Formulae Handbook For Maths & Science

20 Minutes
Revision
Book

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Features of this eBook:

- Quickly revise entire Math Formulas and Science content in 20 Minutes
- Revise important points of Maths and Science
- Comprehensively Covers Entire **Syllabus**

Supporting your Educational Journey throughout the year

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Physics - I

Estimation And Units

(i) Density = $\dfrac{\text{mass}}{\text{volume}}$

(ii) Acceleration = $\dfrac{\text{velocity}}{\text{time}}$

(iii) Speed= $\dfrac{\text{distance}}{\text{time}}$

(iv) Velocity = $\dfrac{\text{displacement}}{\text{time}}$

(v) Momentum = mass x velocity

Equations Of Motion

(i) for accelerating bodies

(a) $\vec{v} = \vec{u} + \overrightarrow{at}$

(b) $\overrightarrow{v^2} - \overrightarrow{u^2} = 2\overrightarrow{as}$

(c) $\vec{s} = \overrightarrow{ut} + \dfrac{1}{2}\overrightarrow{at^2}$

(ii) for deaccelerating bodies

(a) $v = u - at$

(b) $v^2 - u^2 = -2as$

(c) $s = ut - \dfrac{1}{2}at^2$

(iii) for free falling bodies

(a) $a = g$

(b) $v = u + gt$

(c) $v^2 - u^2 = 2gs$

(d) $s = ut + \frac{1}{2}gt^2$

$= 0$ (always)

$\therefore v = gt$

$v^2 = 2gs$

$s = \frac{1}{2}gt^2$

(iv) for body thrown upwards

(a) $a = -g$

(b) $v = u - gt$

(c) $v^2 - u^2 = -2gs$

(d) $s = ut - \frac{1}{2}gt^2$

$v = 0$ (always)

$\therefore u = gt$

$u^2 = 2gs$

$s = ut - \frac{1}{2}gt^2$

where u = initial velocity; v = final velocity;

a = acceleration; t = time and s = displacement.

Newton's Laws Of Motion

(i) Force (F) = mass (m) x accelerration (a)

$\Rightarrow F = ma$

(ii) Momentum (p) = mass (m) x velocity (v)

(iii) $\Delta p = \Delta(mv) = m\Delta v$

(iv) $\frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t} = ma$

(v) $\frac{p_f - p_i}{t} = \frac{mv - mu}{t} = \frac{m(v-u)}{t} = ma$

(vi) $F = \frac{\Delta p}{\Delta t} = ma$

p = momentum; p_i = initial momentum and p_f = *final* momentum

Δ or δ (delta): used in calculus used to indicate a small change in a given quantity.

F = force

m = mass

a = acceleration

v = velocity

Pressure In Fluids And Atmospheric Pressure

(i) Pressure (p) = $\frac{\text{force}}{\text{area (A)}}$

S.I. unit of pressure is pascal (pa)

(ii) $p = h\rho g$

P or p = pressure

h = depth of liquid or gas

ρ (rho) = density of liquid or gas

g = acceleration due to gravity

Density And Relative Density

(i) Density (d) = $\dfrac{\text{mass (m)}}{\text{volume (v)}}$

(ii) Volume = area of cross section $\times$ height

$\Rightarrow$ V=a $\times$ h

(iii) Archimedes' Principle:

Relative Density of a solid = $\dfrac{\text{density of solid}}{\text{density of water at 4°C}}$

$= \dfrac{\text{weight of solid } (w_1)}{\text{weight of an equal volume of water}}$

$= \dfrac{\text{weight of solid in air}}{\text{loss of weight of body in water (weight of body in air - weight of body in water)}}$

$= \dfrac{w_1}{w_1 - w_2}$

Relative Density of a liquid = $\dfrac{\text{density of liquid}}{\text{density of water at 4°C}}$

$= \dfrac{\text{loss of weight of solid in liquid}}{\text{loss of weight of solid in water}}$

w_1 = weight of body in air

w_2 = weight of body in water

w_3 = weight of body in liquid X

(iv) Law of Flotation:

w_1 = weight of solid

w_2 = weight of fluid displaced

as per the law: $w_1 = w_2$

but: w = mg

$\therefore m_1 g = m_2 g$

but $m = V \times d$ (mass = density $\times$ volume)

$\therefore V_1 d_1 = V_2 d_2$ or $V_1 \rho_1 = V_2 \rho_2$

i.e. $\dfrac{\rho_1}{\rho_2} = \dfrac{V_1}{V_2}$

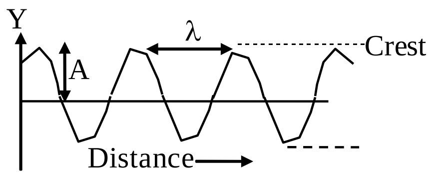
Sound

$v = \nu\lambda$

where V is velocity; ν (nu) is frequency and λ(lambda) is the wave length.

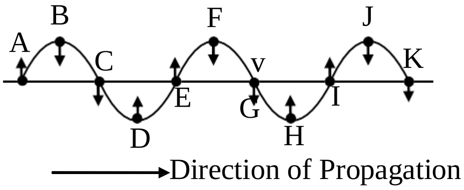
Key Points and Concepts

- Sound is a wave motion, produced by a vibrating source.
- The audible range of hearing for average human beings is in the frequency range of 20 Hz — 20 KHz.
- A medium is necessary for the propagation of sound waves.
- Sound is a longitudinal wave in which the particles of medium move along the direction of motion of wave.
- **Speed of Sound :** The speed of sound is the rate at which sound travels from the sound producing body of our ears. The speed of sound depends on the (i) Nature of Material (ii) Temperature (iii) Humidity of Air.
- The point of maximum positive displacement on a transverse wave is known as crest.
- The point of maximum negative displacement on a transverse wave is known as trough.
- Sound travels faster in solids than in air. The speed of sound in solids is much more than the speed of sound in liquids or gases.
- **Characteristic of Sound:**
  Loudness: *Loudness of a sound depends on the amplitude of the vibration producing that sound.* Greater is the amplitude of vibration, louder is the sound produced by it.
  Pitch: *The shrillness of a sound is called its pitch. The pitch of a sound depends upon its frequency.* Higher the frequency of a sound, higher is its pitch.
  Quality: Quality of a sound is also called timbre. The quality of sound is the characteristic which enable us to distinguish between the sounds produced by different sources.
- **Characteristics of wave:** wavelength, frequency and time period.
- **Wave Length:** The distance between two nearest points in a wave which are in the same phase of vibration is called the wave length. In simple words it is the length of one complete wave. It is denoted by lambda, λ.



- **Amplitude:** The amplitude of a wave is the magnitude of maximum displacement of the vibrating particles on the either side of their mean position. It is denoted by the letter A and its SI unit is metre (m).
- **Time-Period:** The time required to produce one complete wave (or cycle) is called time-period of the wave.

- **Frequency :** The frequency of an oscillating particle is the number of oscillations completed in one second. The unit of frequency is hertz (or Hz). The frequency of the wave is 1/T. It is generally represented by ν (nu)
- **Wave Velocity:** The distance travelled by the wave in one second is called the wave velocity. It is represented by 'v' and its unit is ms^{-1}.
- **Phase:** All the points on a wave which are in the same state of vibration are said to be in the same phase. Thus, in the wave shown in fig.



- The distance between two consecutive compressions or two consecutive rarefactions is called the wavelength.
- Frequency is defined as the number of oscillations per second.
- The time taken by the wave to complete one oscillation is called the time period, T.
- When a body repeats its motion continuously on a definite path in a definite interval of time then its motion is called **periodic motion.**
- The constant interval of time after which the motion is repeated is called the **'Time period of motion.' (T)**
- If a body in periodic motion moves along the same path to and fro about a definite point (equilibrium position), then the motion of the body is a vibratory motion or oscillatory motion.
- **Wave Motion:** The movement of a disturbance produced in one part of a medium to another involving the transfer of energy but not the transfer of matter is called wave motion.
- Wave which do not require any material medium for their propagation are called **electromagnetic waves**. Example : Light waves, Radio waves, Television waves, and X-rays are electromagnetic waves. Thus, Light waves, Radio and Television waves, and X-rays can also travel through vaccum.
- The wave which propagates only in a material medium are called elastic or **mechanical waves.** Example: Sound waves, Water waves (ripples), Waves on stretched strings, Earthquake waves and the Shock waves produced by a supersonic aircraft are mechanical (or elastic) waves.
- Sound of frequency less than 20 Hz is known as infrasound and greater than 20 kHz is known as **ultrasound.**
- Ultrasound has many medical and industrial applications.
- The sound returning back towards the source after suffering reflection from a distance obstacle (a wall, a row of building etc.) is called an **echo.**
- The repeated reflection that results in the persistence of sound in a large hall is called reverberation.
- The human ear is sensitive to sound waves of frequency between **20 Hz to 20 kHz**. This range is known as audible range and these waves are known as audible waves. **Ex.** Waves produced by vibrating sitar, guitar, organ pipes, flutes, shehnai etc.
- **Ultrasonic waves:** A longitudinal wave whose frequency is above the upper limit of audible range i.e. **20 kHz,** is called ultrasonic wave. It is generated by very small

sources.
Ex. Quartz crystal

- **Infrasonic wave:** A longitudinal elastic wave whose frequency is below the audible range i.e. **20 Hz,** is called an infrasonic wave. It is generally generated by a large source.
  Ex. Earthquake.
- **SONAR** stands for Sound Navigation and Ranging and it works on the principle of reflection of sound waves.
- The SONAR technique is used to determine the depth of the sea and to locate under water hills, valleys, submarines, icebergs, sunken ships, etc.
- When a body moves with a speed which is greater than the speed of sound in air, it is said to be travelling at supersonic speed jet fighters, bullets, etc, often travel at supersonic speed, and when they do so, they produce a sharp, loud sound called a sonic boom.

Quantities and Units:

S.No.	Quantities	SI Units
1.	Velocity	m/s
2.	Time	s (sec)
3.	Frequency	Hz (hertz) i.e., s^{-1}
4.	Wavelength	M

Important Formulae:

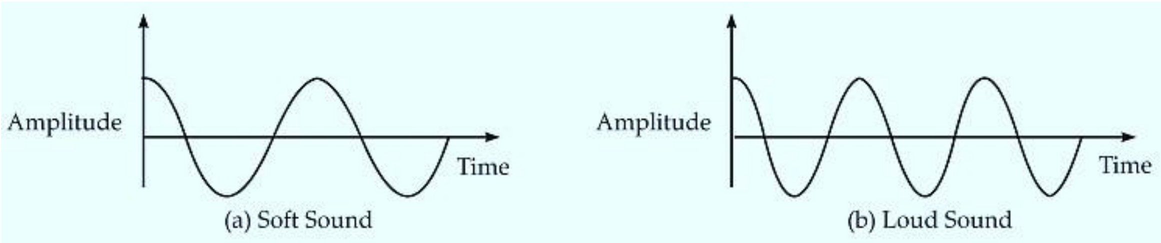
- Frequency and time period are related as follows:
$$\nu = \frac{1}{T}$$
- Speed, $$v = \frac{\text{Distance}}{\text{Time}}$$
- The wave velocity (v), frequency of the wave (f) and its wavelength (R) are related by the formula, $v = \nu\lambda$

Longitudinal and Transverse Waves:

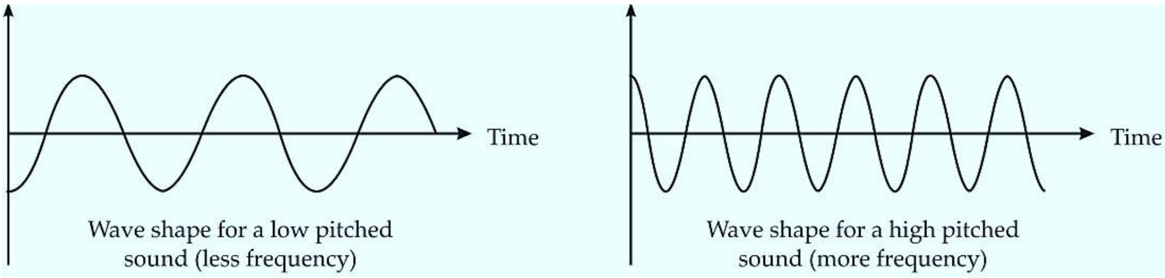
S.No.	Longitudinal	Transverse waves
1.	In a longitudinal wave the particles of the medium oscillate along the direction of propagation of the wave.	In a transverse wave, the particles of the medium oscillate in a direction perpendicular to the direction of propagation of the wave
2.	Longitudinal waves can propagate through solids, liquids, as well as gases.	Transverse waves can propagate through solids, and over the surface of liquids, but not through gases.
3.	Longitudinal waves consist of compression and rarefactions.	Transverse waves consist of crests and troughs.

Important Graphs and Diagrams:

Soft Sound and Louder Sound



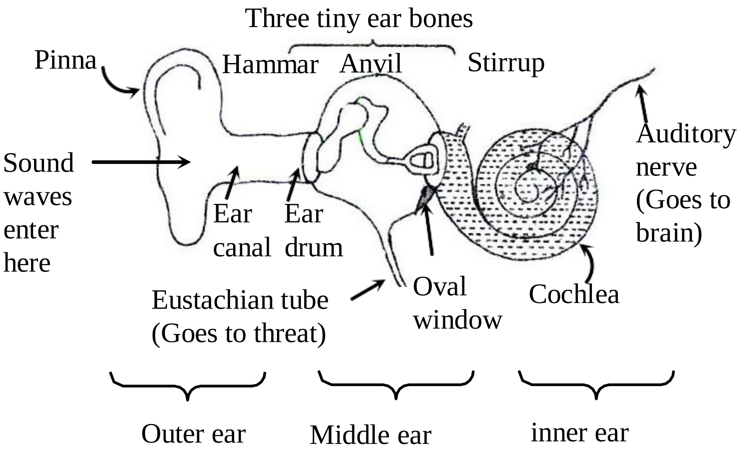
Low pitched and High pitched Sound



The Human Ear

Structure of human ear:

The ear consists of three compartments : outer ear, middle ear and inner ear. The part of ear which we see outside the head is called outer ear. The outer ears consists of broad part called pinna and about 2 to 3 centimeters long passage called ear canal. At the end of ear canal there is a thin, elastic and circular membrane called ear-drum. The ear-drum is also called tympanum. The outer ear contains air. The middle ear contains three small and delicate bones called hammer, anvil and stirrup. The inner ear has a coiled tube called cochlea.



Working of human ear:

Sound waves from outside are collected by the outer ear (called pinna) and reach the eardrum through the auditory canal. When the sound waves strike the eardrum, (tympanic membrane) it starts vibrating. These vibrations are passed on to the oval window by three bones (called the hammer, anvil and stirrup) which act as a lever with the pivot at point P. They magnify the force of the vibrations.

Electricity

(i) $I = \frac{q}{t}$

Where I = current

q = charge

t = time

(ii) Potential differnce in volts (V) $= \frac{\text{work done in joule (W)}}{\text{charge in coulomb (q)}}$

$$\therefore V = \frac{W}{q}$$

(iii) Ohm's Law:

$$\therefore \frac{V}{I} = R$$

$$V = RI$$

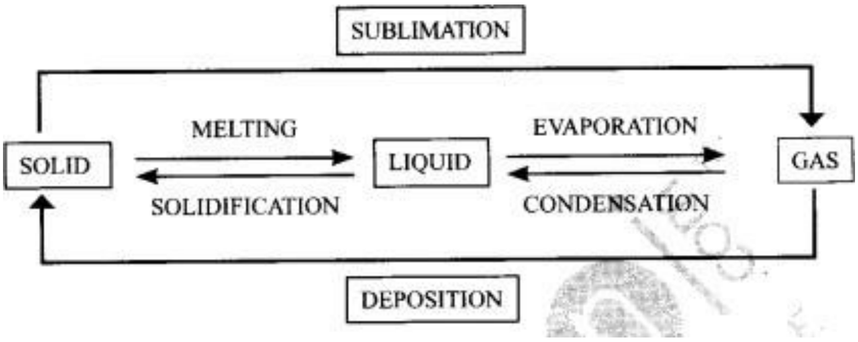
Where,

	SI Unit
V = Potential difference	volt
R = Resistance	ohm
I = Current	ampere

Chemistry – I Matter

And Its Composition

(a) Interconversion of states



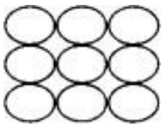
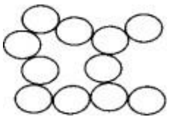
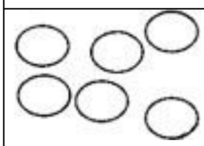
(b) Kinetic Theory of Matter :

(i) All matter is made up of very small particles - such as atoms or molecules.

(ii) Particles are moving all the times (higher the temperature, higher the kinetic energy of the particles)

Higher particles move more slowly than lighter particles at the same temperature.

The Kinetic Theory of matter

Arrangement of Matter	State of Matter	Arrangement and Movement of Particles Matter
	**SOLID** **1.** Has a fixed volume and shape. **2.** Cannot be compressed	**1.**The particles are packed closely together in an orderly manner. (Inter molecular space minimum) **2.** There are strong forces between the particles. (Inter molecular attraction) **3.** The particles can only vibrate and rotate about their fixed positions. (Brownian movement)
	**LIQUID** **1.** Has fixed volume but does not have fixed shape (takes shape of the container). **2.** Cannot be compressed easily	**1.** The particles ard packed closely logother but not in orderly arrangement. **2.** Held together by strong forces but weaker than the forces in a solid. **4.** The particles can vibrate, rotate and move throughout the liquid. **5.** They collide against each other.
	**GAS** **1.** Does not have a fixed shape or volume. **2.** Can be compressed easily.	**1.** The particles are very far apart from each other and in a random motion. **2.** Weak forces between the particles. **3.** The particles can vibrate, rotate and move freely. The rate of collision is greater than the rate of collision in a liquid.

(c) Law of conservcation of Mass :

Sum of weight of all reactants = sum of weight of all products

For Reaction:

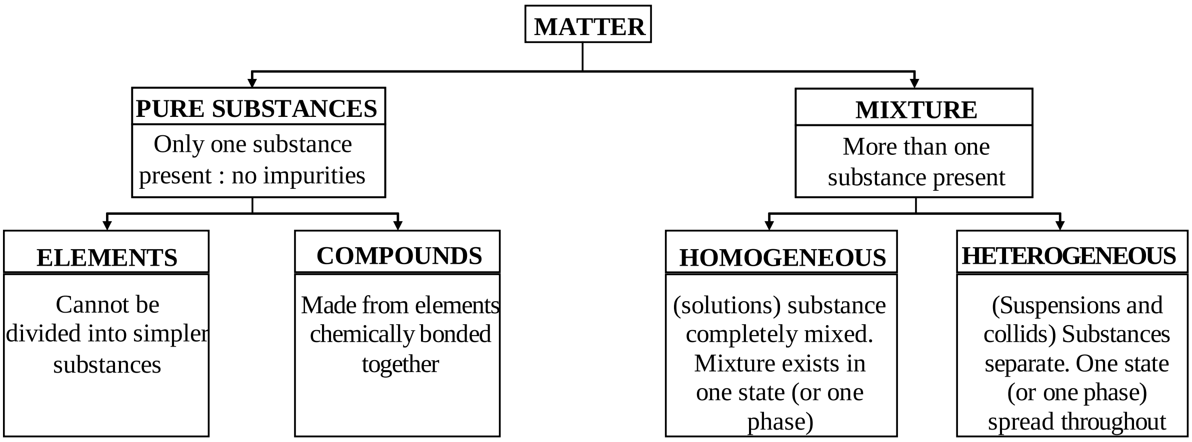
$$A + B \rightarrow C + D$$

Mass of A + Mass of B = Mass of C + Mass of D

Key Points and Concepts

- All the matter around us is not pure. The matter around us is of two types.
  A mixture contains more than one substance (element and/or compound) mixed in any proportion.
- A pure substance consists of a single type of particles.

- Pure substances are always homogeneous.
- Pure substances can be divided into two types.
  (A) Elements (B) Compounds



Element	**Symbol**
Aluminium	Al
Arsenic	As
Barium	Ba
Bromine	Br
Cadmium	Cd
Calcium	Ca
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Fluorine	F
Hydrogen	H
Iodine	I
Magnesium	Mg
Manganese	Mn
Nitrogen	N
Oxygen	O
Phosphorus	P
Sulphur	S
Uranium	U
Zinc	Zn
(symbols from latin names)	
Antimony (stibium)	Sb
Copper (Cuprum)	Cu
Gold (Aurum)	Au
Iron (Ferrum)	Fe

Lead (Plumbum)	Pb
Mercury (Hydrogyrum)	Hg
Potassium (Kalium)	K
Silver (Argentum)	Ag
Sodium (Natrium)	Na
Tin (Stannum)	Sn

Mixtures and Compounds:

S.No.	Mixtures	Compounds
1.	Two or more elements or compounds are mixed in any proportion.	Two or more elements combine and react.
2.	A new substance is formed.	A new substance is formed.
3.	The new substance shows the properties of its constituents.	The new substance has totally different properties.
4.	The composition of the new substance is variable.	The composition of the new substance is always fixed.
5.	The constituents of a mixture can be separated only by physical methods.	The constituents of a compound can be separated only by chemical reactions.

Homogeneous and Heterogeneous Mixture:

S. No.	Homogeneous Mixture	Heterogeneous Mixture
1.	Uniform Composition.	Non-Uniform Composition.
2.	No distinct boundaries of separation. e.g., sugar + water.	Distinct boundaries of separation. e.g., sand + water.

Physical Change and Chemical Change:

S. No.	Physical change	Chemical change
1.	These are reversible changes and their chemical composition do not change.	These are irrreversible changes and the chemical composition also changes.
2.	No new substance is formed. e.g. Tearing of paper.	New substance is formed. e.g. Burning a match-stick.

Metals and Non-Metals:

Metals	Non-Metals
1. Metals are malleable and ductile. That is, metals can be hammered into thin sheets and drawn into thin wires.	1. Non-metals are brittle. They are neither malleable nor ductile.
2. Metals are good conductors of heat and electricity.	2. Non-metals are bad conductors of heat and electricity (except diamond which is a good conductor of heat, and graphite which is a good conductor of electricity)
3. Metals are lustrous (shiny) and can be polished.	3. Non-metals are non-lustrous (dull) and cannot be polished (except iodine which is a lustrous non-metals)
4. Metals are solids at room temperature (except mercury which is a liquid metal).	4. Non-metals may be solid liquid or gases at the room temperature
5. Metals are strong and tough. They have high tensile strength.	5. Non-metals are not strong. They have low tensile strength.
6. Metals are sonorous. They make a ringing sound when struck.	6.Non-metals are not sonorous.

Properties of non-metals:

- Non-metals are not malleable.
- Non-metals are brittle.
- Non-metals are not ductile. This means that non-metals cannot be drawn into wires. They are easily snapped on stretching.
- Non-metals are bad conductors of heat and electricity.
- Non-metals are not lustrous (not shiny). They are dull in appearance.
- Non-metals are generally soft
- Non-metals are not strong. They have low tensile strength.
- Non-metals may be solid, liquid or gases at the room temperature.
- Non-metals have comparatively low melting points and boiling points
- Non-metals have low densities.
- Non-metals are not sonorous.
- Non-metals have many different colours.

Understanding of true solution, colloidal solution and suspension:

S. No.	True Solution	Colloidal Solution	Suspension
1.	A true solution is a homogenous mixture of solute and solvent.	A colloidal solution appears to be a homogenous but actually it is a heterogenous mixture of solute and solvent.	It is a heterogenous mixture.
2.	It is transparent.	It is translucent.	It is opaque.

3.	The solute particles are very small, i.e.,less than 1 nm.	The solute particles are between 1-100 nm.	The solute particles are quite large i.e. more than 100 nm.
4.	The particles are not visible even with a powerful microscope.	The particles are visible with the help of microscope.	The particles are visible with naked eye.
5.	The entire solution passes through filter paper as well as semi-permeable membrane.	The particles can pass through ordinary filter paper but not through a semi-permeable membrane.	The particles cannot pass through either a filter paper or through a semi-permeable membrane.
6.	The solute particles do not show Tyndall effect.	The particles show Tyndall effect.	The particles may or may not show Tyndall effect.
7.	The particles do not settle due to gravity e.g., salt in water solution.	The particles do not settle due to gravity e.g., blood.	The particles may settle due to gravity e.g., chalk powder in water.

Mass by mass percentage of a solution = No. of moles $= \frac{m}{N} = \frac{\text{Mass}}{\text{Molar mass}}$

Mass by volume percentage of a solution $= \frac{\text{Mass of Solute}}{\text{Volume of Solution}}$

Study Of Gas Laws

(a) Conversions :

Volume :

1 *l*t = 1 dm^3 1000 cc = 1000 mlt.

Pressure:

1 atm = 76 cm of Hg = 760 mm of Hg

Temperature:

K = °C + 273

(b) Boyle's law :

$$V \alpha \frac{1}{p} \quad \text{at constant temperature}$$

$$P_1V_1 = P_2 V_2$$

where V_1 = Volume of a given gas at pressure P_1

V_2 = Volume of that gas at pressure P_2

(c) Charle's law :

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{at constant pressure}$$

where V_1 = Volume of a given gas at temperature T_1

V_2 = Volume of a given gas at temperature T_2

(d) Gas Equation :

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Where,

V_1 = volume of a given gas at pressure P_1 & temperature T_1

V_2 = volume of a given gas at pressure P_2 and temperature T_2

(e) S.T.P = standard temperature and pressure

(f) N.T.P = normal temperature and pressure

(g) Standard temperature = 0° = 273 K

(h) Standard pressure = 1 atmosphere = 760 mm Hg

(i) Absolute Zero or Kelvin zero = - 273 °C or 0 K

(j) No. of moles $= \dfrac{\text{mass of the gas}}{\text{molecular mass}}$

Language Of Chemistry

(a) Chemical Formula of Compounds :

Name of Compound	**Formula**
Magnesium chloride	$MgCl_2$
Aluminium phosphate	$AlPO_4$
Sodium Fluoride	NaF
Calcium Phosphate	$Ca_3(PO_4)_2$
Potassium carbonate	K_2CO_3
Barium Chlorate	$Ba(C1O_3)_2$
Sodium Silicate	Na_2SiO_3
Barium Sulphate	$BaSO_4$
Calcium bromide	$CaBr_2$
Chromium sulphate	$Cr_2(SO_4)_2$
Potassium Ferrocyanide	$K_4Fe(CN)_6$
Stannic Oxide	SnO_2
Sodium Zincate	$Na_2Zn(OH)_4$
Sodium Thiosulphate	$Na_2S_2O_3$
Nickel bisulphate	$Ni(HSO_4)_2$
Potassium Manganate	K_2MnO_4
Sodium hypochlorite	$NaClO$
Sodium Chlorite	$NaC1O_2$
Sodium Chlorate	$NaC1O_3$

(b) Formula of common Acids :

Acid	**Name**
HC1	Hydrochloric acid
HNO_3	Nitric acid
H_3PO_4	Phosphoric acid
H_2SO_3	Sulphurous acid
HCOOH	Acetic acid
H_2SO_4	Sulphuric acid
H_2CO_3	Carbonic acid
CH_3COOH	Acetic acid
$H_2C_2O_4$	Oxalic acid
H_3PO_3	Phosphorous acid

(c) Formula of Common Bases :

NaOH	Sodium hydroxide
NH_4OH	Ammonium hydroxide
KOH	Potassium hydroxide
$Ca(OH)_2$	Calcium hydroxide
$Ba(OH)_2$	Barium hydroxide
$Al(OH)_3$	Aluminium hydroxide
LiOH	Lithium hydroxide

(d) Steps to Balance Chemical Equations

Step 1:

Convert the word equation into formula equation.

Step 2:

Note down the number of different atoms present on left hand side and right hand side of the equation.

Step 3:

Add coefficients to balance the equation, so that we have the equal number of atoms of each element on both the reactant (left hand side) and product (right hand side) of the equation.

Example: Balance the chemical equation: Mg + 2HCl —> $MgCl_2 + H_2$

Step 1:

Given chemical equation: Mg + 2HCl $\rightarrow$ $Mgcl_2$ > + H_2

Step 2:

Atoms on

Reactance side		Products side
1	Mg	1
1	Cl	2
1	H	2

Step 3:

Reactance side		Products side
1	Mg	1
2×1	Cl	2
2×1	H	2

$$Mg + 2HCL \rightarrow MgCl_2 + H_2$$

Water

(a) Test for Water:

(i) It turns anhydrous copper sulphate blue

$CuSO4 + 5H_2o \rightarrow CuSO_4.5H_2o$

(ii) It turns anhydrous cobalt chloride pink

$CoCl_2 + 6H2o \rightarrow CoCl_2.6H_2o$

(b) Chemical Properties:

(i) Reaction with sodium

Na, K react with cold water to form hydroxide and liberate hydrogen. Na melts into a silver globule1

$2Na + 2H_2O \rightarrow 2NaOH + H_2 + heat$

This reaction is vigorous and exothermic and the evolved hydrogen burns with golden yellow flame and bubbles of hydrogen are evolved.

(ii) Reaction with Calcium

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

The solution becomes turbid and alkaline.

(iii) Reaction With IVlagnesium

$Mg + H_2O \rightarrow MgO + H_2$

Magnesium bums with intense white light in steam or boiling water liberating hydrogen gas and white ash of magnesium oxide.

(iv) Reaction with Iron:

$$3Fe + 4H_2O \xrightarrow{\Delta} Fe_3O_4 + 4H_2$$

Red hot iron reacts with steam to give iron triferric tetroxide and hydrogen gas. This reaction is reversible when carried out in closed vessel.

(v) Reaction with Carbon:

$C + H_2O \rightarrow CO + H_2$

Red hot coke reacts with water to form water gas.

(vi) Reaction with Chlorine:

$Cl_2 + H_2O \xrightarrow[\text{Direct sunlight}]{\text{diffused sunlight}} HCl + HClO$ (Hypochlorous acid.)

$2Cl_2 + 2H_2O \rightarrow 4HCl + O_2$

(vii) Reaction with Carbon dioxide:

$CO_2 + H_2O \rightarrow H_2CO_3$

(viii) Reaction with calcium carbide:

$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

It gives calcium hydroxide and acetylene

(ix) Reaction with Nitrogen Dioxide:

$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

It gives nitrous acid and nitric acid.

(x) Reaction with Aluminium:

$2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$

Red hot A1 reacts with steam, above 800 °C to give aluminium oxide.

(xi) Reaction with Zinc:

$$Zn + H_2O \rightarrow ZnO + H_2$$

Zinc reacts with steam to give zinc oxide and hydrogen.

(i) Solubility $= \dfrac{\text{weight of solute}}{\text{weight of solvent}} \times 100$

(ii) Concentration $= \dfrac{\text{weight of solute}}{\text{weight of solution}} \times 100$

(iii) Formula of salts

Salt	**Formula**
Blue Vitriol	$CuSO_4.5H_2O$
Quick Lime	CaO
Oil of Vitriol	H_2SO_4
Washing Soda Crystals	$Na_2CO_3.10H_2O$
Epsom Salt	$MgSO_4.7H_2O$
Green Vitriol	$FeSO_4.7H_2O$
Borax	$Na_2B_4O_7.10H_2O$
Glaubers salt	$Na_2SO_4.10H_2O$

(c) Activity series of elements

Activity of metals	
K Na Ca	Can react with cold water and hydrogen.
Mg A1 Zn Fe	Can react with steam and acids, hydrogen

Activity of metals	
Pb	Can react with acids, replacing hydrogen. Forms insoluble $PbCl_2$, $PbSO_4$ on top of Pb. Reaction stops. Very very slow reaction. Elements below hydrogen (Cu, Hg, Ag, Pt, Au) and lead do not displace hydrogen from metals.
H_2 Sb Bi Cu Hg_2	React with oxygen, forming oxides
Ag Pt Au	Fairly unreactive, form oxides only
Activity of Halogens	
F_2 Cl_2 Br_2 li_2	

Key Points and Concepts

- ☐ The materials present in natural environment & useful to living organism are called **natural resources**.
- ☐ Natural Resources can be classified into two groups.
  Physical resources: E.g, Air, water, soil, minerals, coal etc.
  Biological resources: E.g. Microorganisms, plants & animals.
- ☐ Life on earth is responsible for the present atmosphere of earth, consisting of gases like nitrogen, oxygen, carbon dioxide and water vapour.
- ☐ The top surface layer of this exposed, solid part of crust containing weathered minerals and humus and capable of supporting plant growth is called soil.
- ☐ Air is a mixture of gases which is odourless, tasteless & invisible. Air also holds water vapour & dust particles.
- ☐ An undesirable change in the physical, chemical or biological characteristics of the air making it harmful for the living organisms (including man) is termed air pollution.
- ☐ Some common harmful effects of air pollution are -
  - Respiratory problems, e.g., sneezing, allergy, bronchitis, asthma,, tuberculosis and lung cancer.
  - Carbon monoxide poisoning.
  - Acid rain.
  - Depletion of ozone layer.
  - Global warming (green hourse effect).
  - Serious ailments produced by certain metals and pesticides.

- Smog.

☐ Biosphere comprises of biotic and abiotic factors, which interact with each other and maintains a balance.
☐ The wind patterns in a particular region direct the rainfall patterns of that region.
☐ Burning of fossil fuels releases harmful oxides of sulphur and nitrogen, which gives rise to acid.
☐ An undesirable change in the physical, biological or chemical qualities of water (due to addition of foreign organic, inorganic, biological or radioactive substances) that adversely affects the aquatic life, and make the water less fit or unfit for use, is called water pollution.
☐ **Water is important to living organisms because:**
1. All cellular processes require an aqueous medium.
2. Dissolved substances are needed for body reactions as well as for transportation.

☐ **Water pollution is caused by addition of following to water bodies:**
1. Fertilizers and pesticides
2. Sewage
3. Waste from factories
4. Heated water from factories
5. Cold water from dams.

☐ Freezing of water in cracks of rocks causes widening of the cracks.
☐ Soil is a mixture of rock particles, humus and microscopic and small organisms.
☐ Ozone is present in the upper atmospheric strata and contains three atoms of oxygen.
☐ The ozone layer absorbs the sun's harmful ultraviolet radiations, thus preventing them from reaching the Earth's surface and damaging life.
☐ CFCs and other man-made compounds react with the ozone molecules and causes ozone layer depletion.
☐ **Green house effect:** The process in which green house gases like carbon dioxide, cause thermal radiation emitted by the Earth's surface to be reflected back down, therefore causing the increase in worldwide average temperatures.
☐ **Global warming:** An increase in the average temperature of the earth's atmosphere, brought about by the enhanced greenhouse effect.

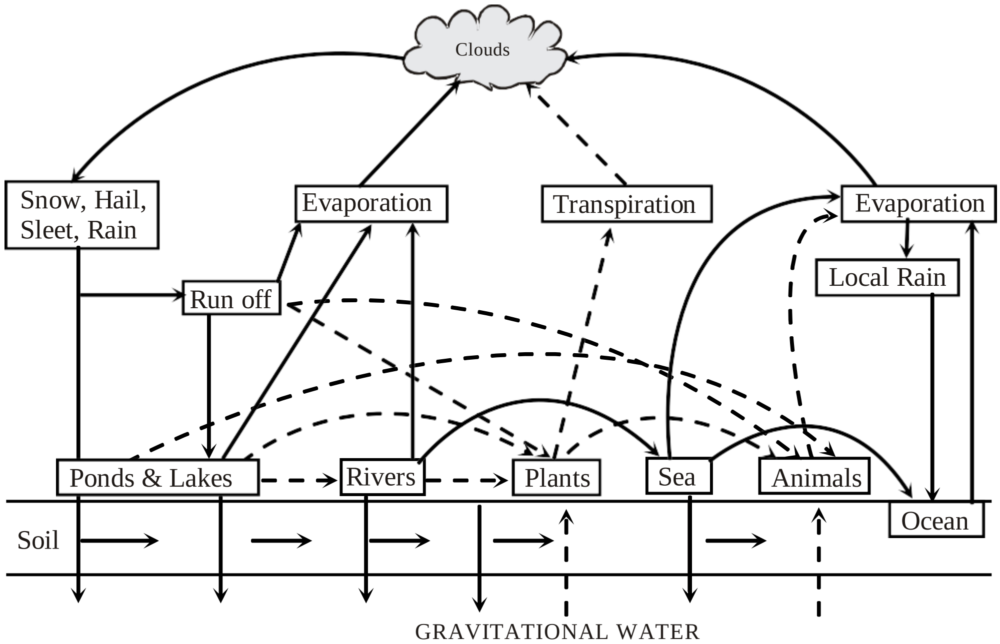
Important Graphs and Diagrams

Water cycle:

Biogenic elements (macro-, micro- & other elements) flow from the environment into and out of the plant in a cyclic manner. This flow of nutrients from abiotic to biotic components of the ecosystem and vice-versa constitute the biogeochemical cycles.

☐ Water on earth is cycled by two processes, **evaporation** and **precipitation**.
☐ The atmospheric precipitation occurs in the form of snow, hail or sleet etc. The run off water is finally collected in ocean through rivers.
☐ Some water remains solid in the form of snow which gradually melts and reaches the sea.
☐ Soil water is used by plants and most of it again reaches the atmosphere through transpiration.
☐ Animals consume water directly from water bodies & also the gravitational water.

☐ By evaporation, the water returns to atmosphere and cycle is repeated.



The Water Cycle

Atomic Structure

(a) Atomic number (Z) = number of electrons

= number of protons

(b) Mass number (A) = number of protons + number of neutrons

= atomic number + number of neutrons

(c) Number of protons = atomic number

= mass number - number of neutrons

(d) Number of electrons = atomic number

= mass number - number of neutrons

(e) Number of neutrons = mass number - atomic number

(f) Bohr and Bury Scheme - Important Rules

(i) Maximum number of electrons that can be accommodated in a shell is given by $2n^2$ where n = shell number

(ii) For 1st energy level, n = 1 Maximum number of electrons in 1st energy level = $2n^2 = 2 \times (1)^2 = 2$

(iii) For 2nd energy level n = 2 Maximum number of electrons in the 2nd energy level = $2n^2 = 2 \times (2)^2 = 2 \times 4 = 8$

(iv) For 3rd energy level n = 3 Maximum number of electrons in the 3rd energy level = $2n^2 = 2 \times (3)^2 = 2 \times 9 = 18$

(v) For 4th energy level n = 4 Maximum number of electrons in the 4th energy level = $2n^2 = 2 \times (4)^2 = 2 \times 16 = 32$

Sl.No	Electron Shell	Maximum Capacity
1	K Shell	2 electrons
2	L Shell	8 electrons
3	M Shell	18 electrons
4	N Shell	32 electrons

The outermost shell of an atom cannot accommodate more than 8 electrons, even if it has a capacity to accommodate more electrons. This is a very important rule and is also called the Octet rule. The presence of 8 electrons in the outermost shell makes the atom very stable.

(g) ISOTOPES - are the atoms of same element having same atomic number but different mass number.

The isotopes have different number of neutrons Eg.

Protium $_1H^1$

Deutrium $_1H^2$

Tritium $_1H^3$

Key Points and Concepts

- ☐ Atoms are made up of three subatomic particles electrons, Protons and neutrons.
- ☐ Electron has negative charge, proton has positive charge, whereas neutron has no charge, it is neutral.
- ☐ Cathode rays always travel in straight line.
- ☐ Cathode rays consist of material particles and possess energy, hence they can produce mechanical effects.
- ☐ Cathode rays consist of negatively charged particles.
- ☐ Anode rays travel in straight lines.
- ☐ Anode rays consist of material particles.
- ☐ Anode rays are deflected by electric field towards negatively charged plate. This indicates that they are positively charged.
- **Electron:** Cathode rays consist of small, negatively charged particles called electrons. The electron is a negatively charged particle found in the atoms of all the elements. The electrons are located outside the nucleus in an atom. An electron is usually represented by the symbol e^-.
- **Charge of an electron:** The absolute charge on an electron is 1.6×10^{-19} coulomb of negative charge. The relative charge of an electron is, – 1.
- **Mass of proton:** The mass of proton has been found to be equal to 1.67×10^{-27} kg

- **Charge of proton:** The charge of proton is equal and opposite to the charge of an electron. The value of charge on proton is 1.602×10^{-19}.
- **Mass of a neutron:** The mass of neutron is equal to the mass of a proton. The relative mass of a neutron is 1 u. The absolute mass of a neutron is 1.6×10^{-27} kg.

☐ **Valency** of an element is the combining capacity of the atoms of the element with atoms of the same or different elements.

☐ The outermost orbit of an atom is called its valence shell.

☐ The electrons present in the outermost orbit are called valence electrons.

☐ **Atomic Number:** The number of protons present in the nucleus of an atom of an element is known as its atomic number.
Atomic number of an element (Z) = Number of protons (p)
= Number of positive charges carried by the nucleus of the atom
or = Number of electrons (e)

☐ **Mass Number:** The sum of the number of protons and neutrons in an atom of the element.
Mass number (A) = No. of protons (p) + No. of neutrons (n)

$$^{A}_{Z}X$$

A = Mass number
Z = Atomic number
X = Symbol of element

☐ **Electrovalency:** In the formation of an electrovalent compound (or ionic compound), the number of electrons lost or gained by one atom of an element to achieve the nearest inert gas electron configuration is known as its electrovalency.

☐ **Covalency :** In the formation of a covalent compound the number of electrons shared by one atom of an element to achieve the nearest inert gas electron configuration is known as its covalency. If an atom shares 1 electron, its covalency will be 1.

☐ **Isotopes** are atoms Of the same element, which have different mass numbers
(i) Carbon, $^{12}_{6}C$ and $^{14}_{6}C$
(ii) Chlorine, $^{35}_{17}Cl$ and $^{37}_{17}Cl$ etc.

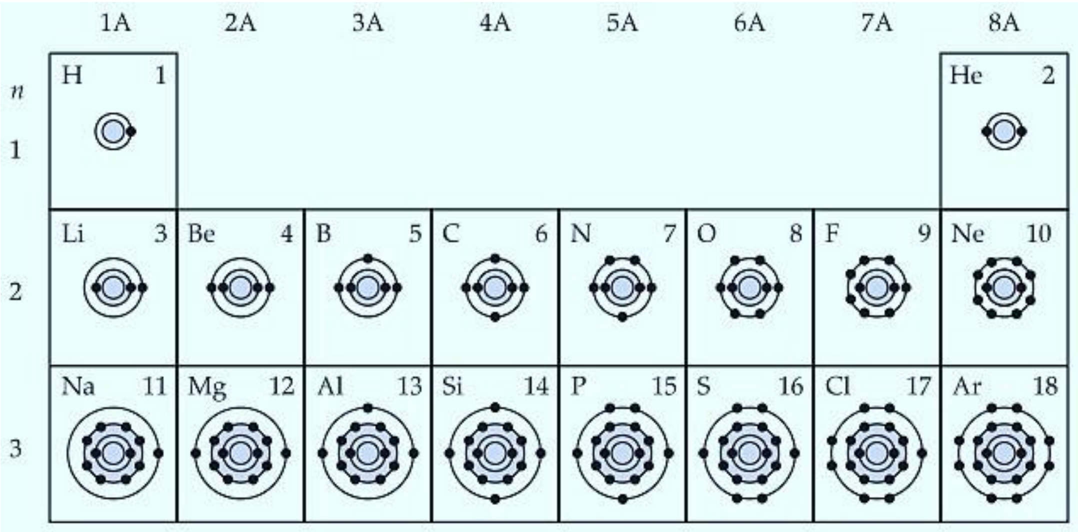
☐ **Isobars** are atoms having the same mass number but different atomic numbers.
$^{76}_{32}Ge$ and $^{76}_{34}Se$ are isobars.

- **Isotones:** The atoms having same number of Neutrons but diffrent mass number are called Isotones. The atoms have different number of protons of atomic number. “(A–Z) is same” “A & Z are different”.

Comparision between Proton, Neutron and Electron:

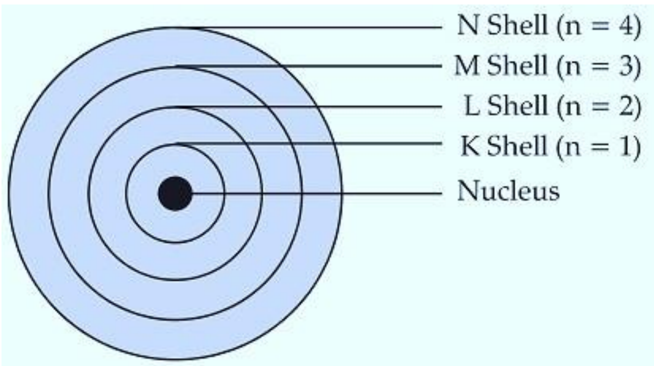
Particle	Relative Mass	Relative Charge	Charge / C	Mass / kg
Protons	1	+ 1	$+ 1.6 \times 10^{-19}$	1.67×10^{-27}
Neutrons	1	neutral	0	1.67×10^{-27}
Electrons	0.0005	- 1	$- 1.6 \times 10^{-19}$	9.11×10^{-31}

First 18 elements:



Important Graphs and Diagrams

Bohr's Model of an atom:



- An atom is made up of three particles: electons, protons and neutrons. Electrons have negative charge, protons have positive charge whereas neutrons have no charge, they are neutral. Due to the presence of equal number negative electrons and positive protons, the atom on the whole is electrically neutral.
- The protons and neutrons are located in a small nucleus at the centre of the atom. Due to the presence of protons, nucleus is positively charged.
- The electrons revolve rapidly around the nucleus in fixed circular paths called energy levels or shells. The energy levels or shells are represented in two ways: either bythe

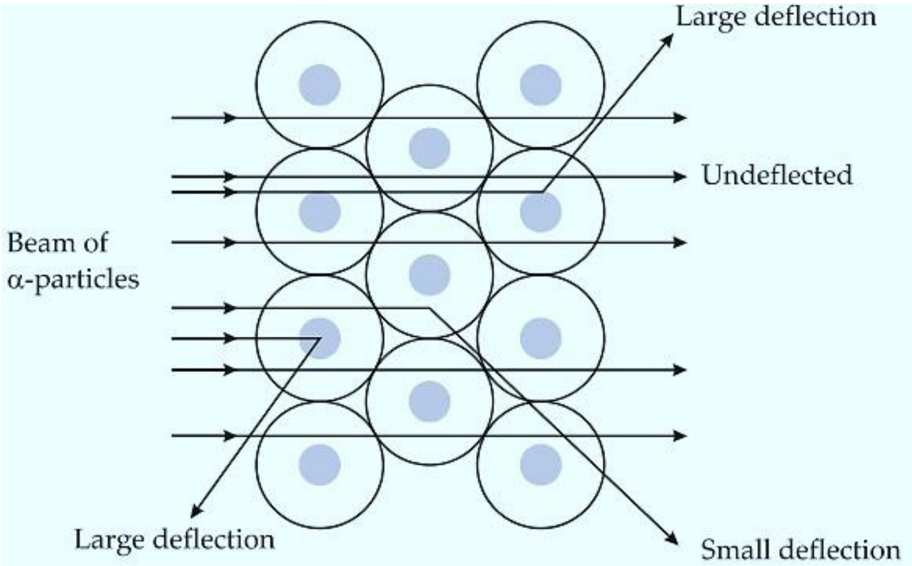
numbers 1, 2, 3, 4, 5 and 6 or by the letters K, L, M, N, O and P. The energy levels are counted from the centre outwards.

- There is a limit to the number of electrons which each energy level can hold.
- Each energy level (or shell) is associated with a fixed amount of energy, the shell nearest to the nucleus having minimum energy and the shell farthest from the nucleus having the maximum energy.

Alpha particle scattering experiment by Rutherford:

Rutherford model of an atom:

- Most of the fast moving α-particles passed straight through the gold foil without any deflection from their original path.
- Some of the α-particles were deflected from their path through small angles.
- Very few (about 1 in 12,000) did not pass through the foil at all but suffered large deflections (more than 90^{0}) or even came back in the direction from which they came.
- Most of the space inside the atom is empty. Therefore, most of the α-particles went through the gold foil without deflecting from their path.
- The deflections of the α-particles to large angles indicate that the α-particles has direct collision with the positively charged nucleus.



Rutherford's Atomic model:

The main features of Rutherford's model of an atom are :

- The atom consists of a positively charged centre called the nucleus.
- Most of the mass of the atom is concentrated in the nucleus.
- The volume of the nucleus is very small as compared to the total volume of the atom.
- The nucleus is surrounded by the negatively charged electrons. the electrons balance the positive charge of the nucleus. Therefore, the number of electrons in an atom is equal to the number of protons in it.
- The magnitude of the positive charge on the nucleus is different for different atoms.

The Periodic Table

Periodic Table of the Elements

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 **H** 1.00794																	2 **He** 4.002602
3 **Li** 6.941	4 **Be** 9.012182											5 **B** 10.811	6 **C** 12.0107	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984032	10 **Ne** 20.1797
11 **Na** 22.989769	12 **Mg** 24.3050											13 **Al** 26.9815386	14 **Si** 28.0855	15 **P** 30.973762	16 **S** 32.065	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.955912	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.938045	26 **Fe** 55.845	27 **Co** 58.933195	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.64	33 **As** 74.92160	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.90585	40 **Zr** 91.224	41 **Nb** 92.90638	42 **Mo** 95.96	43 **Tc** [98]	44 **Ru** 101.07	45 **Rh** 102.90550	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.90447	54 **Xe** 131.293
55 **Cs** 132.9054519	56 **Ba** 137.327	57-71 Lanthanides	72 **Hf** 178.49	73 **Ta** 180.94788	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.084	79 **Au** 196.966569	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.98040	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** 223	88 **Ra** [226]	89-103 Actinides	104 **Rf** [267]	105 **Db** [268]	106 **Sg** [271]	107 **Bh** [272]	108 **Hs** [270]	109 **Mt** [276]	110 **Ds** [281]	111 **Rg** [280]	112 **Uub** [285]	113 **Uut** [284]	114 **Uuq** [289]	115 **Uup** [288]	116 **Uuh** [293]	117 **Uus** [294]	118 **Uuo** [294]

Lanthanides	57 **La** 138.90547	58 **Ce** 140.116	59 **Pr** 140.90765	60 **Nd** 144.242	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.92535	66 **Dy** 162.500	67 **Ho** 164.93032	68 **Er** 167.259	69 **Tm** 168.93421	70 **Yb** 173.054	71 **Lu** 174.9668
Actinides	89 **Ac** [227]	90 **Th** 232.03806	91 **Pa** 231.03588	92 **U** 238.02891	93 **Np** [237]	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]

(a) **Dobereiner's** Triads arranged elements in an increasing order of atomic mass, in groups of three. The atomic mass of the middle element was the arithmetic mean of the other two elements of the triad.

(b) **Newland's law of octaves** states that on arranging elements in increasing order of their atomic mass, the eighth element resembles the first in physical and chemical properties, just like the eighth node on a musical scale resembles the first note.

(c) The law could only be applied upto calcium. No vacant spaces were left for undiscovered elements.

(d) According to **Mendeleev's periodic law**, the physical and chemical properties of elements are periodic functions of their atomic mass.

(e) Mendeleev was able to predict the existence of undiscovered elements like Ga, Sc and Ge.

(f) Mendeleev corrected the atomic masses of a few elements on the basis of their positions in the periodic table.

(g) Mendeleev's table could not assign a proper position to hydrogen or to the lanthanides and actinides and isotopes.

(h) **Modern periodic law** states that the properties of elements are periodic functions of their atomic numbers. It is based on electronic configuration of the elements.

(i) Mendeleev - had arranged elements in the periodic table on the basis of increasing atomic weight.

(j) Modern periodic table - elements are arranged on the basis of increasing atomic number.

Salient Feature of Modern Periodic Table

(i) The vertical columns are called groups, while the horizontal rows are called periods.

There are 7 periods and 8 groups subdivided into 18 sub groups.

(ii) Group number is number of electrons in the valence shell. Elements having the same valence number are grouped together.

(iii) The number of shells present in the atom gives period number.

(iv) Group 1, 2 & 13 to 17 are called normal elements.

(v) Group 3 to 12 are called transition elements.

(vi) Group 18 (zero) at extreme right contains noble or inert gases.

(vii) Reactive metals are placed in group 1 & 2.

(viii) Transition elements are placed in the middle.

(ix) Non-metals are placed in the upper right corner of the periodic table and metals to the left.

Study Of First Element - Hydrogen

(a) Preparation Of Hydrogen

(i) By the Action of Metals

The alkali metals, lithium, sodium and potassium react violently with water at the ordinary temperature, yielding hydrogen.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$$

$$2K + 2H_2O \rightarrow 2KOH + H_2\uparrow$$

Calcium reacts with water more slowly unless the water is hot, when the action is more vigorous.

$$Ca + 2H_2O \rightarrow H_2 + Ca(OH)_2 + 2H_2\uparrow$$

(ii) Preparation of Hydrogen by Decomposition of Water

Steam is decomposed when passed over heated magnesium, zinc and iron to form oxides and liberate hydrogen.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

The reaction, (i.e. with iron and steam) is reversible.

(iii) Preparation of Hydrogen from Action of Acids

Hydrogen is prepared in the laboratory by the action of acids on active metals. Dilute sulphuric acid or dilute hydrochloric acid used is added to granulated zinc. Zinc sulphate or zinc chloride is formed in solution and the hydrogen that is evolved is collected by the downward displacement of water.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

(iv) BOSCH's Process

By passing steam over red hot coke (carbon) at about 1000 °C a mixture of carbon monoxide and hydrogen known as water gas is produced. Carbon monoxide is separated from the mixture by converting it to carbon dioxide.

For conversion of carbon monoxide into carbon dioxide, excess steam is mixed with the water gas and passed over a catalyst.

$Fe_2 0_3 + Cr_2O_3$ at 450 °C.

$$H_2 0 + C \rightarrow CO + H_2 \quad (\text{water gas})$$

$$CO + H_2 + H_2O \rightarrow C0_2 + 2H_2$$

Mixture of carbon dioxide and hydrogen gas is passed through water at a pressure. CO_2 is absorbed in water while H_2 does not dissolve in water and is collected.

(b) Chemical Properties

(i) Reaction with Non-Metals

Hydrogen readily combines with fluorine and chlorine, less readily with bromine, iodine, sulphur, phosphorous, nitrogen and carbon.

$$H_2 + F_2 \rightarrow 2HF$$

Hydrogen burns in chlorine gas and a mixture of hydrogen and chlorine are exposed to diffused sunlight in the pressure of moisture which act as a catalyst.

$$H_2 + Cl_2 \rightarrow 2HC1$$

Hydrogen combines with nitrogen on sparking or in presence of a catalyst, forming ammonia.

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

450 - 500 °C

200 - 900 atmosphere pressure. Finely divided iron catalyst Molybdenum promoter.

(ii) Reaction with Metals

Hydrogen forms hydrides, (e.g. NaH) with a number of metals, including lithium, sodium and calcium.

$$H_2 + 2Na \rightarrow 2NaH$$

These hydrides when pure are white salt-like compounds rapidly decomposed by water.

$$NaH + H_2O \rightarrow NaOH + H_2$$

$$Ca + H_2 \rightarrow CaH_2$$

$$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$$

(iii) Reducing Properties

When hydrogen is passed over many heated metallic oxides (e.g. copper oxide, iron oxide, or lead oxide), they are reduced to the metals.

$$CuO + H_2 \rightarrow Cu + H_2O$$

$$PbO + H_2 \rightarrow Pb + H_2O$$

$$Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$$

It is a strong reducing agent and used in metallurgy.

Mathematics – I

Rational And Irrational Numbers

1. For any two rational numbers

$\frac{a}{b}$ and $\frac{c}{d}$

(i) $\frac{a}{b} = \frac{c}{d} \Leftrightarrow ad = bc$

(ii) $\frac{a}{b} > \frac{c}{d} \Leftrightarrow ad > bc$

(iii) $\frac{a}{b} < \frac{c}{d} \Leftrightarrow ad < bc$

2. Between any two rational numbers a and b, there exists another rational number

$\frac{a+k}{2}$ and

(i) If $a > b$, $\Leftrightarrow a > \frac{a+b}{2} > b$

(ii) If $a<b$, $\Leftrightarrow a < \frac{a+b}{2} < b$

3. If $\sqrt{a}$ and $\sqrt{b}$ are irrationals

(i) $\sqrt{a} > \sqrt{b} \Rightarrow a > b$

(ii) $\sqrt{a} < \sqrt{b} \Rightarrow a < b$

(iii) $b > \sqrt{a} \Rightarrow b^2 > a$

(iv) $a > \sqrt{b} \Rightarrow a^2 > b$

4. Rationalising factor of:

$\sqrt{a} + b$ is $\sqrt{a} - b$

FUNDAMENTALS

- **Natural Numbers:** N = {1, 2, 3, 4, ... }
- **Whole Numbers:** W = {0, 1, 2, 3, 4, ...}
- **Integers:** Z = {...... – 3, – 2, – 1, 0, 1, 2, 3, ...}
- **Rational Numbers:** A number that can be written in the form $\frac{p}{q}$, where p and q are co-prime integers and $q \neq 0$.
- **Irrational Numbers:** A number that cannot be written in the form $\frac{p}{q}$, where p and q are co-prime integers and $q \neq 0$.
- **Real Numbers:** R = All rational and all irrational numbers taken together.
- If x and y are any two rational numbers, then :
  i. $x + y$ is a rational number
  ii. $x - y$ is a rational number
  iii. $x \times y$ is a rational number
  iv. $x \div r\, y$ is a rational number, $(y \neq 0)$

Real Numbers

- Rational no.
  - If remainder = 0
    - Terminating & Non repeating
    - Eg: $\frac{18}{5} = 3.6$
  - f remainder $\neq 0$ & rem. = devidend
    - Non terminating & repeating (recurring)
    - Eg: $\frac{1}{3} = 0.33\ldots\ldots$
- Irrational no.
  - f remainder $\neq 0$ rem. $\neq$ any devidend
    - Non terminating non repeating
    - Eg: 0.671234.....

- ☐ If a is a real number, modulus a is written as |a|; |a| is always positive or zero.
- ☐ All natural number which cannot be divided by any number other than 1 and itself is called a prime number.
- ☐ A non-negative integer *'p'* is said to be divided by an integer *'q'* if there exists an integer *'d'* such that: $p = qd$
- • ±1 divides every non-zero integer.
- ☐ 0 does not divide any integer.

Identities related to square roots:

1. $\sqrt{ab} = \sqrt{a}\sqrt{b}$
2. $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$
3. $\left(\sqrt{a}+\sqrt{b}\right)\left(\sqrt{a}-\sqrt{b}\right) = a - b$
4. $\left(a+\sqrt{b}\right)\left(a-\sqrt{b}\right) = a^2 - b$
5. $\left(\sqrt{a}+\sqrt{b}\right)\left(\sqrt{c}+\sqrt{d}\right) = \sqrt{ac}+\sqrt{ad}+\sqrt{bc}+\sqrt{bd}$
6. $\left(\sqrt{a}+\sqrt{b}\right)^2 = a + 2\sqrt{ab}$

Important Rationalising factors:

Term	Rationalising Factor
$\frac{1}{\sqrt{r}}$	$\frac{\sqrt{r}}{\sqrt{r}}$
$\frac{1}{\sqrt{r}-s}$	$\frac{\sqrt{r}+s}{\sqrt{r}+s}$
$\frac{1}{\sqrt{r}+s}$	$\frac{\sqrt{r}-s}{\sqrt{r}-s}$
$\frac{1}{\sqrt{r}-\sqrt{s}}$	$\frac{\sqrt{r}+\sqrt{s}}{\sqrt{r}+\sqrt{s}}$
$\frac{1}{\sqrt{r}+\sqrt{s}}$	$\frac{\sqrt{r}-\sqrt{s}}{\sqrt{r}-\sqrt{s}}$

Laws of Exponents:

1. $a^r . a^s = a^{r+s}$

2. $\left(a^r\right)^s = a^{rs}$

3. $\frac{a^r}{a^s} = a^{r-s}, r > s$

4. $a^r b^r = (ab)^r$

5. $a^{-r} = \frac{1}{a^r}$

6. $a^{\frac{r}{s}} = \left(a^r\right)^{\frac{1}{s}} = \left(a^{\frac{1}{s}}\right)^r$

7. $\left(\frac{a}{b}\right)^r = \frac{a^r}{b^r}$

8. $\left(\frac{a}{b}\right)^{-m} = \left(\frac{b}{a}\right)^m$

Laws of Radicals:

1. $\left(\sqrt[n]{a}\right)^n = a$

2. $\sqrt[m]{\sqrt[n]{a}} = \sqrt[n]{\sqrt[m]{a}} = \sqrt[mn]{a}$

3. $\sqrt[n]{a} \times \sqrt[n]{b} = \sqrt[n]{ab}$, (a, b > 0, be real number)

4. $\dfrac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\dfrac{a}{b}}$

5. $\dfrac{\sqrt[p]{a^n}}{\sqrt[p]{a^m}} = \sqrt[p]{a^{n-m}}$

6. $\sqrt[p]{a^n \times a^m} = \sqrt[p]{a^{n+m}}$

7. $\sqrt[p]{\left(a^n\right)^m} = \sqrt[p]{a^{n-m}}$

Profit, Loss And Discount

1. Profit = Selling Price – Cost price

2. $\text{Profit } \% = \dfrac{\text{Profit}}{\text{Cost Price}} \times 100$

3. Loss = Cost Price – Selling Price

4. $\text{Loss } \% = \dfrac{\text{Loss}}{\text{Cost Price}} \times 100$

5. In case of PROFIT:

(i) $\text{Selling Price} = \dfrac{100 + \text{profit } \%}{100} \times \text{Cost Price}$

(ii) $\text{Cost Price} = \dfrac{100}{100 + \text{profit } \%} \times \text{Selling Price}$

6. In case of LOSS:

(i) $\text{Selling Price} = \dfrac{100 - \text{loss } \%}{100} \times \text{Cost Price}$

(ii) $\text{Cost Price} = \dfrac{100}{100 - \text{loss } \%} \times \text{Selling Price}$

7. When discount = d %

$$\text{Selling price} = \frac{100 - d}{100} \times \text{Market price}$$

8. In case of two successive discount d_1 % and d_2%

$$\text{Selling Price} = \left(\frac{100 - d_1}{100}\right)\left(\frac{100 - d_2}{100}\right) \times \text{Market Price}$$

9. In case of three successive discount d_1 % and d_2% and d_3%

$$\text{(i) Selling Price} = \left(\frac{100 - d_1}{100}\right)\left(\frac{100 - d_2}{100}\right)\left(\frac{100 - d_3}{100}\right) \times \text{Market Price}$$

Compound Interest

1. $$\text{Simple Interest} = \frac{\text{Principal} \times \text{Rate} \times \text{Time}}{100}$$

2. Amount = Principal + Interest

3. Compound Interest = Final Amount – Original Price

4. $$A = P\left(1 + \frac{r}{100}\right)^n,$$

1. $(a + b)^2 = a^2 + 2ab + b^2$
2. $(a - b)^2 = a^2 - 2ab + b^2$
3. $a^2 - b^2 = (a + b)(a - b)$
4. $(a + b)^2 + (a - b)^2 = 2(a^2 + b^2)$
5. $(a + b)^2 - (a - b)^2 = 4ab$

5. Compound Interest = Amount – Principal

Expansions

1. $(a + b)^2 = a^2 + 2ab + b^2$

2. $(a - b)^2 = a^2 - 2ab + b^2$

3. $a^2 - b^2 = (a + b)(a - b)$

4. $(a + b)^2 + (a - b)^2 = 2(a^2 + b^2)$

5. $(a + b)^2 - (a - b)^2 = 4ab$

6. $(a + b + c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$

7. $\left(a + \frac{1}{a}\right)^2 = a^2 + \frac{1}{a^2} + 2$

8. $a^2 + \frac{1}{a^2} = \left(a + \frac{1}{a}\right)^2 - 2$

9. $\left(a - \frac{1}{a}\right)^2 = a^2 + \frac{1}{a^2} - 2$

10. $a^2 + \frac{1}{a^2} = \left(a - \frac{1}{a}\right)^2 + 2$

11. $\left(a + \frac{1}{a}\right)^2 + \left(a - \frac{1}{a}\right)^2 = 2\left(a^2 - \frac{1}{a^2}\right)$

12. $\left(a + \frac{1}{a}\right)^2 - \left(a - \frac{1}{a}\right)^2 = 4$

13. $(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^2$

14. $a^3 + b^3 = (a + b)^3 - 3ab(a + b)$

15. $(a - b)^3 = a^3 - 3a^2b + 3ab^2 - b^2$

16. $a^3 - b^3 = (a - b)^3 + 3ab(a - b)$

17. $\left(a + \frac{1}{a}\right)^3 = a^3 + \frac{1}{a^3} + 3\left(a + \frac{1}{a}\right)$

18. $a^3 + \frac{1}{a^3} = \left(a + \frac{1}{a}\right)^3 - 3\left(a + \frac{1}{a}\right)$

19. $\left(a - \frac{1}{a}\right)^3 = a^3 - \frac{1}{a^3} - 3\left(a - \frac{1}{a}\right)$

20. $a^3 - \frac{1}{a^3} = \left(a - \frac{1}{a}\right)^3 + 3\left(a - \frac{1}{a}\right)$

Factorisation

1. $a^2 - b^2 = (a+b)(a-b)$

2. $ab + bc + ax + cx = (a+c)(b+x)$

3. $a^3 + b^3 = (a+b)(a^2 - ab + b^2)$

4. $a^3 - b^3 = (a-b)(a^2 + ab + b^2)$

Change The Subject Of A Formula

For eg. $I = \dfrac{P \times R \times T}{100}$

$$P = \frac{I \times 100}{R \times T}$$

$$R = \frac{I \times 100}{P \times T}$$

$$T = \frac{I \times 100}{P \times R}$$

I = Interest

R = Rate per annum

T = Time

P = Principal Amt.

Graphical Solution

1. A linear equation in two variables is given as
$ax + by + c = 0$ where,
x and y are variables and a, b, c are constants

2. Equation of x-axis is $y = 0$

3. Equation of y-axis is $x = 0$

4. The graph $x = a$ [a is a constant] is a straight line parallel to y-axis and at a distance of 'a' units from the y-axis

5. The graph $y = b$ [b is a constant] is a straight line parallel to x-axis and at a distance of V units from the x-axis

Indices (Exponents)

1. $a^m \times a^n = a^{m+n}$
2. $\dfrac{a^m}{a^n} = a^{m-n}$
3. $(a^m)^n = a^{mn}$
4. $(a \times b)^m = a^m \times b^m$
5. $\left(\dfrac{a}{b}\right)^n = \dfrac{a^n}{b^n}$
6. If $a \neq 0$ and n is positive integer

   $\sqrt[n]{a} = a^{\frac{1}{n}}$
7. For $a \neq 0$

   $a^{\frac{m}{n}} = \sqrt[n]{a^m}$
8. For $a \neq 0$

   $a^n = \dfrac{1}{a^{-n}}$ and $a^{-n} = \dfrac{1}{a^n}$
9. For $a \neq 0$

   $a^{\circ} = 1$

Logarithms

1. For $a^b = c$, $\log_c c = b$
2. $\log_a (m \times n) = \log_a m + \log_a n$
3. $\log_a \dfrac{m}{n} = \log_a m - \log_a n$
4. $\log_a (m)^n = n \log_a m$
5. $\log_{10} 1 = 0$ and $\log_{10} 10 = 1$
6. $\log_{10} 100 = 2$

Rectilinear Figures

1. For a n-sided polygon

Sum of interior angles = (2n - 4) x 90°

2. For a regular polygon

Each interior angle = $\dfrac{(2n - 4)\times 90^\circ}{n}$

3. For a regular polygon of 'n' sides

Each exterior angle $= \dfrac{360^\circ}{n}$

Area (Plane Geometric Figures)

1. Area of a triangle = $\frac{1}{2} \times$ base $\times$ height

2. Area of a square = $(\text{side})^2$

3. Area of a Rectangle = length × breadth

4. Area of a Parallelogram = base × height

Mean And Median

1. Mean

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

2. Median

(i) If n is odd,

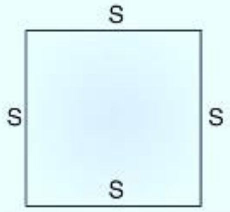
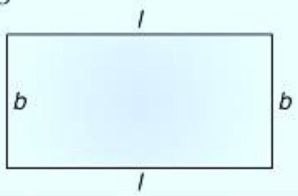
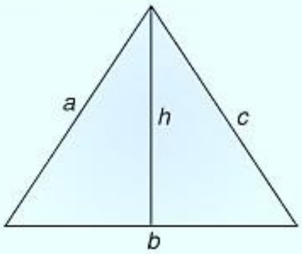
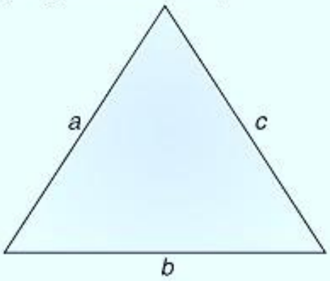
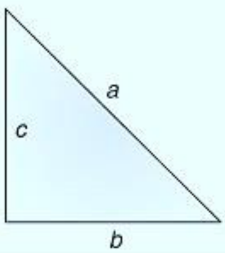
Median = $\left(\dfrac{n+1}{2}\right)^{th}$ term

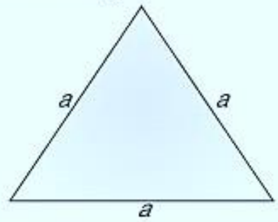
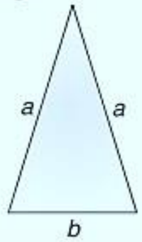
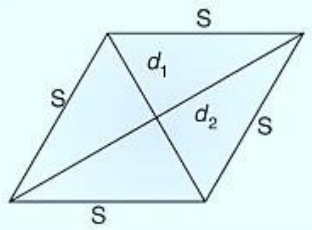
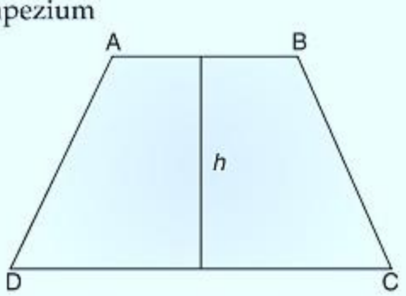
(ii) If n is even,

Median = $\frac{1}{2}$ ×[value of $\left(\dfrac{n}{2}\right)^{th}$ term + value of $\left(\dfrac{n+1}{2}\right)^{th}$ term]

Perimeter And Area

FUNDAMENTALS:

Object	Perimeter (Unit)	Area (Unit^2)
Square 	$4 \times \text{side} = 4s$	$\text{side}^2 = s^2$
Rectangle 	$2(\text{length} + \text{breadth})$ $= 2(l + b)$	$\text{length} \times \text{breadth}$ $= l \times b$
Triangle (given altitude) 	$a + b + c$	$\frac{1}{2} \times \text{base} \times \text{height}$ $= \frac{1}{2} \times b \times h$
Triangle (given all sides) 	$a + b + c$	Heron's Formula : $\sqrt{s(s-a)(s-b)(s-c)}$ where s is semiperimeter *i.e.* $s = \frac{a+b+c}{2}$
Right Triangle 	$a + b + c$	$\frac{1}{2} \times \text{base} \times \text{perpendicular}$ $= \frac{1}{2} \times b \times c$

Equilateral Triangle 	$3a$	$\frac{\sqrt{3}}{4} \times a^2$
Isosceles Triangle 	$2a + b$	$\frac{1}{2} \times b \times \sqrt{a^2 - \frac{b^2}{4}}$
Rhombus 	$4 \times$ side $= 4s$	½ × (product of diagonals) $= ½ \times d_1 \times d_2$
Trapezium 	Sum of all sides $= AB + BC + CD + DA$	$= ½ \times (AB + CD) \times h$

Triangle

1. Area $= \frac{1}{2} \times \text{base} \times \text{height}$

2. When a, b, c are sides of a triangle and S is semi perimeter

Area $= \sqrt{s(s-a)\,(s-b)\,(s-c)}$

3. Area of an equilateral triangle

Area $= \frac{1}{4} \times$ Product of diagonals $\frac{\sqrt{3}}{4} \times (\text{side})^2$

4. Area of an isosceles triangle where a = length of equal sides and b=length of base

Area = $\frac{1}{4} \times b \times \sqrt{4a^2 - b^2}$

Rectangle

1. Area = $(l \times b)$

2. Perimeter = $2(l \times b)$

3. Length of diagonal d = $\sqrt{l^2 \times b^2}$

Square

1. Area =$(\text{side})^2$

2. Perimeter =4 $\times$ side

3. Diagonal d = $\sqrt{2 \times \text{area}}$

Or Diagonal = $\sqrt{2} \times \text{side}$

Parallelogram

1. Area = Base $\times$ Height

Rhombus

1. Perimeter = 4 $\times$ side

2. Area = $\frac{1}{4} \times$ Product of diagonals

Trapezium

1. **Area** = $\frac{1}{2} \times$ (sum of Parallel sides) $\times$ (Distance between Parallel sides)

Circle

1. Circumference C= $2\pi r$ or C= πd

2. Area = πr^2

3. Distance travelled by a wheel or roller in one revolution = its circumference

4. No. of revolutions = $\frac{\text{Total distance}}{\text{circumference}}$

Solids [Areas And Volumes]

1. Cuboid

(i) Volume = $l \times b \times h$

(ii) Total Surface Area = $2(l\,b\times\ bh\times h\,l)$

(iii) Diagonal = $\sqrt{l^2+b^2+h^2}$

(iv) Area of four walls of a rectangular box or room = $2(l+b)\times h$

(v) If box is closed, International Dimensions
Length = $(l-2x)$

Breadth = $(b - 2x)$
Height = $(h - 2x)$

If box is open,

Length = $(l - 2x)$

Breadth = $(b - 2x)$
Height = $(h - x)$

Where x is the thickness of sides of a rectangular box.

2. Cube

(i) Volume = $(\text{edge})^3 = a^3$
where a is the edge

(ii) Total Surface Area = $6a^2$

(iii) Length of diagonal = $\sqrt{3}\ a$

3. Cylinder

(i) Curved Surface Area = $2\pi rh$

(ii) Total Surface Area = $2\pi r(h + r)$

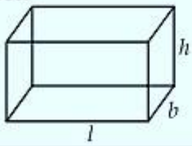
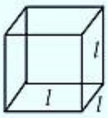
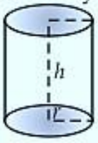
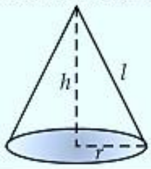
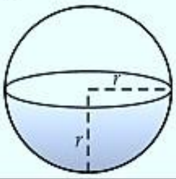
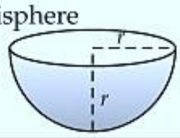
(iii) Volume = $\pi r^2 h$

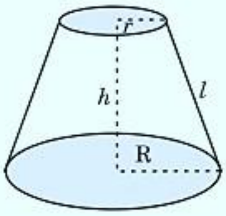
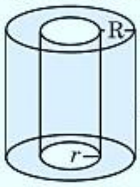
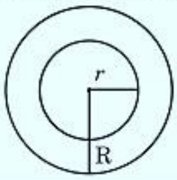
4. Hollow Cylinder

(i) Total Surface Area = $2\pi Rh + 2\ \pi rh + 2\pi(R^2 - r^2)$

(ii) Volume of material = $\pi(R^2 - r^2)h$

FUNDAMENTALS:

S. No.	Object	CSA	TSA	Volume	Nomenclature
1.	Cuboid 	Area of four walls $2(bh + hl)$	$2(lb + bh + hl)$	lbh	l = length b = breadth h = height
2.	Cube 	Area of four walls $4l^2$	$6l^2$	l^3	l = length
3	Right Circular Cylinder 	$2\pi rh$	$2\pi r(r + h)$	$\pi r^2 h$	r = radius of base h = height
4	Right Circular Cone 	πrl	$\pi r(r + l)$	$\frac{1}{3}(\pi r^2 h)$	r = radius of base h = height l = slant height $l = \sqrt{r^2 + h^2}$
5.	Sphere 	$4\pi r^2$	$4\pi r^2$	$\frac{4}{3}(\pi r^3)$	r = radius
6.	Hemisphere 	$2\pi r^2$	$3\pi r^2$	$\frac{2}{3}(\pi r^3)$	r = radius

S. No.	Shape	CSA	TSA	Volume	Nomenclature
7.	**Frustum** 	$\pi l(r + R)$	$\pi\, l(r + R)$ + $\pi\,(r^2 + R^2)$	$\pi\, h(r^2 + R^2 + rR)$	r = radius of small base R = radius of base h = height l = slant height $l = \sqrt{h^2 + (R - r)^2}$
8.	**Right Circular Hollow Cylinder** 	$2\pi h(r + R)$	$2\pi\,(r + R)$ $(R + h + r)$	$\pi\, h(R^2 - r^2)$	r = inner radius R = outer radius h = height
9.	**Spherical Shell** 	$4\pi\, r^2$ [Internal surface Area]	$4\pi\, R^2$ [External surface Area]	$\frac{4}{3}[\pi(R^3 - r^3)]$	r = inner radius R = outer radius

If □, b and h denote respectively the length, breadth and height of a cuboid, then -

(i) Total surface area of the cuboid = 2 (□b+bh+□h) square units.

(ii) Volume of the cuboid = Area of the base × height = □bh cubic units.

(iii) Diagonal of the cuboid or longest rod = $\sqrt{\square^2 + b^2 + h^2}$ units.

(iv) Area of four walls of a room = 2 (□ + b) h sq. units.

2. If the length of each edge of a cube is ‘a’ units, then-

(i) Total surface area of the cube = $6a^2$ sq. units.

(ii) Volume of the cube = a^3 cubic units

(iii) Diagonal of the cube = $\sqrt{3}$ a units.

3. If r and h denote respectively the radius of the base and height of a right circular cylinder, then

(i) Area of each end = πr^2

(ii) Curved surface area = $2\pi rh$

= (circumference) height

(iii) Total surface area = $2\pi r$ (h + r) sq. units.

(iv) Volume = $\pi r^2 h$ = Area of the base × height

4. If R and r (R > r) denote respectively the external and internal radii of a hollow right circular cylinder, then -

(i) Area of each end = $\pi(R^2 - r^2)$

(ii) Curved surface area of hollow cylinder
$= 2\pi\,(R + r)\,h$

(iii) Total surface area = $2\pi\,(R + r)\,(R + h - r)$

(iv) Volume of material = $\pi h\,(R^2 - r^2)$

5. If r, h and ℓ denote respectively the radius of base, height and slant height of a right circular cone, then-

(i) $\ell^2 = r^2 + h^2$

(ii) Curved surface area = $\pi r\ell$

(iii) Total surface area = $\pi r^2 + \pi r\ell$

(iv) Volume = $\frac{1}{3}\pi r^2 h$

6. For a sphere of radius r, we have

(i) Surface area = $4\pi r^2$

(ii) Volume = $\frac{4}{3}\pi r^3$

7. If h is the height, ℓ the slant height and r_1 and r_2 the radii of the circular bases of a frustum of a cone then

(i) Volume of the frustum = $\frac{\pi}{3}\,(r_1^2 + r_1 r_2 + r_2^2)\,h$

(ii) Lateral surface area = $\pi\,(r_1 + r_2)\ell$

(iii) Total surface area = $\pi\{(r_1 + r_2)\ell + r_1^2 + r_2^2\}$

(iv) Slant height of the frustum = $\sqrt{h^2 + (r_1 - r_2)^2}$

(v) Height of the cone of which the frustum is a part = $\frac{h r_1}{r_1 - r_2}$

(vi) Slant height of the cone of which the frustum is a part = $\frac{\ell r_1}{r_1 - r_2}$

(vii) Volume of the frustum = $\frac{h}{3}\left\{A_1 + A_2 + \sqrt{A_1 A_2}\right\}$, where A_1 and A_2 denote the areas of circular bases of the frustum.

Tips:

$$\text{Area} \times \text{Rate} = \text{Cost}$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$1\ m^3 = 1000\ L$$

$$1\ m^3 = 1\ kL$$

$$1\ L = 1000\ cm^3$$

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

$$1\ km = 1000\ m = 10^5\ cm$$

$$1\ km^2 = 10^6\ m^2$$

$$1\ m = 100\ cm$$

$$1\ m^2 = 10000\ cm^2$$

$$1\ km/hr = \frac{5}{18}\ m/sec$$

$$1\ km/hr = \frac{50}{3}\ m/min$$

$$\text{Shape of river} = \text{Cuboid}$$

$$1\ \text{are} = 100\ m^2$$

$$1\ \text{hectare} = 10000\ m^2$$

Trigonometrical Ratios

For any right angled triangle,

1. $\sin\theta = \dfrac{\text{Perpendicular}}{\text{Hypotenuse}}$

2. $\cos\theta = \dfrac{\text{Base}}{\text{Hypotenuse}}$

3. $\tan\theta = \dfrac{\text{Perpendicular}}{\text{Base}}$

4. $\cot\theta = \dfrac{\text{Base}}{\text{Perpendicular}}$

5. $\sec\theta = \dfrac{\text{Hypotenuse}}{\text{Base}}$

6. $\text{cosec}\,\theta = \dfrac{\text{Hypotenuse}}{\text{Perpendicular}}$

7. $\sin^2\theta + \cos^2\theta = 1$

8. $\sec^2\theta - \tan^2\theta = 1$

9. $\text{cosec}^2\theta - \cot^2\theta = 1$

Trigonomatric Ratios Of Standard Angles

Angle	0°	30°	45°	60°	90°
sin	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
tan	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	∞
cot	∞	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	0
Sec	1	$\frac{2}{\sqrt{3}}$	$\sqrt{2}$	2	∞
Cosec	∞	2	$\sqrt{2}$	$\frac{2}{\sqrt{3}}$	1

Solution Of Right Triangle

1. $\cos(90° - \theta) = \sin\theta$

2. $\sin(90° - \theta) = \cos\theta$

Co-Ordinate Geometry

1. For x-axis and every line parallel to x-axis; inclination $\theta = 0°$

$\therefore$ Slope (m) = tan θ = tan 0 = 0

2. For y-axis and every line parallel to y-axis; inclination $\theta = 90°$

$\therefore$ Slope (m) = tan θ = tan 90° = ∞ (infinity)

3. Equation of line in the form y = mx + c

Slope = m

y-intercept = c

FUNDAMENTALS

- Two perpendicular lines (one horizontal and other vertical) are required to locate the position of a point or an object.
- The plane is called the Cartesian or coordinate plane and the lines are called coordinate axes or rectangular axes.
- Horizontal line is called the x-axis and vertical line is called the y-axis.
- The coordinate axes divide the plane into four parts called quadrants.

About Cartesian Plane:

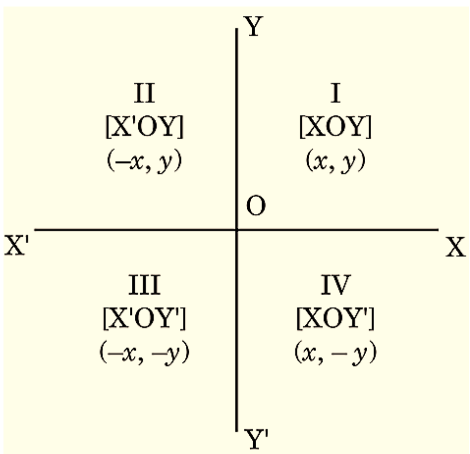
1. Distance of any point from the y-axis is called x co-ordinate or abscissa.
2. Distance of any point from the x-axis is called y co-ordinate or ordinate.
3. Origin: (0, 0).
4. Point on x-axis: (x, 0).
5. Equation of x-axis is y = 0.
6. Equation of y-axis is x = 0.
7. Point on y-axis: (0, y)
8. There are four quadrants in a co-ordinate plane:

In the figure OX and OY are called as x-axis and y-axis respectively and both together are known as axes of co-ordinates.

It has zero distance from both the axes so that its abscissa and ordinate are both zero. Therefore, the coordinates of origin are (0, 0).

The axes divide the plane into four parts. These four parts are called quadrants. So, the plane consists of axes and quadrants. The plane is called the cartesian plane or the coordinate plane or the xy-plane. These axes are called the co-ordinate axes.

A quadrant is $\frac{1}{4}$ part of a plane divided by co-ordinate axes.



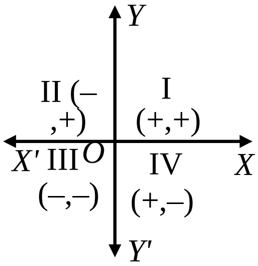
Rules of Signs of Co-ordinates:

(i) In the first quadrant, both co-ordiantes i.e., abscissa and ordinate of a point are positive.

(ii) In the second quadrant, for a point, abscissa is negative and ordinate is positive.

(iii) In the third quadrant, for a point, both abscissa and ordinate are negative.

(iv) In the fourth quadrant, for a point, the abscissa is positive and the ordinate is negative.



Quadrant	x-co-ordinate	y-co-ordinate	Point
First quadrant	+	+	(+,+)
Second quadrant	–	+	(–,+)
Third quadrant	–	–	(–,–)
Fourth quadrant	+	–	(+,–)

Distance Formula:

Distance between two points A (x_1, y_1) and B (x_2, y_2) is:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Corollary: Distance of point A (x, y) from origin is: $\sqrt{x^2 + y^2}$

Tips:

Coordinates will form

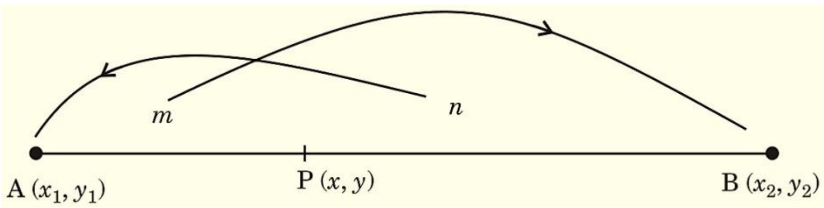
1. Rhombus, if all the four sides are equal.
2. Square, if all the four sides and diagonals are equal.
3. Parallelogram, if opposite sides are equal.
4. Rectangle, if opposite sides and diagonals are equal.
5. Right triangle, if it follows Pythagoras theorem.
6. Colinearity condition. (Sum of two distances = Third distance.)

Section Formula:

Co-ordinates of the point P (x, y), dividing the line segment joining the points A (x_1, y_1) and B (x_2, y_2) internally in the ratio $m : n$ are given by:

$$x = \frac{mx_2 + nx_1}{m+n},\ y = \frac{my_2 + ny_1}{m+n}$$

How to remember the section formula?



Corollary: If P (x, y) is the midpoint, therefore $m : n = 1 : 1$

$$x=\frac{x_2+x_1}{2},\ y=\frac{y_2+y_1}{2}$$

Tips:

If the ratio in which P divides *AB* is not given the then we take assumed ratio as k : 1.

Centroid Formula:

Co-ordinates of the centroid G (x, y) of triangle having vertices (x_1, y_1), (x_2, y_2) and (x_3, y_3) is given by

$$x=\frac{x_1+x_2+x_3}{3},\ y=\frac{y_1+y_2+y_3}{3}$$

Area of Triangle:

Area of triangle having vertices (x_1, y_1), (x_2, y_2) and (x_3, y_3) is given by:

$$A=\frac{1}{2}\left|[x_1(y_2-y_3)+x_1(y_2-y_3)+x_3(y_1-y_2)]\right|$$

Tips:

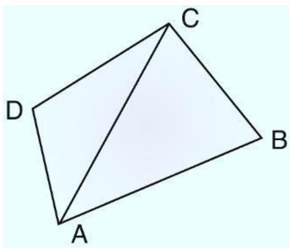
1. To prove three points to be collinear, Area of Triangle = 0

   i.e. $[x_1(y_2-y_3)+x_1(y_2-y_3)+x_3(y_1-y_2)]=0$

2. Area of Quadrilateral *ABCD* = Area of ΔABC + Area of ΔACD.

Or If A (x_1, y_1), B(x_2, y_2), C(x_3, y_3) and D(x_4, y_4) be the vertices of quadrilateral ABCD then area of the quadrilateral ABCD

$$=\frac{1}{2}[x_1y_2-x_2y_1+x_2y_3-x_3y_2+x_3y_4-x_4y_3+x_4y_1-x_1y_4]$$



Physics – II Force

(i) F = ma

Where m is mass of a body and a is acceleration.

(ii) $W = F = mg$

mg is also considered as the weight of the body.

(iii) Momentum = (p) = mv

(iv) SI Units : (F) → newton, (p) → Kg m/s

CGS Units : F → dyne, P → gm cm/s

Machines

(i) For an ideal machine;

Input = Effort x Displacement of effort

Output = Load x Displacement of load

(ii) $\eta = \frac{\text{Work output}}{\text{Work input}} \times 100$

η is efficiency of a machine

(iii) $\text{M.A.} = \frac{\text{Load}}{\text{Effort}}$; where M.A is mechanical advantage.

(iv) $\text{V.R} = \frac{v_E}{v_L} = \frac{d_E}{d_L}$; where V.R is velocity ratio.

v_E is velocity of effort

v_L is velocity of load.

(v) For levers: Load × Load arm = Effort × Effort arm (at equilibrium)

(vi) $\text{M.A for levers} = \frac{\text{Effort}}{\text{Load arm}}$

(vii) $\text{M.A} = \text{V.R.} \times \eta$

If η = 100%, M.A = V.R.

(viii) For an inclined plane:

$$\text{M.A.} = \frac{\text{Load (W)}}{\text{Effort (E)}} = \frac{W}{W\sin\theta} = \frac{1}{\sin\theta} = \frac{s}{h}$$

where s is length of slope and h is height of slope.

$$\text{V.R.} = \frac{d_E}{d_L} = \frac{s}{h}$$

(ix) $V.R = M.A + \frac{x}{E}$

x is the weight due to movable parts of machine and E is effort required.

Work, Power And Energy

(i) W (work done) = $f \times S$ (both acting in the same direction)

(ii) W (work) = $f \times S\cos\theta$

θ is the angle of between f & S

(iii) Work done = Energy

$W = mgh$

$P.E. = mgh$

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

$P = \frac{p^2}{2m}$

p is momentum

Heat Energy = $mc(\Delta\theta)$

$mgh = \frac{1}{2}mv^2 = \frac{p^2}{2m} = mc\Delta\theta$

(delta (Δ) means change in temperature)

(iv) $\text{Power}(p) = \frac{\text{Workdone}}{\text{Time}}$

$= \frac{f \times s}{t}$

(v) Equation of motion

for accelerating bodies

(a) $\vec{v} = \vec{u} + \vec{at}$

(b) $\vec{v^2} - \vec{u^2} = \vec{2as}$

(c) $\vec{s} = \vec{ut} + \frac{1}{2}\vec{at}$

for deaccelerating bodies

(a) $v = u - at$

(b) $v^2 - u^2 = -2as$

(c) $s = ut - \frac{1}{2}at^2$

for free falling bodies

(a) $a = g$

(b) $v = u + gt$

(c) $v^2 - u^2 = 2gs$

(d) $s = ut + \frac{1}{2}gt^2$

$u = 0$ (always)

$\therefore\ v = gt$

$v^2 = 2gs$

$s = \frac{1}{2}gt^2$

for a body thrown upwards:

(a) $a = -g$.

(b) $v = u - gt$

(c) $v^2 - u^2 = -2gs$

(d) $s = ut - \frac{1}{2}gt^2$

$v = 0$ (always)

$\therefore\ u = gt$

$u^2 = 2gs$

$s = ut - \frac{1}{2}gt^2$

where u = initial velocity; v = final velocity; a = acceleration; t = time and s = displacement.

Refraction Through A Lens

Key Points and Concepts:

- Lens Formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

- Linear Magnification: $m = \frac{v}{u}$ or $\frac{h}{h_1}$ (in lens)

$$m = -\frac{v}{u} \text{ or } -\frac{h}{h_1} \text{ (in mirror)}$$

h = Height of object

h1 = Height of image

v = Image distance

u = Object distance

Law of refraction of light:

- **First Law:** The incident ray, the normal to the transparent surface at the point of incidence and the refracted ray, all lie in one and the same plane.
- **Second Law:** The ratio of sine of angle of incidence to the sine of the angle of refraction is constant and is called refractive index of the second medium with respect to the first medium.

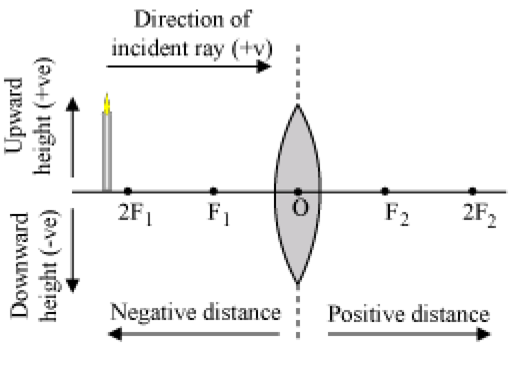
$$\frac{\sin i}{\sin r} = \mu$$

Sign Convention:

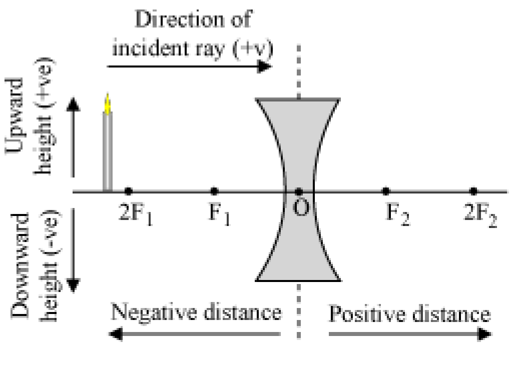
Description: It is a convention which fixes the signs of different distances measured. The sign convention to be followed is the New Cartesian sign convention. It gives the following rules :

1. All distances are measured from the pole of the mirror.
2. The distances measured in the same direction as the direction of incident light from pole are taken as positive.
3. The distances measured in the direction opposite to the direction on incident light from pole are taken as negative.
4. Distances measured upward and perpendicular to the principal axis, are taken as positive.
5. Distances measured downward and perpendicular to the principal axis, are taken as negative.

Sign Convention in Lens:



Convex mirror



Concave mirror

- Power of a lens $P = \frac{1}{f\,(m)}$

Characteristics of the images formed in lenses:

(i) Convex Lens

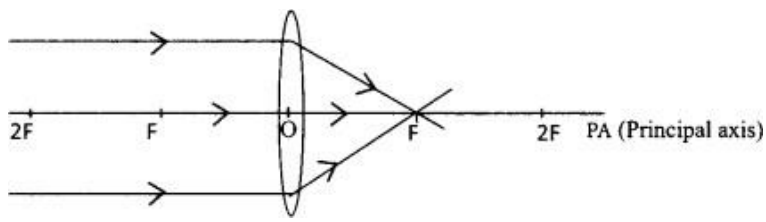
Position of object	Nature of image	Type	Position	Size
At infinity	real	inverted	at F	highly diminished
Beyond 2F	real	inverted	between F & 2F	diminished
At 2F	real	inverted	at 2F	same size as object
Between F & 2 F	real	inverted	beyond 2F	magnified
At F	-	-	at infinity	highly magnified
Between F&O	virtual	erect	on the same side of the lens as the object	magnified

(ii) Concave Lens

Position of object	Nature of image	Type	Position	Size
At infinity	virtual	inverted	at F	highly diminished
At F	virtual	inverted	Within the focal length	diminished

Diagrams for Convex Lens: (converging lens)

(i) Object at infinity:



<u>Characteristics of image:</u>

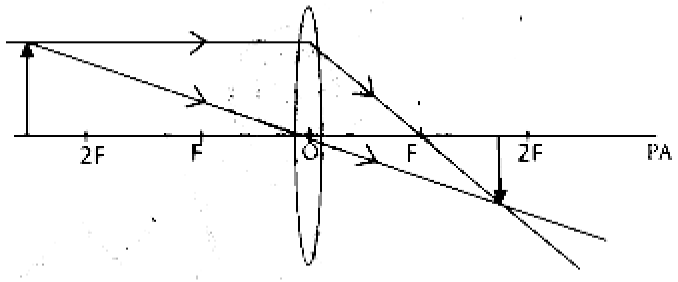
(a) It is real.

(b) It is inverted.

(c) It is at F.

(d) It is highly diminished.

(ii) Object beyond 2F:



Characteristics of image:

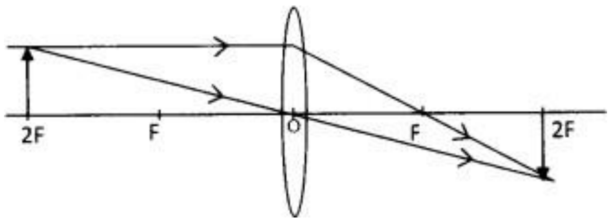
(a) It is real.

(b) It is inverted.

(c) It is between F and 2F.

(d) It is diminished.

(iii) Object at 2F



Characteristics of image:

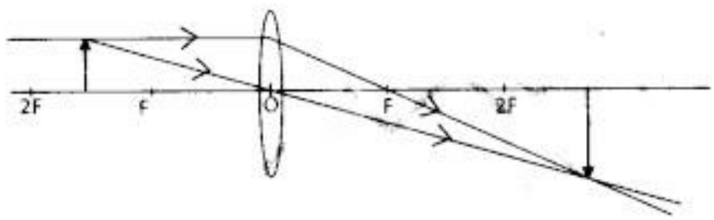
(a) It is real.

(b) It is inverted.

(c) It is at 2F.

(d) It is of the same size as the object.

(iv) Object between F and 2F



Characteristics of image:

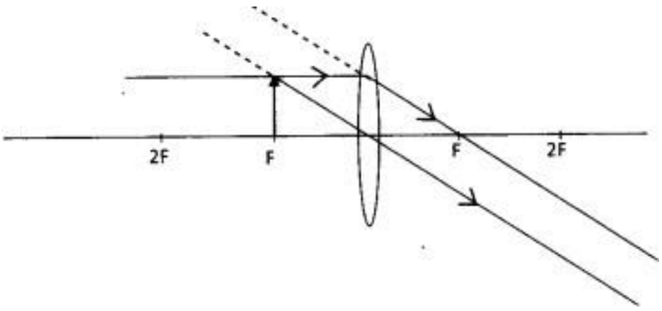
(a) It is real.

(b) It is inverted.

(c) It is at 2F.

(d) It is magnified

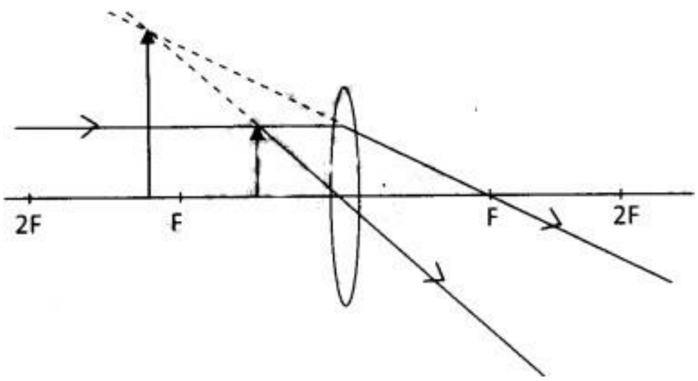
(v) Object at F



The refracted rays are parallel and hence it is assumed that the image is formed at infinity.

In case the characteristics are asked: The image is real, inverted and highly magnified.

(vi) Objects between F and O, the optic centre



Characteristics of image:

(a) The image is virtual.

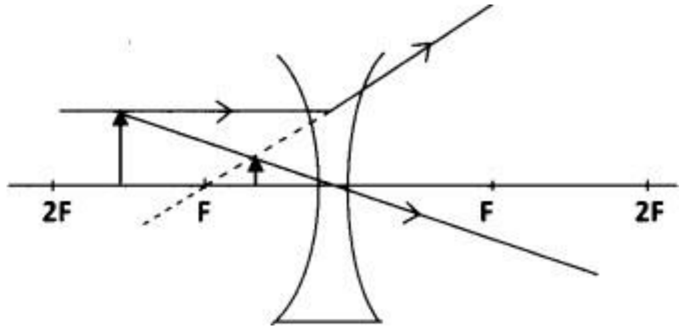
(b) The image is erect.

(c) The image is magnified

(d) The image is on the same side of the lens as the object.

Diagrams for concave lenses (diverging lens):

(i) Object in front of the lens but not at infinity.



<u>Characteristics of image:</u>

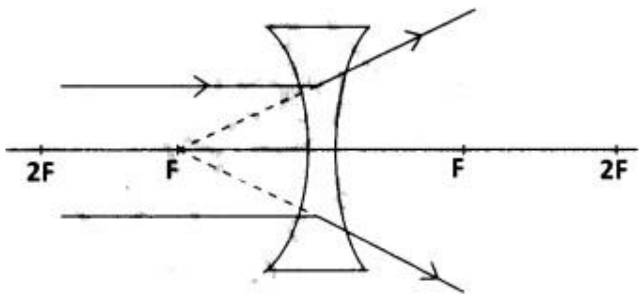
(a) It is virtual.

(b) It is erect.

(c) It is within the focal length.

(d) It is diminished.

(ii) **Objects at infinity:**



<u>Characteristics of image:</u>

(a) It is virtual.

(b) It is erect.

(c) It is at the focus.

(d) It is highly diminished.

Image Formation in Convex Lens Using Ray Diagrams

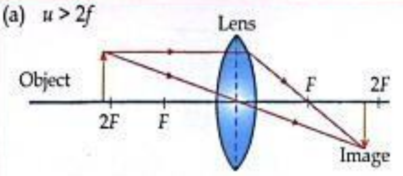
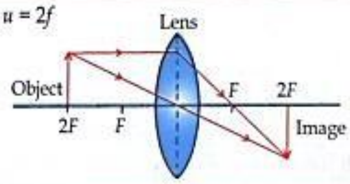
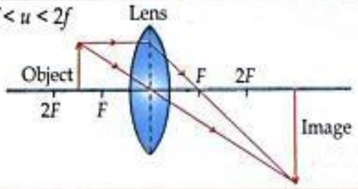
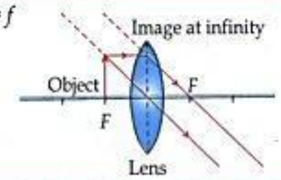
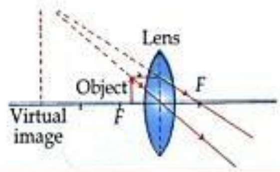
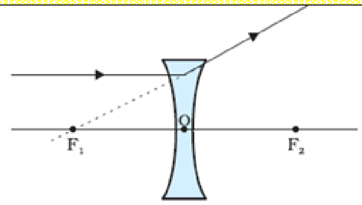
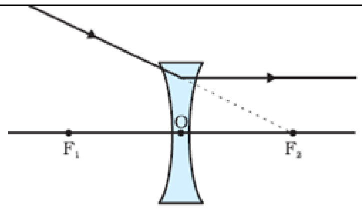
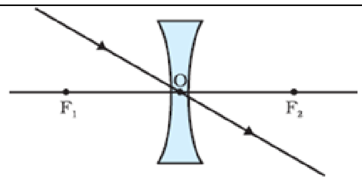
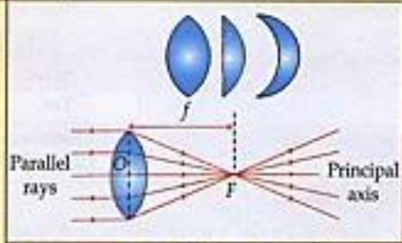
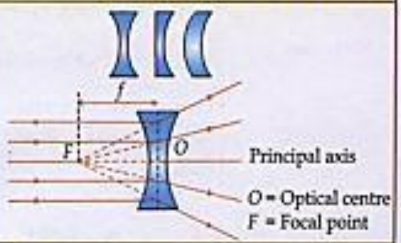
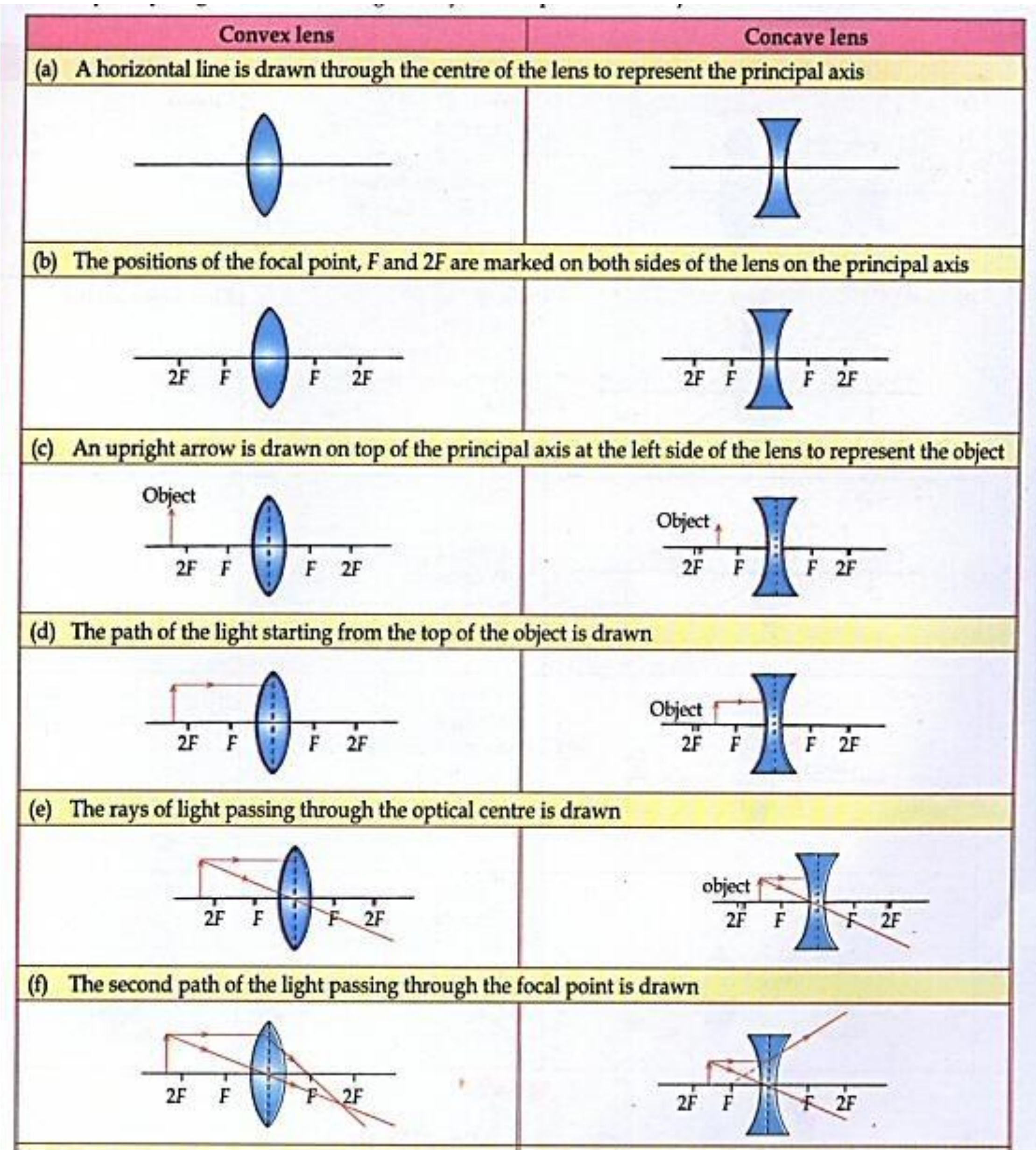
Focal length and ray diagram	Characteristics of image	Used in
(a) $u > 2f$ 	• Real • Inverted • Diminished • Positioned between f and $2f$ in front of the lens	Camera
(b) $u = 2f$ 	• Real • Inverted • Same size as the object • Positioned at $2f$ in front of the lens	Photostat machine
(c) $f < u < 2f$ 	• Real • Inverted • Bigger than the object • Positioned at a distance more than $2f$ in front of the lens	Projector
(d) $u = f$ 	• Virtual • Upright • Bigger than the object • At infinity	Eye lens, astronomical telescope and spotlight
(e) $u < f$ 	• Virtual • Upright • Bigger than the object • Behind the object and behind the lens	Magnifying lens

Image Formation in Concave Lens Using Ray Diagrams

	Light ray from object is	Ray diagram	How it appears after refraction
1	parallel to the principal axis		After refraction from a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens
2	passing through a principal focus		After refraction from a concave lens, will emerge parallel to the principal axis
3	passing through the optical center of a lens		After refraction from a concave lens will emerge without any deviation

Aspects	Convex lens	Concave lens
Shape	• Has a thick middle part and thinner ends	• Has a thin middle part with thicker ends
Uses	• To focus light • The function is the same as the human eye lens	• To disperse light
Characteristics of image	• Change according to the distance of object	• Always virtual, upright and diminished
Optical terms		
	• Optical centre (*O*): A point at the centre of a lens. Light rays passing through it are not refracted • Principal axis: A straight line which passes through the optical centre at a right angle with the axis of the lens • Focal point/principal focus (*F*): A point on the principal axis where light rays that are parallel to the principal axis will converge after passing through a lens • Focal length (*f*): The distance between the focal point and the optical centre • Object distance (*u*): The distance between the object and the optical centre • Image distance (*v*): The distance between the image and the optical centre	



Sound

(i) $v = f \times \lambda$

Where f is frequency; v is wave velocity and λ is wave length of the wave.

(ii) $$\frac{f_A}{f_B} = \frac{\lambda_B}{\lambda_A}$$

If velocity / medium is the same for two waves.

(iii) $$v = \frac{d}{t}$$

$d = \frac{vt}{2}$ for echo.

(a) distance between the sound source & the observer must be atleast 17 m.

(b) For hearing echo, sound after reliction in the medium should reach after $\frac{1}{10}$ th of a second.

(c) The original energy must have sufficient energy.

Current Electricity

(i) $R = \rho \frac{l}{A}$

Where ρ is resistivity or specific resistance.
R is resistance (R in ohm)

l = Length of a wire (m)

a = area of cross section of wire (m^2)

$\delta \rightarrow$ ohm – metre

(ii) Resistors in series combination

$R = R_1 + R_2 + R_3 + \ldots\ldots\ldots + R_n \qquad (n \in N)$

In series, current remains same, but potential difference is different.

(iii) Resistors in parallel combination

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2} + \ldots.. + \frac{1}{R_n} \qquad (n \in N)$$

In parallel, potential difference remains same, but current is different.

(iv) V=IR (ohm's Law)

where V=Potential difference (V in volt)

I = current (I in ampere)

R = resistance (ohm - Ω)

(v) E = I(R+r)

where E is electromotive force (emf)

r is internal resistance

R is the external circuit resistance.

(vi) $Q = I \times t$

where Q is charge and t is time taken (Q in coulomb)

(vii) Power (in elec.) = VI = $\frac{V^2}{R}$ = I^2R [P is measured in watt(w)]

(viii) Electricity Energy = Heat energy

$= V \times Q$

$= IR \times It$

$= I^2Rt$

$= \frac{V^2t}{R}$

$= VIt$

(ix) When a number of cells (of equal emf) are connected in series;
Total emf of all cells = number of cells × emf of each cell

(x) When a number of cells (of equal emf) are connected in parallel;
Total emf of all cells = emf of one cell

Key Points and Concepts

- **Coulomb's Law:** The force of attraction or repulsion between two point charges is (j) directly proportional to the product ($q_1 q_2$) of the two charges and (ii) inversely proportional to the square of distance (r) between them.

  Mathematically,

$$F = \frac{Kq_1q_2}{r^2}$$

The value of K depends on the nature of the medium between the two charges and the system of units chosen. For charges in vacuum $K = 9 \times 10^9 Nm^2/C^2$.

- The quantity of electric charge flowing through cross section of a given conductor in one second is called current. Thus, if Q is the charge which flows through a conductor in time t, then the current (I) is given by

$$\text{Current (I)} = \frac{\text{Charge (Q)}}{\text{Time(t)}}$$

- Potential difference $= \frac{\text{Work done}}{\text{Charge}}$ or $V = \frac{W}{Q}$

- 1 volt $= \frac{1 \text{ Joule}}{1 \text{ Coulomb}}$ or I V $= \frac{1\text{ J}}{1\text{ C}}$

- **Ohm's law:** This law states that the current passing through a conductor is directly proportional to the potential difference across its ends, provided the physical conditions like temperature, density etc., remain unchanged.

$$I \propto V \text{ or } I = (1/R)V$$

R is called resistance of the conductor.

$$\text{Resistance} = \frac{\text{Potential difference}}{\text{Current}} \quad \text{or} \quad R = \frac{V}{I}$$

$$1 \text{ ohm} = \frac{1 \text{ Volt}}{1 \text{ Ampere}} \quad \text{or} \quad 1\,\Omega = \frac{1\text{ V}}{1\text{ A}}$$

- **Factors on which resistance of a conductor depends:** The resistance R of a conductor depends on its length L, area of cross-section A and the nature of its material. It is given by

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

The proportionality constant ρ is called resistivity of the conductor.

- **Joule's law of Heating:** It states that the heat produced in a conductor is directly proportional to (i) the square of the current I through it, (ii) its resistance R and (iii) the time t, for which current is passed.

Mathematically, it can be expressed as

$$H = I^2Rt \text{ joule} = \frac{I^2Rt}{4.18} \text{cal}$$

$$H = VIt \text{ joule} = \frac{VIt}{4.18} \text{cal}$$

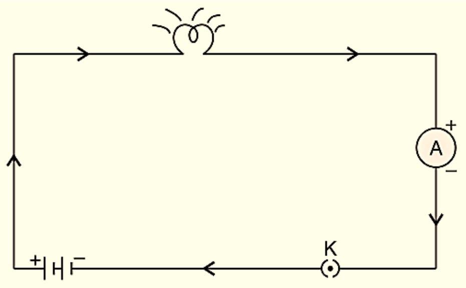
$$P = \frac{W}{t} = VI = I^2R = \frac{V^2}{R}$$

- Electric Power Efficiency, $\eta = \dfrac{\text{Output power}}{\text{Input power}}$

Quantities and Units:

Quantities	S. I. Units
Charge	Coulomb
Electric	Current Ampere
Potential Difference	Volt
Resistance	Ohm
Resistivity	Ohm metre
Heat	Joule
Electric Power	Watt

Schematic Diagram of an electric circuit:



Flow of Current in Metal

Metals show a very different kind of bonding called metallic bonding. According to this bonding, the outermost electrons are not bound to any particular atom, and move freely inside the metal randomly as shown in fig. So, these electrons are free electrons. These free electrons move freely in all the directions. Different electrons move in different directions and with different speeds. So there is no net movement of the electrons in any particular direction. As a result, there is no net flow of current in any particular direction.

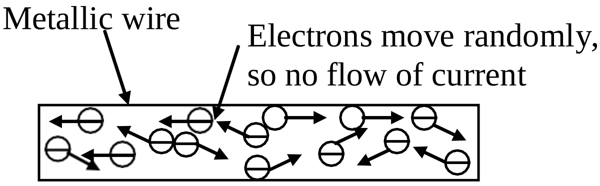


Fig. Flow of electrons inside a metal wire when no potential is applied across its ends

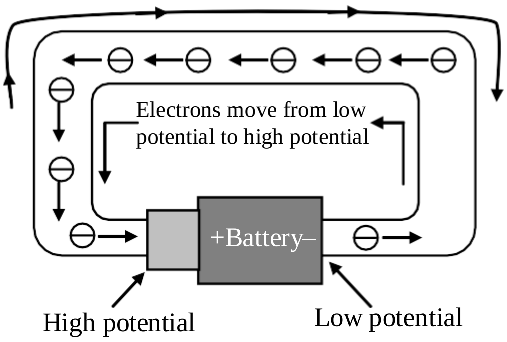


Fig. Flow of electrons inside a metal wire when the two ends of a wire are connected to the two terminals of a battery

Classification of Material on Basis of Resistivity:

Substances showing very low resistivity: The substances which show very low resistivities allow the flow of electric current through them. These type of substances are called conductors.

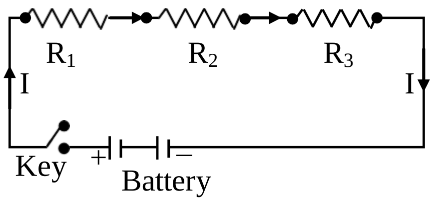
For example, copper, gold, silver, aluminium and electrolytic solutions are conductors.

Substances having moderate resistivity: The substances which have moderate resistivity offer appreciable resistance to the flow of electric current through them. Therefore, such substances are called resistors. For example, alloys such as nichrome, manganin, constantanand carbon are typical resistors.

Substances having very high resistivity: The substances which have very high resistivities do not allow electricity to flow through them. The substances which do not allow electricity to pass through them are called insulators. For example, rubber, plastics, dry wood, etc. are insulators.

Combination of Resistances:

When two or more resistances are joined end-to-end so that the same current flows through each of them, they are said to be connected in series. When a series combination of resistances is connected to a battery, the same current (I) flows through each of them.



When a series combination of resistances is connected to a battery, the same current (I) flows through each of them.

Law of combination of resistances in series: The law of combination of resistances in series states that when a number of resistances are connected in series, their equivalent resistance is equal to the sum of the individual resistances. Thus, if R_1, R_2, R_3 ..., etc. are combined in series, then the equivalent resistance (R) is given by,

$$R = R_1 + R_2 + R_3 + ... \quad .... (i)$$

Derivation of mathematical expression of resistances in series combination: Let, R_1, R_2 and R_3 be the resistances connected in series, I be the current flowing through the circuit, i.e., passing through each resistance, and V_1, V_2 and V_3 be the potential difference across R_1, R_2 and R_3, respectively. Then, from Ohm's law,

$$V_1 = IR_1, V_2 = IR_2 \text{ and } V_3 = IR_3 \quad ... (ii)$$

If, V is the potential difference across the combination of resistances then,

$$V = V_1 + V_2 + V_3 \quad ... (iii)$$

If, R is the equivalent resistance of the circuit, then $V = IR$ ... (iv)

Using Equations (i) to (iv) we can write,

$$IR = V = V_1 + V_2 + V_3$$

$$= IR_1 + IR_2 + IR_3$$

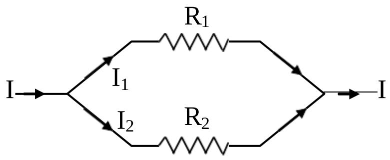
or, $$IR = I (R_1 + R_2 + R_3)$$

or, $$R = R_1 + R_2 + R_3$$

Therefore, when resistances are combined in series, the equivalent resistance is higher than each individual resistance.

Parallel Combination:

When two or more resistances are connected between two common points so that the same potential difference is applied across each of them, they are said to be connected is parallel.



When such a combination of resistance is connected to a battery, all the resistances have the same potential difference across their ends.

Derivation of mathematical expression of parallel combination:

Let, V be the potential difference across the two common points A and B. Then, from Ohm's law

Current passing through R_1, $I_1 = V/R_1$ ... (i)

Current passing through R_2, $I_2 = V/R_2$ ... (ii)

Current passing through R_3, $I_3 = V/R_3$ ... (iii)

If R is the equivalent resistance, then from Ohm's law, the total current flowing through the circuit is given by,

$$I = V/R \quad \text{... (iv)}$$

and

$$I = I_1 + I_2 + I_3 \quad \text{... (v)}$$

Substituting the values of I, I_1, I_2 and I_3 in Eq. (v),

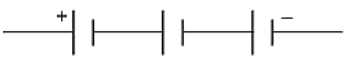
$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \text{... (vi)}$$

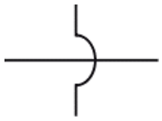
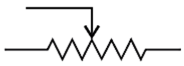
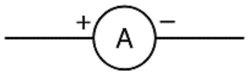
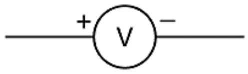
Cancelling common V term, one gets

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The equivalent resistance of a parallel combination of resistance is less than each of all the individual resistances.

Components of electric circuit:

S.No	Components	Symbols
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	

5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	 or 
8	A resistor of resistance	
9	Variable resistance or rheostat	 or 
10	Ammeter	
11	Voltmeter	

Electric Power And Household Electricity

(i) Electrical Energy $= \text{Heat Energy}$

$= I^2Rt$

$= \dfrac{V^2t}{R}$

$= VIt$

$= \text{Power} \times \text{Time}$

SI unit of electrical energy is joule.

(ii) Power at home is in Kw

(iii) 1kW = 1000 watts

(iv) Energy consumed = kWh

= 1kWh is the energy used when 1kW of power is used for 1 hour.

(v) To find the energy in kWh

$$\frac{\text{Power of bulb (in watt)} \times \text{time for which it is used (in hour)}}{1000}$$

This gives the no. of units consumed.

To calculate the cost;

Cost = Number of units × cost/unit

Electromagnetism

For transformers;

$$\frac{\text{Output Potential differnce (Vs)}}{\text{Input Potential differnce (Vp)}} = \frac{\text{No.of turns in secondary}}{\text{No.of turns in primary}}$$

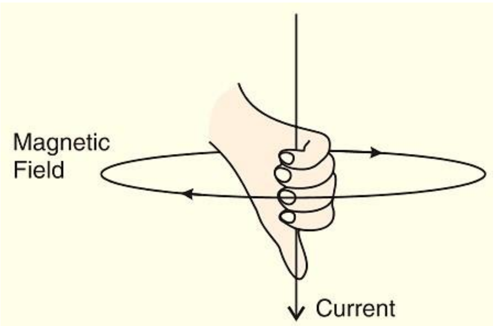
$$= \frac{\text{current in primary}}{\text{current in secondasry}}$$

$$\Rightarrow \frac{Vs}{Vp} = \frac{Ns}{Np} = \frac{Ip}{Is}$$

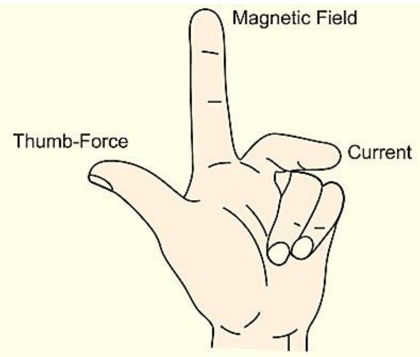
Key Points and Concepts

Magnetism: The property due to which a substance attracts iron pieces towards it, is called magnetism. The substance having property of magnetism, is called magnet.

Right Hand Thumb Rule: Hold the wire carrying current in your right hand, such that the thumb indicates the direction of current, then the folded fingers will indicate the presence of magnetic field (lines) surrounding the wire.



Fleming's Left Hand Rule:



Fleming's left–hand rule is used to find out the direction of motion of a current–carrying conductor when placed in a magnetic field. This rule states as follows.

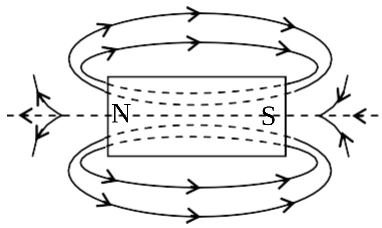
Stretch out the thumb, the forefinger, and the second (middle) finger of the left hand so that these are at right angles to each other. If the forefinger gives the direction of the magnetic field (N to S), the second (middle) finger the direction of current (+ to –), then the thumb gives the direction of the force acting on the conductor.

Since the conductor will move in the direction of the force acting on it hence the thumb gives the direction of motion of the conductor.

Faraday's Law: The rate at which the magnetic flux linked with a coil changes, produces the induced emf or current. More the rate, more the current and vice-versa.

$$I = \frac{e}{R} = \frac{\text{Change in flux}}{\text{Resistance} \times \text{Time}}$$

Properties of Magnetic Lines of Force:



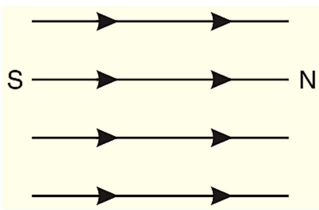
1. They start from a north (positive) pole and end at a south (negative) pole.
2. Two lines of force do not intersect each other.
3. They tend to contract longitudinally (longitudinal contraction).
4. They tend to expand laterally (lateral repulsion) so as to exert lateral pressure on neighboring lines.
5. (The above two properties are similar to that of a stretched rubber band).
6. The number of magnetic lines of force passing normally per unit area about a point, gives the intensity of the magnetic field at the point.

Electric Motor and Generator:

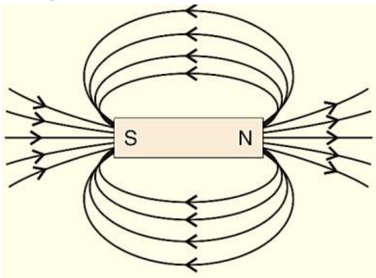
S.No	Electric Motor	Generator
1	Motor converts electrical energy into mechanical energy.	Converts mechanical energy to electrical energy.
2	Works on the principle of Fleming's left hand rule.	Works on the principle of Fleming's right hand rule.

➢ No. of lamps = $\frac{\text{Current rating}}{\text{Current through one lamp}}$

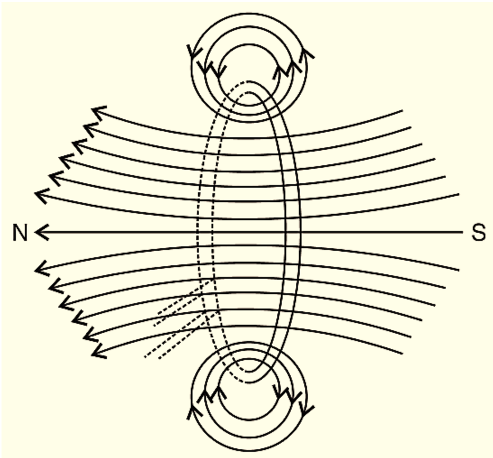
Uniform Magnetic Field:



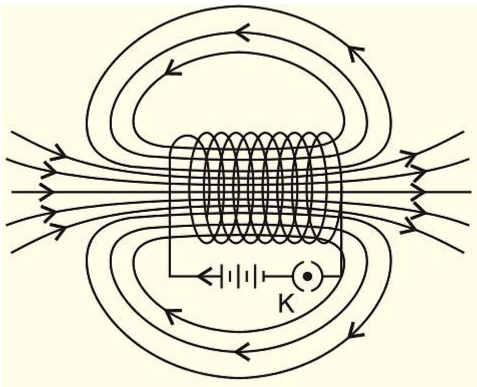
Magnetic Lines around a bar magnet:



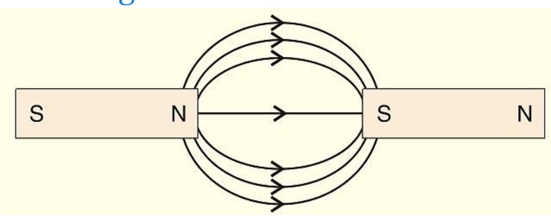
Magnetic Lines due to a current carrying loop:



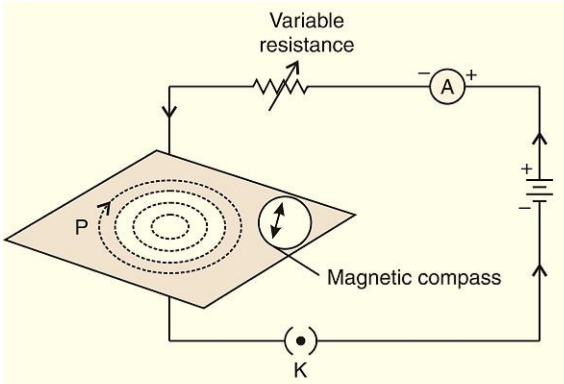
Magnetic field in a solenoid:



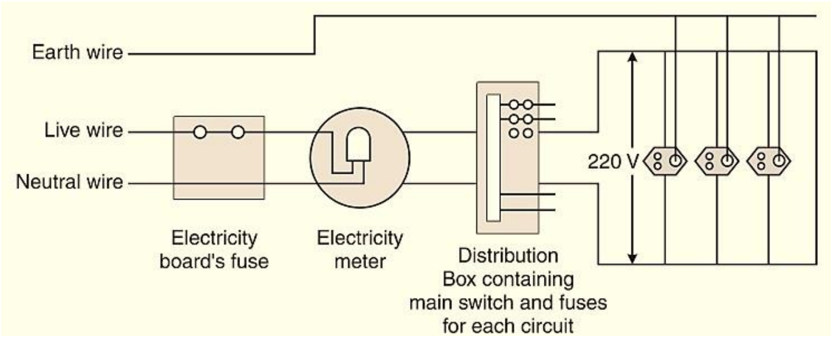
Magnetic Lines around two magnets:



Magnetic Lines Produced Around a current carrying conductor:



Common Domestic Circuit:



Points to Be Remember:

- A freely suspended magnet always stays north–south.
- The region around a magnet in which its magnetic force can be detected is called the magnetic field.
- Magnetic field is represented by magnetic field lines.
- The tangent at any point of a magnetic field line represents the direction of magnetic field at the point.
- The number of lines of force passing through a unit area represents the strength of the field. If the lines of force are closer, the magnetic field is stronger.
- The magnetic field lines around a current–carrying straight conductor are concentric circle around the conductor.
- The direction of magnetic field due to a current–carrying straight conductor is given by Fleming's right–hand rule.
- The magnetic field due to a current–carrying solenoid is similar to that of a bar magnet. The magnetic field inside a solenoid is nearly uniform and is parallel to the axis of the solenoid.
- A magnet formed due to the magnetic field of a current is called an electromagnet. An electromagnet essentially consists of a soft iron core wrapped around with an insulated copper wire coil.
- An electric motor is a device that converts electrical energy into mechanical energy. It is based on the principle that: When a current carrying coil is placed in a magnetic field, a torque acts on it.
- When a conductor moves perpendicular to a magnetic field, an emf is induced across its ends. The direction of induced emf or the induced current is determined by the Fleming's right–hand rule.

- Generator is based on the principle of electromagnetic field, with a continuous change in flux due to which an emf is induced.
- Power is transmitted from the power station to cities at high voltage and low current to minimize power loss.
- A fuse is a wire of high resistance and made up of a material of low melting point.

Calorimetry

(i) Heat energy = $mc\Delta t$

$$c = \frac{Q}{m\Delta\theta} \text{ or } \frac{Q}{m\Delta t}$$

where m is mass of the body (kg)

c is specific heat capacity (J/kg K or J/Kg °C)

θ is change in temperature.

(ii) Heat energy = mL (L is the specific latent heat J/kg)

(when there is change of state at its melting or boiling point of substances)

(iii) Heat lost by hot body or bodies = heat gained by cold body or bodies,
If there is no exchange of heat within surrounding,
i.e. $mc\Delta\theta$ (of hot body) = $mc\theta$ (of cold body)

(iv) Specific heat capacity of water = $4200 \text{ J kg}^{-1}\text{K}^{-1}$
$= 4.2 \text{ Jg}^{-1}\text{K}^{-1}$
$= 1 \text{ kcal kg}^{-1}\text{K}^{-1}$

(v) Specific heat capacity of ice = $2100 \text{ J kg}^{-1}\text{K}^{-1}$
$= 2.1 \text{ Jg}^{-1}\text{K}^{-1}$
$= 0.5 \text{ kcal kg}^{-1}\text{K}^{-1}$

(vi) Specific latent heat of fusion ice = $336000 \text{ J kg}^{-1}\text{K}^{-1}$
$= 336 \text{ Jg}^{-1}\text{K}^{-1}$
$= 80 \text{ kcal kg}^{-1}\text{K}^{-1}$

(vii) Specific latent heat of vaporisation of steam = $2268 \times \text{J kg}^{-1}$
$= 2268 \text{ Jg}^{-1}$
$= 540 \text{ cal g}^{-1}$

Modern Physics

(i) α emission: atomic number reduces by 2 and atomic mass number reduces by 4.

(ii) β emission: mass number is unaffected but atomic number increases by 1.

Chemistry -II

Acids, Bases & Salts

Key Points and Concepts

- Those substances which turn blue litmus solution red are called acids. Acids are sour in taste. They give H^+ ions in aqueous solution. Example:

  $$HCI, H,SO_4, HNO_3, CH_3COOH$$

- Those acids which dissociates into ions completely are called strong acids, e.g. H2So4, HCl.
- Those acids which do not dissociates into ions completely are called weak acids, e.g., citric acid, acetic acid.
- The reaction in which base or basic oxide reacts with acid or acidic oxide is called neutralization reaction. Example: NaOH(aq) + HCI(aq) > NaCl(aq) + H2o
- Hydrated salts which are white in colour:

  Washing soda : $Na_2CO_3.10H_2O$

  Gypsum : $CaSO_4.2H_2O$

  Plaster of paris : $CaSO_4.\frac{1}{2}H_2O$

Reaction of different solutions with different indicators:

S.No	Name of the solution	Colour change (if any) Phenolphthalein	Colour change (if any) Blue litmus
1	Sodium carbonate	tunis pink	no change
2	Hydrochloric acid	no change	turns red
3	Sodium chloride	no change	no change

Important Equations:

Baking Soda

The chemical formula of baking soda is NaHCO3.

It is prepared by using sodium chloride.

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

On heating:

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

Green Vitriol:

$FeSO_4.7H_2O$ is green in colour and loses water of crystallisation when it is heated.

It is then decomposed to Fe_2O_3 (brown coloured), SO_2 and SO_3.

$$FeSO_4.7H_2O \xrightarrow{\Delta} FeSO_4 + 7H_2O$$

$$2FeSO_4(s) \xrightarrow{\Delta} Fe_2SO_3(s) + SO_2(g) + SO_3(g)$$

Plaster of Paris:

$CaSO_4.\frac{1}{2}H_2O$ (Calcium sulphate hemihydrate)

When plaster of paris reacts with water

$$\underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + 1\frac{1}{2}.H_2O \longrightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O}$$

Washing Soda and its Properties:

Chemical name is Sodium carbonate hydrated

Formula : $Na_2CO_3.10H_2O$

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

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

$$Na_2CO_3 + 10H_2O \xrightarrow[32^\circ C]{\text{lower than}} Na_2CO_3.10H_2O$$

It is a basic salt because when dissolved in water it gives a strong base NaOH.

It is used as a cleaning agent, in paper and glass industry.

Bleaching Powder and its Properties:

The common name of $CaOCl_2$ is bleaching powder.

By passing chlorine into dry slaked lime $Ca(OH)_2$, bleaching powder is obtained.

$$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$$

Two uses:

(i) Used for bleaching cotton and linen in the textile industry and wood pulp, paper industry etc.

(ii) It is used for disinfecting drinking water.

- Some of the naturally occurring substances that contain acids are given in Table.

Substance	Acid present
1. Orange, lemon	Citric acid, ascorbic acid (vitamin C)
2. Apple	Malic acid
3. Tamarind (imli), grape	Tartaric acid
4. Vinegar	Acetic acid
5. Curd	Lactic acid
6. Tomato	Oxalic acid
7. Gastric juice	Hydrochloric acid
8. Tea	Tannic acid
9. Red ants	Formic acid

- Examples of a few acids with their basicities are given in the table below.

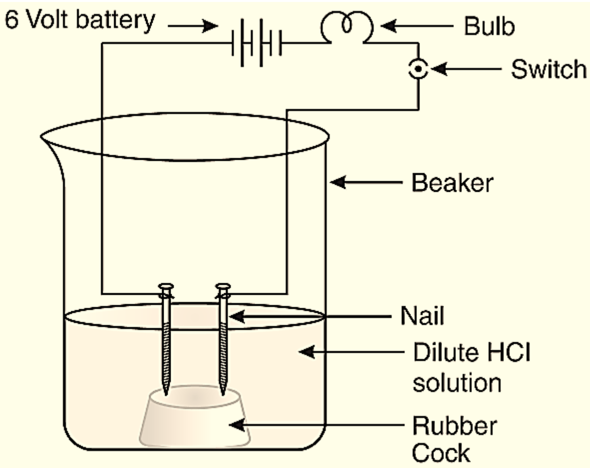
Acid	Basicity
HCl	1
HNO_3	1
H_2SO_4	2
H_3PO_4	3

- The following table shows the uses of some organic and inorganic acids.

Acid	Uses
Organic acids	
Citric acid	1. As a preservative for food
	2. As a flavouring agent
Ascorbic acid (also called vitamin C)	In the treatment of bone marrow and scurvy diseases
Acetic acid	Added to pickles to make them sour
Tartaric acid	A component of baking power (baking powder is a mixture of sodium hydrogencarbonate and tartaric acid)
Inorganic acids	
Hydrochloric acid	1. Its presence in the gastric juice helps digestion of food we eat.
	2. As a bathroom cleaner
	3. In the manufacture of polyvinyl chloride (PVC)
Nitric acid	1. Nitric acid present in rainwater forms nitrates in the soil which are then used by plants to obtain nitrogen.

	2. In the manufacture of fertilizers like ammonium nitrate
	3. In making explosives like TNT and dynamite
Sulphuric acid	1. In storage batteries
	2. In the manufacture of fertilizers, paints and pigments, detergents and artificial fibre
	3. In the manufacture of hydrochloric acid and alum
Phosphric acid	In fertilizer and detergent industries
Boric acid	1. In the manufacture of glass, glazes and enamels, leather, paper, adhesives and explosives
	2. Widely used in detergents
	3. As a grain preservative

Setup which shows acid solution in water conducts electricity:



- Some of the bases are listed here in Table.

Oxides	Soluble hydroxides	Insoluble hydroxides
Sodium monoxide (Na_2O)	Sodium hydroxide ($NaOH$)	Ferric hydroxide ($Fe(OH)_3$).
Calcium oxide (CaO)	Potassium hydroxide (KOH)	Aluminium hydroxide ($Al(OH)_3$)
Cupric oxide (CuO) ZnO	Calcium hydroxide ($Ca(OH)_2$) Ammonium hydroxide NH_4OH	

- Table lists some of the common bases and their uses.

Bases	Uses
Sodium hydroxide	1. In the manuacture of soaps, textile, paper, medicines 2. In the refining of petroleum
Ammonium hydroxide	1. As a reagent in the laboratory 2. In making fertilizers, rayon, plastics and dyes
Calcium hydroxide	1. In making cement and mortar 2. In making bleaching powder 3. In whitewashing 4. In removing acidity of soils

- Some of the most commonly used acid-base indicators that change colour as follows.

Indicator	Acid solution	Basic solution	Neutral solution
Blue litmus solution	Red	No change in colour	No change in colour
Red litmus solution	No change in colour	Blue	No change in colour
Methyl orange	Red	Yellow	Orange
Phenolphthalein	Colourless	Red	Colourless

- The following table lists uses of some salts.

Salts	Uses
Sodium chloride	1. An essential requirement of our food 2. In the preservation offood 3. In curing fish andmeat 4. In making a freezing mixture which is used by icecream vendors 5. In the manufacture ofsoaps
Sodium carbonate	1. As washing soda for cleaning clothes 2. Used in the manufacture of glass, paper, textiles, caustic soda, etc. 3. In the refining ofpetroleum 4. In fire extinguishers
Sodium bicarbonate	1. Used as baking soda 2. In fire extinguishers 3. As an antacid in medicine
Potassium nitrate	1. To make gunpowder, fireworks and glass 2. As a fertilizer inagriculture
Copper sulphate	1. Commonly called 'blue vitriol', used as a fungicide to kill certain germs 2. In electroplating 3. In dyeing
Potash alum	1. Used to purify water; makes suspended particles in water settle down 2. As an antiseptic 3. In dyeing

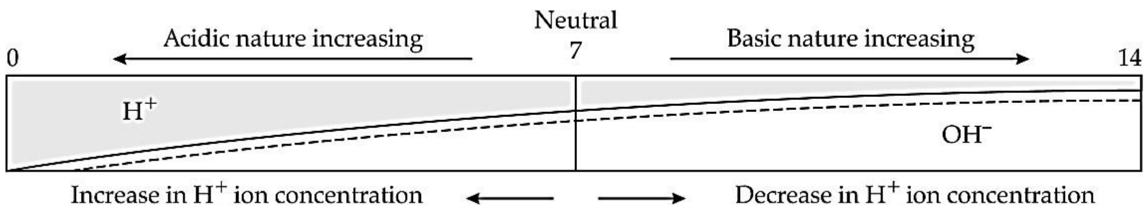
pH Indicator:

The acidity or basicity (alkalinity) of a solution is usually expressed in terms of a function of the H^+ ion concentration. This function is called the pH of a solution.

The pH of an aqueous solution is the negative logarithm of its H+ ion concentration. That is,

$$pH = -\log [H^+].$$

$$pOH = -\log [OH^-].$$



- The pH of a neutral solution is 7.
- The pH of an acidic solution is less than 7.
- The pH of an alkaline solution is more than 7.

Rules for pH scale (at 298 K)

1. Acidic solutions have pH less than 7.
2. The lower the pH, the more acidic is the solution.
3. Neutral solutions or pure water has pH equal to 7.
4. Basic solutions have pH greater than 7.
5. The higher the pH, the more basic is the solution.

The pH values of some common solutions:

Substance	pH
Gastric juice	1.0
Lemon juice	2.5
Vinegar	3.0
Wine	3.5
Tomato juice	4.1
Acid rain	5.6
Urine	6.0
Milk	6.5
Pure water	7
Blood	7.4
Lime water	11.0

Point to Remember:

- Everything that tastes sour contains an acid.
- Acetic acid, citric acid, tartaric acid are a few organic acids. Sulphuric acid, nitric acid and hydrochloric acid are examples of inorganic acids.
- Acids turn blue litmus red, whereas bases turn red litmus blue.
- When a solution of an acid contains larger amount of the acid, it is said to be concentrated, while that containing smaller amount of the acid, is said to be dilute.
- Metals like sodium, potassium and calcium react with an acid to liberate hydrogen gas.
- Acids react with bases to produce salts and water.
- Acids react with the carbonates and the hydrogencarbonates to give carbon dioxide gas.
- The hydrogen atoms of an acid which can be partially or completely replaced by an atom or a group of atoms are called replaceable hydrogen atoms. They are also called acidic hydrogen.
- The number of replaceable hydrogen atoms present in a molecule of the acid is known as the basicity of the acid.
- A compound that reacts with an acid to form a salt and water is called a base.
- Bases that are soluble in water are called alkalis. All alkalis are bases, but all bases are not alkalis.
- The reaction between an acid and a base is called neutralization reaction. In such a reaction, the acid and the base destroy the properties of each other.
- The number of hydroxyl groups (OH) present in a molecule of the base is called the acidity of the base.
- A salt is a compound formed by the reaction of an acid with a base.
- Na_2SO_4, $CaSO_4$ and Na_3PO_4 are normal salts, whereas $NaHSO_4$, $NaHCO_3$, Na_2HPO_4 are acid salts.
- A strong acid is one which gets almost completely dissociated when dissolved in water to give hydrogen ions, whereas a weak acid gets only partially dissociated in water to give hydrogen ions.
- A strong base gets almost completely dissociated when dissolved in water to give hydroxide ions (OH^-), whereas a weak base, when treated as such, gets only partially dissociated to provide hydroxide ions.

PREPARATION OF ACIDS:

(a) Direct combination/synthesis: used to prepare hydra acids

$$H_2 + Cl_2 \rightarrow 2Hcl \qquad H_2 + F_2 \rightarrow 2HF$$

$$H_2 + l_2 \rightarrow 2HI \qquad H_2 + S \rightarrow H_2S$$

(b) Starting non metal (C, P, S)

Non metals combine with O_2 to form acidic oxides (acid anhydride).

Oxides dissolves in H_2O to form their resp. acids.

$C + O_2 \rightarrow CO_2$ $S + O_2 \rightarrow SO_2$ $2P_2 + 5O_2 \rightarrow 2P_2O_5$ acid solid

$CO_2 + H_2O \rightarrow H_2CO_3$ $SO_2 + H_2O \rightarrow H_2SO_3$ $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$

carbonic acid sulphurous acid phospheric acid

Note: NO_2 is called a mixed acid anhydride

NO_2 dissolves in water to produce nitrous acid and nitric acid (2 acids)

$2NO_2 + H_2O$ $HNO_2 + HNO_3$. It is called mixed acid anhydride

(c) Action of non volatile acid (conc. H_2SO_4) on salt of volatic acid (NaCl, KCl)

$$NaNO_3 + H_2SO_4 \xrightarrow{< 220°C} NaHSO_4 + HNO_3$$

$$KNO_3 + H_2SO_4 \xrightarrow{< 220°C} KHSO_4 + HNO_3$$

$$KCL + H_2SO_4 \xrightarrow{< 220°C} KHSO_4 + HCL$$

$$NaCL + H_2SO_4 \xrightarrow{< 220°C} NaHSO_4 + HCL$$

salt of non volatile

volatile volatile acid

(d) Oxidation of non metals (P, S) with cone. HNO_3- volatile acid

$$P + 5HNO_3 \rightarrow H_3PO_4 + H_2O + 5NO_2 \uparrow$$

$$S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2 \uparrow$$

Note: Acidic oxides are called acid anhydrides. They are oxides of non metals which dissolve in water in to form acids.

$SO_2 + H_2O \rightarrow H_2SO_3$ $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$

$SO_3 + H_2O \rightarrow H_2SO_4$ $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

$CO_2 + H_2O \rightarrow H_2CO_3$ Acid anhydrides are acids without water

$H_2CO_3 - H_2O \rightarrow CO_2$

$H_2SO_3 - H_2O \rightarrow SO_2$ $H_2SO_4 - H_2O \rightarrow SO_3$ (acid anhydride)

$2H_3PO_4 - 3H_2O \rightarrow P_2O_5$ (acidic solid)

acidic acid

PREPARATION OF BASES:

(a) Metals + $O_2 \rightarrow$ Metallic oxides (Bases)

$4Na + O_2 \rightarrow 2Na_2O$ $2Cu + O_2 \rightarrow 2CuO$

$4K + O_2 \rightarrow 2K_2O$ $2Ca + O_2 \rightarrow 2CaO$

(b) Basic oxides dissolve in water to form alkalis

$K_2O + H_2O \rightarrow 2KOH$ $CaO + H_2O \rightarrow Ca(OH)_2$

$Na_2O + H_2O \rightarrow 2NaOH$ $NH_3 + H_2O \rightarrow NH_4OH$

(non metallic base)

(c) Thermal Decomposition of carbonates and nitrates

(i) Carbonates: Na_2CO_3, K_2CO_3 do not decompose on heating

$CaCO_3 \rightarrow CaO + CO_2\uparrow$ $MgCO_3 \rightarrow MgO + CO_2\uparrow$

$CuCO_3 \rightarrow CuO + CO_2\uparrow$ $FeCO_3 \rightarrow FeO + CO_2\uparrow$

(ii) Nitrate of heavy metals on heating form bases except KNO_3, $NaNO_3$

$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2\uparrow + O_2\uparrow$

$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2\uparrow + O_2\uparrow$

$2Zn(NO_3)_2 \rightarrow 2ZnO + 4NO_2\uparrow + O_2\uparrow$

(d) Active Metal + H_2O → alkali + H_2

$2K + 2H_2O \rightarrow 2KOH + H_2\uparrow$ $2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2\uparrow$

(e) By precipitation of 2 solutions

$3NaOH + FeCl_3 \rightarrow 3NaCl + Fe(OH)_3\downarrow$

$2NaOH + CuSO_4 \rightarrow Cu(OH)_2 + Na_2SO_4$

$2NaOH + FeSO_4 \rightarrow Fe(OH)_2 + Na_2SO_4$

PREPARATION OF SALTS (V.Imp)

(a) Direct Combination: Synthesis

(i) Chlorides which are soluble but $AgCl_3$, $PbCl_2$

(ii) Sulphides which are insoluble

$Mg + Cl_2 \rightarrow MgCl_2$

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$ (ferric chloride is a coloured deliquescent (salt)

$2Al + 3Cl_2 \rightarrow 2AlCl_3$

$2Ag + Cl_2 \rightarrow 2AgCl$ (insoluble)

$Zn + S \rightarrow NnS$ (insoluble)

$Fe + S \rightarrow FeS$

$Pb + S \rightarrow PbS$

(b) Simple Displacement (Generally sulphates)

All SO_4^{--} are soluble but $CaSO_4$, $BaSO_4$, $PbSO_4$ which is insoluble

(salt of active metals prepared)

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$ [Green vitriol - $FeSO_4.7H_2O$]

$Zn + H SO_4 \rightarrow ZnSO_4 + H_2$ [White vitriol - $ZnSO_4.7H_2O$]

$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ [Epson salt - $MgSO_4.7H_2O$]

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$

(c) Neutralisation: (Acid + Alkali)

Soluble salts - K, Na, NH_4^+

(i) Titration: alkali + acid $\rightarrow$ salt + water

$NaOH + HCl \rightarrow NaCl + H_2O$

$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

$KOH + HCl \rightarrow KCl + H_2O$

(ii) Insoluble base + acid $\rightarrow$ soluble salt + H_2O

$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

$Cu(OH)_2 + H_2SO_4 \rightarrow CuSO_4 + 2H_2O$

$PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$

$Pb(OH)_2 + 2HNO_3 \rightarrow Pb(NO_3)_2 + 2H_2O$

Imp: pb salts are only prepared from lead nitrate

(d) Decomposition of insoluble $\rightarrow$ Carbonates

$$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$$
$$PbCO_3 + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + CO_2$$

(e) Insoluble salts by precipitation or double decomposition

Two salt solutions taken. Both salts are soluble in water.

Product: one insoluble salt - ppt second soluble salt in solution.
($CaSO_4$, Ba SO_4, $PbSO_4$, AgCl, $ZnCO_3$)

Carbonates are prepared by double decomposition from sodium carbonate solution.

$$ZnSO_4 + (NH_4)_2CO_3 \rightarrow ZnCO_3\downarrow + (NH_4)_2SO_4$$
$$CaCl_2 + K_2SO_4 \rightarrow CaSO_4\downarrow + 2KCl$$
$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2NaCl$$

Note: Pb salts from $Pb(NO_3)_2$

Note: Carbonates from Na_2CO_3

$$AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3$$

Imp. To prepare an insoluble salt ($PbCO_3$) from another insoluble salt PbO

1st covert to nitrate.

$$PbCO_3 + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + CO_2$$
$$Pb(NO_3)_2 + Na_2CO_3 \rightarrow 2NaNO_3 + PbCO_3$$
$$Pb(NO_3)_2 + Na_2SO_4 \rightarrow 2NaNO_3 + PbSO_4$$

To lead carbonate if H_2SO_4 is to added it forms an insoluble sulphate of $PbSO_4$ on $PbCO_3$. The reaction will stop.

Analytical Chemistry

To determine cations by:

(i) Flame test

(ii) Action of alkalies

Zn/Al/Pb reacts with alkalis to form corresponding zincate [ZnO_2^{-2}],

Aluminate AlO_2^{-1} and plumbates PbO_2^{--}

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

$Pb + 2NaOH \rightarrow Na_2PbO_2 + H_2$

$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$ $(V.imp)$

Oxides

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

$PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$

$Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$

Hydroxides

$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

$Pb(OH)_2 + 2NaOH \rightarrow Na_2PbO_2 + H_2O$

$Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

Note:

Note:

(a) Alkalis + salt solution → insoluble coloured precipitates.

e.g. NaOH reacts with $CuSO_4$ to form a blue precipitate (incorrect) NaOH <u>solution</u> reacts with $CuSO_4$ solution to form a blue precipitate (correct)

If the word solution is not there, the sentence is incorrect.

(b) Both observations - drop by drop and explanation are to be given.

(I) Ammonium Hydroxide

Salt Solution	Add NH_4OH drop by drop	Add NH_4OH in excess
Ferrous sulphate solution	$FeSO_4 + 2NH_4OH \rightarrow Fe(OH)_2\downarrow + (NH_4)_2SO_4$ dirty green ppt	insoluble in excess
Ferric chloride solution	$FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$ reddish brown ppt	insoluble in excess
Copper sulphate solution	$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$ pale blue ppt	$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow$ $Cu(NH_3)_4SO_4 + 4H_2O$ (tetramine copper sulphate) Ink blue colouration
Calcium chloride solution	No ppt	No ppt
Lead Nitrate solution	$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$ curdy white ppt	Insoluble in excess
Zinc sulphate solution	$ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$ white ppt	$Zn(OH)_2 + (NH_4)_2SO_4 \rightarrow Zn(NH_3)_4SO_4 + 4H_2O$ ppt soluble

Note:

ppt soluble in NH_4OH: $Cu(OH)_2$, $Zn(OH)_2$

ppt insoluble in NH_4OH: $Fe(OH)_2$, $Fe(OH)_3$, $Pb(OH)_2$

Note:

Ammonium salts react with alkalis to liberate ammonia.
$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$

(II) Sodium Hydroxide

Salt Solution	Add NaOH drop by drop	Add NaOH in excess
Ferrous sulphate solution	$FeSO_4 + 2NaOH \rightarrow Fe(OH)_2\downarrow + Na_2SO_4$ dirty green ppt	ppt is insoluble
Ferric chloride solution	$FeCl_3 + 3NaOH \rightarrow Fe(OH)_3\downarrow + 3NaCl$ reddish brown ppt	ppt insoluble in excess
Copper sulphate sol ution	$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$ pale blue ppt	ppt insoluble in excess
Calcium chloride solution	$CaCl_2 + 2NaOH \rightarrow Ca(OH)_2\downarrow + 2NaCl$ dull white ppt	insoluble in excess
Lead Nitrate solution	$Pb(NO_3)_2 + 2NaOH \rightarrow Pb(OH)_2\downarrow + 2NaNO_3$ curdy white ppt	$Pb(OH)_2 + 2NaOH \rightarrow Na_2PbO_2\downarrow + 2H_2O$ ppt dissolves
Zinc sulphate solution	$ZnSO_4 + 2NaOH \rightarrow Zn(OH)_2\downarrow + Na_2SO_4$	$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2\downarrow + 2H_2O$ ppt soluble

Soluble ppts - $Zn(OH)_2$, $Pb(OH)_2$
Insoluble ppts - $Fe(OH)_2$, $Fe(OH)_3$, $Cu(OH)_2$, $Ca(OH)_2$,

ELECTROLYSIS

Electrolysis of Metal	Electrolyte	Material of		Electrolyte Reaction	Ions at		Anode Reaction	Cathode Reaction
		Anode	Cathode		Anode	Cathode		
Molten Lead Bromide	$Pb\,Br_2$	Graphite	Steel or graphite	$PbBr_2 \rightleftharpoons$ $Pb^{++} + 2Br^{-}$	Br^-	Pb^{++}	$Br^- - 1e \rightarrow [Br]$ $Br + Br \rightarrow Br_2\uparrow$	$Pb^{++} + 2e \rightarrow Pb$
Acidified water	H_2O+ H_2SO_4	Pt	Pt	$H_2O \rightleftharpoons H^+ + OH$ $H_2SO_4 \rightleftharpoons 2H^+ + SO_4$	OH SO_4	H^+	$OH - 1e \rightarrow (OH)$ $4OH \rightarrow 2H_2O + O_2\uparrow$	$H^+ + 1e \rightarrow (H)$ $H + H \rightarrow H_2\uparrow$
$CuSO_4$ sol^n	$CuSO_4$, H_2O	Pt	Pt	$CuSO_4 \rightleftharpoons Cu^{++} + SO_4$ $H_2O \rightleftharpoons H^+ + OH^-$	OH SO_4	Cu^{++}, H^+	$OH - 1e \rightarrow OH$ $4OH \rightarrow 2H_2O + O_2$	$Cu^{++} + 2e \rightarrow Cu$
$CuSO_4$ sol^n	$CuSO_4$, H_2O	Impure Cu	Pure Cu	$CuSO_4 \rightleftharpoons Cu^{++} + SO_4$ $H_2O \rightleftharpoons H^+ + OH^-$	OH^- SO_4^{--}	Cu^{++}, H^+	$Cu - 2e^- \rightarrow Cu^{++}$	$Cu^{++} + 2e \rightarrow Cu$
Silver planning	$NaAg(CN)_2$ H_2O	Block of Ag	Article to be placed	$NaAg(CN)_2 \rightleftharpoons$ $Na^+ + Ag^+ + 2CN$ $H_2O \rightleftharpoons H^+ + OH$	CN	Na^+, Ag^+	$Ag - 1e^- \rightarrow Ag^+$	$Ag^+ + 1e \rightarrow Ag$
Nickel plating	$NiSO_4$ sol^n H_2O	Block of Nickel	Article to be plated	$NiSO_4 \rightleftharpoons Ni^{++} + SO_4$ $H_2O \rightleftharpoons H^+ + OH$	SO_4 OH	Ni^{++}, H+	$Ni - 2e \rightarrow Ni^{++}$	$Ni^{++} + 2e^-$ Ni

Metallurgy

(a) Reduction of metal oxides

K

Na

Ca — Reduced only by electrolysis in molten state

Mg

Al

Zn — Zinc oxide ONLY by COKE.

Fe

Pb — Oxides are reduced by CO, C, H_2

Cu

(b) Metals + dil acid → salt + H_2

K — Violent reaction. Liberate

Na

Ca — Liberate H_2 from dilute acid.

$Mg + 2HCl \rightarrow MgCl_2 + H_2c$

Mg

Al

Zn — $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

Fe — $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$

Pb

Cu

H

Hg — Do not liberate H_2

Ag

Au

Pt

(c) Action of Δ on oxides

All oxides are stable to Δ but higher oxides,

eg. Pb_3O_4, PbO_2

$2HgO \rightarrow 2Hg + O_2$
$2Ag_2O \rightarrow 4AgO + O_2$

K	Combine with o2 at ordinary temp
Na	$4K + O_2 \rightarrow 2K_2O$
Ca	Heated metal + steam → oxide + H_2
Mg	
Al	$4Al + 3O_2 \rightarrow 2Al_2O_3$
Zn	$2Zn + O_2 \rightarrow 2ZnO$
Fe	$3Fe + 2O_2 \rightarrow Fe_3O_4$
Pb	
H	$2Cu + o_2 \rightarrow 2CuO$
Cu	
Hg	
Ag	Do not form oxides
Au	
Pt	

(d) Action of Δ on Hydroxides

KOH	Stable to heat
NaOH	
$Ca(OH)_2$	$\xrightarrow{\Delta}$ Metal oxide + H_2O
$Mg(OH)_2$	
$2Al(OH)_3$	$\xrightarrow{\Delta}$ $Al_2O_3 + 3H_2O$
$Zn(OH)_2$	$ZnO + H_2O$

$Fe(OH)_2$	$\xrightarrow{\Delta}$ $FeO + H_2O$
$Pb(OH)_2$	$PbO + H_2O$
$Cu(OH)_2$	$CuO + H_2O$
$Hg(OH)_2$	Metal + O_2 + H_2O
$AgOH$	

(e) Action of Δ on Carbonates

K_2CO_3	Stable to heat
Na_2CO_3	
$CaCO_3$	Metal Oxide + CO_2
$MgCO_3$	
$ZnCO_3$	$ZnO + CO_2$
$PbCO_3$	$PbO + CO_2$
$CuCO_3$	$CuO + CO_2$
$FeCO_3$	$FeO + CO_2$
$Hg(OH)_2$	
Ag_2CO_3	Metal + O_2 + CO_2

(f) Action of A on nitrates

$2KNO_3$		$2KNO_2 + O_2$
$2NaNO_3$		$2NaNO_2 + O_2$
$2Ca(NO_3)_2$		
$2Mg(NO_3)_2$	$\xrightarrow{\Delta}$	2 metal oxide + $4NO_2 + O_2$
$2Zn(NO_3)_2$	$\rightarrow$	$2ZnO + 4NO_2 + O_2$
$2Pb(NO_3)_2$	$\rightarrow$	$2PbO + 4NO_2 + O_2$
$2Cu(NO_3)_2$	$\rightarrow$	$2CuO + 4NO_2 + O_2$

Extraction of zinc

Ore: Zinc Blend ZnS/Calamine $ZnCO_3$

(i) **Roasting:** $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

(ii) **Calcination:** $ZnCO_3 \rightarrow ZnO + CO_2$

(iii) **Reduction:** $ZnO + C \rightarrow Zn + CO$ (By coke - reducing agent)

Extraction of Iron Blast Furnace:

Main ore: Haematite Fe_2O_3

Lower region: $C + O_2 \rightarrow CO_2$

Middle region:

(i) $CaCO_3 \rightarrow CaO + O_2$

(ii) (flux) $CaO + SiO_2 \rightarrow CaSiO_2$

Gangue slag

(iii) $CO_2 + C$ —> 2CO (reducing agent)

Upper region: Fe2o3 + 3CO —► 2Fe + 3Co2

Extraction of Aluminium (V.Imp)

(a) **Concentration of the ore - Baeyer's Process**

Bauxite: $Al_2O_3.2H_2O + 2NaOH \xrightarrow[<200°C]{} 2NaA1O_2 + 3H_2O$

(seeding) $NaA1O_2 + 2H_2O \xrightarrow[50\text{ to }60°C]{Al(OH)_3} NaOH + A1(OH)_3$

$2A1(OH)_3 \xrightarrow{1100°C} A1_2O_3 + 3H_2O$

(b) Reduction of Alumina - Hall and Heroult's Process

Electrolytic dissociation of electrolyte

Na_3AlF_6 □ $3Na^+ + Al^{+++} + 6F$

CaF_2 □ $ca^{++} + 2F^-$

$A1_2O_3$ □ $2A1^{+++} + 3O^-$

Anode reaction	Cathode reaction
$O^{--} - 2e \rightarrow (O)$	$Al^{+++} + 3e \rightarrow Al \downarrow$ (pure Al)
$(O) + (O) \rightarrow O_2 \uparrow$	
$C + O_2 \rightarrow CO_2 \uparrow$	

Thermite Welding $MnO_2 + 4HC1 \rightarrow MnCl_2 + 2H_20 + Cl_2 \uparrow$

(ii) Pb02 + 4HC1 PbCl2 + 2H20 + Cl, |

$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$

Study Of Compounds – Hydrochloric Acid

Preparation of Hydrochloric Acid:

(a) Direct Synthesis:

$$H_2 + Cl_2 \xrightarrow[\text{Diffused sunlight}]{\text{Moisture}} 2HCl$$

(b) Laboratory Preparation:

$$NaCl + H_2SO_4 \xrightarrow{<200° C} NaHSO_4 + HCl$$

Above 200 °C not used

$$2NaCl + H_2S0_4 \rightarrow Na_2SO_4 + 2HCI$$

(c) Drying agent not used:

(i) Quicklime: $CaO + 2HCl \rightarrow CaCl_2 + H_2O$

(ii) $2P_20_5 + 3HC1 \rightarrow POC1_3, + 3HPO_3,$ (P_2O_3 - acidic solid)

(d) Thermal dissociation:

$$2HC1 \xrightarrow{500°C} H_2 + G1_2$$

(e) $NH_{3(g)} + HCl_{(g)} \rightarrow NH_4C1$ solid

(f) Basicity

$HC1 + H_2 0 \rightarrow H_3O^+ + Cl^-$ (Monobatic)

(g) Acidic Properties - Typical Acid

(i) Active Metal + dil acid → salt + H_2

$Mg + 2HC_1 \rightarrow MgCl_2 + H_2$
$Fe + 2HC_1 \rightarrow FeCl_2 + H_2$

(ii) Base + Acid → salt + H_2o

$2HC1 + CuO \rightarrow CuCl_2 + H_2 0$

$HC1 + NaOH \rightarrow NaCl + H_2 0$

(iii) Carbonates/Bicarbonates + dil acid → salt + H_2O + CO_2

$Na_2CO_3 + 2HC1 \rightarrow 2NaCl + H_2O + CO_2\uparrow$
$KHC0_3 + HC1 \rightarrow KC1 + H_2O + CO_2\uparrow$

(iv) Metal sulphites/bisulphites + dil acid → salt + H_2O+ SO_2

$K_2S0_3 + 2HC1 \rightarrow 2KC1 + H_2O + SO_2\uparrow$
$NaHSO_3 + HC1 \rightarrow NaCl + H_2O + SO_2\uparrow$

(v) Metal sulphide + dil HCl → salt + H_2S

$ZnS + 2HC1 \rightarrow ZnCl_2 + H_2S\uparrow$
$FeS + 2HC1 \rightarrow FeCl_2 + H_2S\uparrow$

(h) Preparation of two insoluble Chloride [$PbCl_2$, AgCl)

$Pb(NO_3)_2 + 2HC1 \rightarrow PbCl_2\downarrow + 2HNO_3$ (soluble in hot water)
$AgNO_3 + HC1 \rightarrow AgCl\downarrow + HNO_3$ (soluble in NH_4OH)

(i) Sodium thiosulphate (Imp)

$Na_2S_2O_3 + 2HC1 \rightarrow 2NaCl + SO_2\uparrow + S + H_2 0$

(j) Cone. HCl - Reducing Agent [Oxidising agents liberate Cl_2]

(i) $MnO_2 + 4HC1 \rightarrow MnCl_2 + 2H_2 0 + Cl_2\uparrow$

(ii) $PbO_2 + 4HC1 \rightarrow PbCl_2 + 2H_2 0 + Cl_2\uparrow$

Aqua Regia

$$HNO_3 + 3HC1 \rightarrow NOC1 + 2H_20 + 2(C1)$$

$$Au + 3[Cl] \rightarrow AuC1_3$$

$$Pt + 4[C1] \rightarrow PtCl_4$$

Tests:

(i) $NH_3 + HCL_{(conc)} \rightarrow NH_4Cl$ (dense white fumes)

(ii) $AgNO_3 + HCl_{(dil)} \rightarrow HNO_3 + AgCl \downarrow$ (white ppt)

$AgCl + 2NH_4Cl \rightarrow Ag(NH_3)_2Cl + 2HCl$ (soluble)

diamine silver chloride

(iii) $MnO_2 + 4HCl_{(conc)} \rightarrow MnCl_2 + 2H_2O + Cl_2 \uparrow$ (greenish yellow gas)

suffocating odour

Study Of Compounds - Ammonia

(a) Preparation of ammonia:

(i) Laboratory preparation (from ammonium salts)

Ammonium chloride + alkali (slacked lime + sal ammonia)

$$2NH_4C1 + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3 \uparrow$$

(ii) Reactions of ammonia with drying agents.

1. Sulphuric acid (conc.)

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

2. Phosphorous pentoxide

$$6NH_3 + P_2O_5 + 3H_2O \rightarrow 2(NH_4)_3 3PO_4$$

3. Calcium chloride

$$8NH_3 + CaCl_2(fused) \rightarrow CaCl_2.8NH_3$$

(iii) Laboratory preparation (from metal nitrides)

1. Magnesium nitride.

$$Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3 \uparrow$$

2. Calcium nitride.

$$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3 \uparrow$$

3. Aluminium nitride.

$$AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3 \uparrow$$

(b) Manufacture of ammonia

(i) Haber's process: $N_2 + 3H_2 \rightarrow 2NH_3 + \Delta$

Temperature: 450-500 °C Pressure: 200 to 900 atmosphere.

Catalyst: finely divided iron Promoter: molybdenum

(c) Combustibility

(i) Burning of ammonia in oxygen, (greenish yellow frame)

$$4NH_3 + 3O_2 \rightarrow 6H_2O + 2N_2 \uparrow$$

(ii) Catalytic oxidation of ammonia (mfg. of nitric acid-ostwalds process)

$$4NH_3 + 5O_2 \xrightarrow{Pt} 6H_2O + 4NO + \Delta$$

Basic nature

(d) Reaction of ammonia gas with

(i) Hydrochloric acid

$$NH_3 + HCl \rightarrow NH_4Cl$$

(ii) Nitric acid

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

(iii) Sulphuric acid

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

(iv) Water (Dissociation of aq. soln.)

Monoacidic base

$$NH_4OH \rightleftharpoons NH_4^{++}OH^-$$

(e) Reaction of ammonia (aq. soln) with

(i) Hydrochloric acid

$$NH_4OH + HC1 \rightarrow NH_4C1 + H_2O$$

(ii) Nitric acid

$$NH_4OH + HNO_3 \rightarrow NH_4NO_3 + H_2O$$

(iii) Sulphuric acid

$$2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O$$

(f) Reaction of ammonia (aq. soln) with metallic salt solutions

(i) Iron(II) sulphate

$$FeSO_4 + 2NH_4OH \rightarrow \underset{\text{dirty green}}{Fe(OH)2\downarrow} + (NH_4)_2SO_4$$

(ii) Iron(III) chloride

$$FeCl_3 + 3NH_4OH \rightarrow 3NH_4C1 + Fe(OH)_3\downarrow$$

(iii) Lead nitrate

$$Pb(NO_3)_2 + NH_4OH \rightarrow PbOH + NH_4(NO_3)_2$$

(iv) Zinc sulphate

$$Zn(OH)_2 + (NH_4)2SO_4 + 2NH_4OH \rightarrow \underset{\text{colourless solution}}{CuZn(NH_3)_4SO_4} + 4H_2O$$

(v) Copper sulphate

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow Cu(NH_3)_4SO_4 + 4H_2O$$

(g) As a reducing agent (ammonia gas)

(i) Heated copper oxide (black baric oxide)

$$3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2\uparrow$$

(ii) Heated lead oxide (yellow amphoteric oxide)

$$3PbO + 2NH_3 \rightarrow 3Pb + 3H_2O + N_2\uparrow$$

(iii) Chlorine(ammonia in excess)

$$8NH_3 + 3C1_2 \rightarrow 6NH_4C1 + N_2\uparrow$$

$$NH_3 + 3C1_2 \rightarrow NC1_3 + 3HC1$$

Study Of Compounds - Nitric Acid

(a) Preparation of nitric acid

(i) Laboratory preparation from nitrates

1. Potassium nitrate (nitre)

$$KNO_3 + H_2SO_4 \xrightarrow{<200^\circ C} K.HSO4 + HNO_3$$

2. Sodium nitrate (chile salt petre)

$$NaNO_3 + H_2SO_4 \xrightarrow{< 200°C} NaHSO_4 + HNO_3$$

(ii) Atmospheric nitrogen to nitric acid

1. Nitrogen to nitric acid

$$N_2 + O_2 \xrightarrow{< 300°C} 2NO$$

2. Nitrogen oxide to nitric dioxide.

$$2NO + O_2 \xrightarrow{< 50°C} 2NO_2$$

3. Nitrogen dioxide to nitric acid.

$$4NO_2 + O_2 + 2H_2 0 \rightarrow 4HNO_3$$

(iii) Industrial manufacture of nitric acid - Ostwalds Process

1. Step 1 (Catalytic chamber)

$$4NH_3 + 5O_2 \xrightarrow[700-800°C]{pt.} 4NO + 6H_2O$$

2. Step 2 (Oxidation chamber)

$$2NO + O_2 \xrightarrow{< 50°C} 2NO_2$$

3. Step 3 (Absorption tower)

$$NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

(b) Chemical Properties of nitric acid

(i) Stability of nitric acid

Decomposition

$$4HNO_3 \rightarrow 2H_2O + O_2 + 4NO_2\uparrow$$

(ii) Ionization of dilute nitric acid

1. Dissociation

$$HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$$

2. Base (sodium hydroxide)

$$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$$

3. Magnesium Hydroxide

$$Mg(OH)_2 + 2HNO_3 \rightarrow Mg(NO_3)_2 + 2H_2O$$

4. Carbonate (calcium carbonate)

$$PbCO_3 + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + CO_2 \uparrow$$

5. Bicarbonate (calcium bicarbonate)

$$Ca(HCO_3)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O + 2CO_2 \uparrow$$

6. Sulphite (potassium sulphite)

$$K_2SO_3 + 2HNO_3 \rightarrow 2KNO_3 + H_2O + SO_2 \uparrow$$

7. Bisulphite (calcium bisulphite)

$$Ca(HSO_3)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O + SO_2 \uparrow$$

(iii) Non - metals (cone. Nitric acid)

1. Carbon

$$C + 4HNO_3 \rightarrow 2H_2O + CO_2 \uparrow + 4NO_2 \uparrow$$

2. Sulphur

$$S + 6HNO_3 \rightarrow H_2SO_4 + 6NO_2 \uparrow + 2H_2O$$

3. Phosphorous

$$P + 5HNO_3 \rightarrow H_3PO_4 + H_2O + 5NO_2 \uparrow$$

(iv) Metals (Imp)

1. *dil. Nitric acid Copper*

$$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO \uparrow$$

2. *Cone. Nitric acid (hot nitric acid)*

Copper

$$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2 \uparrow$$

(v) Aqua regia (1 part conc. HNO_3 + 3 parts HCl)

$$HNO_3 + 3HCl \rightarrow 2H_2O + 2[C1] + NOCl \text{ (nitrosyl chloride)}$$

(c) Test for nitric acid

Heat on nitric acid

$$4HNO_3 \rightarrow 2H_2O + O_2 + 4NO_2 \uparrow \text{ (reddish brown fumes evolved)}$$

Heat on copper and conc. HNO_3

$$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2 \uparrow \text{(reddish brown fumes evolved)}$$

Brown ring test

$$FeSO_4 + NO \rightarrow FeSO_4.NO \text{ (nitroso ferrous sulphate)}$$

Study Of Compounds - Sulphuric Acid

(a) Manufacture - Contact process

(i) Step 1 [sulphur or pyrite burner] - roasting

$$S + O_2 \rightarrow SO_2$$
$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$$

(ii) Step 2 [contact chamber]

$$2SO_2 + O_2 \rightarrow 2SO_3 \text{ [Catalyst } V_2O_5 \text{ temp, 450-500 °C, pressure 1 -2 atm]}$$

(iii) Step 3 [absorption tower]

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

The oleum, so obtained is then passed into water to obtain sulphuric acid. This is then diluted to the desired extent by adding it to water.

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

(b) Chemical properties of sulphuric acid as an acid(dilute)

(i) Forms hydronium ions in aq. soln.

$$H_2SO_4 + 2H_2O \rightarrow 2H_3O^+ + SO_4^{2-}$$

Reaction with

(ii) Active metal (zinc/iron/magnesium)

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2 \uparrow$$

(iii) Base(Sodium oxide)

$$Na_2O + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$$

(iv) Base(Sodium hydroxide)

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(v) Carbonate (Potassium carbonate)

$$K_2CO_3 + H_2SO_4 \rightarrow K_2SO_4 + H_2O + CO_2\uparrow$$

(vi) Sulphite (Sodium sulphite)

$$Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2\uparrow$$

(vii) Bisulphite (Sodium bisulphite)

$$2NaHSO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2SO_2\uparrow$$

(viii) Sulphide (Iron(II) sulphide)

$$FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$$

(c) As a dibasic acid

(i) Basicity is two

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

(ii) Dissociates in two types

$$H_2SO_4 \rightleftharpoons H^+ + HSO_4^{2-}$$
$$HSO_4 \rightleftharpoons H^+ + SO_4^{2-}$$

(iii) Forms two types of salts - acid salt, normal salt

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
$$NaOH + H_2SO_4 \rightarrow NaSO_4 + 2H_2O$$

(d) As a non volatile acid (conc.)

Displaces volatile acid from salt below 200 °C

(i) Sodium chloride (Imp)

$$NaCl + H_2SO_4 \xrightarrow[\text{Below 200°C}]{} NaHSO_4 + HCl$$

(ii) Sodium nitrate (Imp)

$$NaNO_3 + H_2SO_4 \xrightarrow{\text{Below 200°C}} NaHSO_4 + HNO_3$$

(e) An oxidising agent (conc. acid)

(i) Oxidation of Non-Metals

1. Carbon (Imp)

$$C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$$

2. Sulphur (Imp)

$$S + 2H_2SO_4 \rightarrow 2H_2O + 2SO_2$$

(ii) Oxidation of Metals

1. Copper (V. Imp)

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$$

2. Sucrose(sugar) (V. Imp)

$$C_{12}H_{22}O_{11} \rightarrow 12C + 11H_2O$$

→ hissing sound

→ black porous mass of sugar charcoal

3. Hydrated copper sulphate.

$$CuSO_4.5H_2O \rightarrow CuSO_4 + 5H_2O$$

→ blue crystal turn white

→ crystals turn into a white anhydrous power

(f) Test for dil H_2SO_4

(i) $BaCl_2 + \text{dil } H_2SO_4 \rightarrow 2HC1 + BaSO_4\downarrow$

(white ppt. insoluble in HNO_3)

(ii) $Pb(NO_3)_2 + \text{dil } H_2SO_4 \rightarrow PbSO_4\downarrow + 2HNO_3$

(white ppt. of $PbSO_4$)

(g) Test for conc. H_2SO_4

(i) $Cu + 2H_2SO_4 \xrightarrow{\Delta} CuSO_4(\text{blue soln}) + 2H_20 + SO_2$

(smell of burning matches) (Imp)

(ii) $NaCl + H_2SO_4 \xrightarrow{\Delta} NaHSO_4 + HC1.$

(HCl forms dense white fumes with ammonia.)

Organic Chemistry

(I) Paraffins: ALKANES - C_nH_{2n+2} [C - C]

Saturated compounds undergo substitution reactions.

(a) Laboratory Preparation:

Decarboxylation:

[mix of $NaOH_3CaO$-soda lime-removes moisture]

(i) Methane

$$CH_3COONa + NaOH \xrightarrow[300\,^{\circ}C]{CaO} CH4 + Na_2CO_3$$

sodium ethconate methane

(ii) Ethane

$$C_2H_5COONa + NaOH \xrightarrow[300\,^{\circ}C]{CaO} C_2H_6 Na_2CO$$

sodium propionate collection of gas - download displ. of water

(b) Reduction of alkyl halide:

(i) $$CH_3I+2[H] \xrightarrow[\text{alcohol}]{\text{Zn, Cu couple in}} CH_4 + HI$$

Iodo methane

(ii) $$C_2H_5Br+2[H] \xrightarrow[\text{alcohol}]{\text{Zn, Cu couple in}} C_2H_6 + HBr$$

Bromo ethane

(c) Chemical Properties:

(i) Combustible - Burns with a non luminous flame:

1. Limited supply of air $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$

$2C_2H_6 + 7O_2 \rightarrow 4CO + 6H_2O$

2. Plenty of air $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$2C_2H_6 + 5O_2 \rightarrow 4CO_2 + 6H_2O$

(ii) Substitution Reaction: (V. Imp)

1. $$CH_4 + 4C1_2 \xrightarrow[\text{sunlight}]{\text{u.v.light}} CC1_4 + 4HC1$$

tetra chloro methane

2. $$C_2H_6 + 6C1_2 \xrightarrow{\text{sunlight}} CC1_4 + 4HC1$$

hexachloro ethane

(iii) Conversions [A] using copper tube:

$$\text{alkane} \xrightarrow[\text{acidified } K_2Cr_2O_7]{\text{Cu-tube } 300\,^{\circ}C} \text{aldehyde} \xrightarrow[\text{acidified } K_2Cr_2O_7]{\text{Cu-tube } 300\,^{\circ}C} \text{acid}$$

$$2CH_4 + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2CH_3OH$$

methanol

$$2CH_3 + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2HCHO + 2H_2O$$

methanal

$$2HCHO + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2HCOOH + 2H_2O$$

methanoic acid

$$2C_2H_6 + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2C_2H_5OH$$

ethanol

$$2C_2H_5 + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2CH_3CHO + 2H_2O$$

ethanal

$$2CH_3CHO + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2CH_3COOH$$

ethanoic acid

(iv) Using acidified $K_2Cr_2O_7$

$$2CH_4 + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2CH_3OH$$

$$CH_3OH + (O) \xrightarrow[K_2Cr_2O_7]{\text{acidified}} HCHO + H_2O$$

$$HCHO + (O) \xrightarrow[K_2Cr_2O_7]{\text{acidified}} HCOOH$$

$$2C_2H_6 + O_2 \xrightarrow[300\ ^\circ C]{\text{Cu-tube}} 2C_2H_5OH$$

$$C_2H_5OH + (O) \xrightarrow[K_2Cr_2O_7]{\text{acidified}} CH_3CHO + H_2O$$

$$CH_3CHO + (O) \xrightarrow[K_2Cr_2O_7]{\text{acidified}} CH_3COOH$$

(v) Direct Conversion of methane to methanol is 1 step

$$CH_4 + O_2 \xrightarrow[100\ ^\circ C]{\text{MoO}} HCHO + H_2O$$

$$C_2H_6 + O_2 \xrightarrow[100\ ^\circ C]{\text{MoO}} CH_3CHO + H_2O$$

(II) Paraffins: ALKANES - C_nH_{2n} [C - C]

Ethene

$$\begin{array}{ccc} H & & H \\ | & & | \\ H\text{-}C & = & C\text{-}H \end{array}$$

Unsaturated compound undergoes addition reaction.

(a) Laboratory preparation:

(i) Dehydration of ethanol

$$C_2H_5OH + 2[H] \xrightarrow[Al_2O_3 \text{ at } 350°C]{\text{boil conc.} H_2SO_4 170\ °C} C_2H_4 + H_2O$$

(ii) Dehydrohalogenation

$$C_2H_5Br + KOH \xrightarrow[\text{alcoholic}]{\text{boil}} KBr + H_2O + C_2H_4$$

Bromo ethane

(b) Chemical Properties [Addition reaction]

(i) Addition Reactions

1 $C_2H_4 + H_2 \xrightarrow{\text{Nickel } 300\ °C} C_2H_6$

2 $C_2H_4 + Cl_2 \xrightarrow[C1_{CCl_4}]{\text{inert solution of}} C_2H_4Cl_2$ (dichloro ethane)

3 $C_2H_4 + Br_2 \xrightarrow[Br_{CCl_4}]{\text{inert solution of}} C_2H_4Br_2$ (dibromoethane)

The brown colour of bromine disappears. Test for unsaturation.

4 $C_2H_4 + I_2 \xrightarrow{\text{inert sol}^n \text{ of } CCl_4} C_2H_4I_2$ (ethyl dibromide)

$C_2H_4 + HBr \rightarrow C_2H_5Br$ (monobromo ethane)

5 $C_2H_4 + H_2SO_4 \rightarrow C_2H_5HSO_4$ (ethyl hydrogen sulphate)

6 ($KMnO_4$ solution - cold and dilute)

$$\underset{KMnO_4 \text{ soln}}{C_2H_4 + H_2O + [H]} \rightarrow \begin{array}{ccc} H_2C & — & CH_2 \\ | & & | \\ H\text{-}C & = & C\text{-}H \end{array} \quad \begin{array}{l} \text{ethane 1, 2 diol} \\ \text{ethylene glycol} \end{array}$$

Baeyers solution: It decolourises $KMnO_4$ solution. It first turns into a green solution which becomes colourless with a brown residue.

(ii) Combustion: $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ (pale blue flame)

(III) <u>Acetylene Series: ALKYNES Cn H2n-2 [-C = C-]</u>

Highly unsaturated compounds - undergo addition reaction Acetylene - Ethyne C_2H_2

(a) Laboratory preparation:

(i) Calcium Carbide

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

warm water

(ii) Dehydrohalogenation of 1, 2 dibromoethane

$$C_2H_4Br_2 + 2KOH \xrightarrow{boil} 2KBr + 2H_2O + C_2H_2$$

alcoholic

(b) Chemical Properties:

Undergo Addition reactions

(i) $C_2H_2 + H_2 \xrightarrow[300°C]{Ni} C_2H_4 \quad : C_2H_4 + H_2 \xrightarrow[300°C]{Ni} C_2H_6$

(ii) $C_2H_2 + Br_2 \xrightarrow{CCl_4} C_2H_2Br_2 \quad : C_2H_2Br_2 + Br_2 \rightarrow C_2H_2Br_4$

(iii) $C_2H_2 + Cl_2 \xrightarrow{CCl_4} C_2H_2Cl_2 \quad : C_2H_2Cl_2 + Cl_2 \rightarrow C_2H_2Cl_4$

(iv) $C_2H_2 + I_2 \xrightarrow{alcohol} C_2H_2I_2$: [Iodine unreactive]

(v) $C_2H_2 + HCl \rightarrow C_2H_3Cl \quad : C_2H_3Cl + HCl \rightarrow C_2H_4Cl_2$

Chloroethene dichloro methane

(vi) $C_2H_2 + HBr \rightarrow C_2H_3Br \quad : C_2H_3Br + HBr \rightarrow C_2H_3Br_2$

bromo ethene dichloro methane

Observation:

The brown colour of bromine disappears. This is a test for unsaturation

Note: alkyne → alkene →alkane

(c) Test for ethene:

(i) With ammonical cuprous chloride it forms a red precipitate of copper acetalide.

(ii) With ammonical silver nitrate it forms a white precipitate of silver acetalide.

(IV) ALCOHOL - R - OH

Ethanol - Ethyl alcohol C_2H_5OH

(a) Laboratory Preparation by hydrolysis of alkyl halide

$$C_2H_5Br + KOH_{(aq)} \xrightarrow{boil} KBr + C_2H_5OH$$

ethyl bromide aqueous ethanol

$$C_2H_5Cl + KOH_{(aq)} \xrightarrow{boil} KCl + C_2H_5OH \text{ (ethyl alcohol)}$$

(b) Industrial Preparation by hydration of ethene with cone. H_2SO_4

$$C_2H_4 + H_2SO_4 \xrightarrow[\text{30 atms pressure}]{80\ ^\circ C} C_2H_5HSO_4$$

$$C_2H_5HSO_4 + H_2O \rightarrow C_2H_5OH + H_2SO_4$$

(c) Fermentation of sugar [sucrose]

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow[\text{invertese}]{\text{yeast}} C_6H_{12}O_6 + C_6H_{12}O_6$$

glucose fructose

$$C_6H_{12}O_6 \xrightarrow[\text{fermentation}]{\text{yeast zymase}} C_2H_5OH + 2CO_2$$

(d) Chemical Properties of ethanol

(i) Combustion $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ (blue flame)

(ii) Dehydration

$$C_2H_5OH + \xrightarrow[170\ ^\circ C]{\text{conc. } H_2SO_4} C_2H_4 + H_2O \text{ (Imp)}$$

ethene

$$C_2H_5OH \xrightarrow[140\ ^\circ C]{\text{conc. } H_2SO_4} C_2H_5\text{-O-}C_2H_5 \text{ diethyl ether}$$

(iii) Estrification

$$C_2H_5OH + CH_3COOH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

ethyl acetate

(iv) Test for alcohols

$$2C_2H_5OH + 2Na \rightarrow 2C_2H_5OONa + H_2$$

sodium ethoxide

Effervescence - A gas bums with a pop sound + blue flame - H_2

(e) Conversion:

$$\underset{\text{ethanol}}{\text{alcohol}} \xrightarrow[K_2Cr_2O_7]{(O)\text{ acidified}} \underset{\text{acetaldehyde}}{\text{aldehyde}} \xrightarrow[K_2Cr_2O_7]{(O)\text{ acidified}} \underset{\text{ethanoic acid}}{\text{Acid}}$$

(V) <u>CARBOXYLIC ACIDS [R - COOH]</u>

(a) Preparation of acetic acid

(i) Ethanoic acid

$$C_2H_5OH + (O) \xrightarrow{\text{acidified K2Cr2 } O_7} CH_3CHO + H_20$$

ethanol acetaldehyde

$$CH_3CHO + (O) \xrightarrow{\text{acidified K2Cr2 } O_7} CH_3COOH \text{ [acetic acid ethanoic acid]}$$

(ii) Hydrolysis of ethyl acetate

$$\underset{\text{ethyl acetate}}{CH_3COOC_2H_5} + H_2O \xrightarrow{\text{conc.}H_2SO_4} CH_3COOH + C_2H_5OH$$

(b) Chemical Properties:

(i) Acidic Nature: Acid + alkali → salt + H_2O

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O\ [\text{Na-acetate}]$$
$$CH_3COOH + NH_4OH \rightarrow CH3COONH_4 + H_2O\ [\text{Ammonium acetate}]$$
$$2CH_3COOH + Ca(OH)_2 \rightarrow (CH_3COO)_2Ca + 2H_2O\ [\text{calcium acetate}]$$

(ii) Active metal + acetic acid → salt [acetate] + H_2↑

$$2CH_3COOH + 2Na \rightarrow 2CH_3COONa + H_2\uparrow$$
$$2CH_3COOH + Mg \rightarrow (CH_3COO)_2Mg + H_2\uparrow$$

(iii) Carbonates (CO_3^{--})/Bicarbonates + Acid → salt + H_2O + CO_2

$$NaHCO_3 + CH_3COOH \rightarrow CH_3COONa + H_2O + CO_2$$
$$Na_2CO_3 + 2CH_3COOH \rightarrow 2CH_3COONa + H_2O + CO_2$$

Estrification: $$\underset{\text{ethanol}}{\text{Alcohol}} + \text{Acetic acid} \xrightarrow{\text{conc. }H_2SO_4} \underset{\text{ester with a fruity smell}}{\text{Ethyl etheonate}} + H_2O$$

Mathematics - II

Compound Interest

1. The interest calculated every year on the amount due at the end of the year is known as compound interest.
2. The amount at the end of every year becomes the principal for next year and so on.
3. For the first year, Simple Interest and Compound Interest is the same.
4. If some amount of money is paid back at the end of every year, we subtract the money paid back from the amount due at the end of every year to get the amount balance. This amount balance becomes the principal for the next year and so on.

5. If the interest is calculated semi annually then take time as $\frac{1}{2}$ year and calculate the interest for every $\frac{1}{2}$ year.

6. For consecutive years: To find rate percent.

(i) If interests are given: $CI_2 - CI_1 = \frac{CI_1 \times R \times 1}{100}$

(ii) If amounts are given: $A_2 - A_1 = \frac{A_1 \times R \times 1}{100}$

7 If value of a machine or population after x years is asked take the given value of the machine or population as the principal and calculate the amount.

8 If value of a machine or population before x years is asked take the given value of the machine or population as the amount and calculate the principal.

9 If the depreciation for two successive years are given in order to get rate percent use:

$$D_1 - D_2 = \frac{D_1 \times R \times 1}{100}$$

Formula method:

10. $A = P(1 + \frac{R}{100})^n$ ......Compounded yearly.

11. $A = P(1 + \frac{R}{100})^{2n}$ ...... Compounded half yearly.

12 $A = P(1 + \frac{R_1}{100})(1 + \frac{R_2}{100})$ ...... If rates are different for different years.

13. $A = P(1 + \frac{R}{100})(1 + \frac{R_2}{100})$ ......If lime is given as a fraction, n is the whole number

14. For non-consecutive years: To-get rate percent.

(i) If interests are given $CI_x = CI_y (1 + \frac{R}{100})^n$ where CI_x and CI_y are the interest for the two non-consecutive years and n is the time difference between the two non-consecutive years.

(ii) If amounts arc given: $A_x = A_y \left(1+\frac{R}{100}\right)^n$ where A_x and A_y are the interest for the two non-consecutive years and n is the time difference between the two non-consecutive years.

15. Depreciation $A = P\left(1 - \frac{R}{100}\right)^n$ where A is the latter value or the depreciated value d and P is the former value.

16. Population : $A = P\left(1 + \frac{R}{100}\right)^n$ where A is the latter value and P is the former value, if the population is increasing.

Shares And Dividend

Face value is also called the nominal value of the shares.

1. No. of shares (n) $= \frac{\text{investment}}{\text{market value}}$
2. Sale proceeds = no. of shares × selling price of each share.
3. Annual income or dividend $= \frac{\text{dividend \%}}{100} \times$ no. of shares $\times$ face value
4. Percentage income on investment or yield % $= \frac{\text{income}}{\text{investment}} \times 100$
5. Yield % × market value = dividend % × face value.
6. Market value = face value + premium (shares available above par)
7. Market value = face value - discount (shares available below par)
8. Shares available at par means market value = face value.

Banking

To fill the pass book:

Add the credit, subtract the debit.

Qualifying balance is the minimum balance between 10^{th} and the last day of the month.

The month in which the account is opened after the 10th is not counted.

The month in which the account is closed is not counted

Recurring Deposit:

If the table of recurring deposit amount is not given, then

Step 1: Find the equivalent principal using the formula: $P = \dfrac{n(n+1)x}{2}$

Where n = the number of equal monthly instalments and x = the amount deposited every month.

Step 2: Find the interest on this equivalent principal for **one month** using

$$I = \frac{PTR}{100} \text{ where } T = \frac{1}{12}$$

$$\text{i.e. } I = \frac{PR}{1200}$$

Step 3: The amount payable at the end of the term i.e maturity value will be

$A = nx + 1.$

Sales Tax And Value Added Tax (Vat)

(a) Sales Tax

1. Rate of sales tax = $\dfrac{\text{sales tax}}{\text{selling price}} \times 100$
2. Nett selling price = selling price + sales tax
3. Rebate means discount which is always calculated on the list price
4. Selling price = (list price - rebate) + sales tax.

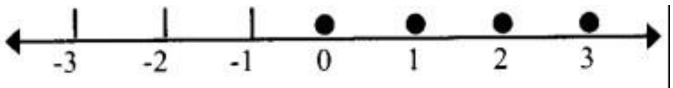
(b) Value Added Tax (VAT)

1. Calculate the tax on the selling price of the first seller.
2. Calculate the tax on the selling price of the second seller.
3. VAT paid by the second seller = tax obtained in step 2 - tax obtained in step 1.
4. Calculate the tax on the selling price of third seller.
5. VAT paid by the third seller = tax obtained in step 5 - tax obtained in step 2.

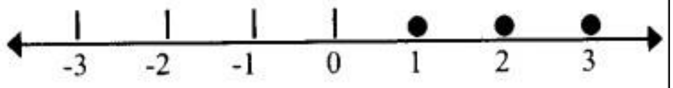
And so on............

Inequations

W = {0, 1, 2, 3....}

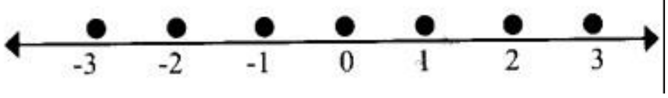


N = {1, 2, 3 ....}



Z or I

= {-3, -2, -1, 0, 1, 2, 3....}



R or Q = {all negative numbers, all positive numbers, 0, including fractions}

$-2 \leq x < 2, x \in R$

$-3\frac{1}{3} \leq x \leq 4\frac{1}{2}, x \in R$

$A \cap B$: common elements between A and B

$A \cup B$: all elements that belong to A and B

Compliment of A written as A^1 – element other than belonging to A

A - B: all elements in A which do not belong to B.

Quadratic Equations

For quadratic equation of the form $ax^2 + bx + c = 0; a \neq 0$

1. The roots of the quadratic are $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

2. $b^2 - 4ac$ is called the discriminant.

   (i) if $b^2 - 4ac < 0$, roots are complex or imaginary or unreal

   (ii) if $b^2 - 4ac = 0$, roots are real and equal.

   (iii) if $b^2 - 4ac > 0$, roots are real and unequal.

   (iv) if $b^2 - 4ac$ is a perfect square, roots are rational.

   (v) if $b^2 - 4ac$ is not a perfect square, roots are irrational.

3. Sum of roots = $\dfrac{-b}{a}$: product of roots = $\dfrac{c}{a}$

4. Equation: $x^2 - (\text{sum of roots})x + (\text{product of roots}) = 0$.

Remainder And Factor Theorem

Remainder Theorem: When a polynomial f(x) is divided by (x - a), then remainder = f(a)

Factor Theorem: If x - a is a factor of f(x), then f(a) = 0.

Ratio And Proportion

1. If a : b is the given ratio then a is called **antecedent** and b is called the **Consequent.**

2.

duplicate ratio	$a^2 : b^2$
triplicate ratio	$a^3 : b^3$
sub-duplicate ratio	$\sqrt{a} : \sqrt{b}$
sub-triplicate ratio	$\sqrt[3]{a} : \sqrt[3]{b}$
reciprocal ratio	$\frac{1}{a} : \frac{1}{a}$ or b : a

3 If the given ratios a : b and c : d; then **compound ratio** is $(a \times c) : (b \times d)$ or Simply multiply the ratios.

4 In a : b = c : d, 'a' and 'd' are called extremes (end - terms) and 'b' and 'c' are called means (middle terms).

$$a : b = c : d \rightarrow \frac{a}{b} = \frac{c}{d} \rightarrow a \times d = b \times c$$

$\rightarrow$ product of extremes = product of means.

5 If a, b and c are in **continued proportion** a : b = b : c or $b^2 = ac$

6 **Fourth proportion** of a, b, c is $a : b = c : x$ where x is fourth proportion.

7 **Third proportion** of a, b is $a : b = b : x$ where x is third proportion.

8 **Mean proportion** of a, b is $a : x = x : b$ where x is the mean proportion.

9 Given that $\frac{a}{b} = \frac{c}{d}$

$\frac{b}{a} = \frac{d}{c}$	**Invertendo**
$\frac{a}{c} = \frac{b}{d}$	**altcrnendo**
$\frac{a+b}{b} = \frac{c+d}{d}$	**componendo**
$\frac{a-b}{b} = \frac{c-d}{d}$	**dividendo**
$\frac{a+b}{a-b} = \frac{c+d}{c-d}$	**componendo - dividendo**
$\frac{a+c}{b+d}$ = value of each ratio	**theorem on equal ratios**

Matrices

Unit or identity Matrix: A diagonal matrix, in which each element of the leading diagonal is unity. It is denoted by I.

$$\text{e.g. } I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Transpose of a matrix: Transpose of a matrix obtained on interchanging its row and columns. If A is matrix, then its transpose is denoted by A^t.

$$\text{e.g. } I = \begin{bmatrix} 3 & 1 & -2 \\ 0 & 6 & -4 \end{bmatrix}, \text{ then its transpose } A^t = \begin{bmatrix} 3 & 0 \\ 1 & 6 \\ -2 & -4 \end{bmatrix}$$

Addition of two matrices: Possible only if both matrices have the same order. If A, B and C are the matrices of same order, then

1. A + B = B + A, the addition of matrices is commutative.
2. A + (B + C) = (A + B) + C, the addition of matrices is associative.
3. $A + X = B \rightarrow X = B - A$

4. Null matrix = $\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$

Multiplication of two matrices:

Two matrices are compatible for multiplication if and only if the number of columns of the first matrix is equal to the number of rows of the second.

e.g. $A_{m \times n} \times B_{n \times p} \rightarrow C_{m \times p}$

Remember:

1. For any matrices A, B and C which are compatible for multiplication

   the number of column of first should be equal to number of rows of the second.

2. Number of rows of first is equal to number of rows of product matrix.

3. Number of columns of second matrix is equal to number of columns of product matrix.

4. In general AB ≠ BA i.e product of matrices is not **commutative.**

5. (AB) C = A(BC) i.e product of matrices is **associative.**

6. If A ≠ 0 and AB = AC, then it is not necessary that B = C.

7. If AB = 0, then it is not necessary that A = 0 or B =0.

8. If A = 0 or B = 0, then AB = 0 = BA.

9. A (B + C) = AB + AC i.e multiplication of matrices is **distributive** with respect to matrix addition.

10. I - the unit matrix is called the **identity matrix for multiplication**, i.e. A × I = I × A = A.

11. If $\begin{bmatrix} a & b \\ c & d \end{bmatrix} M = \begin{bmatrix} e \\ f \end{bmatrix}$ then order of M is 2 × 1

    If $M \begin{bmatrix} a & b \\ c & d \end{bmatrix} = \begin{bmatrix} e & f \end{bmatrix}$ then order of M is 1 × 2

Co-Ordinate Geometry / Equation Of A Line

1. **Reflection:**

$$M_x(x, y) = (x, -y)$$
$$M_y(x, y) = (-x, y)$$
$$M_0(x, y) = (-x - y)$$

2. **Invariant points:** (i) Do not change on being reflected.

(ii) They lie on the reflecting line.

3. Equation of a line parallel to x-axis and 'a' units away is y = a
Equation of a line parallel to y-axis and 'b' units away is x = b

4. Equation of the x -axis is y = 0. Equation of y-axis is x = 0

5. The mirror line is the perpendicular bisector of the segment joining the point and its image.

6. x co-ordinate is also known as abscissa and
y co-ordinate is also known as ordinate

7. If a point lies on the x -axis its y co-ordinate is zero. It is assumed as (x ,0)

8. If a point lies on the y-axis its x -co-ordinate is zero. It is assumed as (0, y)

9. **Distance formula:** $AB = \sqrt{(x_2 - x_1) + (y_2 - y_1)^2}$

10. **Section formula:** $(x, y) = \left(\frac{mx_2 + nx_1}{m+n}, \frac{my_2 + ny_1}{m+n}\right)$

11. **Mid point formula:** $(x, y) = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$

12. Slope (gradient): m = tan θ. (θ -inclination - ∠ line makes with the positive direction of x-axis)

14. y = m x + c (m - slope, c → y - intercept)

15. **If two lines are parallel $m_1 = m_2$: perpendicular $m_1 \times m_2 = -1$**

16. **Equation of line:** To find the equation,

(i) Slope point form: $y - y_1 = m(x - x_1)$

(ii) slope intercept form: y = m x + c : m slope, c = y intercept.

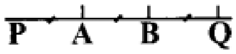
17. **Equidistant:** PA = PB. Use distance formula.

i.	Isosceles triangle	Two sides equal
ii.	Right angled triangle	Pythagoras satisfied
iii.	Equilateral triangle	All sides equal
iv.	Parallelogram	Opposite sides are equal

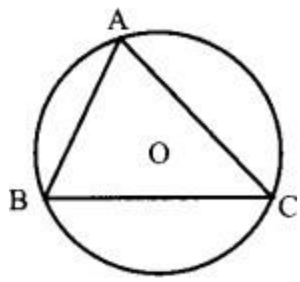
18.

V.	Rectangle	Opposite sides and diagonals equal
vi.	Rhombus	All sides equal
vii.	Square	All sides and diagonals equal

19. **Point of Trisection :** A divides PQ in ratio 1 : 2 and B divides PQ in ratio 2 : 1.



20. **Circumcentre:** Point where perpendicular bisectors of sides meet, it is equidistant from the vertices.



OA = OB = OC

$OA^2 = OB^2 \rightarrow$ gives equation 1

OB2 = OC2 $\rightarrow$ gives equation 2

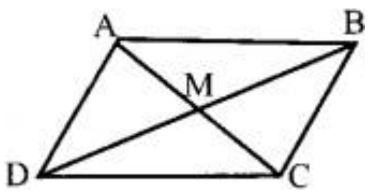
Solve simultaneously.

21. **Orthocentre:** Find the equation of ALTITIDES of two sides of the given triangle. Solve the above equations simultaneously.

22. **Centroid:** co-ordinates of centroid $\left(\frac{x_1+x_2+x_3}{3}, \frac{y_1+y_2+y_2}{3}\right)$

where (x_1, y_1), (x_2, y_2) and (x_3, y_3) are the vertices of triangle.

23. To find the fourth vertex of parallelogram, rectangle, square, rhombus. Suppose A, B, D are given to find C.



(i) Find M - mid point of BD

(ii) Find C - using M as mid point of AC.

24. If three points A, B and C are collinear - slope of AB = slope of BC.

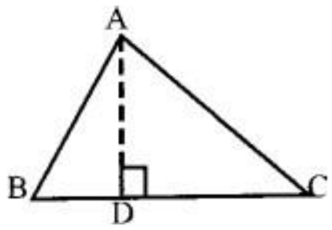
25. To find the x - intercept of a line substitute y = 0 in the equation.

26. To find the y-intercept of a line substitute $x = 0$ in the equation.

27. To find the point of intersection of two lines - solve the equation simultaneously.

28. If a point lies on a line it satisfies the equation of the line.

29. To find equation of **ALTITUDE:**

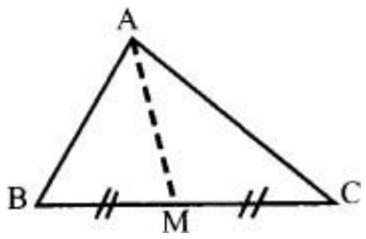


(i) Find slope of BC.

(ii) Slope of altitude is negative reciprocal B,

(iii) Use slope point form, given A is a point on the line.

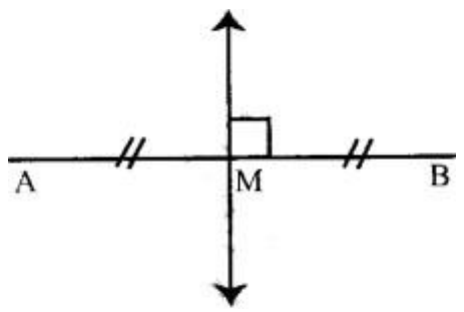
30. To find equation of MEDIAN:



(i) Use mid point formula to find M.

(ii) A and M two points are known, get slope and use slope point form.

31. To find the equation of **PERPENDICULAR BISECTOR:**



(i) Mid point of AB

(ii) Slope of AB

(iii) Negative reciprocal of AB ~

(iv) Use slope point form.

Symmetry

Figure	No. of lines of symmetry	Whether has point symmetry
Scalene triangle	no line of symmetry	no point symmetry
Isosceles triangle	one line	no point symmetry
Equilateral triangle	Three lines	no point symmetry
Parallelogram	no line of symmetry	One point symmetry
Rectangle	Two lines	One point symmetry
Rhombus	Two lines-diagonal	One point symmetry
Square	Four lines	One point symmetry
Kite	One line	no
Isosceles trapezium	One line	no
Regular pentagon	Five lines	no
Regular hexagon	Six lines	One point symmetry
Circle	Infinite	One

Similarity

Postulates of similarity: **(i)** A - A or A - A - A

(ii) S – A - S

(iii) S - S - S

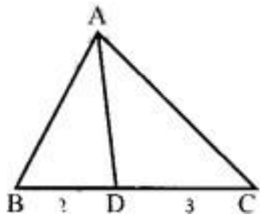
Properties of similar triangles:

(i) If two triangles are similar, their corresponding sides are proportional.

(ii) Their corresponding angles are equal.

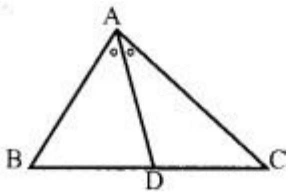
(iii) The ratio of their areas is square of their corresponding sides.

If two triangles have a common vertex then the ratio of their areas is equal to ratio of their bases.



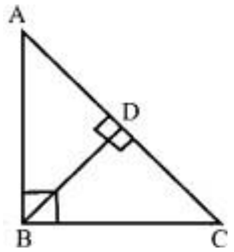
$$\frac{\Delta ABD}{\Delta ADC}=\frac{2}{3};\ \frac{\Delta ABC}{\Delta ADC}=\frac{5}{3};\ \frac{\Delta ABD}{\Delta ABC}=\frac{2}{5}$$

If angle is bisected by segment AD in triangle ABC then,



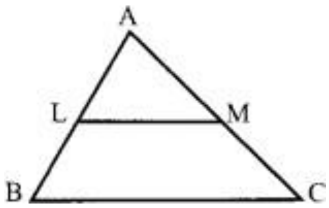
$$\frac{BD}{DC}=\frac{AB}{AC}$$

The length of the perpendicular from the right angle of a right angled triangle to the hypotenuse is equal to the product of the parts of the hypotenuse i.e.



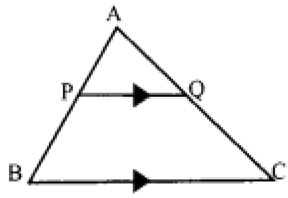
$BD^2 = AD \times DC$.

Mid-point Theorem: The segment joining the midpoints of two sides of a triangle is parallel to the third side and is half of the third side.



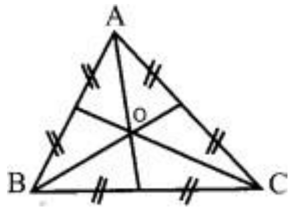
$$LM = \frac{1}{2}\ BC \text{ and } LM \,//\, BC$$

Basic proportionality Theorem: A line drawn parallel to the base of the triangle divides the other two sides proportionally.



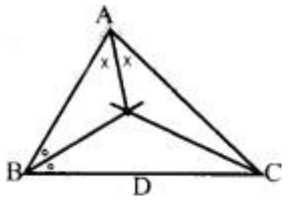
If PQ // BC then $\frac{AP}{PB} = \frac{AQ}{QC}$

CENTRIOD : Point intersection of medians in a triangle.



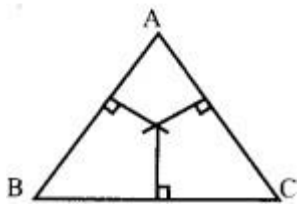
A centriod divides a median in ratio 2:1.

INCENTRE: Point of intersection of angle bisectors of triangle.



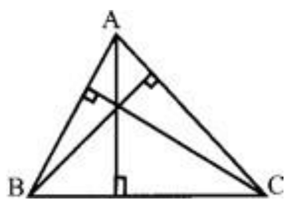
It is equidistant from the sides of the triangle.

CIRCUMCENTRE: Point of intersection of perpendicular bisector of sides.



It is equidistant from the vertices of the triangle.

ORTHOCENTRE: Point of intersection of the altitudes of triangle.



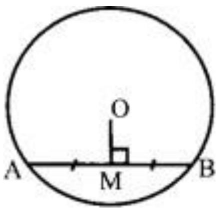
Locus

Points to remember for construction:

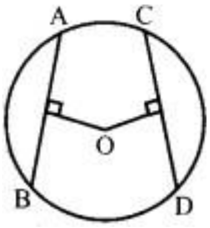
1. Equidistant from two fixed points (AP = BP) → draw perpendicular bisector.
2. Equidistant from two sides (P is equidistant from AB and BC) → draw angle bisector.
3. At a fixed distance from a fixed point → draw CIRCLE
4. At a fixed distance from a fixed line → draw a line parallel, equal to the given distance on both sides.

Circle

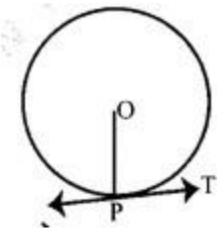
1. The segment joining the centre of the circle to mid point of chord is perpendicular to the chord.



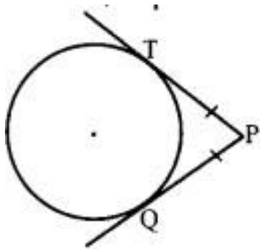
2. **CONVERSE:** Perpendicular segment from the centre bisects the chord.
3. Equal chords in a circle or equal circles are equidistant from the centre.



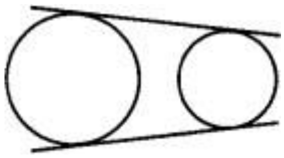
4. **CONVERSE:** Equidistant chords in a circle or equal circles are equal.
5. The tangent and the radius at any point on a circle are perpendicular to each other.



6. Tangent segment from an exterior points is equal in length and the segment joining the centre to the exterior point, bisects the angle between the tangents, i.e PT = PQ

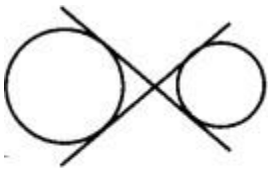


7. $\text{DCT} = \sqrt{d^2 - (R - r)^2}$



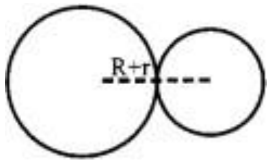
DCT - Direct Common Tangent

8. $\text{TCT} = \sqrt{d^2 - (R - r)^2}$



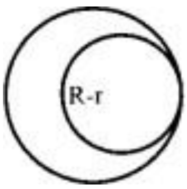
TCT - Transverse Common Tangent

9. If two circle touch each other externally their



centres and the point of contact lie on a straight line, the distance between their centres is (R + r)

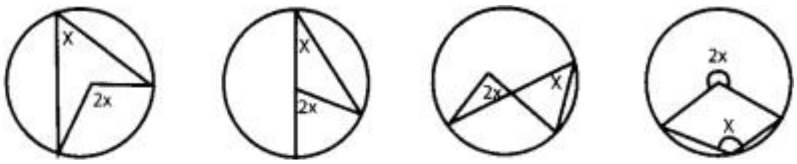
10. If two circle touch each other internally, their centres and the point of contact lie on a straight line the distance between their centres is (R - r).



11. The angle subtended by an arc at the centre is twice the angle subtended on the circumference.

Angle Properties

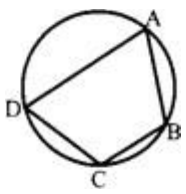
1. The angle subtended by an arc at the centre is twice the angle subtended on the circumference.



2. Angles in the same segment of a circle are equal.

3. The angle inscribed in a semicircle is a right angle.

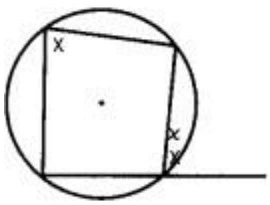
4. The opposite angles of a cyclic quadrilateral are supplementary.



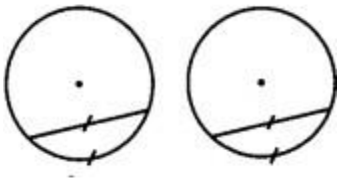
A + C = 180°

B + D = 180°

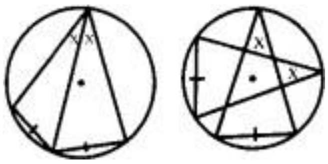
5. The exterior angle of a cyclic quadrilateral is equal to interior opposite angle



6. If two chords are equal, the corresponding arcs are equal and converse.

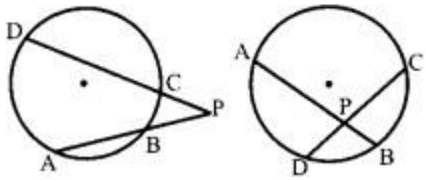


7. If two chords are equal, the angle



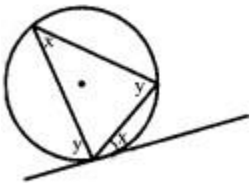
inscribed on the circumference and the centre are also equal.

8. If two chords of a circle intersect internally or externally then the product of the lengths of their segments are equal.

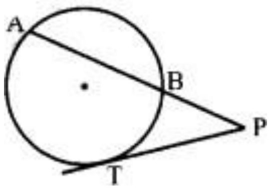


AP × BP = CP × DP

9. The angle between a tangent and a chord through the point of contact is equal to an angle in the alternate segment.



10. If a chord and a tangent intersect externally, then the product of the lengths of the segments of the chord is equal to the square of the length of the tangent from the point of contact to the point of intersection.



PT^2 = PA x PB

11. Base angles of isosceles triangle are congruent.

12. Sum of angles of triangle = 180°

13. Sum of angles of quadrilateral = 360°

14. Opposite angles of parallelogram are equal.

Area Of Circle

	Parallelogram	Rectangle	Square	Rhombus	Trapezium
Area	base x height	$l \times b$	l^2 or $\frac{1}{2}d^2A$	$\frac{1}{2}d_1 \times d_2$	$\frac{1}{2}(a+b)h$
Perimeter		$2(1 \times b)$	$4l$		

	Circle	Semicircle	Quadrant	Ring	Sector
Area	πr^2	$\frac{1}{2}\pi r^2$	$\frac{1}{4}\pi r^2$	$\pi(R+r)(R-r)$	$\frac{\theta}{360} \times \pi r^2$
Perimeter	$2\pi r$ or $7\pi d$	$\pi r + 2r$ only curved $= \pi r$	$\frac{\pi r}{2} + 2r$		$\frac{\theta}{360} \times 2\pi r$

Area of a scalene triangle $A = \sqrt{s(s-a)(s-b)(s-c)}$

where $s = \dfrac{a+b+c}{2}$

Area of $\Delta = \dfrac{1}{2}(b \times h)$

Area of equilateral $\Delta = \dfrac{\sqrt{3}}{4}(\text{side})^2$

No. ot revolution $= \dfrac{\text{distance covered}}{\text{circumference}} = \dfrac{\text{distance covered}}{2\pi r}$

Mensuration

CSA - Curved Surface Area
TSA - Total Surface Area

	VOLUME	CSA	TSA
Cylinder	$\pi r^2 h$	$2\pi rh$	$2\pi r(r+h)$

Cone	$\frac{1}{3}\pi r^2 h$	$\pi r l$ where $l^2 = r^2 + h^2$	$\pi r (r + l)$
Sphere	$\frac{4}{3}\pi r^3$	$4\pi r^2$	$4\pi r^2$
Hollow Cylinder	$\pi h (R + r)(R - r)$ $t = (R - r)$ t = thickness	$2\pi rh + 2\pi RH$	$2\pi Rh + 2\pi rh + 2\pi (R^2 - r^2)$

	VOLUME	CSA	TSA
Hemisphere	$\frac{2}{3}\pi r^3$	$2\pi r^2$	$3\pi r^2$
Hollow Sphere	$\frac{4}{3}\pi (R^3 - r^3)$		

CUBE: Volume = l^3 ; diagonal = $1\sqrt{3}$ TSA = $6l^2$

CUBOID: Volume = $l\,b\,h$; diagonal = $\sqrt{l^2 + b^2 + h^2}$;

$$TSA = 2(l\,b + b\,h + l\,h)$$

1. MELTING AND RECASTING

Volume of larger = n × volume of smaller.

2. DENSITY

Weight = density × volume (use corresponding formula)

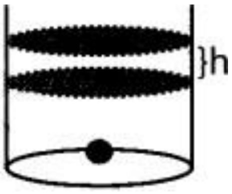
3. TIME

Volume of water discharged per second = πr^2 × speed (use r = radius of pipe)

$$\text{Time} = \frac{\text{Volume of tank}}{\pi r^2 \times \text{speed}}$$

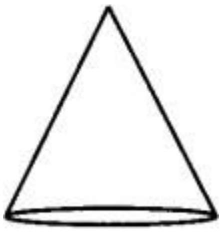
4. DISPLACEMENT

$n \times$ volume of each solid submereged $= \pi r^2 h$



r - radius of cylinder vessel, h - rise in level

5. **TENT**



Area of each = $\pi r l$

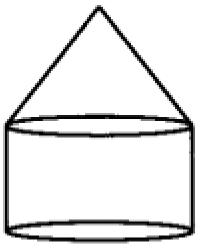
length × width of canvass = $\pi r l$

Area of canvas = $\pi r l + 2\pi r h$

length × width - area of canvas

6. **ROLLER**

distance travelled in 'n' revolutions = $2\pi r n$



area covered in 'n' revolutions = $2\pi r h n$

7. (i) Volume of well = volume of platform

$\pi r^2 h = l \times b \times h$

(ii) **EMBANKMENT**

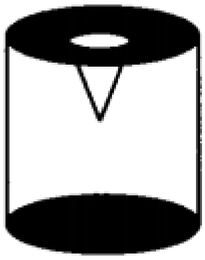
Volume of well = volume of hollow cylinder ar2h = π (R + r) (R - r)h

8. **SECTOR FOLDED TO FORM CONE**

(i) area of the sector = curved surface of the cone

(ii) the radius r of the sector is the slant height of the cone.

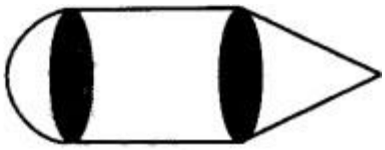
9. (i) Volume of remaining solid = $\pi R^2 H - \frac{1}{3}\pi r^2 h$



TSA of remaining solid =

$2\pi RH + \pi R^2 + \pi(R + r)(R - r) + \pi rL$

(ii) Volume = $\frac{2}{3}\pi r^3 + \pi r^2 h + \frac{1}{3}\pi r^3$



TSA = $2\pi r^2 + 2\pi rh + \pi rl$

(iii) **BUOY:** volume = $\frac{1}{3}\pi r^3 h + \frac{2}{3}\pi r^3$

TSA = $\pi rl + 2\pi r^2$

Trigonometry

Trigonometric Identities:

1. $\frac{\sin\theta}{\cos\theta} = \tan\theta$

2. $\frac{\cos\theta}{\sin\theta} = \cot\theta$

3. $\frac{1}{\sin\theta} = \text{cosec}\,\theta$

4. $\frac{1}{\cos\theta} = \sec\theta$

5. $\sin^2\theta + \cos^2\theta = 1$

6. $1 + \tan^2\theta = \sec^2\theta$

7. $1 + \cot^2\theta = \text{cosec}^2\theta$

8. $\sin\theta = \cos(90° - \theta)$

9. $\cos\theta = \sin(90° - \theta)$

10. $\tan\theta = \cot(90° - \theta)$

11. $\cot\theta = \tan(90° - \theta)$

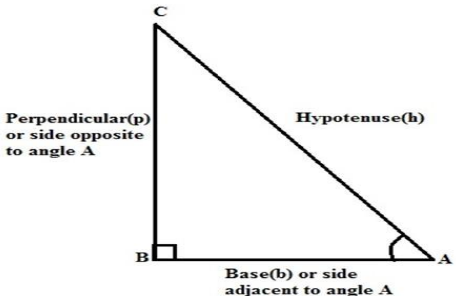
12. $\sec\theta = \text{cosec}(90° - \theta)$

13. $\text{cosec}\,\theta = \sec(90° - \theta)$

	0^0	30^0	45^0	60^0	90^0
sin	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
tan	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	∞

Fundamentals:

- Trigonometry is the branch of mathematics dealing with the relations of the sides and angles of triangles and with the relevant functions of any angles.
- **Trigonometric Ratios:** The values of the ratios of the sides of any right triangle with respect to any angle (other than 90°) are called trigonometric ratios of that angle. For example: In right triangle ABC, the ratios of the sides of the triangle with respect to $\angle A$ are called trigonometric ratios of $\angle A$.



There are six different trigonometric ratios as follows:

1. Sine A $= \dfrac{\text{Opposite side to angle A}}{\text{Hypotenuse}} = \dfrac{BC}{AC} = \dfrac{\text{Perpendicular}}{\text{Hypotenuse}}$

2. Cosine A $= \dfrac{\text{Adjacent side to angle A}}{\text{Hypotenuse}} = \dfrac{AB}{AC} = \dfrac{\text{Base}}{\text{Hypotenuse}}$

3. Tangent A $= \dfrac{\text{Opposite side to angle A}}{\text{Adjacent side to angle A}} = \dfrac{BC}{AB} = \dfrac{\text{Perpendicular}}{\text{Base}}$

4. Cosecant A $= \dfrac{\text{Hypotenuse}}{\text{Opposite side to angle A}} = \dfrac{AC}{BC} = \dfrac{\text{Hypotenuse}}{\text{Perpendicular}}$

5. Secant A $= \dfrac{\text{Hypotenuse}}{\text{Adjacent side to angle A}} = \dfrac{AC}{AB} = \dfrac{\text{Hypotenuse}}{\text{Base}}$

6. Cotangent A $= \dfrac{\text{Adjacent side to angle A}}{\text{Opposite side to angle A}} = \dfrac{AB}{BC} = \dfrac{\text{Base}}{\text{Perpendicular}}$

Tips:

1. sin A is written for sine A.
2. cos A is written for cosine A.
3. tan A is written for tangent A.
4. cosec A is written for cosecant A.
5. sec A is written for secant A.
6. cot A is written for cotangent A.

Short way to learn above ratios:

Just learn first three, because if you see other three are reciprocals of first three respectively. Let *P* denotes perpendicular, *B* for base and *H* for hypotenuse.

sin		cos		tan	
PANDIT	(P)	BADRI	(B)	PRASAD	(P)
HAR	(H)	HAR	(H)	BOLE	(B)

Similarly:

cosec		sec		cot	
HAR	(H)	HAR	(H)	BOLE	(B)
PADNIT	(P)	BADRI	(B)	PRASAD	(P)

Relation between Trigonometric Ratios:

$$\sin\theta = \frac{1}{\text{cosec}\,\theta} \quad \text{OR} \quad \text{cosec}\,\theta = \frac{1}{\sin\theta}$$

$$\cos\theta = \frac{1}{\sec\theta} \quad \text{OR} \quad \sec\theta = \frac{1}{\cos\theta}$$

$$\tan\theta = \frac{1}{\cot\theta} \quad \text{OR} \quad \cot\theta = \frac{1}{\tan\theta}$$

$$\tan\theta = \frac{\sin\theta}{\cot\theta} \quad \text{OR} \quad \cot\theta = \frac{\cos\theta}{\sin\theta}$$

Trigonometric Ratios of Some Specific Angles:

In this part, we will put values of angles as 0°, 30°, 45°, 60° and 90°, hence we will find ratios.

θ	0°	30°	45°	60°	90°
Sin	0	1/2	$1/\sqrt{2}$	$\sqrt{3}/2$	1
Cos	1	$\sqrt{3}/2$	$1/\sqrt{2}$	1/2	0
Tan	0	$1/\sqrt{3}$	1	$\sqrt{3}$	∞
Cosec	∞	2	$\sqrt{2}$	$2/\sqrt{3}$	1
Sec	1	$2/\sqrt{3}$	$\sqrt{2}$	2	∞
Cot	∞	$\sqrt{3}$	1	$1/\sqrt{3}$	0

- **How to remember trigonometric ratios of some specific angles?**

  1. First of all learn only sin row. If you can't learn then follow the step to find sin θrow

θ	0°	30°	45°	60°	90°
Sin θ	$\frac{\sqrt{0}}{\sqrt{4}}$	$\frac{\sqrt{1}}{\sqrt{4}}$	$\frac{\sqrt{2}}{\sqrt{4}}$	$\frac{\sqrt{3}}{\sqrt{4}}$	$\frac{\sqrt{4}}{\sqrt{4}}$
	0	1/2	$1/\sqrt{2}$	$\sqrt{3}/2$	1

2. For cos θ row, write all the values of sin θ row in inverse order, i.e. from right to left.
3. For $\tan\theta = \frac{\sin\theta}{\cot\theta}$
4. For $\operatorname{cosec}\theta = \frac{1}{\sin\theta}$
5. For $\sec\theta = \frac{1}{\cos\theta}$
6. For $\cot\theta = \frac{\cos\theta}{\sin\theta}$

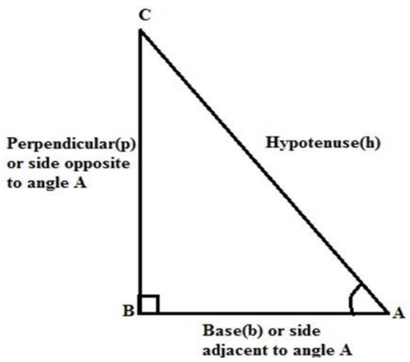
Trigonometric Ratios of Complementary Angles:

In Δ *ABC*, ∠ *B* = 90°, Let ∠ *A* = θ, hence ∠ *C* = 90° - θ.

Thus angles θ and (90° - θ) are complementary angles.

Complementary Angle:

- $\sin\theta = \cos(90^\circ - \theta)$
- $\cos\theta = \sin(90^\circ - \theta)$
- $\tan\theta = \cot(90^\circ - \theta)$
- $\cot\theta = \tan(90^\circ - \theta)$
- $\sec\theta = \operatorname{cosec}(90^\circ - \theta)$
- $\operatorname{cosec}\theta = \sec(90^\circ - \theta)$



Fundamental Trigonometric Identities:

Reciprocal and Quotient Identities	$\sin\theta = \frac{1}{\csc\theta}$ $\csc\theta = \frac{1}{\sin\theta}$ $\cos\theta = \frac{1}{\sec\theta}$ $\sec\theta = \frac{1}{\cos\theta}$ $\tan\theta = \frac{1}{\cot\theta} = \frac{\sin\theta}{\cos\theta}$ $\cot\theta = \frac{1}{\tan\theta} = \frac{\cos\theta}{\sin\theta}$
Pythagorean Identities	$\sin^2\theta + \cos^2\theta = 1$ $\tan^2\theta + 1 = \sec^2\theta$ $\cot^2\theta + 1 = \csc^2\theta$
Sum and Difference Identities	$\sin(A+B) = \sin A\cos B + \cos A\sin B$ $\cos(A+B) = \cos A\cos B - \sin A\sin B$ $\sin(A-B) = \sin A\cos B - \cos A\sin B$ $\cos(A-B) = \cos A\cos B + \sin A\sin B$ $\tan(A+B) = \frac{\tan A + \tan B}{1 - \tan A\tan B}$ $\tan(A-B) = \frac{\tan A - \tan B}{1 + \tan A\tan B}$
Double Angle Identities	$\sin(2A) = 2\sin A\cos A$ $\cos(2A) = \cos^2 A - \sin^2 A = 1 - 2\sin^2 A = 2\cos^2 A - 1$ $\tan(2A) = \frac{2\tan A}{1-\tan^2 A}$
Half Angle Identities	$\sin\left(\frac{A}{2}\right) = \pm\sqrt{\frac{1-\cos A}{2}}$ $\cos\left(\frac{A}{2}\right) = \pm\sqrt{\frac{1+\cos A}{2}}$ $\tan\left(\frac{A}{2}\right) = \frac{\sin A}{1+\cos A} = \frac{1-\cos A}{\sin A}$

Statistics

	MEAN	MEDIAN	MODE
Ungrouped Data	mean = $\frac{\sum x}{n}$	i) arrange in ascending order ii) Median rank $= \left(\frac{n+1}{2}\right)$ item	number that appears the most
Grouped data without C. I.	mean = $\frac{\sum fx}{\sum f}$	i) find cumulative frequency ii) median rank $= \left(\frac{N+1}{2}\right)^{th}$ [x, c, f]	x with maximum frequency
Grouped data with C. I.	**Direct method** mean = $\frac{\sum fx}{\sum f}$ **Short cut Method** mean = A + $\frac{\sum fd}{\sum f}$ Step deviation method mean = A + $\frac{\sum fu}{\sum f} \times i$	i) find CF ii) PLOT OGIVE iii) median $= \left(\frac{N}{4}\right)$ item iv) lower quartile $= \left(\frac{N}{4}\right)$ item v) upper quartile $= \left(\frac{3N}{4}\right)$ item	i) PLOT HISTOGRAM

Interquartile range = $Q_3 - Q_1$

semi interquartile range = $\frac{Q_3 - Q_1}{2}$

Fundamentals:

1. The word statistics is used in both singular as well as plural.
2. In singular, it means "science of collection, presentation, analysis and interpretation of numerical data".
3. In plural, it means "numerical facts collected with definite purpose".
4. The number of times an observation occurs in the given data is called the frequency.

5. Frequency distribution is of two types :
   i. Discrete Frequency distribution
   ii. Continuous or Grouped Frequency distribution
6. Classes/class intervals are the groups in which all the observations are divided.
7. Suppose class-interval is 10-20, then 10 is called lower limit and 20 is called upper limit of the class.
8. Mid-value of class-interval is called **Class-mark**

$$\text{Class-mark} = \frac{\text{lower limit} + \text{upper limit}}{2}$$

$$\text{Class-mark} = \text{lower limit} + \frac{1}{2}$$

9. If the frequency of first class interval is added to the frequency of second class and this sum is added to third class and so on then frequencies so obtained are known as **Cumulative Frequency (c.f.).**
10. The commonly used measures of central tendency are as follows :

Arithmetic Mean (MEAN), Geometric Mean, Harmonic Mean, Median and Mode.

Acc. to course, we will study mean, median & mode

Relation between mean, median and mode:

3 Median = Mode + 2 Mean

Mean Of Grouped Data: If $x_1, x_2, x_3, \ldots\ldots. x_n$, are observations with respective frequency $f_1, f_2, f_3, \ldots\ldots. f_n$, it means observation x_1 occurs f_1 times, observation x_2 occurs f_2 times and so on. Mean is denoted by $\bar{x}$. There are three different ways to find the mean of a grouped data which are:

1. Direct Method.
2. Assumed Mean Method.
3. Shortcut Method (Step-Deviation Method).

1. Direct Method:

$$\text{Mean } (\overline{X}) = \frac{\text{Sum of all the observations}}{\text{No. of observations}}$$

$$\bar{x} = \frac{f_1x_1 + f_2x_2 + \ldots\ldots\ldots\ldots + f_nx_n}{f_1 + f_2 + \ldots\ldots\ldots\ldots + f_n}$$

$$\bar{x} = \frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i}$$

2. Assumed Mean Method: The formula used in the assumed mean method is given as below:

$$\text{Mean } (\bar{x}) = a + \frac{\sum_{i=1}^{n} f_i d_i}{\sum_{i=1}^{n} f_i}$$

Where a is any arbitrary value, chosen as assumed mean (somewhere in the middle of x_i), and $d_i = x_i - a$.

3. Step-Deviation Method (Shortcut Method): The formula used is given below:

$$(\bar{x}) = a + \frac{\left(\sum f_i u_i\right)}{\left(\sum f_i\right)} \times h,$$

Where a is any arbitrary value, chosen as assumed mean (somewhere in the middle of x_i).

$$h = \text{class-size}$$

and $$u_i = \frac{x_i - a}{h}$$

Combined Mean: If $\bar{x}_1$ and $\bar{x}_2$ are the means of two groups having same unit of measurement computed from n_1 and n_2 values.

$$\text{Mean } (\bar{x}) = \frac{n_1\bar{x}_1 + n_2\bar{x}_2}{n_1 + n_2}$$

Arithmetic mean of raw data (when frequency is not given): The arithmetic mean of a raw data is obtained by adding all the values of the variables and dividing the sum by total number of values that are added.

Arithmetic mean $$(\bar{x}) = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Median of Grouped Data:

Condition I: When the data is discrete.

Step 1: Arrange data in ascending order.

Step 2: If the total frequency n is odd:

Then, $\left(\frac{n+1}{2}\right)^{th}$, observation is the median.

Step 3: If the total frequency n is even:

Then, mean of $\frac{n^{th}}{2}$ and $\left(\frac{n}{2}+1\right)^{th}$, observations the median.

Condition II: When the data is continuous and in the form of frequency distribution:

$$\text{Then, Median} = l + \left[\frac{\frac{n}{2} - c}{f}\right] \times h$$

Median class = the class whose cumulative frequency is greater than (nearest to) $\frac{N}{2}$.

Where, l = lower limit of median class

f = frequency of median class

h = class-size

n = number of observations

c = cumulative frequency of class preceding the median class.

Mode of Grouped Data: The class with maximum frequency is called the modal class.

$$\text{Mode} = l + \left[\frac{f_1 - f_0}{2f_1 - f_0 - f_2}\right] \times h$$

Where, l = lower limit of the modal class

h = class-size

f_1 = frequency of the modal class

f_0 = frequency of the class preceding the modal class

f_2 = frequency of the class succeeding the modal class

OGIVE or Cumulative Frequency Curve: The term ogive is derived from the word ogee.

An ogee is a shape consisting of concave arc flowing into a convex arc.

An OGIVE of less than type: It is drawn for less than type cumulative frequency distribution.

Here we mark upper limit of class interval on horizontal axis while respective cumulative frequency is marked on vertical axis and plot the corresponding points and join them by a free, hand curve. Cumulative frequency is counted up to down.

An OGIVE of more than type: It is drawn for more than type cumulative frequency distribution.

Here we mark lower limit of class interval on horizontal axis while respective cumulative frequency is marked on vertical axis and plot the corresponding points and join them by a free hand curve. Cumulative frequency is counted down to up.

Note: Intersecting point of less than ogive and more than ogive gives median.

Note: The median of the grouped data can be obtained on any one of the ogive by locating $\frac{N}{2}$ on the y-axis. Locate corresponding point on the ogive, x-coordinate of that point determines the median of the data.

Miscellaneous

EXPANSION

1. $(x \pm y)^2 = x^2 + y^2 \pm 2xy$
2. $(x \pm y)^3 = x^3 \pm y^3 \pm 3xy\,(x \pm y)$
3. $(x + y + z)^2 = x^2 + y^2 + z^2 + 2xy + 2yz + 2xz$
4. $(x + y)2 = (x - y)^2 + 4xy$

FACTORISATION

1. $x^2 - y^2 = (x - y)\,(x + y)$
2. $x^3 + y^3 = (x + y)\,(x^2 - xy + y^2)$
3. $x^3 - y^3 = (x - y)\,(x^2 + xy + y^2)$

INDICES

1. $a^m \times a^n = a^{m+n}$
2. $\dfrac{a^m}{a^n} = a^{m-n}$
3. $(a^m)^n = a^{mn}$
4. $\sqrt[n]{a} = a^{1/n}$
5. $\sqrt[n]{a^2} = a^{1/n}$
6. $a^0 = 1$
7. $a^{-n} = \dfrac{1}{a^n}$
8. $\left(\dfrac{a}{b}\right)^{-n} = \left(\dfrac{b}{a}\right)^n = \dfrac{b^n}{a^n}$
9. $(a \times b) = a^m \times b^m$

Logarithms

1. $\log(a \times b) = \log a + \log b$
2. $\log\left(\frac{a}{b}\right) = \log a - \log b$
3. $\log a^b = b\log a$
4. If $a = b^c$ then $\log_b a = c$

$$\textbf{SPEED} = \frac{\text{distance}}{\text{Time}}$$

To convert from km/hr to m/s multiply by $\frac{5}{18}$

To convert from m/s to km/hr multiply by $\frac{18}{5}$

Profit Loss And Discount

1. Profit = Selling price - Cost price
2. Loss = Cost price - Selling price
3. $\text{Profit }\% = \frac{\text{Profit}}{\text{Cost Price}} \times 100$
4. $\text{Loss }\% = \frac{\text{Loss}}{\text{Cost Price}} \times 100$
5. Discount = Market price - Selling price
6. $\text{Discount }\% = \frac{\text{Discount}}{\text{Market price}} \times 100$

Mathematical Formulae

Algebra:

1. $(a+b)^2 = a^2 + 2ab + b^2;\ a^2 + b^2 = (a+b)^2 - 2ab$
2. $(a-b)^2 = a^2 - 2ab + b^2;\ a^2 + b^2 = (a-b)^2 + 2ab$
3. $(a+b+c)^2 = a^2 + b^2 + c^2 + 2(ab + bc + ca)$
4. $(a+b)^3 = a^3 + b^3 + 3ab(a+b);\ a^3 + b^3 = (a+b)^3 - 3ab(a+b)$
5. $(a-b)^3 = a^3 - b^3 - 3ab(a-b);\ a^3 - b^3 = (a-b)^3 + 3ab(a-b)$
6. $a^2 - b^2 = (a+b)(a-b)$
7. $a^3 - b^3 = (a-b)(a^2 + ab + b^2)$
8. $a^3 + b^3 = (a+b)(a^2 - ab + b^2)$
9. $a^n - b^n = (a-b)(a^{n-1} + a^{n-2}b + a^{n-3}b^2 + \cdots + b^{n-1})$
10. $a^n = a.a.a \ldots n$ times
11. $a^m.a^n = a^{m+n}$
12. $\dfrac{a^m}{a^n} = a^{m-n}$ if $m > n$

    $= 1 \qquad$ if $m = n$

    $= \dfrac{1}{a^{n-m}}$ if $m < n; a \in R, a \neq 0$
13. $(a^m)^n = a^{mn} = (a^n)^m$
14. $(ab)^n = a^n.b^n$
15. $\left(\dfrac{a}{b}\right)^n = \dfrac{a^n}{b^n}$
16. $a^0 = 1$ where $a \in R, a \neq 0$
17. $a^{-n} = \dfrac{1}{a^n}, a^n = \dfrac{1}{a^{-n}}$
18. $a^{p/q} = \sqrt[q]{a^p}$
19. If $a^m = a^n$ and $a \neq \pm 1, a \neq 0$ then $m = n$
20. If $a^n = b^n$ where $n \neq 0$, then $a = \pm b$
21. If $\sqrt{x}, \sqrt{y}$ are quadratic surds and if $a + \sqrt{x} = \sqrt{y}$, then $a = 0$ and $x = y$
22. If $\sqrt{x}, \sqrt{y}$ are quadratic surds and if $a + \sqrt{x} = b + \sqrt{y}$ then $a = b$ and $x = y$
23. If a, m, n are positive real numbers and $a \neq 1$, then $\log_a mn = \log_a m + \log_a n$

24. If a, m, n are positive real numbers, $a \neq 1$, then $\log_a\left(\frac{m}{n}\right) = \log_a m - \log_a n$
25. If a and m are positive real numbers, $a \neq 1$ then $\log_a m^n = n \log_a m$
26. If a, b and k are positive real numbers, $b \neq 1, k \neq 1$, then $\log_b a = \dfrac{\log_k a}{\log_k b}$
27. $\log_b a = \dfrac{1}{\log_a b}$ where a, b are positive real numbers, $a \neq 1, b \neq 1$
28. if a, m, n are positive real numbers, $a \neq 1$ and if $\log_a m = \log_a n$, then $m = n$
29. if $a + ib = 0$ where $i = \sqrt{-1}$, then $a = b = 0$
30. if $a + ib = x + iy$, where $i = \sqrt{-1}$, then $a = x$ and $b = y$
31. The roots of the quadratic equation $ax^2+bx+c = 0$; $a \neq 0$ are $\dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

    The solution set of the equation is $\left\{\dfrac{-b + \sqrt{\Delta}}{2a}, \dfrac{-b - \sqrt{\Delta}}{2a}\right\}$

    where $\Delta =$ discriminant $= b^2 - 4ac$
32. The roots are real and distinct if $\Delta > 0$.
33. The roots are real and coincident if $\Delta = 0$.
34. The roots are non-real if $\Delta < 0$.
35. If α and β are the roots of the equation $ax^2 + bx + c = 0, a \neq 0$ then
    i) $\alpha + \beta = \dfrac{-b}{a} = -\dfrac{\text{coeff. of } x}{\text{coeff. of } x^2}$
    ii) $\alpha \cdot \beta = \dfrac{c}{a} = \dfrac{\text{constant term}}{\text{coeff. of } x^2}$
36. The quadratic equation whose roots are α and β is $(x - \alpha)(x - \beta) = 0$

    i.e. $x^2 - (\alpha + \beta)x + \alpha\beta = 0$

    i.e. $x^2 - Sx + P = 0$ where $S =$Sum of the roots and $P =$Product of the roots.
37. For an arithmetic progression (A.P.) whose first term is (a) and the common difference is (d).
    i) n^{th} term$= t_n = a + (n - 1)d$
    ii) The sum of the first (n) terms $= S_n = \dfrac{n}{2}(a + l) = \dfrac{n}{2}\{2a + (n - 1)d\}$

        where $l =$last term$= a + (n - 1)d$.

38. For a geometric progression (G.P.) whose first term is (a) and common ratio is (γ),

i) n^{th} term$= t_n = a\gamma^{n-1}$.

ii) The sum of the first (n) terms:

$$\begin{aligned} S_n &= \frac{a(1-\gamma^n)}{1-\gamma} && \text{if} \gamma < 1 \\ &= \frac{a(\gamma^n - 1)}{\gamma - 1} && \text{if } \gamma > 1 \\ &= na && \text{if } \gamma = 1 \end{aligned}.$$

39. For any sequence $\{t_n\}, S_n - S_{n-1} = t_n$ where S_n =Sum of the first (n) terms.

40. $\sum\limits_{\gamma=1}^{n} \gamma = 1 + 2 + 3 + \cdots + n = \frac{n}{2}(n+1)$.

41. $\sum\limits_{\gamma=1}^{n} \gamma^2 = 1^2 + 2^2 + 3^2 + \cdots + n^2 = \frac{n}{6}(n+1)(2n+1)$.

42. $\sum\limits_{\gamma=1}^{n} \gamma^3 = 1^3 + 2^3 + 3^3 + 4^3 + \cdots + n^3 = \frac{n^2}{4}(n+1)^2$.

43. $n! = (1).(2).(3).\ldots.(n-1).n$.

44. $n! = n(n-1)! = n(n-1)(n-2)! = \ldots..$

45. $0! = 1$.

46. $(a+b)^n = a^n + na^{n-1}b + \frac{n(n-1)}{2!}a^{n-2}b^2 + \frac{n(n-1)(n-2)}{3!}a^{n-3}b^3 + \cdots + b^n, n > 1$.

Power series with real variables:

$$e^x = 1 + x + \frac{x^2}{2!} + \cdots + \frac{x^n}{n!} + \cdots \qquad \text{valid for all } x$$

$$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} + \cdots + (-1)^{n+1}\frac{x^n}{n} + \cdots \qquad \text{valid for } -1 < x \le 1$$

$$\cos x = \frac{e^{ix} + e^{-ix}}{2} = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots \qquad \text{valid for all values of } x$$

$$\sin x = \frac{e^{ix} - e^{-ix}}{2i} = x - \frac{x^3}{3!} + \frac{x^5}{5!} + \cdots \qquad \text{valid for all values of } x$$

$$\tan x = x + \frac{1}{3}x^3 + \frac{2}{15}x^5 + \cdots \qquad \text{valid for } -\frac{\pi}{2} < x < \frac{\pi}{2}$$

$$\tan^{-1} x = x - \frac{x^3}{3} + \frac{x^5}{5} - \cdots \qquad \text{valid for } -1 \le x \le 1$$

$$\sin^{-1} x = x + \frac{1}{2}\frac{x^3}{3} + \frac{1.3}{2.4}\frac{x^5}{5} + \cdots \qquad \text{valid for } -1 < x < 1$$

Integer series:

$$\sum_{1}^{N} n = 1+2+3+\cdots+N = \frac{N(N+1)}{2}$$

$$\sum_{1}^{N} n^2 = 1^2+2^2+3^2+\cdots+N^2 = \frac{N(N+1)(2N+1)}{6}$$

$$\sum_{1}^{N} n^3 = 1^3+2^3+3^3+\cdots+N^3 = [1+2+3+\cdots N]^2 = \frac{N^2(N+1)^2}{4}$$

$$\sum_{1}^{\infty} \frac{(-1)^{n+1}}{n} = 1-\frac{1}{2}+\frac{1}{3}-\frac{1}{4}+\cdots = \ln 2 \qquad \text{[see expansion of } \ln(1+x)\text{]}$$

$$\sum_{1}^{\infty} \frac{(-1)^{n+1}}{2n-1} = 1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\cdots = \frac{\pi}{4} \qquad \text{[see expansion of } \tan^{-1} x\text{]}$$

$$\sum_{1}^{\infty} \frac{1}{n^2} = 1+\frac{1}{4}+\frac{1}{9}+\frac{1}{16}+\cdots = \frac{\pi^2}{6}$$

$$\sum_{1}^{N} n(n+1)(n+2) = 1.2.3+2.3.4+\cdots+N(N+1)(N+2) = \frac{N(N+1)(N+2)(N+3)}{4}$$

This last result is a special case of the more general formula,

$$\sum_{1}^{N} n(n+1)(n+2)\ldots(n+r) = \frac{N(N+1)(N+2)\ldots(N+r)(N+r+1)}{r+2}.$$

Physical Constants:

speed of light in a vacuum	c	$2{\cdot}997\,924\,58 \times 10^{8}$ m s^{-1} (by definition)
permeability of a vacuum	μ_0	$4\pi \times 10^{-7}$ H m^{-1} (by definition)
permittivity of a vacuum	ϵ_0	$1/\mu_0 c^2 = 8{\cdot}854\,187\,817\ldots \times 10^{-12}$ F m^{-1}
elementary charge	e	$1{\cdot}602\,177\,33(49) \times 10^{-19}$ C
Planck constant	h	$6{\cdot}626\,075\,5(40) \times 10^{-34}$ J s
$h/2\pi$	$\hbar$	$1{\cdot}054\,572\,66(63) \times 10^{-34}$ J s
Avogadro constant	N_A	$6{\cdot}022\,136\,7(36) \times 10^{23}$ mol^{-1}
unified atomic mass constant	m_u	$1{\cdot}660\,540\,2(10) \times 10^{-27}$ kg
mass of electron	m_e	$9{\cdot}109\,389\,7(54) \times 10^{-31}$ kg
mass of proton	m_p	$1{\cdot}672\,623\,1(10) \times 10^{-27}$ kg
Bohr magneton $eh/4\pi m_e$	μ_B	$9{\cdot}274\,015\,4(31) \times 10^{-24}$ J T^{-1}
molar gas constant	R	$8{\cdot}314\,510(70)$ J K^{-1} mol^{-1}
Boltzmann constant	k_B	$1{\cdot}380\,658(12) \times 10^{-23}$ J K^{-1}
Stefan–Boltzmann constant	σ	$5{\cdot}670\,51(19) \times 10^{-8}$ W m^{-2} K^{-4}
gravitational constant	G	$6{\cdot}672\,59(85) \times 10^{-11}$ N m^{2} kg^{-2}
Other data		
acceleration of free fall	g	$9{\cdot}806\,65$ m s^{-2} (standard value at sea level)

List of perfect Square roots:

√1	1
√4	2
√9	3
√16	4
√25	5
√36	6
√49	7
√64	8
√81	9
√100	10
√121	11
√144	12
√169	13
√196	14
√225	15
√256	16

√289	17
√324	18
√361	19
√400	20
√441	21
√484	22
√529	23
√576	24
√625	25
√676	26
√729	27
√784	28
√841	29
√900	30
√961	31
√1024	32
√1089	33

√1156	34
√1225	35
√1296	36
√1369	37
√1444	38
√1521	39
√1600	40
√1681	41
√1764	42
√1849	43
√1936	44
√2025	45
√2116	46
√2209	47
√2304	48
√2401	49
√2500	50

Perfect Cube Roots chart:

$\sqrt[3]{1} = 1$	$\sqrt[3]{1331} = 11$	$\sqrt[3]{9261} = 21$	$\sqrt[3]{29791} = 31$	$\sqrt[3]{68921} = 41$
$\sqrt[3]{8} = 2$	$\sqrt[3]{1728} = 12$	$\sqrt[3]{10648} = 22$	$\sqrt[3]{32768} = 32$	$\sqrt[3]{74088} = 42$
$\sqrt[3]{27} = 3$	$\sqrt[3]{2197} = 13$	$\sqrt[3]{12167} = 23$	$\sqrt[3]{35937} = 33$	$\sqrt[3]{79507} = 43$
$\sqrt[3]{64} = 4$	$\sqrt[3]{2744} = 14$	$\sqrt[3]{13824} = 24$	$\sqrt[3]{39304} = 34$	$\sqrt[3]{85184} = 44$
$\sqrt[3]{125} = 5$	$\sqrt[3]{3375} = 15$	$\sqrt[3]{15625} = 25$	$\sqrt[3]{42875} = 35$	$\sqrt[3]{91125} = 45$
$\sqrt[3]{216} = 6$	$\sqrt[3]{4096} = 16$	$\sqrt[3]{17576} = 26$	$\sqrt[3]{46656} = 36$	$\sqrt[3]{97336} = 46$
$\sqrt[3]{343} = 7$	$\sqrt[3]{4913} = 17$	$\sqrt[3]{19683} = 27$	$\sqrt[3]{50653} = 37$	$\sqrt[3]{103823} = 47$
$\sqrt[3]{512} = 8$	$\sqrt[3]{5832} = 18$	$\sqrt[3]{21952} = 28$	$\sqrt[3]{54872} = 38$	$\sqrt[3]{110592} = 48$
$\sqrt[3]{729} = 9$	$\sqrt[3]{6859} = 19$	$\sqrt[3]{24389} = 29$	$\sqrt[3]{59319} = 39$	$\sqrt[3]{117649} = 49$
$\sqrt[3]{1000} = 10$	$\sqrt[3]{8000} = 20$	$\sqrt[3]{27000} = 30$	$\sqrt[3]{64000} = 40$	$\sqrt[3]{125000} = 50$

Surface Area and Volume Formulas:

AREA(A)	Square	$A = s^2;$	where s = any side of the square
	Rectangle	$A = lw;$	where l = length and w = width
	Parallelogram	$A = bh;$	where b = base and h = height
	Triangle	$A = 1/2bh;$	where b = base and h = height
	Circle	$A = \pi r^2;$	where π= 3.14 and r = radius
	Trapezoid	$A = 1/2\ (b1 + b2)\ h;$	
	Sphere	$S = 4\pi r^2$	where s= Surface area

SURFACE AREA (SA) of a:

cube	SA = $6s^2$	where s = any side
cylinder (lateral)	$SA = 2\pi rh$;	where π=3.14, r = radius, and h = height

PERIMETER (P) of a:

Square	$P = 4s$;	where s = any side
Rectangle	$P = 2l + 2w$;	where l = length and w = width
Triangle	$P = s1 + s2 + s3$;	where s = a side
Any shape	P = the length of all sides added together	
Circle (Circumference)	$C = \pi d$;	where π= 3.14 and d = diameter

VOLUME (V) of a:

Cube	$V = S^3$;	where S = any side
Rectangular Container	$V = lwh$;	where l = length, w = width, and h = height
Square Pyramid	$V = 1/3(b)^2h$;	where b = base length, h = height,
Cylinder	$V = \pi r^2h$;	where π= 3.14, r = radius, and h = height
Cone	$V = 1/3\pi r^2h$;	where π= 3.14, r = radius, and h = height
Sphere	$V = \frac{4}{3}\pi r^3$	where r=radius, v = volume
Right Circular Cylinder	$V = \pi r^2h$	where r= radius, v=volume, h = height

Equations:

Distance between two points	$d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$
Slope of a line	$m = \frac{y2 - y}{x2 - x1}$
Quadratic Equation	$ax^2 + bx + c = 0$
Standard Equation of a circle	$(x - h)^2 + (y - k)^2 = r^2$
Standard Equation of a circle	$(x - h)^2 + (y - k)^2 = r^2$
Point-Slope Equation of a line	$y - y_1 = m(x - x_1)$
Slope-Intercept Equation of a line	$y = mx + b$

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