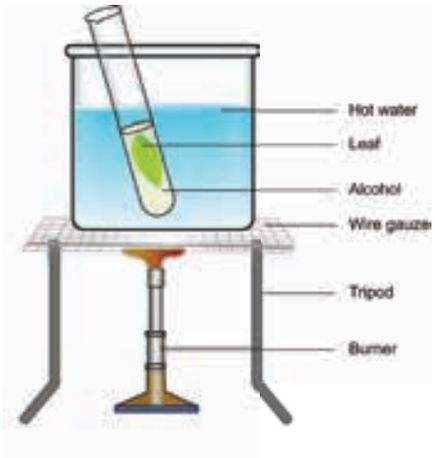
We need *Coleus* (croton) plant with variegated leaves, boiling water, alcohol and iodine solution.

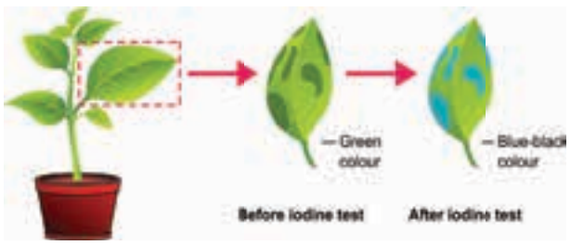
How to do?

Variegated leaf is plucked from *Coleus* plant kept in sunlight after de-starching by keeping it in dark room for 24 hours. The picture of the leaf is drawn and the patches of cholorphyll on the leaf are marked. After immersing the leaf in boiling water then in alcohol it is tested for starch with iodine solution.

What do you observe? The patches of the leaf with chlorophyll turn blue-black. The other portions remain colourless.

What you conclude? The chlorophyll is essential for photosynthesis.





Plants take up water through their roots and air through stomata of their leaves. Chlorophyll is present in the leaf. What else is needed for photosynthesis? The question that remains to be answered is whether the process of forming starch by combining carbon dioxide and water also requires light. Let us do an experiment.

Light

Aim: To show that sunlight is necessary for photosynthesis.

What do you need? potted plant, black paper, boiling water, alcohol and iodine solution.

How to do?

A potted plant is placed in a dark room for about 2 days to de-starch its leaves. One of its leaves is covered with the thin strip of black paper as shown in the picture. make sure that the leaf is covered on both sides.

The potted plant is kept in bright sunlight for 4 to 6 hours. The selected covered leaf is plucked and the black paper is removed. The leaf is immersed in boiling water for a few minutes and then in alcohol to remove chlorophyll. The leaf is now tested with iodine solution for the presence of starch. The covered part of the leaf does not turn blue-black whereas the uncovered part of the leaf turns blue-black colour. The covered part of the leaf which did not receive the sunlight was unable to synthesize starch. Hence it does not turn blue-black colour. But the uncovered part of the leaf which received sunlight was able to synthesise starch and so it turns blue-black in colour.

DO YOU KNOW?

Scientists have discovered a brilliant emerald green sea slug, *Elysia chlorotica* that was photosynthetic to produce energy. The sea slug consumes alga *Vaucheria litorea*, which is not fully digested. Instead, the algae remain in the creature's system and continue to provide food for the slug through continued photosynthesis.

DO YOU KNOW?

Sunlight can penetrate 100 m to 200m into the oceans, gradually dims as the depth increases. Is it possible for the organisms that live deep into the ocean to do photosynthesis?

A team of researchers including a photosynthesis expert from ASU (Arizona State University, USA) have found that photosynthesis taking place deep within the Pacific Ocean. They discovered a green sulphur bacteria living near hydrothermal vents nearly 2400m deep into the ocean of Mexico. This bacteria lives in the razor-thin interface between extremely hot water (350° C or 662° F) and very cold water (2°C or 36° F) surrounding it. "This is just one example of life in extreme environments."

All these four things must be in the leaf, the site where plants make their food. That raises an interesting question. Of the four,

chlorophyll is present in the leaf. Sunlight falls on the leaf. But how do plants take air and water to its leaf? How does the water reach the leaves from the roots? What path does it follow? How does air enter the leaf?

6.6.2 Exchange of gas

Roots of the plant take the water from the soil and transport it to leaves. How water and other nutrients reach the leaf from the roots? Is the only question that we need to find out? We will see this later. This leaves us with only one question? How does the plant get air? The leaves have tiny holes, called **stomata**, through which the exchange of air takes place. These holes are so minute that we need a microscope to see them. The air exchange takes place continuously through the stomata. Plants inhale and exhale continuously through these stomata.

6.6.3 Transpiration

The loss of water in the form of water vapour from the aerial parts of the plant body is called as transpiration. There are three types of transpiration:

1. Stomatal transpiration - This is the most dominant form of transpiration being responsible for most of the water loss in plants. It accounts for 90-95% of the water transpired from leaves.
2. Cuticular Transpiration – This type of transpiration is responsible for the loss of water in plants via the cuticle.
3. Lenticular Transpiration – This type of transpiration is the loss of water from plants as vapor through the lenticels. The lenticels are tiny openings that protrude from the barks in woody stems and twigs as well as in other plant organs.

More to Know

Plant absorbs water from soil and uses it for photosynthesis. A chemical analysis shows that 100 grams of water reacts with 260 grams of carbon dioxide to form 180 grams of carbohydrate. 180 grams of oxygen is created in this process. But the plant does not use all the water it absorbs through its roots to produce carbohydrates. Actually, most of this water evaporates in the air.

Experiment 1

If you tie a plastic bag over a leaf and place the plant in light, you will be able to see water condensing inside the plastic bag. The water is let out by the leaves.

The leaves have tiny, microscopic holes called stomata. Water evaporates through these stomata. Each stomata is surrounded by guard cells. These guard cells help in regulating the rate of transpiration by opening and closing of stomata.

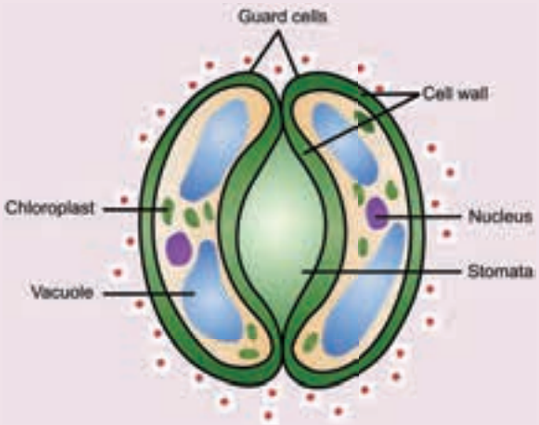
Typically, only 0.1 percent of water taken up by the plant is used by the plant for producing carbohydrates. That is, if a plant absorbs one litre of water, only one millilitre will be used to produce carbohydrate. The remaining 999 millilitres evaporates from the leaf. You will be able to see how much water a plant releases in the air.

DO YOU KNOW?

Guard cells of stomata are green but can't photosynthesize.

Why?

It is Because, Enzymes RUBISCO and NADP-dehydrogenase are absent.



Info bits

Plant use only 1% of water absorbed and remaining 99% is lost through transpiration. A maize plant transpire 54 gallons of water during its life span.

Activity 4

To observe the impression of stomata.

Nail polish is applied on the lower surface of the leaves of a potted plant. After a few minutes, the nail polish is gently peeled off. This nail polish peeling is placed a drop of water on a slide. The cover slip is placed and the peeling is observed under the microscope. Through the microscope, we can see the impression of the cells and the stomata. We know that more water evaporates when the weather is hot. In such a situation, the stomata begin to close. This lessens the amount of water that evaporates from the leaves. Like manner plants adapted to dry land and desert habitat have special adaptations to ensure conservation of water.

Transpiration is a necessary evil

- creates a pull in leaf
- creates a pull in stem
- creates an absorption force in roots, so takes more water

But

- this is necessary for continuous supply of minerals
- This regulates the temperature of the plant.

DO YOU KNOW?

The conifers have a pyramid shape - Isn't it wonderful? Coniferous trees like spruces, pines and firs have a unique geometrical three-sided pyramid shape. They rely on the sunlight all around the year for photosynthesis. Their pyramidal shape allows all the branches to receive more sunlight since the top branches don't shade the bottom branches. The major branches of the conifers are layered with an open area between the layers. This helps in passing through light and the tree to get enough light especially when sunlight comes in at a low angle during the winter months.

DO YOU KNOW?

Why do we get more rainfall in the Amazon? The Amazon is the most biodiverse terrestrial place on the planet. In the Amazon, deep-rooted trees increase local transpiration and high tree cover increase local interception evaporation. These increased evapotranspiration fluxes have positive effects on forests as they stimulate rainfall. ¾ of the rainfall received by the Amazon tropical rainforest comes from plant transpired water vapour, which is visible as a mist.

Suppose the weather is hot and the stomata close; what would be the effect of such a situation in the absorption of carbon dioxide? Will the rate of photosynthesis be the same? If the plant does not get water at this time, what effect would this have on its growth? Relate your answer to the problem of drought affecting agricultural growth. Global warming implies increased level of average temperature. Can you reason what all the effect it can have on photosynthesis?

6.6.4 Macronutrients and micronutrients for plants

Nutrients such as carbon, hydrogen, oxygen, nitrogen, potassium, calcium, magnesium, sulphur and phosphorus, are required in substantial quantity and are called **macronutrient**. Plants also require many other nutrients like iron, manganese, copper, boron, molybdenum, chlorine, silicon, cobalt, and zinc, but only in minute quantities, hence, they are called **micronutrients**. The water transportation systems of the plants take these nutrients from the soil and circulate it in the plant.

DO YOU KNOW?

The plants trap solar energy for photosynthesis. Do the insects also trap solar energy? Tel Aviv University Scientists have found out that *Vespa orientalis* (Oriental Hornets) have similar capabilities to trap solar energy. It has a yellow patch on its abdomen and an unusual cuticle structure which is a stack of 30 layers thick. The cuticle does not contain chlorophyll but it contains the yellow light sensitive pigment called xanthopterin. This works as a light harvesting molecule transforming light energy into electrical energy.

6.7 Food chain: the Link between Plants, Animals and Microorganisms

Plants are called primary producers. They produce starch, protein and fats from sunlight, water and carbon dioxide and other nutrients. Some of the animals and microorganism consume the plants and grow and gain weight. The carnivorous animals eat the animals that graze and gather energy from the plants. The dead plants and animals are decomposed by microorganisms. Some of the microorganisms decompose and make some of the nutrient available in a manner for the plants to absorb from soil. Thus a series of organisms each dependent on the next as a source of food. This link is called as food chain.

6.8 Respiration in plants

Like animals, plants too respire. During respiration, plants inhale oxygen and exhale carbon dioxide like animals. This process goes on 24 hours of the day and night. It is during the photosynthesis that it uptake carbon dioxide and exhale oxygen. Obviously photosynthesis occurs in most plants only during the daytime.

A-Z GLOSSARY

1. **Tropism** Growth movement whose direction is determined by the direction of the stimulus.
2. **Phototropism** The unidirectional movement of a plant part to light stimulus.
3. **Geotropism** Response of a plant part to gravity stimulus.
4. **Hydrotropism** Response of a plant part to water stimulus.
5. **Thigmotropism** Response of a plant part to touch stimulus.
6. **Chemotropism** Response of a plant part to chemical stimulus.
7. **Nastic movement** Non-directional, response of a plant part to stimulus.
8. **Thigmonasty** The non-directional movement of a plant part in response to the touch of an object.
9. **Photonasty** The non-directional movement of a plant part in response to the light.
10. **Photosynthesis** The process by which plants prepare their food material.
11. **Transpiration** The loss of water in the form of water vapour from the aerial parts of the plant body.
12. **Stomata** Minute opening on the leaves.

EXERCISE

EXANR9

I. Multiple Choice Questions (MCQs)

1. A big tree falls in a forest but its roots are still in contact with the soil. The branches of this fallen tree straight up. This happens in response to _____.
   a) water and light
   b) water and minerals
   c) gravity and water
   d) light and gravity

2. The tropic movement that helps the climbing vines to find a suitable support is _____.
   a) phototropism
   b) geotropism
   c) thigmotropism
   d) chemotropism

3. The chemical reaction occurs during photosynthesis is _____.
   a) CO_2 is reduced and water is oxidized
   b) water is reduced and CO_2 is oxidized
   c) both CO_2 and water are oxidized
   d) both CO_2 and water are produced

4. Transpiration is best defined as _____.
   a) loss of water by the plant
   b) evaporation of water from the aerial surfaces from the plant
   c) loss of water in the form of water vapour from the underground parts of the plant body
   d) release of water from the plant into the atmosphere

II. State whether the following statements are true or false. If false, write the correct statement

1. The response of a plant part to the chemical stimulus is called phototropism.
2. Shoot is positively phototropic and negatively geotropic.
3. Scientific term used to represent the bending of roots towards water is called geotropism.
4. Joseph Priestley devised an experiment to find out that water alone was the cause of the increase in the weight of the plant.
5. When the weather is hot, water evaporates lesser which is due to opening of stomata.

III. Fill in the blanks

1. The shoot system grows upward in response to _____
2. _____ is positively hydrotropic as well as positively geotropic.
3. The green pigment present in the plant is _____
4. The minerals like nitrogen, potassium and phosphorus, are required in substantial quantity by the plants are called _____

IV. Match column A with column B

	Column A	Column B
1.	Roots growing downwards into soil	Positive phototropism
2.	Shoots growing towards the light	Negative geotropism
3.	Shoots growing upward	Negative phototropism
4.	Roots growing downwards away from light	Positive geotropism

V. Analog

1. Towards a stimulus :_____ Away from the stimulus : Negative tropism
2. Hydrotropism : Response towards water Phototropism : _____
3. Photosynthesis : _____ Transpiration : Stomata

VI. Answer in a word or two

1. Give an example for a plant whose leaf shows a mesmerizing movement.
2. Write the scientific terms used to represent the following:
   a) Growing of roots towards the gravity.
   b) Bending of roots towards the water.
3. **Observe the given picture.**
   a) Identify this plant. What type of special movement is shown by this plant?

   b) What are the other movements seen in this plant?
4. What is the end product of photosynthesis?
5. Name the minute openings seen on the lower surface of the leaf.

VII. Answer the following in one or two sentences

1. What is nastic movement?
2. Name the plant part
   a) Which bends in the direction of gravity but away from the light.
   b) Which bends towards light but away from the force of gravity.
3. Differentiate phototropism from photonasty.
4. Photosynthesis converts energy X into energy Y.
   a) What are X and Y?
   b) Green plants are autotrophic in their mode of nutrition. Why?
5. Define transpiration.

VIII. Answer in detail

1. Design an experiment to demonstrate hydrotropism.

WORK BOOK

I. Multiple Choice Questions

1. The bending of root of a plant in response to water is called _____.

a) thigmonasty

b) phototropism

c) hydrotropism

d) photonasty

2. A growing seedling is kept in the dark room. A burning candle is placed near it for a few days. The top part of the seedling bends towards the burning candle. This is an example of _____.

a) chemotropism

b) thigmotropism

c) phototropism

d) geotropism

3. The root of the plant is _____.

i) positively phototropic but negatively geotropic

ii) positively geotropic but negatively phototropic

iii) negatively phototropic but positively hydrotropic

iv) negatively hydrotropic but positively phototropic

a) (i) and (ii)

b) (ii) and (iii)

c) (iii) and (iv)

d) (i) and (iv)

4. The plant part which exhibits negative geotropism is _____.

a) root

b) stem

c) branch

d) leaves

5. The non-directional movement of a plant part in response to temperature is called _____.

a) thermotropism

b) Thermonasty

c) chemotropism

d) thigmonasty

6. Dandelion flowers open the petals in bright light during the day time but close the petals in dark at night. This response of Dandelion flowers is called _____.

a) geonasty

b) thigmonasty

c) chemonasty

d) photonasty

7. During photosynthesis plants exhale _____.

a) Carbon dioxide

b) oxygen

c) hydrogen

d) helium

8. Chlorophyll in a leaf is required for _____.

a) photosynthesis

b) transpiration

c) tropic movement

d) nastic movement

9. A plant is kept in a dark room for about 24 hours before conducting any experiment on photosynthesis in order to _____.

a) remove chlorophyll from the leaf

b) remove starch from the leaves

c) ensure that photosynthesis occurred

d) to prove transpiration

10. Transpiration takes place through _____.

a) fruit b) seed

c) flower d) stomata

II. Fill in the blanks

1. The solar tracking of sunflower in accordance with the path of sun is due to _____.
2. The response of a plant part towards gravity is _____.
3. When the leaves of a sensitive plant are touched with a finger, they fold up and when light fades at dusk the petals of a Dandelion flower close. These two plants show _____ and_____ movements.
4. Opening and closing of Moon flower is not a tropism because the movement in this is _____.
5. The raw materials for photosynthesis are _____ and _____.
6. When iodine solution is added for testing starch, part of the leaf with _____ turn blue-black colour.
7. In leaves, the food is stored in the form of _____.
8. Plants may inhale carbon dioxide for photosynthesis but need _____ for their living.
9. Plants utilize only _____% of the absorbed water for photosynthesis and the other activities.
10. Plants inhale and exhale continuously through the _____.

III. State whether the following statements are true or false. If false write the correct

statement:

1. When the leaves of ***Mimosa pudica*** plant are touched with the finger, they fold up quickly.
   This is an example of thigmonasty.
2. The petals of moon flower open up in morning and closes in the evening. This is called photonasty.
3. Photosynthesis produces glucose and carbon dioxide.
4. Photosynthesis is important in releasing oxygen to keep the atmosphere in balance.
5. Plants lose water when the stomata on leaves are closed.

IV Match the following

S. No.	Column A	Column B	Column C
1.	Photonasty	Response to temperature	*Tulipa sp*
2.	Thigmonasty	Response to light	*Mimosa pudica*
3.	Thermonasty	Response to touch	Moon flower

V. Answer in a word or two

1. Give the technical terms for the following:
   a) Growth dependent movement in plants.
   b) Growth independent movement in plants.
2. Study the pictures below and then complete the table by putting a plus (+) if the shoot or root grows towards the stimulus and a minus (-) if it grows away from it.

Stimulus	Light	Gravity
Shoot	+	_
Root	?	+

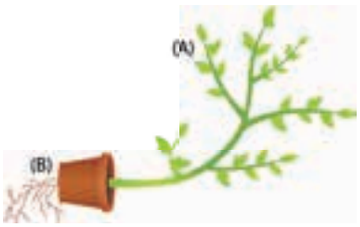
3. Name the movement seen in Pneumatophores of *Avicennia*.
4. What is the other name for thigmonasty?
5. Which flowering plant shows photonasty just opposite to that of Dandelion?
6. Give an example for negative hydrotropism.
7. Fill in the blanks:

$$6CO_2 + \_\_\_ \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \_\_\_ + 6H_2O + 6O_2\uparrow$$

8. Which gas is evolved during photosynthesis?
9. What is chlorophyll?
10. Give an example for micronutrients.

VI. Answer the following in one or two sentences

1. Name the part of plant which shows positive geotropism. Why?
2. What does a *Mimosa pudica* plant do in response to touch? What is the phenomenon known as?
3. i) What happens to the dandelion flower
   a) during the daytime?
   b) at night?
   ii) What is the phenomenon known as?
4. What is the difference between movement of flower in sunflower plant and closing of the leaves in the *Mimosa pudica.?*
5. Define photosynthesis.
6. Suppose you have a rose plant growing in a pot, how will you demonstrate transpiration in it?
7. Draw the diagram of open stoma and label the parts.
8. A potted plant is kept horizontally for a considerable time. The three positions of the part A and B of the potted plant are shown in the following figures.
   (i) Potted plant with shoot and root growing downward. (Diagram to be drawn)
   (ii)



   (iii) Potted plant with shoot and root growing upward (Diagram to be drawn)
   a) Which figure shows the correct position taken by the parts A and B of the plant?
   b) What type of phenomenon is exhibited by the figure by (A) in the figure (ii)?

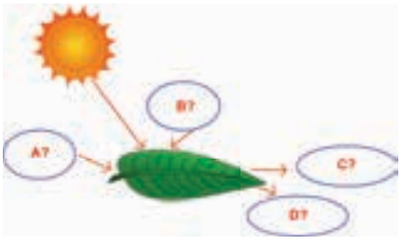
9. Complete the following table with the different types of tropism:

Stimulus		Gravity	Unilateral light	Water
Tropism		Geotropism	?	Hydrotropism
Response	Shoot	?	Positive	No response
	Root	Positive	?	?

10. Cover the tip of the shoot with tin foil cap and light it from the side as shown in the given picture. What would you expect to happen? Why?

11. In the given photosynthetic experiment, what will happen to the leaf closed with black paper in starch test? Why?

12. Label the diagram with the raw materials and products of photosynthesis.



13. Mention the differences between stomatal and lenticular transpiration
14. Give an example for the movement plant part which is very quick and can be observed easily.
15. To which directional stimuli do (a) roots respond (b) shoots respond?
16. Name the cell that surrounds the stoma.

VII. Assertion and reason

1. Assertion (A): If the plant part moves in the direction of gravity, it is called positive geotropism.

   Reason (R) : Stem shows positive geotropism

   a) A and R are incorrect
   b) A is incorrect, R is correct
   c) A is correct, R is incorrect
   d) Both A and R are correct

2. Assertion (A): The loss of excess water from the aerial parts of the plant in the form of water vapour is known as transpiration.

   Reason (R) : Stomata of the leaf perform transpiration.

   a) A and R are incorrect
   b) A is incorrect, R is correct
   c) A is correct, R is incorrect
   d) Both A and R are correct

VIII. Higher order thinking questions (HOTS)

1. There are 3 plants A, B and C. The flowers of A open their petals in bright light during the day but close them when it gets dark at night. On the other hand, the flowers of plant B open their petals at night but close them during the day when there is bright light. The leaves of plant C fold up and droop when touched when fingers or any other solid object.

   a) Name the phenomenon shown by the flowers of plant A and B.

   b) Name one flower each which behaves like the flowers of plant A and B.

   c) Name the phenomenon exhibited by the leaves of plant C.

   d) Name a plant whose leaves behave like those of plant C.

2. While conducting experiments to study the effects of various stimuli on the plants, it was observed that the roots of a plant X grow and bend towards two stimuli A and B but bend away from a third stimulus C. The stem of the plant X however bends away from stimulus A and B but bends towards the stimulus C. The stimulus B is known to act on the roots due to factors related with Earth. Keeping these points in mind, answer the following questions:
   a) What could be stimulus A ?
   b) Name the stimulus seen in B.
   c) What could be stimulus C ?
3. An organism A which cannot move from one place to another makes a simple food B from the substances C and D available in the environment. This food is made in the presence of green coloured substance E present in organs F in the presence of light energy in a process called G. Some of the simple food B also gets converted into a complex food H for storage purposes. This food gives blue-black colour with iodine solution?
   a) What is (i) organism A (ii) food B and food H?
   b) What are C and D?
   c) Name (i) green pigments E and organ F.
   d) What is the process G?
4. Imagine that student A studied the importance of certain factors in photosynthesis. He took a potted plant and kept it in dark for over 24 hours. In the early hours of the next morning, he covered one of the leaves with dark paper in the centre only. Then he placed the plant in sunlight for a few hours and tested the leaf which was covered with black paper for starch.
   a) What aspect of photosynthesis was being investigated?
   b) Why was the plant kept in the dark before the experiment?
   c) How will you prove that starch is present in the leaves?
   d) What are the other raw materials for photosynthesis?

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INTERNET RESOURCES

1. http://web.mit.edu/esgbio
2. http://www.cellbiol.com/bioinformatics_web_development
3. http://www.bioedonline.org/
4. http://www.biology.arizona.edu/default.html
5. https://www.gbif.org/

UNIT 7

Living World of Animals - Diversity in Living Organism - Kingdom Animalia

Learning Objectives

EXJJSH

At the end of this Unit the students will be able to understand,

- the classification of various types of animals
- makes it easier to observe, identify and study the different groups of animals on the basis of certain characteristics they have in common
- list out the general characteristics of animals based on grades of organization, types of symmetry, coelom and various body activity
- recognize that binomial classification has Latin and Greek words given to each animal and plant, the first name is genus and second as species
- recall the salient features of each phylum

Introduction

The enormous variety of living organisms surrounding us is incomprehensible. About 1.5 million species of animals are already described and named. Without suitable method of classification, the study of various organisms would be difficult.

For example, among the butterflies, it is difficult to identify their varieties. Because there are different colour of butterflies (blue, red, brown, yellow) and butterflies with spots (big and small).

Tigers and zebras have stripes. On the other hand tigers look more like cats and zebras are more like horses. Can we classify them based upon their appearances? What factors are significant for their classification?

Long ago, when human civilization was confined to small place, the number and variety of animals and plants that they were aware was limited. However, when the European explorers went around the world during the 15th and 16th centuries, they could collect information on plants and animals from across the world. The immense diversity in shape, size and features baffled them.

The first systematic approach to the classification of living organisms was made by a Swedish botanist, Carolus Linnaeus. He generated the standard system for naming organisms in terms of genus, species and more extensive groupings using Latin terms.

For example, the tiger is a carnivore and the zebra is an herbivore, both are striped animals, but the tiger resemble a cat more than zebra. However all the three produce milk and feed their young ones.

Taxonomists realized that wide features are shared for the ranking of higher group in classification. Therefore characters that strike the eye, like the tiger's stripes, are often less significant than subtler ones, such as how many toes the animal possesses.

Different types of animals produce milk to feed their young ones. Therefore all of them could be grouped into one major category, known as mammals. Higher ranks are more comprehensive.

Human beings have a wonderful capacity to discriminate different animals. While walking through a field we may come across a jumping frog. Is it a frog or a toad? We may see a snake. Is it poisonous or not? We may hear a bird call but we are not familiar with it. Sometimes a fish may be seen in a temple tank. What kind is it?

In order to find an answer to such questions, we should know how to identify animals. For a biologist it is necessary to identify the organism, which have a name for identification and to know the group it belongs to.

Taxonomy

It is the theoretical study of classification including its basic principles, procedures and rules.

Classification

It is the ordering of organism into groups on the basis of their similarities, dissimilarities and relationship.

You are in a village, which is part of a taluk. Your taluk is part of district, which falls under a state- Tamilnadu. Tamilnadu is a state in India which is a country in South East Asia. Similarly, the Tiger is classified as **Kingdom**: Animalia; **Phylum**: Chordata; **Sub phylum**; Vertebrata; **Class**: Mammalia; **Subclass**: Eutheria; **Order**: Carnivora; **Family**: Felidae; **Subfamily**: Panthernae; **Genus**: *Panthera*; **Species**: *tigris*. Find out the classification of cat and humans?

7.1 Classification of Living Organisms

Imagine a bacteria, neem tree and toad. All of them are living things and their basic unit is a cell. However, one major difference is that the cells in neem tree and toad have nucleus, whereas the bacterium has no nucleus. Thus all life can be divided into two major categories Prokaryotes and Eukaryotes. Among the eukaryotes like pond algae, fern and a rabbit, the pond algae is a single celled organism, whereas rest are multicellular organisms. On the basis of significant characteristic features like the presence or absence of cell wall and the photosynthetic activity, the organisms (living beings) are divided into major groups as shown in Figure 1 and 2.

7.2 Criteria for Classification of Animal Kingdom

Look at this list of animals: sponge, rotifer, jelly fish, flatworm, roundworm, snail, earthworm, grasshopper, star fish and peacock.

Among the above listed animals, sponge does not have any true tissues. We can divide the animalia into two major

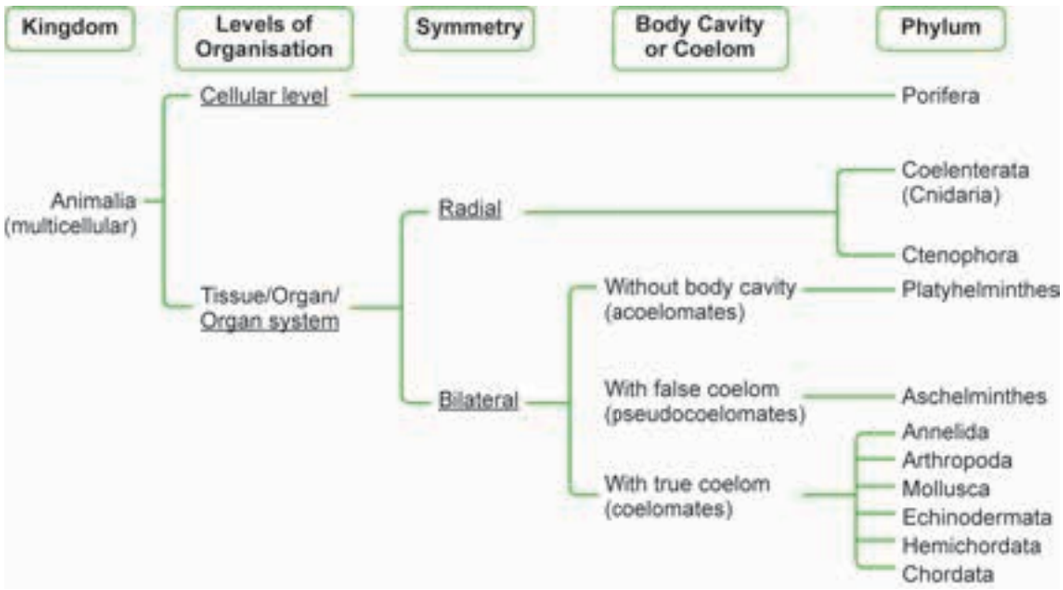


Figure 1 Classification of kingdom Animalia based on common features

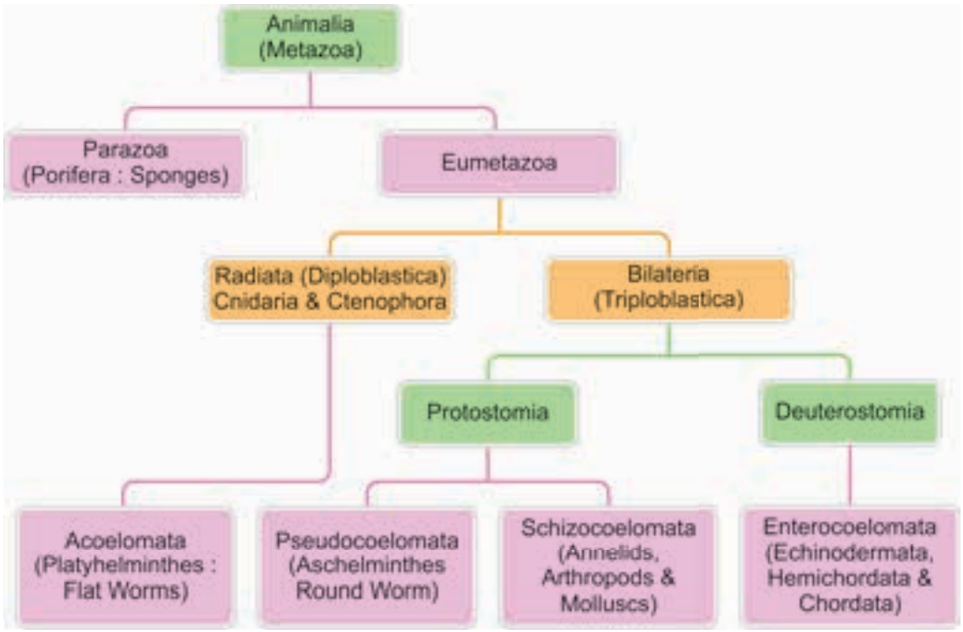


Figure 2 Classification of kingdom Animalia

divisions - those with true tissues and those without true tissues. The group of animals that lack true tissues are called as Porifera.

It is seen that the jelly fish and star fish have radial symmetry, while if we look at flatworm, roundworm, rotifer, snail, earthworm, grasshopper and peacock have bilateral symmetry.

1. **Grade of organization** – Animals are grouped as unicellular or multicellular based on the number of cells.
2. **Symmetry** – It is a plane of arrangement of body parts. Radial symmetry and bilateral symmetry are the two types of symmetry (Figure 3).

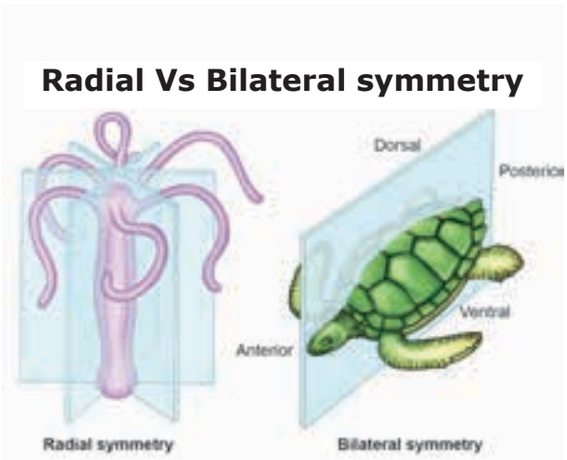


Figure 3 Radial and Bilateral Symmetry

In radial symmetry the body parts are arranged around the central axis, if we cut through the central axis in any direction, it can be divided into similar halves. E.g. Hydra, jelly fish and star fish. In bilateral symmetry, the body parts are arranged along a central axis, if we cut through the central axis, we get two identical halves E.g. Frog.

3. **Germ layers** – Germ layers are formed during the development of an embryo. These layers give rise to different organs, as the embryo becomes an adult. If an organism has two germ layers, the ectoderm and the endoderm it is said to be diploblastic. If they have three germ layers, the ectoderm, the mesoderm and the endoderm they are triploblastic animals.

4. **Coelom** – Coelom refers to a fluid-filled cavity inside the body. It separates the digestive tract and other organs from the body wall. A true body cavity or coelom is one that is located within the mesoderm. Based on the nature of the coelom, animals are divided into 3 groups (Figure 4). Organisms like the earthworm are called coelomates or eucoelomates because they have true coelom. Tapeworm is an example of an acoelomate because it does not have a body cavity. Animals like the roundworm have a body cavity but it is located between the endoderm and the mesoderm.

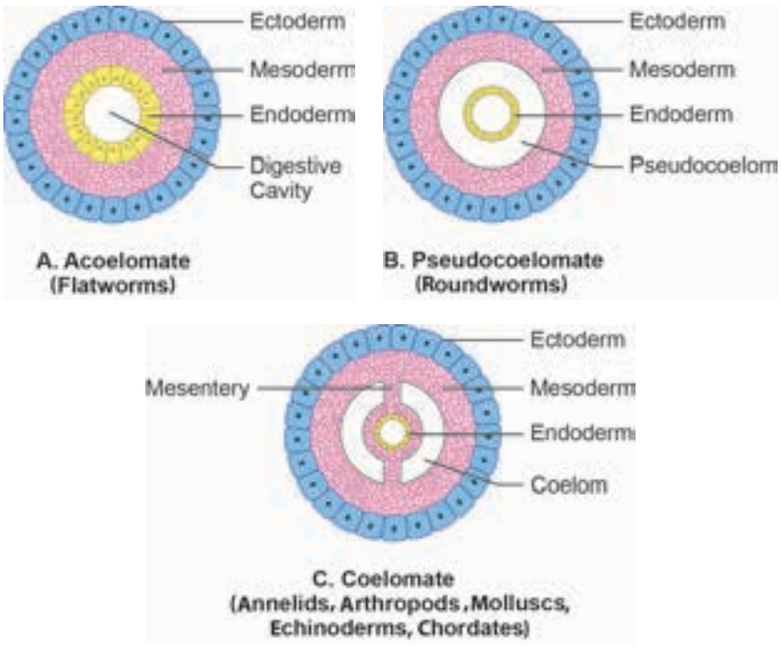


Figure 4 Types of Coelom

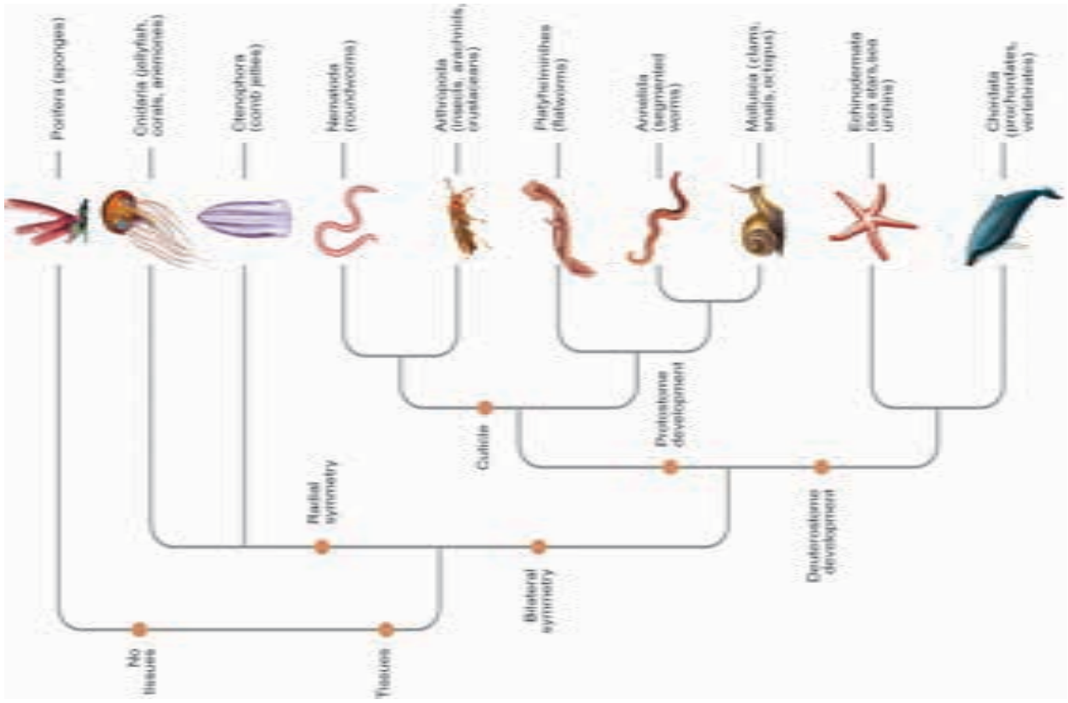


Figure 5 Classification of kingdom Animalia using different criteria

This is considered to be a false coelom and these organisms are called pseudocoelomates.

Characters like presence or absence of body cavity (coelom), segmentation, exoskeleton, jointed legs (appendages), notochord are used to classify the animalia into ten major Phyla (Figure 5).

More to Know

- Deuterostome & Protostome : In the development of embryo, deuterostomes, the first opening (the blastopore) becomes the anus, while in protostomes, it becomes the mouth.

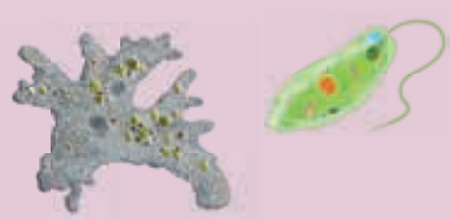
Kingdom Animalia is divided into two groups, based on the presence or absence of notochord **Invertebrata** and **Chordata** (Prochordata and Vertebrata). The groups invertebrata is classified as follows

7.3 Phylum - Protozoa

(*Proto-first; zoa-animals*) This phylum includes a great diversity of small, microscopic organisms. These are **single celled eukaryotes**. Their locomotion occur through **pseudopodia** (false feet), **cilia** or **flagella**. The nutrition is either **autotrophic** or **heterotrophic**. Respiration and excretion is carried out through general body surface or through **contractile vacuole.** They reproduce either asexually or sexually.

Activity 1

Both are protozoans. Identify their names and locomotor organ



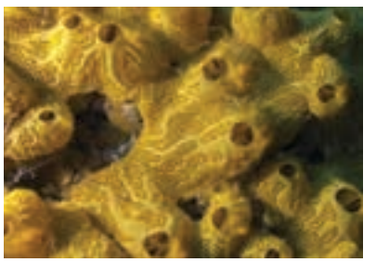
More to Know

Parasitic Protozoans

- Amoebic dysentery is caused by protozoa called *Entamoeba histolytica* which spreads through contaminated food and water.
- Malaria is caused by *Plasmodium sp*. which spreads through female *Anopheles* mosquitoes.

7.4 Phylum - Porifera (Pore bearers)

These are multicellular, aquatic organisms. They are commonly called **sponges**. They have a **cellular grade** of organization without the occurrence of tissues. The body has many pores called **ostia** and **osculum** for circulation of water. The body wall contains **spicules** which form the skeletal framework. They can reproduce both by asexual and sexual methods.



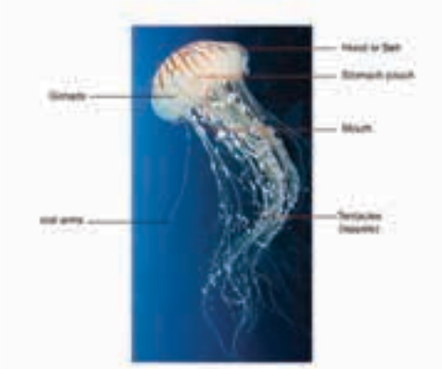
7.5 Phylum - Coelenterata or Cnidaria

All coelenterates are aquatic animals, they are mostly marine in habitat. The body symmetry is radial. The body wall is of two layers of cells namely the outer **ectoderm** and the inner **endoderm,** which is separated from each other by a non-cellular jelly-like substance called **mesoglea**. Due to the presence of two layers in the body wall, they are said to be **diploblastic animals**. Many coelenterates exhibit **polymorphism**. In this phylum, organisms may exist in two different body forms namely, a **polyp** and a **medusa**. The tentacles bear stinging cells called **nematocysts** (**cnidoblasts**). Due to the presence of cnidocil, they are also called as **Cnidaria**. They reproduce both asexually and sexually.

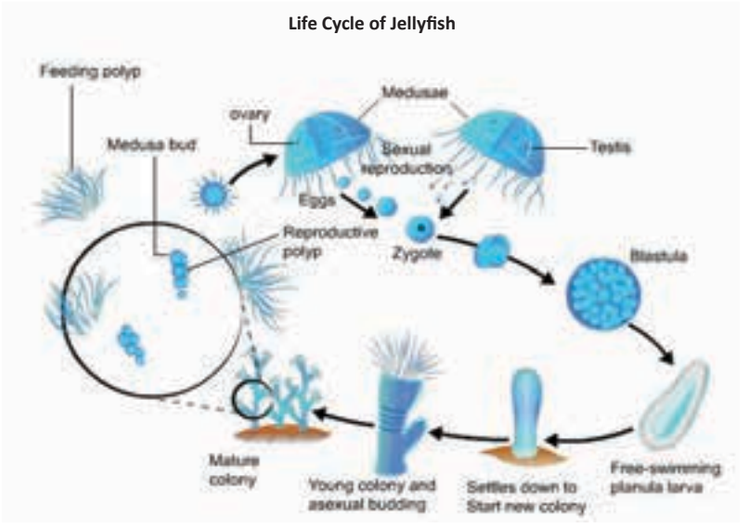
Hydra- a polyp

Info bits

If a moon jelly fish loses its limb, it rearranges the remaining limbs until they are symmetrically placed around its body so it can swim more efficiently.

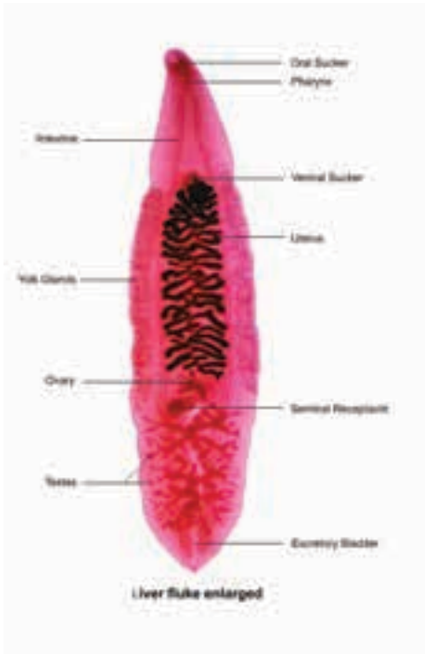


Jelly fish- a medusa



7.6 Phylum: Platyhelminthes - (Flat worms)

This phylum includes flatworms. The alimentary canal is either absent or very simple. Excretion and osmoregulation occur through **flame cells**. These worms are **hermaphrodites** having both male and female reproductive organs in a single individual. Most of the members are **parasitic** in nature.



Liver fluke enlarged

Tape worm infection in Human intestine

Taenia solium (Tape worm) and Scolex (sucker) enlarged

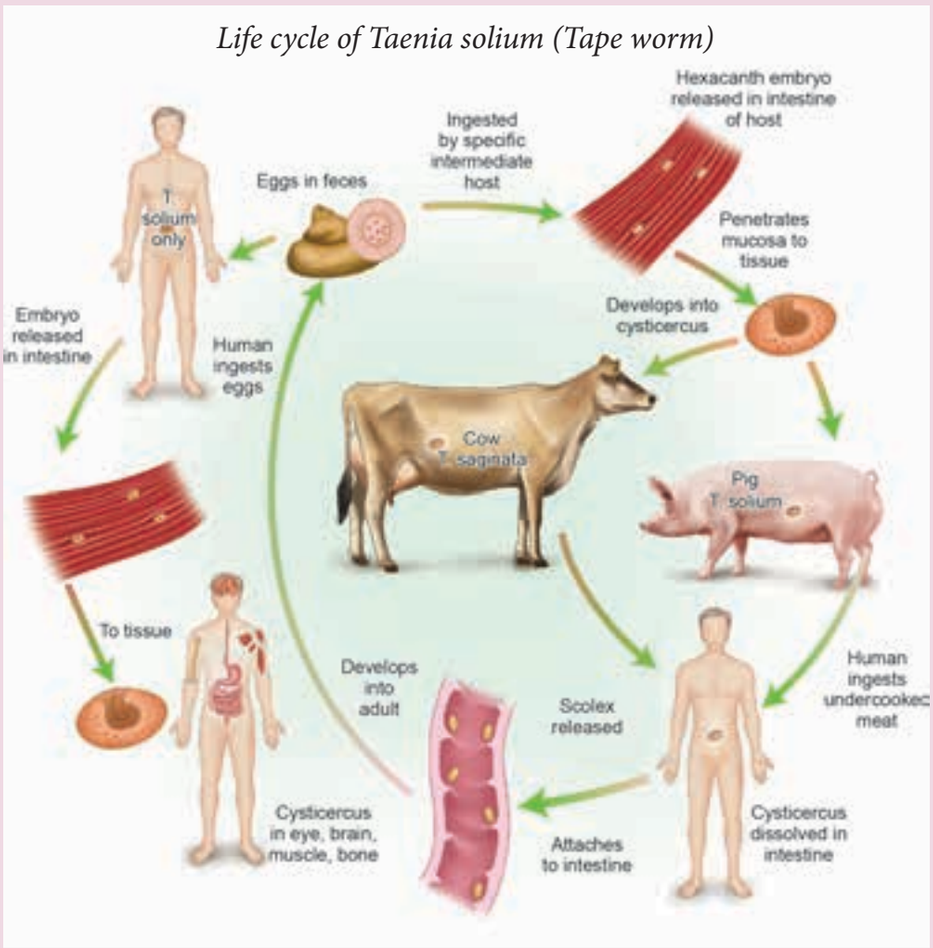
7.7 Phylum - Nematoda Aschelminthes (Round worms)

Aschelminthes comprises the **round worms**. The body is narrow and pointed at both the ends. There are no body segments. The body is covered by a **thin cuticle**. The body cavity is considered as a **pseudocoelom**. The alimentary canal is a straight tube. They reproduce sexually and the sexes are separate. They exist as free living soil nematodes or as parasites.

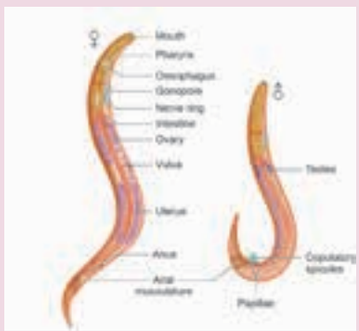
More to Know

Taeniasis is an intestinal infection in mammals caused by an adult tape worm. Due to intake of partially cooked pork meat.

Life cycle of Taenia solium (Tape worm)



Your class mate suffers from stomach pain. The teacher takes him to the doctor. The doctor advises that he is infected with round worms. Have you ever experienced such stomach pain?



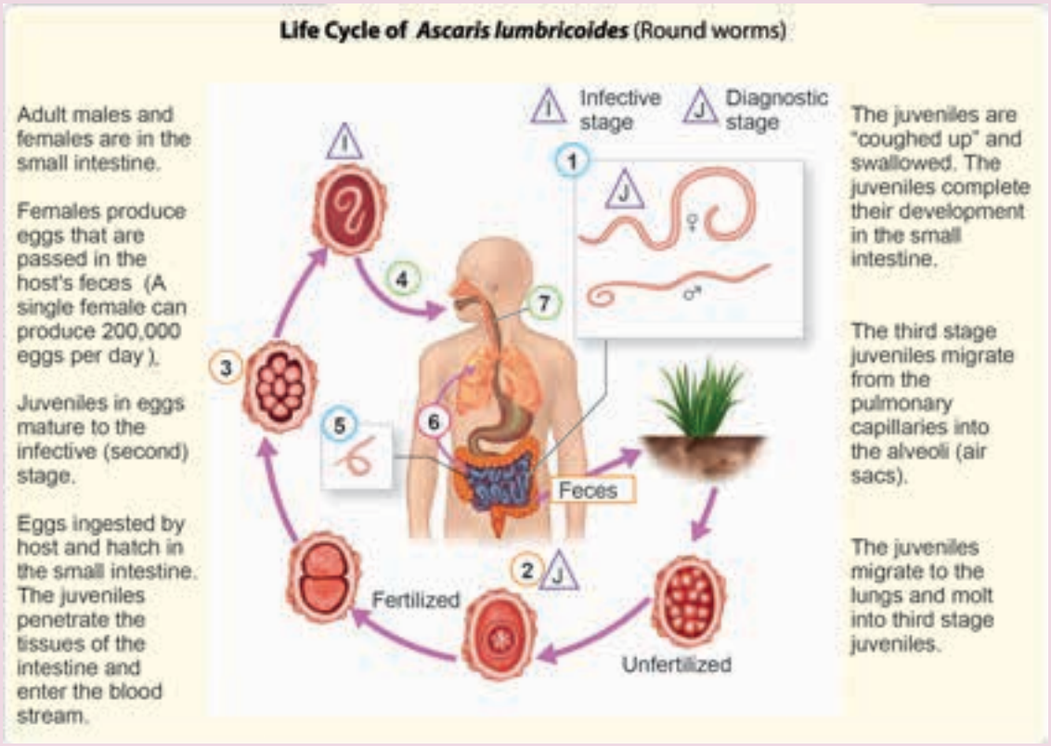
Ascaris lumbricoides – Female and Male Worm

***Ascaris lumbricoides* (Round worms)**

Adult worms	Male 15 to 30 cms Female 20 to 40 cms, oviparous
Eggs	60 μ, bile stained Albuminous coat with unsegmented ovum
Infective form	Embryonated eggs
Mode of transmission	Ingestion
Site of localization	Small intestine

More to Know

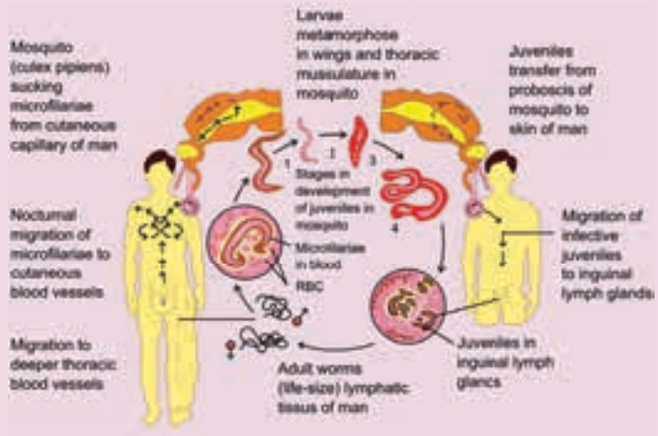
Deworming is treatment for *Ascaris* infection. National Deworming day is observed on February 10th every year in India



More to Know

Filariasis or Elephantiasis is caused by *Wuchereria bancrofti*. It leads to the swelling of legs and groin due to the accumulation of excess of lymph.

***Wuchereria bancrofti*-**
Female and Male worm



Life cycle of *Wuchereria bancrofti*

7.8 Phylum - Annelida - (Segmented Worms)

Earthworms, leeches and a group of marine worms are included in this phylum. The name Annelida comes from the Greek word "**annulations**" which are ring like structures joined together. This is called **metamerism** which means the property of having repeated homologous organs in each segment functioning in coordination with each other. Further these animals are characterized by the possession of a body cavity called **coelom**. Some of them have movable bristles called **setae** involved in locomotion .

The body is covered by a moist outer cuticle, a thick multi-layered structure outside the epidermis providing protection. Nephridia are excretory structures and help to remove metabolic wastes. They have a nervous system with brain (**cerebral ganglia**). The most common larva is **trochophore**.

Think

- Annelida have no leg; yet they move.
- What is the role of setae in locomotion?

Earth worm (*Lampito mauritii*)

When you dig garden soil, you may come across earthworms which are often called- '**the friend of farmers'.** Why are they called so?

Leech (*Hirudinaria medicinalis*)

Have you heard about leeches? How are they different from earthworms in feeding habits?

7.9 Phylum - Arthropoda - (Organisms with Jointed Legs)

Arthropod is an ancient and largest phylum with more than 9,00,000 species. The word Arthropod means '**jointed legs**'. Insects, spiders, crabs, shrimps, butterflies, millipedes, centipedes and scorpions belongs to this phylum. The body plan is distinct with segmentation – **head, thorax** and **abdomen**. The exoskeleton is made up of **chitin**. As the size of exoskeleton cannot change during growth the animals has to shed it periodically by a process called **moulting**.

The coelomic cavity is filled with **haemolymph**(blood). The haemolymph circulates through the body cavity. They do not have well defined blood vessels. This is called **open circulatory** system wherein the tissues and cells of the animal body are bathed directly in blood.

Small arthropods directly absorb oxygen through their body surface. Many of the larger aquatic species breathe through feathery **book gills** and many land

arthropods breathe through a system of tiny body tubes called **tracheae**. Excretion occurs through **malphigian tubules** and **green glands.**

Think

Most agricultural pests are insects. Is there a harmful effect on respiratory system of insects, due to the application of chemicals as insecticides?

Activity 2

- Observe these figures.
- Have you seen any of them alive?
- Where have you seen them?
- What is the major difference you observe with reference to their legs?

Info bits

Copepods are tiny crustaceans (like shrimp) that live in the sea. They are the only creatures known to have only one eye.

Centipedes

They are fast hunters. They come out at night and feed on animals such as slugs, woodlice and earwigs. They grasp them with their fangs and kill them with poison. Female centipedes lay their eggs in the soil and guard them fiercely against predators. There are 2,800 species of centipedes and they are found all over the world. Giant centipedes over 30 cm (12 inches) long live in rain forests. Centipede means 'hundred legs' but most species have only 30 pairs.

Centipede

Millipedes

There are about 8,000 different species of millipedes. They live in the soil and feed mainly on rotting plants. The segments of their skin overlap to protect them and some can curl up into balls. Millipedes have two pairs of legs on each segment. This name means "thousand legs" but, most millipedes have only about a hundred. The longest have 750 pairs. Millipedes curl into tight balls when they are disturbed. Pilli millipedes look like woodlice but have more legs.

Millipede

Activity 3

Do you see honey bee visiting flowering plants of your garden. When do they visit? Why do they visit? What is the great service they render to us?

7.10 Phylum Mollusca - (Soft Bodied Animals)

It is the second largest phylum of animal kingdom. It is a very successful and diverse group of aquatic animals living in both marine and freshwater habitats. These are soft bodied animals without segmentation. The body is divided into **head**, **muscular foot** and **visceral mass**. The body is covered by a **mantle** enclosed by an **outer shell**. Respiration is carried through **gills (ctenidia)** or **lungs** or both. The most common larva is **trochophore**, and **veliger larva**.

Garden Snail

The Octopus is incredibly intelligent

It is the only invertebrate that is capable of emotion, empathy, cognitive function, self awareness, personality and even relationships with humans. Some speculate that without humans, octopus would eventually take our place as the dominate life form on earth.

The Giant squid

It has a donut-shaped brain that encircles the oesophagus.

More to Know

Pearl Culture

Pearl is synthesised by Pearl oyster. It is precious and used in jewellery making.

7.11 Phylum Echinodermata - (Spiny Skinned Animals)

They are exclusively marine organisms and the adults are radially symmetrical, but the larvae remain bilaterally symmetrical. They have an exoskeleton with **calcareous ossicles**, presence of external spines called **Pedicellaria**. The mouth is on the lower surface. **Water vascular system** is a unique feature of these animals. **Tube feet** is involved in locomotion. The most common larva is a **bipinnaria larva.**

Star Fish

Sea Urchin

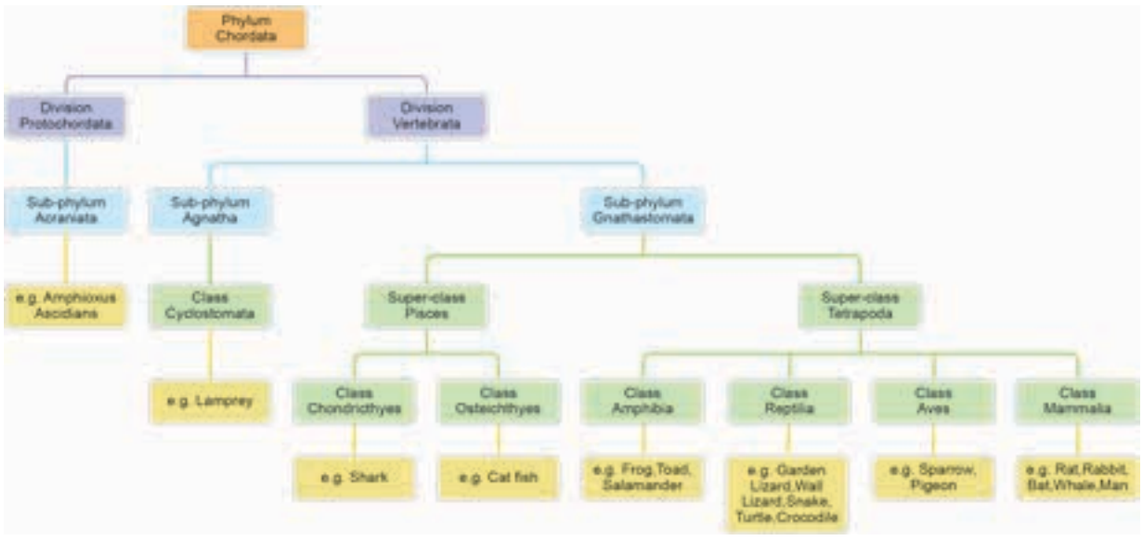
Sea Lily

More to Know

Ornamental Echinoderms

Dried star fish and sea urchin are used as decorative items.

Sea Cucumber is a costly dish served in foreign countries.



Activity 4

Go on a field trip, record what you observe.

Activity 5

Prepare a report on diseases spread through pet animals.

7.12 Phylum Chordata

This phylum derives its name from one of the common characteristics of this group namely the **notochord** (Gr. *Noton* - back + L. *chorda* - cord). The animals belonging to all other phyla of the Animal Kingdom are often termed 'as non -chordates' or 'invertebrates' since they neither have notochord nor backbone in their body. The animals with backbones are chordates. Chordates are of primary interest because human beings are members of this group.

7.12.1 Sub-phylum Acraniata - Prochordata

The Prochordates are considered as the forerunner of vertebrata. Since they do not have a cranium or skull they are referred to as **Acrania**. The classification of the Prochordates is based on the nature of the notochord. The Phylum Prochordata is classified into three sub phyla namely Hemichordata, Cephalochordata and Urochordata.

7.12.2 Sub phylum Hemichordata

Hemichordates are marine organisms without backbone. They mostly remain as **tubiculous forms**. The body is soft, vermiform, unsegmented, bilaterally symmetrical and triploblastic. The **notochord is persistent as the stomochord in the anterior region** of the animal. Eg. Balanoglossus (Acon worms)

7.12.3 Sub phylum Cephalochordata

Cephalochordates are small fish like marine chordates with unpaired dorsal fins. The persistent **notochord extends forward beyond the brain**. Eg. Amphioxus.

7.12.4 Sub phylum Urochordata

In Urochordata the **notochord** is **confined to the tail region** of the larva. The adults are mostly degenerate, and are sessile forms. The body is enveloped by a tunic or test. Eg. Asicidian

Balanoglossus (Hemichordate)

Amphioxus (Cephalochordate)

Ascidian (Urochordate)

7.13 Division Vertebrata (Craniata)

This group is characterized by the presence of **brain case** or **cranium** and **vertebral column**. The notochord is an embryonic structure gets replaced by a **vertebral column** which forms the chief skeletal axis of the body. They have ventral muscular heart with two, three or four chambers. The **locomotor** organs may be fins or limbs. Excretion and osmoregulation are carried out by a pair of kidneys. They exhibit sexual dimorphism.

7.13.1 Super Class: Pisces (Fishes)

Fishes are **poikilothermic**, aquatic vertebrates with jaws. The body is streamlined. It is differentiated into head, trunk and tail. Locomotion is by **paired** and **median fins.** The body has a covering of **scales**. Body muscles are arranged into segments called **myotomes**. Respiration is performed by **gills**. Gill slits are 5-7 pairs. They are covered by an **operculum**. The heart is **two chambered** with an auricle and a ventricle. **Lateral line sense organs** are well developed.

Info bits

The cosmopolitan sailfish can swim faster than a cheetah can run! It can swim at least 109 kilometres (68 miles) per hour, while a cheetah can only manage 100 kilometres (62 miles) per hour.

More to Know

The smallest vertebrate, **Philippine goby/dwarf pygmy goby is a tropical** species fish found in brackish water and mangrove areas in south East Asia, measuring only 10 mm in length.

The gigantic **Blue whale** which is 35 meters long and 120 tons in weight is the biggest vertebrate animal.

- Have you seen an aquarium anywhere?
- Are you interested in maintaining an aquarium at home?

More to Know

Blue Revolution

The term blue revolution refers to remarkable emergence of aquaculture through fish and prawn production. Culturing of aquatic organisms is referred to as **Aquaculture.**

Flying fish: *Exocoetus*

7.14 Super Class Tetrapoda

Animals having four limbs or descended from four-limbed ancestors.

7.14.1 Class: Amphibia

The transition from aquatic to terrestrial living is clearly indicated in the Class Amphibia. They are the first vertebrates to live on land with **dual adaptation** to live in aquatic and land environments. This **double life** is expressed as **amphibious**. The body is divisible into head and trunk. In frogs, hind limbs have **webbed feet**. The skin is moist and glandular usually without scales. Respiration is effected by **gills, skin, bucco-pharynx** and **lungs**. The heart is **three chambered** with **two auricles** and **a single ventricle**. Sexes are separate. Fertilization is mostly external and the larva is a tadpole which metamorphoses into an adult.

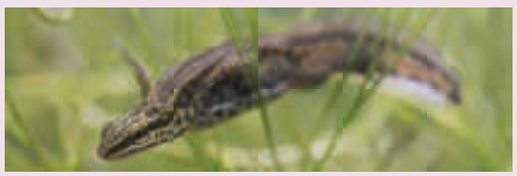
Tadpole - larva of frog

A boy was playing in the ground enjoying the shower of rain. Suddenly he was surprised to see an organism which was jumping like frog. He tried to catch with his hand, at once he was instructed by his mother not to touch as it is poisonous. Is it a toad? Is it not a frog?

DO YOU KNOW?

The Chinese giant salamander *Andrias davidians* is the largest amphibian in the world. Its length is about five feet and eleven inches. It weighs about 65 kg, found in Central and South China.

The arrow poison frog, *Triturus helveticus* found in Cuba, is the smallest amphibian in the world. Its length varies from 8.5 – 12.5 mm.



7.14.2 Class: Reptilia

Reptilia represents the first class of vertebrates that is fully adapted for life on dry land. It is covered with an exoskeleton of horny imbricate **epidermal scales**. Skin glands are absent. Respiration is through **lungs**. The heart is **three chambered** with an exemption of **crocodiles** with **four chambered**. Sexes are separate. Fertilization is internal. Eggs are covered with an outer **shell**.

Have you seen wall lizard at home or in a common place?

Often it is found stuck to the wall. What enables it to do so?.

Info bits

Dimetrodon was a mammal like reptile with a snail like structure on its back. This acted as a radiator to cool the body of the animal.

Can you imagine the size of Dinosaur and Home lizard which belong to the same class? Do you find both of them around us now? Give reasons. Which age is known as Golden age of reptiles?

7.14.3 Class: Aves

Birds (Aves) are the first **homeothermic** vertebrates with spindle shaped body which is divisible into four distinct regions namely head, neck, trunk and tail. They have two pairs of limbs, in that forelimbs are modified as **wings**. The hind limbs are adapted for walking and running. The **feet** are covered with **scales,** while the body is covered with feathers. A horny **beak** is present. Alimentary canal is provided with **crop** and **gizzard**. Respiration is through **spongy lungs**. **Air sacs** are present to make the bird light weight. The bones are filled with air, so they are called **pneumatic bones**. Their eggs are **yolk laden** and covered by hard **calcareous shell**.

Activity 6

- Often you wake up hearing the calls of birds. Have you even tried to identify the birds from their voices?
- Make a list of birds you often observe near your home or school?

Info bits

Archaeopteryx was the first bird. It was covered with feathers, but it had teeth, not a beak.

DO YOU KNOW?

State bird of Tamil Nadu

Common Emerald dove.
(*Chalcophaps indica*)

TYPES OF BEAK IN BIRDS

DO YOU KNOW?

The bird with largest wing span

Length of wing span of Albatross is 3.5 m. Which bird flies at the highest altitude?

Have you observed different shapes of bird's beak? Do you know the purpose of this modification?

DO YOU KNOW?

American golden plover, *Pluvialis dominica*, covers long distance during migration, breeding in Alaska and Arctic. It flies to South America in autumn and then reaches New Zealand. It takes more than six months to cover 24,000 – 27,000 km.

7.14.4 Class: Mammalia

This is a successful group of animals called mammals that adapt themselves readily to new situations and to new food habits. The integument is provided with **epidermal hairs, sweat**, **sebaceous** and **scent glands**. **Mammary glands** are the modified integumentary glands. The external ear or the **pinna** is present in most of the mammals. The heart is **four chambered**. **Testes** lie outside the body cavity, enclosed in **scrotal sacs**. Eggs are small with little or no yolk. Fertilization is always internal. They give birth to young ones and feed their young with milk. **Placenta** is a characteristic feature.

Info bits

A mole can dig a tunnel 300 feet long in just one night.

Can you identify these mammals? Do you see them near your home? If you wish to see many of them which place will you visit?

Info bits

Flying fox - The largest bat is the flying fox. Some are found on the island of Java and have a wing span of 1.7 m with a length of upto 42 cm. The smallest bat lives in Thailand. It weighs just 2 grams and is no longer than 3.3 cm

Activity 7

Make a list of animals having flight adaptations in major classes of invertebrates and vertebrates. Compare their adaptations and classify them and comment.

7.15 Binomial Names of Common Animals

As we find it difficult in identifying the required organism with their local names, we need a common name to be followed universally. To overcome this problem Carolus Linnaeus introduced the method of naming the animals with two names known as binomial names. The first name is called **genus** which is always written with the first letter capital and the second one is the **species** name always written in small letter. The binomial names of some of the common animals are as follows.

7.15.1 Invertebrates

Common name	Binomial name
Amoeba	*Amoeba proteus*
Hydra	*Hydra vulgaris*
Tape worm	*Taenia solium*
Round worm	*Ascaris lumbricoides*
Earthworm	*Lampito mauritii/Perionyx excavatus*
Leech	*Hirudinaria granulosa*
Cockroach	*Periplaneta americana*
Snail	*Pila globosa*
Star fish	*Asterias rubens*
Pearl oyster	*Pinctada fucata*

7.15.2 Vertebrates

Common name	Binomial name
Frog	*Rana hexadactyla*
Toad	*Bufo melanosticus*
Wall lizard	*Podarcis muralis*
Crow	*Corvus splendens*
Peacock	*Pavo cristatus*
Dog	*Canis familiaris*
Cat	*Felis felis*
Tiger	*Panthera tigris*
Man	*Homo sapiens*

A-Z GLOSSARY

1. **Amphibian** cold-blooded vertebrate animal of a class that comprises the frogs, toads, newts, salamanders and caecilians. They are distinguished by having an aquatic gill-breathing larval stage followed (typically) by a terrestrial lung-breathing adult stage.
2. **Annelida** a large phylum that comprises the segmented worms which include earthworms and leeches.
3. **Arthropods** Phylum Arthropoda; include the members of the Class Crustacea (prawn, shrimp, crabs), Arachnida (spiders, ticks, mites, scorpions) and Insecta (e.g., mosquitoes, flies, lice, fleas).
4. **Aves** a class of vertebrates which comprises the birds.
5. **Classification** is the arrangement of groups of animals, the members of which have one or more characteristics in common.
6. **Chordata** a large phylum of animals that includes the prochordates and vertebrates. They are distinguished by the possession of a notochord at some stage during their development.
7. **Coelom** body cavity located between the digestive tract and the body wall.
8. **Coelenterata** an aquatic invertebrate animal of a phylum that includes jellyfishes, corals, and sea anemones. They typically have a tube- or cup-shaped body with a single opening ringed with tentacles that bear stinging cells (nematocysts).
9. **Echinodermata** a phylum of marine invertebrates which includes starfishes, sea urchins, brittle stars, crinoids and sea cucumbers. They have five fold radial symmetry, a calcareous skeleton, and tube feet operated by fluid pressure.
10. **Invertebrates** animals lacking a vertebral column.
11. **Mammals** Warm-blooded vertebrate animals that possess hairs, mammary glands and feed their young ones.
12. **Mollusca** an invertebrate of a large phylum which includes snails, slugs, mussels and octopus. They have a soft unsegmented body and live in aquatic or damp habitats and most kinds have an external calcareous shell.
13. **Nematoda** a large phylum of worms with slender, unsegmented, cylindrical bodies, including the roundworms, threadworms and pinworms. They are found abundantly in soil and water, and many are parasites.
14. **Platyhelminthes** a phylum of invertebrates that comprises the flatworms.
15. **Porifera** a phylum of aquatic invertebrate animals that comprises the sponges.
16. **Protozoa** includes diverse minute acellular or unicellular organisms usually non photosynthetic.
17. **Pseudocoleomates** false body cavity it has a fluid filled body cavity which is not bounded by true epithelial layers
18. **Reptile** a vertebrate animal of a class that includes snakes, lizards, crocodiles, turtles, and tortoises. They are distinguished by having a dry scaly skin and typically laying soft-shelled eggs on land.
19. **Taxonomy** it is the theoretical study of classification including its basic principles, procedures and rules
20. **Toads** anurans with less smooth skin than that of frogs, exclusively terrestrial and hop rather than jump.

EXERCISE

EXTFUJ

I. Choose the correct answer

1. Which is not an insect?

(a) House fly (b) Bedbug

(c) Mosquito (d) Spider

2. Find the group having only marine members

(a) Mollusca

(b) Porifera

(c) Coelenterata

(d) Echinodermata

3. Mesoglea is present in

(a) Porifera

(b) Coelenterata

(c) Annelida

(d) Arthropoda

4. Dysentery is caused by

(a) Entamoeba (b) Euglena

(c) Plasmodium (d) Paramecium

5. Which one of the following pairs is not a poikilothermic animal

(a) Fishes and Amphibians

(b) Amphibians and Aves

(c) Aves and Mammals

(d) Reptiles and mammals

6. Identify the animal having four chambered heart

(a) Lizard (b) Snake

(c) Crocodile (d) Calotes

7. Which is not a feature of chordates

(a) Green glands

(b) Sweat glands

(c) Sebaceous gland

(d) Mammary gland

8. The bilaterally symmetrical larvae which transform into radially symmetrical adult is

(a) Bipinnaria (b) Trochophore

(c) Tadpole (d) Polyp

9. The animal without skull is

(a) Acrania (b) Acephalia

(c) Apteria (d) Acoelomate

10. Choose the correct terms related for Hemichordate

(a) Vermiform, unsegmented, triploblastic, ciliary feeders

(b) Vermiform, segmented, triploblastic, ciliary feeders

(c) Vermiform, unsegmented, diploblastic, ciliary feeders

(d) Vermiform, unsegmented, triploblastic, filter feeders

11. Hermaphrodite organisms are

(a) Hydra, Tape worm, Earthworm, Amphioxus

(b) Hydra, Tape worm, Earthworm, Ascidian

(c) Hydra, Tape worm, Earthworm, Balanoglossus

(d) Hydra, Tape worm, Ascaris, Earthworm

12. Poikilothermic organisms are

(a) Fish, Frog, lizard, man

(b) Fish, Frog, lizard, cow

(c) Fish, Frog, lizard, snake

(d) Fish, Frog, lizard, crow

13. Crop, gizzard and air sacs are seen in

(a) Fish (b) Frog

(c) Bird (d) Bat

14. Excretory organ of tape worm is
    (a) Flame cells (b) Nephridia
    (c) Body surface (d) Solenocytes
15. Tube like alimentary canal is found in
    (a) Hydra (b) Earth worm
    (c) Starfish (d) Ascaris
16. During ecdysis which of the following is shed off
    (a) Chitin (b) Mantle
    (c) Scales (d) Operculum
17. Cephalization is related to
    (a) Head formation
    (b) Gut formation
    (c) Coelom formation
    (d) Gonad formation

II. Fill in the blanks

1. The excretory opening of Porifera is _____
2. The second largest phylum of animal kingdom is _____
3. In India National deworming day is observed on _____
4. Myotomes are seen in _____
5. The larvae of an amphibian is _____
6. In birds the air sacs communicate with _____
7. Placenta is the unique characteristic feature of _____
8. The binomial name of our National Bird is _____
9. Blue revolution is the rearing of _____
10. In mammals testis are enclosed by _____

III. State whether true or false

1. Canal system is seen in coelenterates.
2. Hermaphrodite animals have both male and female sex organs.
3. Nephridia are the respiratory organ of Annelida.
4. Bipinnaria is the larva of Mollusca.
5. Balanoglossus is a ciliary feeder.
6. Fishes have two chambered heart.
7. Skin of reptilians are smooth and moist
8. Wings of birds are the modified forelimbs
9. Female mammals have scrotal sacs
10. Cloaca is present in all vertebrates

IV. Match the following

PHYLUM	EXAMPLES
(A) Coelenterata	(i) Snail
(B) Platyhelminthes	(ii) Starfish
(C) Echinodermata	(iii) Tapeworm
(D) Mollusca	(iv) Hydra

V. Understand the assertion statement. Justify the reason given and choose the correct choice

1. **Assertion:** The hydra is a diploblastic organism
   Reason: They have two germ layers
   (a) Assertion is correct and the reason is wrong
   (b) Reason is correct and the Assertion is wrong
   (c) Both assertion and reason is correct
   (d) Both assertion and reason is wrong

2. Assertion :The prochordate are grouped under Acrania

   Reason: They have well defined cranium

   a) Assertion is correct and the reason is wrong

   b) Reason is correct and the assertion is wrong

   c) Both assertion and reason is correct

   d) Both assertion and reason is wrong

VI. Give very short answers

1. Define taxonomy?
2. What is a nematocyst?
3. Why coelenterates are called diploblastic animals?
4. Which organism is called as Friend of farmers? Why?
5. List the respiratory organs of amphibians
6. Differentiate between tube feet and false feet
7. Are Jelly fish and star fish similar to catfish? Give reasons
8. What is acrania?
9. What are the sub-phylum of prochordates?
10. Why are frogs said to be amphibians?
11. What is silver revolution?

VII. Give short answers

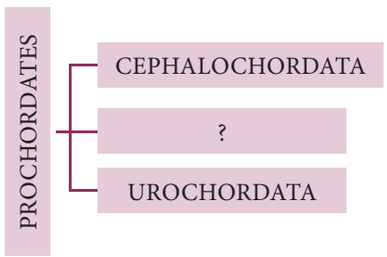
1. Give an account on phylum Annelida
2. List the excretory organs of invertebrates in relation to their habitats.
3. How is the body wall of coelenterates arranged?
4. Differentiate between flat worms and round worms?
5. Outline the flow charts of Phylum Chordata
6. List five characteristic features of fishes
7. Comment on the aquatic and terrestrial habits of amphibians
8. How is the reproductive characters of mammals different from those of Aves
9. On the basis of Position of notochord, classify the different Prochordates. Justify your answer
10. How are the limbs of the birds adapted for avian life?
11. List the integumentary glands of mammals

VIII. Give long answers

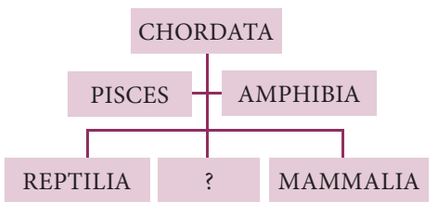
1. Describe the characteristic features of different Prochordates with suitable diagrams
2. Outline the flow chart of invertebrate phyla
3. List the excretory organs of invertebrates in relation with the animals
4. Give an account on phylum Arthropoda.

IX. Flow chart

1. Find the missing group



2. Find the missing group



3. Find the correct sequence

(a) Frog → Fish → Snake → Dove → Lion

(b) Fish → Snake → Frog → Lion → Dove

(c) Fish → Snake → Frog → Lion → Crow

(d) Fish → Frog → Snake → Dove → Lion

4. Visit to the near by garden of your school and give the answers for the following questions

(1) List out the arthropods you have observed and give their binomial names

(2) What are the harmful animals you have observed?

(3) Have you seen eggs of any animals? If yes, mention the name of its adult

(4) Name the birds that you could identify

5. Visit to a pond ecosystem and collect the names of animals observed. Give answer for the following questions.

- Prepare a list of aquatic and terrestrial animals found in the pond
- Arrange them under respective taxonomical group and submit your answer

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INTERNET RESOURCES

http://home.pcisys.net/~dlblanc/taxonomy.html

http://www.utm.edu/~riwin/b120lab.htm

http://can-do.com/uci/lessons 98/Invertebrates.html

http://www.student.loretto.org/zoology/chordates.htm

UNIT 8

Health and Hygiene-Food for Living

Learning Objectives

EY3BH7

This unit will help the students to

- understand the classification of nutrients
- gain knowledge on the intake of balanced diet and the significance of food
- list the common deficiency disorders, their causes, symptoms and recommended food sources
- gain knowledge about different methods of food preservation
- identify the adulterants in food
- explain the role of different food quality certifying agents of our country
- analyze the classes of food
- evaluate the importance of a balanced diet
- put into practice the healthy habit of eating

Introduction

Food is the basic necessity of life. Food is defined as "any substance (of either plant or animal origin) consumed to provide nutritional support for an organism". It contains essential nutrients like carbohydrates, proteins, fats, vitamins and minerals that help for normal growth, provide energy, repairs the worn out tissues and protects us from diseases. The term nutrients refers to the compounds which give us energy, and act as building blocks for tissues and protect us from diseases.

8.1 Classes of Nutrients

Nutrients are classified into six major groups as follows

- Carbohydrates
- Proteins
- Fats
- Vitamins
- Minerals
- Water

8.1.1 Carbohydrates

Carbohydrates are organic compounds composed of carbon, hydrogen, and oxygen in a ratio of 1:2:1. Carbohydrates are the chief source of energy. Edible sugar, starch, cellulose

More to Know

The major dietary carbohydrates

Class of carbohydrates	Components
Monosaccharides	Glucose, fructose, galactose
Disaccharides	Sucrose, lactose, maltose
Polysaccharides	Amylose, amylopectin, starch
	cellulose, hemicellulose, glycogen

are few examples for carbohydrates. Glucose is a monosaccharide, edible sugar is a disaccharide and cellulose in vegetables is a polysaccharide.

Sucrose is found in honey, sugarcane and fruits. Starch is found in rice, potatoes and bread. Glycogen is stored in our liver and muscles. Plant cell wall is made up of cellulose and other complex organic compounds.

8.1.2 Proteins

Proteins are essential nutrients for the human body. They are one of the building blocks of body tissue, and can also serve as a fuel source. As a fuel, proteins provide maximum energy than carbohydrates which provide 4 kcal (17 kJ) per gram and lipids which provide 9 kcal (37 kJ) per gram. The most important aspect and defining characteristic of protein from a nutritional standpoint is its amino acid composition.

Proteins are polypeptide chains made of amino acids linked together by peptide bonds. During the process of digestion, proteins are broken down in the stomach and small intestine to smaller polypeptide by action of proteases. This is crucial for the absorption of the essential amino acids that cannot be biosynthesized by the body.

There are nine essential amino acids (EAA) which humans must obtain from their diet in order to prevent protein-energy malnutrition. They are phenylalanine, valine, threonine, tryptophan, methionine, leucine, isoleucine, lysine and histidine.

8.1.3 Fats

Fats also known as triglycerides which are esters of free fatty acid chains and glycerol. Fat is an important foodstuff for many forms of life and serve in both structural and metabolic functions. They are a necessary part of the diet of most heterotrophs (including humans). Lipases are enzymes involved in the break down of fats in the small intestine during the process of digestion .

Essential fatty acids cannot be synthesized in the body and provided through diet. There are two essential fatty acids (EFAs) in human nutrition: alpha-linolenic acid (omega-3 fatty acid) and linoleic acid (omega-6 fatty acid).

8.1.4 Vitamins

Vitamins are vital nutrients, required in minute amounts to perform special functions to maintain a healthy body. An organic chemical compound (or related set of compounds) is called a vitamin when the organism cannot synthesize the compound in sufficient quantities, and it must be obtained through the diet.

EYC7XU

Do you know?

Food source	Lysine (mg/gm protein)	Threonine (mg/gm protein)	Tryptophan (mg/gm protein)	Sulfur-containing amino acids (mg/gm protein)
Legumes	64	38	12	25
Cereals and whole grains	31	32	12	37
Nuts and seeds	45	36	17	46
Fruits	45	29	11	27
Animal	85	44	12	38
Protein source with highest density of respective amino acid.				
Protein source with lowest density of respective amino acid.				

8.1.5 Mineral nutrients

In the context of nutrition, a mineral is a chemical element required as an essential nutrient by organisms to perform various functions necessary for life. Minerals originate in the earth and cannot be made by living organisms. Minerals are very important to maintain the physiological processes in our body. They are the constituents of teeth, bones, tissues, blood, muscle and nerve cells.

More to Know

- Dr. Funk introduced the term vitamin. Vitamin A was given the first letter of the alphabet, as it was the first to be discovered.
- Vitamin D improves bone strength by helping body to absorb calcium.
- Iron from meat (heme iron) and plant sources (non-heme iron) are absorbed by the body differentially. While the iron in meat protein is readily absorbed, non-heme iron requires Vitamin C for absorption.

How Vitamin D is synthesized by our skin?

Human skin can synthesize Vitamin D when exposed to sunlight (especially early morning). When the sun rays falls on the skin dehydro cholesterol is converted into Vitamin D. Hence, Vitamin D is called as **"Sunshine vitamin"**

The five major minerals in the human body are calcium, phosphorus, potassium, sodium and magnesium. All of the remaining elements in the human body are called "trace elements", such as sulfur, iron, chlorine, cobalt, copper, zinc, manganese, molybdenum, iodine and selenium.

8.1.6 Water

Water is vital as a solvent in which many of the body's solutes dissolve and also an essential part of many metabolic processes within the body. Metabolism include two process namely anabolism and catabolism. In anabolism, water is removed from molecules (through energy requiring

Vitamins, their sources, deficiency disorders and symptoms

Vitamins	Sources	Deficiency disorders	Symptoms
		Fat soluble vitamins	
Vitamin A (Retinol)	Carrot, papaya, leafy vegetables, fish liver oil, egg yolk, liver, dairy products	Xerophthalmia Nyctalopia (Night blindness)	Dryness of Cornea Unable to see in the night (dim light) Scaly skin
Vitamin D (Calciferol)	Egg, liver, dairy products, Fish, synthesized by the skin in sunlight	Rickets (in children)	Bow legs, defective ribs, development of pigeon chest
Vitamin E (Tocopherol)	Whole wheat, meat, vegetable oil, milk	Sterility in rats, Reproductive abnormalities	Sterility
Vitamin K (Derivative of Quinone)	Leafy vegetables, soyabeans, milk	Blood clotting is prevented	Excessive bleeding due to delayed blood clotting
		Water soluble vitamins	
Vitamin B1 (Thiamine)	Whole grains, yeast, eggs, liver, sprouted pulses	Beriberi	Degenerative changes in the nerves, muscles become weak, paralysis
Vitamin B2 (Riboflavin)	Milk, eggs, liver, green vegetables, whole grains	Ariboflavinosis (Cheilosis)	Irritation in eyes, dry skin, inflammation of lips, fissures in the corners of the mouth
Vitamin B3 (Niacin)	Milk, eggs, liver, lean meat, ground nuts, bran	Pellagra	Inflammation of skin, loss of memory, diarrhoea
Vitamin B6 (Pyridoxine)	Meat, fish, eggs, germs of grains and cereals, rice, polishings	Dermatitis	Scaly skin, nerve disorders
Vitamin B12 (Cyanocobalamine)	Milk, meat, liver, pulses, cereals, fish	Pernicious anaemia	Decrease in red blood cell production, degeneration of spinal cord
Vitamin C (Ascorbic acid)	Leafy vegetables, sprouts, citrus fruits like goose berry (Amala), lemon, orange	Scurvy	Swollen and bleeding gums, delay in healing of wounds, Teeth and bones malformed

enzymatic chemical reactions) in order to synthesize larger molecules (e.g. starch, triglycerides and proteins). In catabolism, water is used to break bonds in order to generate smaller molecules (e.g. glucose, fatty acids and amino acids to be used as fuels for energy use or other purposes). Without water, these particular metabolic processes could not exist.

8.2 A Case Study

Rani, of class IX, fainted during the morning assembly. When the teacher enquired, she replied that she had skipped her breakfast. It was also found that she has a regular habit of skipping breakfast in spite of her mother's advice.

Think

- Do you think by skipping your breakfast, you can concentrate on your studies?

Discuss in classroom: What are the health implications of skipping meals?

Do you know what happens when your diet lacks any of these essential nutrients?

Absence of certain nutrients in our daily diet over a long period of time leads to deficiency diseases. This condition is referred to as Malnutrition.

Let us study some common deficiency diseases

8.3 Protein Energy Malnutrition (PEM)

Protein is essential for growth and repair of body cells and tissues. Deficiency of proteins leads to weakness but its severe conditions causes diseases like:

1. Kwashiorkar
2. Marasmus

Kwashiorkar

It is a condition of severe protein deficiency. It affects children between 1-5 years of age, whose diet mainly consists of carbohydrates but poor in proteins.

Marasmus

It usually affects infants below the age of one year when the diet is poor in carbohydrates, fats and proteins. Look at the pictures of these children in picture 1 and 3. What differences can you observe in terms of growth, weight and appearance when compared to healthy children in picture 2?

Kwashiorkar condition

Healthy Children

Marasmus condition

Recommended nutritional requirements for a child

Nutrients	Daily requirements (grams)
Carbohydrates	150-200
Proteins	40
Lipids/fats	35

October 21st is declared as Global Iodine Deficiency Day.

Goitre:

It is a swelling of the region below the neck due to the enlargement of thyroid gland. It is caused due to iodine deficiency.

8.4 Minerals - Functions and Deficiency Diseases

Minerals, their sources, functions and deficiency diseases

Minerals	Sources	Functions	Diseases
		Macro nutrients	
Calcium	Dairy foods, beans, cabbage, eggs, fish	Constitution of bone, enamel of teeth, clotting of blood and controls muscle contraction	Bone deformities, poor skeletal growth, osteoporosis in adults.
Sodium	Table salt	maintains fluid balance and involved in neurotransmission	Muscular cramps, nerve impulses do not get transmitted.
Potassium	Banana, sweet potato, nuts, whole grains, citrus fruits	Regulates nerve and muscle activity	Muscular fatigue, nerve impulses do not get transmitted.
		Micro nutrients	
Iron	Spinach, dates, greens, broccoli, whole cereals, nuts, fish, liver	Important component of haemoglobin	Anaemia
Iodine	Milk, Seafood, Table salt	Formation of thyroid hormones	Goitre

8.5 Vitaminosis

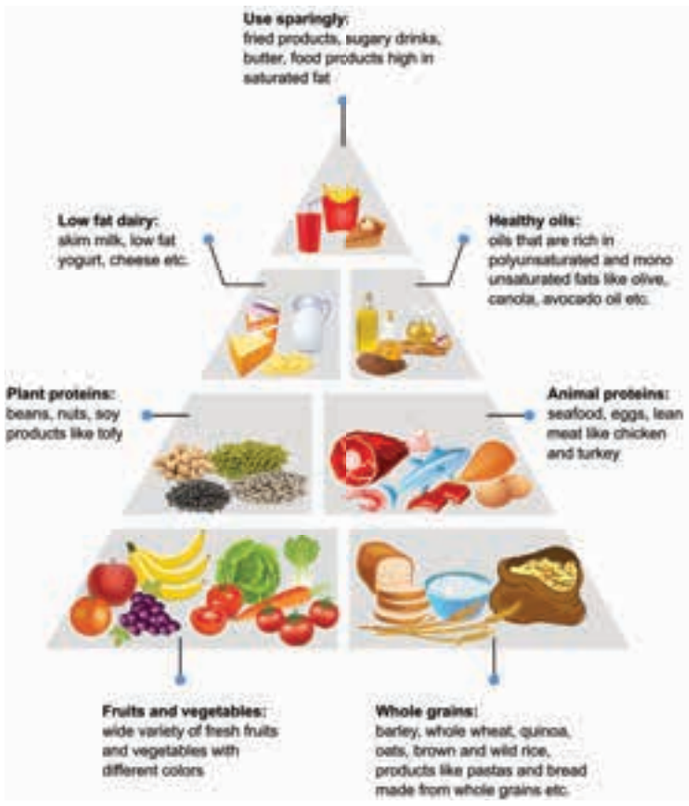
Any disease caused by the presence of excess of vitamin is called as **Vitaminosis**. **Hyper vitaminosis** is a condition of abnormally high storage of vitamins which can lead to toxic symptoms. **For Example:** An excess of Vitamin A is called Hyper Vitaminosis A.

How to overcome these deficiency diseases?

A diet containing essential nutrients in right proportion (**balanced diet**) is required for normal growth and development and to prevent malnutrition.

Food Pyramid

The food pyramid acts as a nutrition guide to select the types and proportion of food for good health. The food items at the top of the pyramid such as fat, and oil should be consumed in less quantity when compared to the food items at the bottom of the pyramid.



Activity 1

Prepare a balanced diet chart for a day to meet your nutritional requirements.

a. Breakfast _____
b. Midmorning _____
c. Lunch _____
d. Snacks _____
e. Dinner _____

Visit your kitchen. With the help of your mother note down the food items that are kept in dry condition and food items that are stored in fresh condition.

Observe and discuss

Keep a tomato and a potato at room temperature for a week.

1. What do you observe?

   Tomato showing signs of spoilage while potato remains unchanged

2. Can you guess why?

   The moisture content in tomato promotes the growth of microorganisms which start decaying it.

3. What do you infer from this?

   Every food has a different shelf life. The shelf life of potato is longer than that of tomato at room temperature.

Food spoilage

Food spoilage is an undesirable change in the food's normal state and is not suitable for human consumption. Signs of food spoilage may include a change in appearance, colour, texture, odour and taste.

Factors responsible for Food Spoilage:

Food gets spoiled due to two reasons

- Internal factors (spoilage from within)
- External factors (spoilage from outside)

Internal factors which include enzymatic activities and moisture content of the food.

External factors like adulterants in food, contaminated utensils and equipment, unhygienic cooking area, lack of storage facilities and poor personal hygiene may allow pathogenic microorganisms to cause food spoilage.

How to avoid food from being spoiled?

Food Preservation is the process of prevention from decay or spoilage of food, by storing in a condition fit for future use. Food is preserved to

- increase the shelf life of food
- retain the colour, texture, flavour and nutritive value
- increase food supply
- decrease wastage of food
- add variety to the food

8.6 Methods of Food Preservation

8.6.1 Dehydration/Drying

Drying or dehydration is the process of removal of water/moisture content in the food. It can be done either by sun-drying, (e.g. cereals, fish) or vacuum drying (e.g. milk powder, cheese powder) or hot air drying (e.g. grapes, dry fruits, potato flakes). Drying inhibits the growth of microorganism such as bacteria, yeasts and moulds.

Dried neem leaves, turmeric are used to store food grains in our home to protect the grains from insects and beetles.

8.6.2 Smoking

In this process, food products like meat and fish are exposed to smoke. The drying action of the smoke tends to preserve the food.

8.6.3 Irradiation

Food irradiation is the process of exposing food to optimum levels of ionizing

Why do dry grapes (raisins) not spoil at room temperature when fresh grape does?

radiations like x-rays, gamma rays or UV rays to kill harmful bacteria and pests and to preserve its freshness. This process is sometimes called 'cold pasteurization' as the product is not heated. Irradiation does not destroy the taste or nutritive value of food. The shelf life of onions and potatoes increases when exposed to radiation.

8.6.4 Use of inert gas

Nitrogen gas is filled in air-tight packets of potato wafers and other food products thus preventing the growth of fungus and insects in them.

8.6.5 Cold storage

The process of storing the perishable foods such as vegetables, fruits and fruit products, milk and milk products etc. at low temperature in a refrigerator is called cold storage. Preserving the food at low temperature slows down the biological and chemical reactions in food products and prevents its spoilage.

8.6.6 Freezing

Freezing is one of the widely used methods of food preservation. This process involves storing the food below 0^0C at which microorganisms cannot grow, chemical reactions are reduced and metabolic reactions are also delayed.

Bananas are not kept in refrigerator why?

Bananas are best stored at room temperature. When it is kept in a refrigerator, the enzyme responsible for ripening becomes inactive. In addition, the enzyme responsible for browning and cell damage becomes more active thereby causing the skin colour change from yellow to dark brown.

Deep freezing is a method of food preservation where the food materials are kept inside a cold room in a temperature range of -23^0C to -30^0C. Seeds are preserved at sub - zero temperature.

8.6.7 Pasteurization

Pasteurization is a process of food preservation, which is named after the scientist Louis Pasteur. This process involves boiling of milk to a temperature of 63°C for about 30 minutes and suddenly cooling to destroy the microbes present in the milk. Pasteurisation helps in avoiding spoilage of milk.

Simple representation of the process of pasteurisation of milk

Know your scientist

Louis Pasteur (1822 – 1895)

French chemist and microbiologist, was the founder of microbiology. He discovered that microorganisms cause fermentation and diseases. He invented the process of pasteurisation and developed vaccination against rabies and anthrax.

DO YOU KNOW?

Methylene Dye Reduction Test - It is widely used in milk processing units to assess the microbial quality of raw and pasteurised milk. The quality of the milk is considered superior or inferior based on the time taken by the milk to decolourize after the addition of Methylene blue dye solution to it. Sooner the decolourization, more inferior is the bacteriological quality of milk and requires further processing.

8.6.8 Canning

In this method of food preservation, most vegetables, fruits, meat and dairy products, fruit juices and some ready-to-eat foods are processed and stored in a clean, steamed air tight containers under pressure and then sealed. It is then subjected to high temperature and cooled to destroy all microbes.

More to Know

- Operation Flood, launched in 1970 by National Dairy Development Board, started the White Revolution in India and transformed our country from a milk deficient nation into the World's largest producer of milk and milk products. Dr. Verges Kurien, the founder of "Anand Milk Union Limited"(AMUL) was the brain behind the success of the programme.

8.6.9 Addition of preservatives

Food can be preserved by adding natural and synthetic preservatives.

A) Natural preservatives

Some naturally available materials like salt, sugar and oil are used as food preservatives.

1. **Addition of salt**: It is one of the oldest methods of preserving food. Addition of salt removes the moisture content in the food by the process of osmosis.

This prevents the growth of bacteria and reduces the activity of microbial enzymes. Meat, fish, gooseberry, lemon and raw mangoes are preserved by salting. Salt is also used as a preservative in pickles, canned foods etc.

2. **Addition of sugar**: Sugar/Honey is added as a preservative to increase the shelf life of fruits and fruit products like jams, jellies, squash, etc. The hygroscopic nature of sugar/ honey helps in reducing the water content of food and also minimizing the process of oxidation in fruits.
3. **Addition of oil**: Addition of oil in pickles prevents the contact of air with food. Hence microorganisms cannot grow and spoil the food.

DO YOU KNOW?

In addition to microbiological and chemical contamination, preservatives like excess salt, sugar and oil also make food unsafe for consumption and are linked with non-communicable diseases such as diabetes, obesity and heart diseases.

Think

- Why is a layer of oil seen above the vegetables in pickles?

B. Synthetic preservatives

Synthetic food preservatives like sodium benzoate, citric acid, vinegar, sodium meta bisulphate and potassium bisulphate are added to food products like sauces, jams, jellies, packed foods and ready- to-eat foods. These preservatives delay the microbial growth and keep the food safe for long duration.

Activity 2

Bring food items like rice, black gram, milk packet, dry fish, pickle, apple, tomato, brinjal, jam, dry grapes and sprouted grains. Now classify and display these food items separately based on their storage methods.

S.no	Cold storage	Dry storage	Preserva-tives	Pasteuri-sation

More to Know

- October 16th is World Food Day. It emphasizes on food safety and avoid food wastage.

8.7 Adulteration

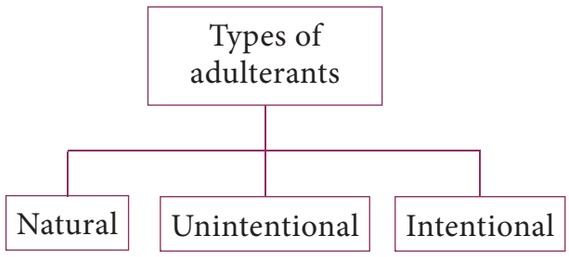
Observe the picture

What do you think the man in the picture is doing?

Food safety is becoming a major concern in these days. Food is contaminated or adulterated from production to consumption for financial gain or due to ignorance, carelessness and poor hygienic conditions during processing, storing and marketing. Adulteration is defined as "the addition or subtraction of any substance to or from food, so that the natural composition and the quality of food substance is affected."

Some of the common adulterated foods are milk and milk products, cereals, pulses, coffee powder, tea powder, turmeric powder, saffron, confectionary, non-alcoholic beverages, spices, edible oils, meat, poultry products etc. The adulterants in food can be classified in three categories based on whether they occur naturally in food, or added intentionally or unintentionally.

Types of adulterants



1. Natural adulterants

Natural adulterants are those chemicals, organic compounds or radicals that are naturally present in food. They include,

a. Naturally occurring toxic substances in certain poisonous mushrooms, Prussic acid in seeds of apples, cherry and peach pits, marine toxins, fish oil poisoning etc.,

b. Environmental contaminants like pollutants in air, water and land.

2. Incidental/ unintentionally added adulterants

These types of adulterants are added unknowingly due to ignorance or carelessness during food handling and packaging. It includes

a. Pesticide residues

b. Droppings of rodents, insects, rodent bites and larva in food during its storage

c. Microbial contamination due to the presence of pathogens like *Escherichia coli*, *Salmonella* in fruits, vegetables, ready-to-eat meat and poultry products

3. Intentionally added adulterants

These adulterants are added intentionally for financial gain and have serious impact on the health of the consumers. These types of adulterants include:

a. Additives and preservatives like vinegar, citric acid, sodium bicarbonate (baking soda), hydrogen peroxide in milk, modified food starch, food flavours, synthetic preservatives and artificial sweeteners.

SOURCES OF FOOD CONTAMINATION

HOW TO DETECT FOOD ADULTERATION?

BANANAS
ADULTERANT
Calcium carbide (CaC), to ripen the fruit

HOW TO DETECT
If the stem of banana appears green, instead of a shiny yellow, it has probably been ripened by CaC

HEALTH EFFECTS
Carcinogenic, can harm digestive system and liver

APPLES
ADULTERANT
Wax coating

HOW TO DETECT
The apple will appear very glossy and shiny. It could have slight scratches and you may notice a thin layer peeling off, which is the wax

HEALTH EFFECTS
Can harm the digestive system. Can also lead to ulcers and gastric problems

MANGOES
ADULTERANT
CaC, to ripen the fruit

HOW TO DETECT
If the colour of the mango is uniform, or if you find dark green patches around the mangoes on the surface where they are kept

HEALTH EFFECTS
Can lead to headache, dizziness, nausea and neurological problems.

GREEN VEGETABLES
bitter gourd, green chilli
ADULTERANT:Malachite Green

HOW TO DETECT
Take a small portion and place it on moistened white blotting paper. The impression of colour on paper shows the use of adulterant.

HEALTH EFFECTS
Carcinogenic if consumed over a long period of time.

COMMON SALT
ADULTERANT
White chalk

HOW TO DETECT
Stir a small amount of salt in water. If there is chalk, the solution will turn white and other insoluble impurities will settle

HEALTH EFFECTS
May lead to gastric problems.

CHILI POWDER
ADULTERANT
Brick powder

HOW TO DETECT
Add a small amount of chilli powder in water. The brick powder will settle and the pure chilli powder will float

HEALTH EFFECTS
Can cause loss of vision, respiratory and digestive problems

TEA LEAVES
ADULTERANT
Coal tar dye

HOW TO DETECT
Scatter sample on moistened blotting paper. Appearance of colour spots after minutes shows presence of adulterant

HEALTH EFFECTS
Carcinogenic

ICE CREAM
ADULTERANT
Washing powder

HOW TO DETECT
Take a sample and add drops of limejuice. If froth or bubbles develop on the sample, then it shows presence of washing powder

HEALTH EFFECTS
Can cause severe stomach and liver disorders

b. Chemicals like calcium carbide to ripen bananas and mangoes.

c. Non certified food colours containing chemicals like metallic lead are used to give colours to vegetables like green leafy vegetables, bitter gourd, green peas etc. These colours are added to give a fresh look to the vegetables.

d. Edible synthetic wax like shellac or carnauba wax is coated on fruits like apple, pear to give a shining appearance.

e. Growth hormones, steroids and antibiotics are administered as adulterants to vegetables, cattle, sheep and poultry for faster growth and to increase milk production in dairy cows.

Follow-up activity

Look at the picture and discuss the answer

- How these apples are different in their appearance?
- Why is it so?
- Which one is safe for consumption?

Consumption of these adulterated foods may lead to serious health issues like fever, diarrhoea, nausea, vomiting, gastrointestinal disorders, asthma, allergy, neurological disorder, skin allergies, immune suppression, kidney and liver failure, colon cancer and even birth defects.

Fruit flies are more attracted towards fruits that are naturally ripened.

Difference between naturally ripened fruit and artificially ripened fruit

Properties	Naturally ripened fruit	Artificially ripened fruit
Colour	Attractive, but not uniformly coloured	Uniformly coloured but very attractive
Aroma	Good	Mild
Firmness	Good	Fair to some extent
Taste	Sweet and pleasant	Though appears ripe, inner core is sour
Shelf life	Long	Short. Black blotches appear on fruit after two to three days

Activity 3

Test to identify the purity of milk.

Aim: To detect the presence of starch in milk.

Materiel required: Test tube, milk, iodine solution.

Procedure: Take 10ml of different warm milk samples in a test tube and add few drops of iodine solution to it.

Observation: Formation of blue colour indicates the presence of starch.

Some simple techniques used to detect adulterants at home

1. Milk: Place a drop of milk on a slanting polished surface. Pure milk flows slowly leaving a trail behind while the milk adulterated with water will flow fast without leaving a trail.
2. Honey: Dip a cotton wick in honey and light it with a match stick. Pure honey burns while adulterated honey with sugar solution gives a cracking sound.
3. Sugar: Dissolve sugar in water. If chalk powder is added as an adulterant, it will settle down.
4. Coffee powder: Sprinkle a few pinches of coffee powder in a glass of water. Coffee powder floats. If it is adulterated with tamarind powder it settles down.
5. Food grains: They have visible adulterants like marble, sand grit, stones, etc. These are removed by sorting, hand picking, washing etc.

Project

Project: Collect information on the methods of organic or non-chemical farming and its role in maintaining food quality.

Food quality control agencies of our Country

A slogan "**From farm to plate, make food safe**" was raised on World Health Day (7th April 2015) to promote and improve food safety.

Food should be pure, nutritious and free from any adulteration for proper maintenance of human health.

It is the duty of every government to make pure and safe food available to public in sufficient quantities. In 1954, the Indian government enacted the food law known as Prevention of Food Adulteration Act and the Prevention of Food Adulteration Rules in 1955 with the objective of ensuring pure and wholesome food to the consumers and protect them from fraudulent trade practices.

Minimum standards of quality for food and strict hygienic conditions for its sale are clearly outlined in the Act. Any food that does not conform to the minimum standards laid down in the Act is said to be adulterated. The Act also intends to penalise the dealers who are engaged in the production and sale of contaminated food substances. This Act is periodically amended based on requirements.

Quality control agencies such as

- ISI, AGMARK, FPO, FCI and other health departments enforce minimum standards for the consumer products.

FCI (Food Corporation of India) was set up in the year 1965 with the following objectives:

- Effective price support operations for safeguarding the interest of farmers.
- Distributing food grains throughout the country.

Food control agencies, their standardized mark and their role in food safety

	ISI (Indian Standards Institution) known as Bureau of Indian Standard (BIS)	Certifies industrial products like electrical appliances like switches, wiring cables, water heater, electric motor, kitchen appliances etc.
	AGMARK (Agricultural Marking)	Certifies agricultural and livestock products like cereals, essential oils, pulses, honey, butter etc.
	FPO (Fruit Process Order)	Certifies the fruit products like juice, jams, sauce, canned fruits and vegetables, pickles etc.,
	Food Safety and Standards Authority of India	Responsible for protecting and promoting the public health through regulation and supervision of food safety.

- Maintaining satisfactory levels of operational and buffer stock of food grains to ensure national security.
- Regulate the market price to provide food grains to consumers at reliable price.

A Case Study

Siddanth came back from school. He was feeling very hungry. His mother sent him to buy a packet of biscuits from a nearby shop. When his mother opened the packet, she

More to Know

The **Codex Alimentarius** (Latin for "Food Code") is a collection of internationally recognised standards, codes of practice, guidelines, and other recommendations relating to foods, food production and food safety. The Codex Alimentarius is recognized by the World Trade Organisation (WTO) as an International reference point for the resolution of disputes concerning food safety and consumer protection.

realized that it was not fresh. So she asked him to return the packet for a new one.

What do you think Siddanth should have observed before buying the biscuit packet?

Activity 4

Let each of the student bring any food packet (jam, juice, pickle, bread, biscuit, etc). Note down the details like name of the product, manufacturer's details, contents/ ingredients, net weight, Maximum Retail Price (MRP), date of manufacture, date of expiry/best before twelve months from the date of manufacture and standardized marks like ISI, AGMARK or FPO printed on the label for each of the items to create awareness

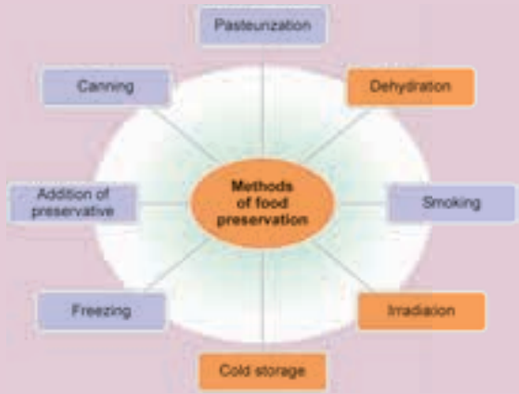
HOTS

Is it so?

- Cereal is the healthiest way to start the day
- Healthy means low fat.
- Bottle water is better than tap water

Activity 5

Look at the given mind map showing different methods of food preservation. Give one example for each of the following methods



Points to remember

- Food is necessary for normal growth and development of living organisms.
- Prolonged deficiency of certain nutrient causes deficiency diseases leading to Malnutrition.
- Drying, smoking, irradiation, refrigeration, freezing, pasteurization and canning are some of the methods of food preservation.
- Adulterants are undesirable substances added to the food against the Food Safety Standards.
- Prevention of Food Adulteration Act, 1954 laid down the minimum standards for consumer products.

GLOSSARY

1. **Fatigue** extreme tiredness due to mental or physical illness
2. **Hygroscopic** the property of absorbing moisture from the air
3. **Insomnia** loss of sleep
4. **Microbiology** branch of science that deals with the study of microorganisms
5. **Muscular cramps** sudden and involuntary contractions of one or more muscles
6. **Nutrients** substance that provide nourishment for normal growth and development
7. **Nerve impulse** electric signals that travels along a nerve fibre
8. **Neurotransmitter** chemical substance released at the end of a nerve fibre which transmits the nerve impulse to the next nerve fibre
9. **Nourishment** food that you need to grow and stay healthy
10. **Osteoporosis** a diseases which weakens the bones and makes it brittle
11. **Oxidation** loss of electrons
12. **Paralysis** loss of muscle function in any part of our body which can be either temporary or permanent
13. **Shelf life** time for which a food can be kept fresh
14. **Toxins** any poisonous substance produced by bacteria, animals or plants

ICT CORNER

Deficiency Diseases

Step 1. Type the following URL in the browser or scan the QR code from your mobile.

Step 2. A home of ICMR opens, Select **Nutri Guide** you can find various nutrients like Vitamins, Minerals Proteins.

Step 3. Now Click on the Vitamins and you can find different types of Vitamins.

Step 4. Click on any Vitamins button and a new screen will open with Vitamin chart with Biochemical, RDA, Dietary Sources Signs & Symptoms.

http://218.248.6.39/nutritionatlas/home.php

QR Code

EXERCISES

EYL3ZH

I. Choose the best answer

1. The nutrient required in trace amounts to accomplish various body functions is _____

a) Carbohydrate b) Protein c) Vitamin d) Fat

2. The physician who discovered that scurvy can be cured by ingestion of citrus fruits is _____
   a) James Lind
   b) Louis Pasteur
   c) Charles Darwin
   d) Isaac Newton

3. The sprouting of onion and potatoes can be delayed by the process of _____
   a) Freezing b) Irradiation
   c) Salting d) Canning

4. Food and Adulteration Act was enacted by Government of India in the year _____
   a) 1964 b) 1954
   c) 1950 d) 1963

5. An internal factor responsible for spoilage of food is _____
   a) Wax coating
   b) Contaminated utensils
   c) Moisture content in food
   d) Synthetic preservatives

II. Fill in the blanks

1. Deficiency diseases can be prevented by taking _____ diet.
2. The process of affecting the natural composition and the quality of food substance is known as _____
3. Vitamin D is called as _____ vitamin as it can be synthesised by the body from the rays of the sun.
4. Dehydration is based on the principle of removal of _____.
5. Do not purchase food beyond the date of _____
6. AGMARK is used to certify _____and_____ products in India.

III. Mention whether the following statements are true or false. If false, give the correct statements

1. Iron is required for the proper functioning of thyroid gland.
2. Vitamins are required in large quantities for normal functioning of the body -
3. Vitamin C is a water soluble Vitamin
4. Lack of adequate fats in diet may result in low body weight
5. ISI mark is mandatory to certify agricultual products.

IV. Match the following

A	B
1. Calcium	a. Muscular fatigue
2. Sodium	b. Anaemia
3. Potassium	c. Osteoporosis
4. Iron	d. Goitre
5. Iodine	e. Muscular cramps

V. Fill in the blanks with suitable answers

Vitamin	Rich source	Deficiency disease
Calciferol		Rickets
	Papaya	Night blindness
Ascorbic acid		
	Whole grains	Beriberi

VI. Unscramble the words in the brackets to complete the sentence

Salting is a process involving addition of ____ (aslt) removes the ____ (oitmsuer) content in the_____ (dofo) by the process of _____ (sosisom) and prevents the growth of_____ (artcaeib).

VII. Give abbreviations for the following food standards

i. ISI _____

ii. FPO _____

iii. AGMARK _____

iv. FCI _____

v. FSSAI _____

VIII. Assertion and Reason

Direction: In the following question, a statement of a Assertion is given and a corresponding Reason is given just below it. Of the statements given below, mark the correct answer as:

(a) If both Assertion and Reason are true and the Reason is the correct explanation of Assertion

(b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion

(c) If Assertion is true but Reason is false

(d) If both Assertion and Reason is false

1. Assertion: Haemoglobin contains iron.
   Reason: Iron deficiency leads to anaemia
2. Assertion: AGMARK is a quality control agency
   Reason: ISI is a symbol of quality

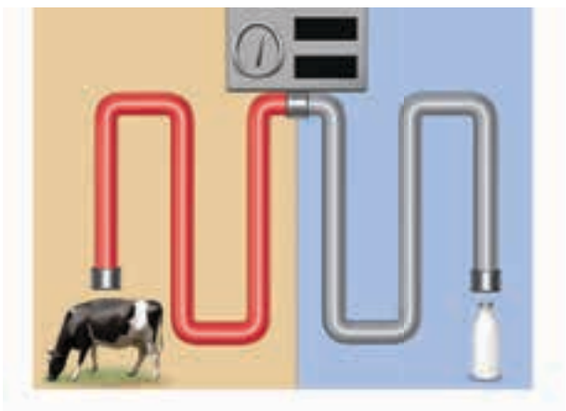
IX. Very short answers

1. Differentiate
   a) Kwashiorkar from Marasmus
   b) Macronutrients from micronutrients
2. Give reasons why salt is used as preservative in food.
3. What is an adulterant?
4. A doctor advices an adolescent girl who is suffering from anaemia to include more of leafy vegetables and dates in her diet. Why so?
5. Name any two naturally occuring toxic substances in food.
6. What factors are required for the absorption of Vitamin D from the food by the body?

X. Short answers

1. Write any one function of the following minerals
   a) Calcium b) Sodium
   c) Iron d) Iodine
2. Explain any two methods of food preservation.
3. Sanjana wants to buy a jam bottle in a grocery shop. What are the things she should observe on the label before purchasing it.
4. Give one reason for the following statements:
   a. Salt is added as a preservative in pickles_____
   b. We should not eat food items beyond the expiry date _____
   c. Deficiency of calcium in diet leads to poor skeletal growth _____
5. What are the effects of consuming adulterated food?

6. Look at the picture and answer the question that follows



a) Name the process involved in the given picture.

b) Which food is preserved by this process?

c) What is the temperature required for the above process?

XI. Detail answer

1. How are vitamins useful to us? Tabulate the sources, deficiency diseases and symptoms of fat soluble vitamins
2. Explain the role of food control agencies in India.

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UNIT 9

Computer – An Introduction

Learning Objectives

EYUZ25

This Unit will help the students to,

- Understand the importance of the computer
- Know the history of computer
- Know the generations of computer
- Distinguish data and information

(Kayalvizhi and Amuthan had a discussion with their mother on computer).

Kayalvizhi	:	Mom! I received an SMS about a computer course in summer holidays.
Mother	:	Is it Kayal? Do you wish to join the course?
Kayalvizhi	:	Yes mom. Yesterday, our teacher told us that computers play a vital role in our day-today life. So it is a need of the hour to learn computer.

(Kayalvizhi's younger brother Amuthan interrupts)

Amuthan	:	What are you saying Kayal? Do we use computer in our daily life?
Kayalvizhi	:	Yes of course. Have you not noticed?
Amuthan	:	Sister, I have seen it in a few places. Can you say where do we use computer in day-today life?
Kayalvizhi	:	Do you remember, yesterday our dad used ATM card to withdraw money, when he was running out of cash?
Amuthan	:	Yes sister, I do remember.
Kayalvizhi	:	That ATM machine works with the help of a computer only.
Amuthan	:	Oh! Is it so sister?
Kayalvizhi	:	Not only that. Most of the bills of our daily purchases are computer generated ones.
Amuthan	:	Do we have these two usages only?
Kayalvizhi	:	No Amuthan. We use computers either directly or indirectly in our life. For example, we can see them at use in banks, hospitals, post offices, transport, market, media, defence sector, education, space research and so many other fields as well. Computer plays an important role in our life. So we should learn to operate a computer.

We come to know about the uses of computer from the above conversation. Now let us know about computer in detail.

9.1.1 Computer

Computer is an electronic device, which manipulates and stores data and information through commands or program codes.

The computer that was designed in the year 1946 was equivalent to the size of a huge class room. When compared to the computers of earlier stages with today, the size is minimized but the efficiency and speed has increased infinitely. Not only in the speed but also it can be used according to our convenience as desktops, laptops and mobile devices. The size and shape of the computer has been modified on the basis of our need.

Generally, the computer operates by the exchange of commands between the hardware and software. Hardware can be touched and felt, but the software cannot be.

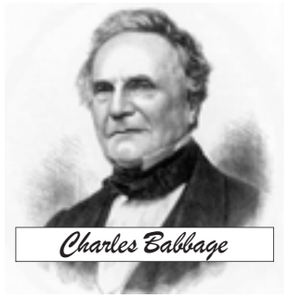
9.1.2 History of computer

Now a days, we can find computer in many forms like desktop, laptop, palmtop, tablet etc. This kind of transformation in data handling and processing has happened over a long period of time. Let us know about the advancement of computer here.

ENIAC- A computer had approximately 18,000 vacuum tubes. The size occupied by the ENIAC could be equivalent to a class room.

Around 2000 years ago, the people of China used Abacus. This was considered as the most basic model of a computer. Nineteenth century was considered as the birth of the computer when Charles Babbage designed the basic construction of a computer.

ENIAC, which was used by the American Military in 1946 to predict the trajectory of artillery shells, recognized as the world's first general purpose computer. Lady Augusta Ada Lovelace was honored as the first programmer as she gave the first programming to do arithmetic operations.



9.1.3 Generations of computer

The history of computer has been classified into many stages. The main difference between the generations is the speed and efficiency of the computer. On the basis of performance and speed, the generations of the computer was categorised.

1940-56 1956-63 1964-71 1972-2010 After-2010

Generations of Computer

Period	Generation	Digital devices
1940-1956	I Generation	Vacuum tubes
1956-1963	II Generation	Transistor

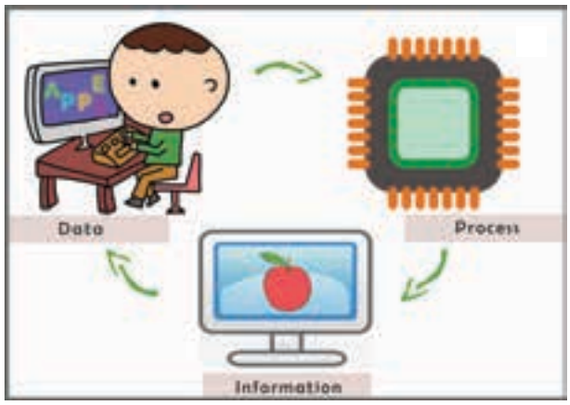
1964-1971	III Generation	Integrated circuits
1972-2010	IV Generation	Micro processors
After 2010	V Generation	Artificial Intelligence

9.1.4 Data

Data is the set of values of qualitative and quantitative variables. The data that is fed to the computer can be text, number or statistics. These data stored in computer memory cannot be used directly. It has to be processed.

Data processing

The data processing in a computer is collecting data and converting it into information according to our needs and requirements.



DO YOU KNOW?

The first 1 GB disk drive weighed around 250 kilograms and its cost was approximately 25 lakhs.

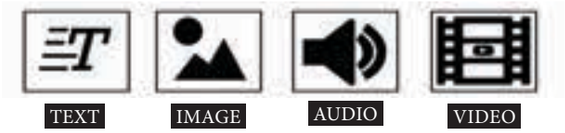
The steps in Data Processing

Data processing has six steps. They are:

- Data collection
- Data storage
- data sorting
- the data processing
- Data analysis
- Data presentation and conclusions

9.1.5 Information

The information we get or obtain or receive using the data from the computer can be used directly.



EZ4V3S

EXERCISE

I. Choose the correct answer

1. _____ is an electronic device which stores data and information.
   a) Telescope
   b) Television
   c) Computer
   d) Radio

2. _____ belongs to the generation IV of the computer
   a) Microprocessor
   b) Artificial intelligence
   c) Transistor
   d) Vaccum Tubes

3. Data processing involves_____ steps.
   a) seven b) four
   c) six d) eight

4. 1. Abacus belongs to the first generation of the computer.

2.ENIAC was used in the American military.

a) Both the statements are correct

b) Statement 1 is wrong but 2 is correct

c) Statement 1 is correct but 2 is wrong

d) Both the statements are wrong.

II. Match the following

1.	III generation computer	-	Integrated circuit
2.	Text, number	-	Information
3.	Transistor	-	Father of computer
4.	Directly used	-	Data
5.	Charles Babbage	-	II generation

III. Answer the following in brief:

1. Define computer.
2. Differentiate data and information.
3. What is data processing?

IV. Answer the following in detail

1. What are the different steps involved in data processing?
2. List out the generations of computer.

PRACTICAL - TABLE OF CONTENTS

Sl. No.	Name of the Experiment	Time
1.	To Find the diameter of a spherical body	40 minutes
2.	To Find the thickness of given iron nail	40 minutes
3.	Refraction of light through a rectangular slab	40 minutes
4.	Measurement of volume of liquids	40 minutes
5.	Adaptations in plants	40 minutes
6.	Adaptations in animals	40 minutes
7.	To detect the adulterants in food samples	40 minutes

I. TO FIND THE DIAMETER OF A SPHERICAL BODY

QLMB36

Aim:

To determine the diameter of a spherical body using Vernier Caliper

Apparatus required:

Vernier Caliper, given spherical body (cricket ball)

Formula: (i) Least count (LC) =1 Main scale division -1 Vernier scale division

LC = 1mm – 0.9 mm

LC = 0.1 mm (or) 0.01 cm

(ii) Diameter of the spherical object (d) = M.S.R. + (VC × LC) ± ZC cm

where, MSR - Main Scale Reading

VC = Vernier Coincide

LC - Least Count. (0.01 cm)

ZC - Zero Correction.

Procedure:

- Find the least count of the Vernier caliper.
- Find the zero correction of the Vernier caliper.
- Fix the object firmly in between the two lower jaws of the Vernier.
- Measure the main scale reading and the Vernier scale Coincidence.
- Repeat the experiment by placing the jaws of the Vernier at different position of the object.
- Using formula find the diameter of the object.

Least Count : 0.01cm (LC)

Zero Correction :---------- (ZC)

Sl. No.	Main Scale Reading (MSR) cm	Vernier coincidence (VC)	Diameter of object d = MSR + (VC x LC) ± ZC (cm)
1			
2			
3			

Average _____ cm

Result: The diameter of the given spherical object (Cricket ball) is _____ cm

II. TO FIND THE THICKNESS OF GIVEN IRON NAIL

Aim:

To find the thickness of the given iron nail

Apparatus required:

Screw gauge and iron nail

Formula:

(i) Least Count

$$(LC) = \frac{\text{Pitch scale Reading}}{\text{No of divisions in the Head scale}}$$

(ii) Thickness (t) = Pitch scale Reading (PSR) +

[Head scale coincidence (HSC) x Least Count (LC)] ± zero correction

$$t = PSR + (HSC \times LC) \pm ZC$$

Error:

(i) Positive error: If positive error is 5points, for zero correction subtracts 5 points.

$t = PSR + (HSC \times LC) - ZC$

$t = PSR + (HSC \times LC) - 5$

(ii) Negative error: Negative error is 95 points, so (100 -95) =5 points, for zero correction add 5 points

$t = PSR + (HSC \times LC) + ZC$

$t = PSR + (HSC \times LC) + 5$

(iii) No correction is needed $t = PSR + (HSC \times 0.01) \pm 0$

Procedure:

- The Least count of screw gauge is 0.01 mm
- The zero error is to be found when the two faces of the screw gauge touches each other.
- Then place the iron nail between the two faces of the screw gauge. The pitch scale reading (PSR) and head scale coincidence (HSC) are to be noted.
- Repeat the process by placing others parts of the iron nail in the screw gauge
- Tabulate the readings as.

	Zero corection:		Least count: 0.01 mm .....
Sl. No.	Pitch Scale Reading PSR (mm)	Head Scale Coincidence (HSC)	Thickness of the iron nail t = PSR + (H S C x LC) ± ZC (mm)
1			
2			
3			

Average _____ cm

Result: The (Thickness) diameter of the iron nail is ------mm.

III. REFRACTION OF LIGHT THROUGH A RECTANGULAR SLAB

Aim:

I. To study the path of light through a rectangular slab

II. To measure the angle of incidence, angle of refraction and angle of emergence and interpret the result.

QLSJFW

Materials required:

Glass slab, drawing board, white paper, protractor, a measuring scale, pins and drawing pins.

Procedure:

Fix a white sheet of paper on a drawing board. Place the rectangular glass slab in the middle of the paper and mark its boundary as ABCD with the pencil. Remove the rectangular slab. Draw a thin line PQ directing towards Q and inclined to the face AD of the glass slab at any angle preferably between 30^0 and 60^0. Replace the glass slab exactly over the boundary marked on the paper.

Fix two pins X_1 and X_2 vertically about 5 cm apart by gently pressing their heads with thumb or the line PQ

Diagram:

Observe the images of pins X_1 and X_2 through the face BC of the rectangular glass slab. Now Fix two more pins X_3 and X_4 such that Feet of all the pins appear to be in a straight line. In other words the pins X_3 and X_4 are collinear with the images of Pins X_1 and X_2

Remove the pins and glass slab and mark the position of the Feet of all the four pins. Join points that mark the position of the pins X_3 and X_4 and extend the line up to point R where it meets the face BC Join Q and R as given in figure.

Draw the normal NQM to the face AD, at the point Q and similarly the normal N_1RM_1 to the face BC at the point R. Measure the angle of incidence < PQN (<i), angle of refraction < MQR (<r) and angle of emergence (M'RS (<e) Record the value in the table.

Repeat the experiment for three more angle of incidence in the angle between 30^0 and 60^0 and record your observations.

Sl. No.	Angle of incidence < i	Angle of refraction < r	Angle of emergence < e
1			
2			
3			
4.			

Result: The path of the light through a rectangular slab is drawn. The angle of refraction and angle of emergence for various angle of incidence are obtained.

IV. MEASUREMENT OF VOLUME OF LIQUIDS

Aim:

To measure the volume of given colourless and coloured liquids.

Materials required:

Pipette (20ml), sample liquids and beakers

Procedure:

Take a 20 ml pipette. Wash it thoroughly with water and then rinse it with the given liquid. Insert the lower end of the pipette into the given liquid and suck the solution slowly till the solution rises well above the circular mark on the stem. Take the pipette out of the mouth and quickly close it with the fore finger. Take the pipette out the liquid and keep it such a way that the circular mark on the stem is at the level of the eyes. Now slowly release the fore finger to let the liquid drop out until the lower meniscus touches the circular mark on the stem. The liquid in the pipette is exactly 20 ml and this can be transferred to an empty beaker by removing the fore finger.

Tabulation

Sl. No.	Name of the liquid	Colour of the liquid	Nature of the meniscus	Volume of the liquid
1				
2				
3				
4.				

Report:

Exactly 20 ml of various liquids are measured using a standard 20 ml pipette.

Note:

1. Keeping the circular mark on the stem of the pipette above or below the level of the eyes will lead to error.
2. When colored liquids are measured, the upper meniscus should be taken into account.
3. Never suck strong acids or strong alkalis using a pipette.

V. ADAPTATIONS IN PLANTS

Aim:

To identify the given plant specimen and list out its adaptations

1. Mesophytic plant – Tomato or Brinjal plant
2. Xerophytic plant – *Opuntia*
3. Aquatic plant – *Eichhornia sp*
4. Insectivorous plant – *Nepenthes*

Observation:

The given plants are identified and the following adaptations are noted.

1.

2.

3.

4.

5.

VI. IDENTIFICATION OF THE ADAPTATIONS IN ANIMALS

Aim:

To identify the given vertebrate (chordate) animal and list out the following adaptations seen in them.

Required specimens:

1. Pisces (Fishes), 2. Amphibian (Frog), 3. Reptiles (Calotes), 4. Aves (Dove), 5. Mammals (Rat)

The given specimen is identified and the following adaptations are noted

Sl. No.	Name of the animal	Habitat	Body structure	Body covering	Locomotory organs
1	Fish				
2	Frog				
3	Calotes				
4.	Dove				
5.	Rat				

VII. TO DETECT THE ADULTERANTS IN FOOD SAMPLES

Aim:

To detect the adulterants in the given samples

Requirements:

Beakers, glass bowl, spoon, match box

Materials required:

Given sample, pepper (A), honey (B), Sugar (C), chilli powder (D), green peas (E), water.

Procedure:

- Take 5 beakers with water and name it us A, B, C, D, E.
- Take samples A, B, C, D, E and add to the respective beaker.
- Observe the changes in each beaker.
- Record your observations.

Observation:

Sl. No.	Sample	Observation	Indication
1.	A		
2.	B		
3.	C		
4.	D		
5.	E		

GLOSSARY

1.	Measurement	அளவீடு
	Area	பரப்பு
	Volume	கனஅளவு / பருமன்
	Density	அடர்த்தி
	Velocity	திசைவேகம்
	Momentum	உந்தம்
	Acceleration	முடுக்கம்
	Force	விசை
	Pressure	அழுத்தம்
	Energy	ஆற்றல்
	Mass	நிறை
	Least count	மீச்சிற்றளவு
	Zero error	சுழிப்பிழை
2.	Motion	இயக்கம்
	Distance	தொலைவு
	Displacement	இடப்பெயர்ச்சி
	Uniform motion	சீரான இயக்கம்
	Centripetal force	மையநோக்கு விசை
	Centrifugal force	மைய விலக்கு விசை
3.	Light	ஒளி
	Reflection	எதிரொளிப்பு
	Spherical mirrors	கோளக ஆடிகள்
	Real and virtual image	மெய் மற்றும் மாயபிம்பம்
	Refraction	ஒளி விலகல்
	Total internal reflection	முழு அக எதிரொளிப்பு
	Optical fibers	ஒளி இழை
	Plane mirror	சமதள ஆடி
4.	Matter around us	நம்மைச் சுற்றியுள்ள பருப்பொருள்கள்
	Matter	பருப்பொருள்
	Pure substance	தூய பொருள்
	Elements	தனிமம்
	Compounds	சேர்மம்
	Mixture	கலவை
	Homogenous	ஒரு படித்தான தன்மை
	Heterogeneous	பல படித்தான தன்மை
	Evaporation	ஆவியாதல்
	Melting	உருகுதல்
	Sublimation	பதங்கமாதல்
	Colloidal solution	கூழ்ம கரைசல்
	Gels	அரைத் திண்மக் கரைசல்
	Pharmacology	மருந்தியல்
	Crystallization	படிகமாதல்
	Distillation	வடிகட்டுதல்
	Absorption	உட்கவர்தல், உறிஞ்சுதல்
5.	Atomic Structure	அணு அமைப்பு
	Mass number	நிறை எண்
	Valence	இணைதிறன்
	Zero Valence	சுழி இணைதிறன்
	Atomic number	அணு எண்
	Nucleus	அணு உட்கரு

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GLOSSARY

6.	Plants	தாவரங்கள்
	Phototropism	ஒளிநாட்டம்
	Geotropism	புவிநாட்டம்
	Hydrotropism	நீர் நாட்டம்
	Photosynthesis	ஒளிச்சேர்க்கை
	Transpiration	நீராவிப்போக்கு
	Stomata	இலைத்துளை
7.	Animals	விலங்குகள்
	Taxonomy	வகைப்பாடு
	Kingdom	உலகம்
	Phylum	தொகுதி
	Sub phylum	துணைத் தொகுதி
	Class	வகுப்பு
	Sub class	துணைவகுப்பு
	Order	வரிசை
	Family	குடும்பம்
	Sub family	துணைக்குடும்பம்
	Genus	பேரினம்
	Species	சிற்றினம்
	Radial Symmetry	ஆர சமச்சீர்
	Bilateral Symmetry	இரு பக்கச் சமச்சீர்
	Coelom	உடற்குழி
	Autotrophic	தற்சார்பு
	Heterotrophic	பிறசார்பு
	Ectoderm	புறஅடுக்கு
	Endoderm	அகஅடுக்கு
	Mesoglea	நடு அடுக்கு
	Diploblastic	ஈரடுக்கு
	Polymorphism	பல்லுருவமைப்பு
	Flame cell	சுடர் செல்
	Mantle	மேன்டல் உறை
	Notochord	முதுகு நாண்
	Operculum	செவுள் மூடி
	Poikilothermic Animal	குளிர் இரத்த விலங்கு
	Homoeothermic Animal	வெப்ப இரத்த விலங்கு
8.	Food	உணவு
	Balanced diet	சரிவிகித உணவு
	Dehydration	நீரகற்றல்
	Radiation	கதிரியக்கம்
	Pasteurization	பாஸ்டர் பதனம் / பாஸ்டிரை சேஷன்
	Canning	கலனடைத்தல்
	Preservatives	பதப்படுத்திகள்
	Adulteration	கலப்படம்
9.	Computer	கணினி
	Input	உள்ளீட்டகம்
	Output	வெளியீட்டகம்
	Memory unit	நினைவகம்
	Keyboard	விசைப்பலகை
	Mouse	சுட்டி
	Monitor	திரையகம்

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This book has been printed on 80 G.S.M.
Elegant Maplitho paper.

Printed by offset at: