SSLC SCIENCE

Quick Recap Notes

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Chapter

1

Chemical Reactions and Equations

QUICK RECAP

- **Physical changes :** Those changes which are accompanied with change in physical properties of the substances but no new substance is formed are called *physical changes e.g.*, melting of ice, boiling of water, etc.
- **Chemical changes :** Those changes in which the original substances lose their nature and identity to form new chemical substances with different properties are called *chemical changes e.g.,* burning of candle, cooking food, etc.
- **Chemical reactions :** The process involving a chemical change is known as a *chemical reaction*. The chemical substances taken initially are called *reactants* and the chemical substances which are formed during a chemical reaction are called *products*. Thus, chemical reaction is a process in which breaking of chemical bonds (present in the reactant molecules) and making of new chemical bonds (in the product molecules) occur *e.g.*, burning of magnesium ribbon in air.

$$\underbrace{Mg + O_2}_{\text{Reactants}} \longrightarrow \underbrace{MgO}_{\text{Product}}$$

Characteristics of chemical reactions : The following observations help us to determine whether a chemical reaction has taken place or not :

- **Change in state :** Certain chemical reactions are accompanied with the change of state *e.g.*, when a mixture of hydrogen gas and oxygen gas is ignited with an electric spark at room temperature, liquid water is formed.

$$\underset{\text{Hydrogen}}{2H_{2(g)}} + \underset{\text{Oxygen}}{O_{2(g)}} \xrightarrow[\text{room temp.}]{\text{electric spark}} \underset{\text{Water}}{2H_2O_{(l)}}$$

- **Change in colour :** Certain chemical reactions are accompanied with the change of colour *e.g.*, when red lead oxide is heated yellow lead monoxide is formed.

$$\underset{\substack{\text{Lead oxide}\\\text{(red colour)}}}{2Pb_3O_{4(s)}} \xrightarrow{\text{heat}} \underset{\substack{\text{Lead monoxide}\\\text{(yellow colour)}}}{6PbO_{(s)}} + \underset{\text{Oxygen}}{O_{2(g)}}\uparrow$$

- **Evolution of a gas :** Some chemical reactions are accompanied with the evolution of a gas *e.g.*, reaction between a metal (like zinc, magnesium or iron) and dilute sulphuric acid produces hydrogen gas.

$$\underset{\text{Zinc}}{Zn_{(s)}} + \underset{\text{Sulphuric acid}}{H_2SO_4\,(\text{dil.})} \longrightarrow \underset{\substack{\text{Zinc}\\\text{sulphate}}}{ZnSO_{4(aq)}} + \underset{\text{Hydrogen}}{H_{2(g)}}\uparrow$$

- **Change in temperature :** Some chemical reactions occur with change in heat energy or with change in temperature.
  - Reactions which result in rise in temperature *i.e.* in which heat is evolved are called *exothermic reactions*.

$$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)} + \text{Heat}$$

  - Reactions which result in fall in temperature *i.e.* in which heat is absorbed are called *endothermic reactions*.

$$\underset{\text{Lime stone}}{CaCO_{3(s)}} + \text{Heat} \longrightarrow \underset{\substack{\text{Quick lime}\\\text{or lime}}}{CaO_{(s)}} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_{2(g)}}$$

Chemical equation : A method of representing a chemical reaction in terms of symbols and formulae of the substances participated is known as *chemical equation*. There are two ways to represent a chemical equation :

- **In terms of words :** When a chemical equation is written in terms of words, it is called a *word equation*. The chemical reaction between granulated zinc and hydrochloric acid can be written in terms of words as

$$\underbrace{\text{Zinc} + \text{Hydrochloric acid}}_{\text{Reactants}} \longrightarrow \underbrace{\text{Zinc chloride} + \text{Hydrogen}}_{\text{Products}}$$

- **In terms of symbols and formulae :** Chemical reaction between granulated zinc and hydrochloric acid can be written in terms of symbols and formulae as

$$\underbrace{Zn + 2HCl}_{\text{Reactants}} \longrightarrow \underbrace{ZnCl_2 + H_2}_{\text{Products}}$$

- **Conventions used in chemical equations :**
  - The reactants are written on the left hand side along with plus (+) sign between them.
  - Similarly, products are written on the right hand side along with plus (+) sign between them.
  - An arrow (⟶) separates the reactants from the products.
  - The arrowhead points towards the products and tells about the direction of the reaction.

Balanced and unbalanced chemical equations :

- **Balanced chemical equation :** The equation which contains an equal number of atoms of each element on both sides of the arrow is called a *balanced chemical equation*.

$$2Mg + O_2 \longrightarrow 2MgO$$

A balanced chemical equation must obeys the law of conservation of mass.

- **Unbalanced chemical equation:** The equation in which the number of atoms of each element on both sides of the arrow is not equal.

$$H_2 + O_2 \longrightarrow H_2O$$

Balancing a chemical equation : Balancing of a chemical equation means to equalise the number of atoms of each element on both sides of the equation.

Consider the following steps for balancing the chemical equation :

For example, iron reacts with water (steam) to form iron(II, III) oxide and hydrogen.

Step-I : Write the chemical equation in the form of a word equation. Keep the reactants on the left hand side and the products on the right hand side. Separate them by an arrow (⟶) with head pointing from the reactants to products.

Iron + Steam ⟶ Iron (II, III) oxide + Hydrogen

Step-II : Write down the symbols and formulae of the various reactants and products which gives skeletal chemical equation.

$Fe + H_2O \longrightarrow Fe_3O_4 + H_2$

Step-III : Listing number of atoms of different elements.

Elements	Number of atoms on LHS	Number of atoms on RHS
Fe	1	3
H	2	2
O	1	4

Step-IV : Select the compound with maximum number of atoms to start balancing. In that compound, balance the element with maximum number of atoms (*e.g.*, oxygen in the given equation). It may be a reactant or a product.

Atoms of oxygen	In reactants	In products
(i) Initial	1 (in H_2O)	4 (in Fe_3O_4)
(ii) To balance	1 × 4	4

$Fe + 4H_2O \longrightarrow Fe_3O_4 + H_2$

Step-V : To balance the atoms of an element, put a whole number coefficient before the formula of the compound. If selection of the biggest formula appears inconvenient, balance the atoms of that element which occurs at minimum number of places on both sides of the equation. Atoms of the element which occur at maximum places are balanced at last.

To balance H-atoms on both sides :

Atoms of hydrogen	In reactants	In products
(i) Initial	8 in ($4H_2O$)	2 (in H_2)
(ii) To balance	8	2 × 4

$Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$

To balance Fe-atoms on both sides :

Atoms of iron	In reactants	In products
(i) Initial	1 (in Fe)	3 (in Fe_3O_4)
(ii) To balance	1 × 3	3

So, the equation would be

$3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$

Step VI : For checking the correct balanced equation, we count atoms of each element on both sides of the equation.

Elements	Number of atoms on LHS	Number of atoms on RHS
Fe	3	3
H	8	8
O	4	4

As the number of atoms of each element on both sides of the equation are equal, the equation is balanced.

$3Fe_{(s)} + 4H_2O_{(g)} \longrightarrow Fe_3O_{4(s)} + 4H_{2(g)}$

How can a chemical equation be made more informative?

A chemical equation can be made more informative by adding some extra information to the chemical equation which may be summarised as :

- Write the state symbols for the reactants and products taking part in a chemical reaction. Use symbols (*g*) for gases, (*s*) for solids, (*l*) for liquids and (*aq*) for aqueous solutions.
- Indicate the gas evolved in the reaction by (↑).
- Indicate the precipitate obtained in the reaction by (↓).
- Mention the heat evolved by (+) sign and heat absorbed by (–) sign on the product side.

- Mention the reaction conditions, temperature as t°C or K, pressure as atm, catalyst, etc. above or below the arrow.
- When reactants are converted into products and products cannot be converted back to reactants then the reaction is called an *irreversible reaction* and is represented by ($\longrightarrow$). On the other hand, if in a chemical reaction, reactants are converted into products in forward direction and again products are converted back into reactants in backward direction then, it is called a *reversible reaction* and is represented by ($\rightleftharpoons$).

Types of chemical reactions : As we know, in chemical reactions, bonds present in reactants break and new bonds form in the products. This exchange of species can take place in a number of ways resulting in different types of reactions, which can be explained as follows :

- **Combination reactions :** The reactions in which two or more substances combine to form a single substance under suitable conditions.

  Examples :
  - Combustion of coal
    $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$
  - Combination of nitric oxide with oxygen to form nitrogen dioxide.
    $2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$
    Nitric oxide — Nitrogen dioxide (brown gas)
  - Combination of ammonia with hydrogen chloride gas to form a white solid mass of ammonium chloride.
    $NH_{3(g)} + HCl_{(g)} \longrightarrow NH_4Cl_{(s)}$
    Ammonium chloride (white)

- **Decomposition reactions :** Those reactions in which a single substance breaks down to give two or more smaller substances under suitable conditions. Three types of decomposition reactions are as follows :
  - **Thermal decomposition reactions :** These reactions occur in presence of heat.

    $2FeSO_{4(s)} \xrightarrow{heat} Fe_2O_{3(s)} + SO_{2(g)}\uparrow + SO_{3(g)}\uparrow$

    Ferrous sulphate (green) — Ferric oxide (reddish brown) — Sulphur dioxide (smell of burning sulphur) — Sulphur trioxide
  - **Electrolytic decomposition reactions :** These reactions occur in presence of electric current.
    $2H_2O_{(l)} \xrightarrow[\text{current}]{\text{electric}} 2H_{2(g)} + O_{2(g)}$
  - **Photodecomposition reactions :** These reactions occur in presence of sunlight.
    $2AgBr_{(s)} \xrightarrow{\text{sunlight}} 2Ag_{(s)} + Br_{2(g)}$
    Silver bromide — Silver — Bromine

- **Displacement reactions :** Those chemical reactions in which one element takes the position of another element present in the compound.

  Examples :
  $Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$
  $Pb_{(s)} + CuCl_{2(aq)} \longrightarrow PbCl_{2(aq)} + Cu_{(s)}$

  Note : All displacement reactions are exothermic reactions.

- **Double displacement reactions :** Those reactions in which two compounds react by exchange of ions to form two new compounds, are called *double displacement reactions*.

  Example :
  $AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow AgCl_{(s)}\downarrow + NaNO_{3(aq)}$
  Silver nitrate — Sodium chloride — Silver chloride — Sodium nitrate

  There are two types of double displacement reactions :
  - **Precipitation reactions :** Those reactions in which aqueous solution of two compounds on mixing react to form an insoluble compound which further separates out as a precipitate are called *precipitation reactions*.

    Examples :
    $FeCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Fe(OH)_{2(s)}\downarrow + 2NaCl_{(aq)}$
    Ferrous hydroxide (dirty green ppt.)
    $Na_2SO_{4(aq)} + BaCl_{2(aq)} \longrightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$
    (Barium sulphate) (white ppt.)
  - **Neutralisation reactions :** Those reactions of acids and bases in which product formed is neutral to litmus are known as *neutralisation reactions*.

Examples :

$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O$
Base Acid Salt

$CuO_{(s)} + 2HCl_{(aq)} \longrightarrow CuCl_{2(aq)} + H_2O$
Base Acid Salt

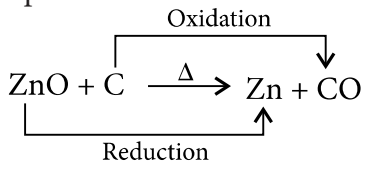
- **Redox reactions :** Reactions in which oxidation and reduction take place simultaneously are called *redox reactions*.
  - **Oxidation :** Those reactions in which the addition of oxygen to a substance or removal of hydrogen from a substance takes place are called *oxidation reactions*.

On the other hand, the substance which either gives oxygen or removes hydrogen in an oxidation reaction is known as an *oxidising agent*.

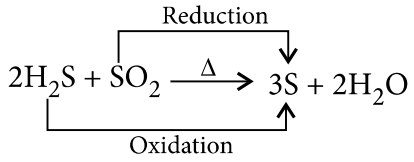
- **Reduction :** Those reactions in which addition of hydrogen to a substance or removal of oxygen from a substance takes place are called *reduction reactions*.

On the other hand, the substance which either gives hydrogen or removes oxygen in a reduction reaction is known as *reducing agent*.

Examples :



Here, ZnO : Oxidising agent
C : Reducing agent



Here, SO_2 : Oxidising agent
H_2S : Reducing agent

Effect of oxidation reactions in everyday life : As oxygen is the most essential element for sustaining life, it is involved in variety of reactions which has wide range of effects on our daily life. The two effects are discussed below :

- **Corrosion :** It is a process in which metals are decayed gradually by the action of air, moisture and acids on their surface. Basically, it is caused by oxidation of metals by oxygen present in the air.

Example : Rusting of iron,

$4Fe_{(s)} + 3O_{2(g)} + 2xH_2O_{(l)} \longrightarrow 2Fe_2O_3{\cdot}xH_2O_{(s)}$
Iron Air Moisture Hydrated Iron(III) oxide

$2Cu_{(s)} + \underbrace{CO_{2(g)} + O_{2(g)}}_{\text{Air}} + H_2O_{(l)} \longrightarrow$
Moisture

$CuCO_3{\cdot}Cu(OH)_2$
Basic copper carbonate (green)

Corrosion causes damage to car bodies, iron railings, ships and to all objects made up of metals, specially those of iron.

- **Prevention of corrosion :** Corrosion can be prevented
  - by coating the surface by a layer of another metal which does not corrode *e.g.*, coating of iron with zinc.
  - by coating surface with grease, paint or oil, etc.

- **Rancidity :** The slow oxidation of oils and fats present in food materials resulting in compounds with unpleasant smell is known as *rancidity*. Vacuum packing, refrigeration of food materials, placing of food materials away from direct sunlight will slow down the process of rancidity.

Chapter

2

Acids, Bases and Salts

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Indicator : The chemical substance which is added to the solutions in very small amount to detect their acidic or basic nature is known as *indicator*.

Depending upon the property of the indicators, they are classified into two types :

- **Acid – base indicators :** The indicators which show different colours or odours in acidic and basic medium are called *acid-base indicators. e.g.*, litmus, phenolphthalein, methyl orange, etc.
- **Olfactory indicators :** The substances which give one type of odour in acidic medium and a different odour in basic medium are called *olfactory indicators*. *e.g.*, vanilla essence, onion, clove oil, etc.

Acid-base indicators showing different colours are of two types :

- **Natural indicators :** Litmus is a natural indicator which is a purple coloured dye. Turmeric and red cabbage juice are other examples of natural indicators.

Natural indicators with their characteristic colours			
Indicator	**Colour in neutral medium**	**Colour in acidic medium**	**Colour in basic medium**
Litmus	Purple	Red	Blue
Turmeric	Yellow	Yellow	Reddish brown
Red cabbage leaves extract	Red	Red	Green

– **Synthetic indicators :** Phenolphthalein and methyl orange are synthetic indicators.

Synthetic indicators with their characteristic colours			
Indicator	**Colour in neutral medium**	**Colour in acidic medium**	**Colour in basic medium**
Phenol-phthalein	Colourless	Colourless	Pink
Methyl orange	Orange	Red	Yellow

Acids : The substances which are sour in taste and change the colour of blue litmus to red are *acids*.

According to Arrhenius concept, acids are substances which dissociate in aqueous solution to furnish hydrogen or hydronium ions.

Classification of acids :

▸ **Based on the strength of the acids :**

– **Strong acids :** Acids which undergo complete dissociation in aqueous solution producing a high concentration of H^+ ions, are called *strong acids*.
e.g., (HCl), (H_2SO_4), (HNO_3), etc.

– **Weak acids :** Acids which undergo partial dissociation in aqueous solution producing a low concentration of H^+ ions, are called *weak acids*.
e.g., Carbonic acid H_2CO_3, phosphoric acid H_3PO_4, formic acid HCOOH, etc.

▸ **Based on the basicity of acids :** On the basis of basicity (number of replaceable H^+ ions present in an acid), acids can be classified as :

– **Monobasic acids :** HCl, HNO_3, CH_3COOH, etc.
– **Dibasic acids :** H_2SO_4, H_2CO_3, H_2SO_3, etc.
– **Tribasic acids :** H_3PO_4

Dilute acids : A dilute acid is obtained by mixing the concentrated acid with water.

▸ The process of mixing the concentrated acid with water is *highly exothermic* (or heat producing). So, when a concentrated acid and water are mixed together, a large amount of heat is evolved.

▸ The dilution of a concentrated acid should always be done by adding concentrated acid to water gradually with continuous stirring and not by adding water to concentrated acid.

General properties of acids :

▸ **Physical properties :**

– Almost all acidic substances have sour taste.
– Acids turn blue litmus solution to red.
– Most of the acids are corrosive in nature.
– The solutions of acids in water conduct electricity.

▸ **Chemical properties :**

– **Reaction with metals :** Acids react with active metals such as zinc, magnesium, etc. and hydrogen gas is evolved. *e.g.*,

$$Zn_{(s)} + \text{dil. } H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$$

– **Reaction with metal carbonates and metal hydrogen carbonates :** Acids react with metal carbonates and bicarbonates to give carbon dioxide with brisk effervescence. *e.g.*,

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_4} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2\uparrow}$$

$$\underset{\text{Sodium bicarbonate}}{NaHCO_3} + \underset{\text{Hydrochloric acid}}{HCl} \longrightarrow \underset{\text{Sodium chloride}}{NaCl} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2\uparrow}$$

- **Reaction with bases :** When an acid reacts with a base, it forms salt and water.

$$\underset{\text{Hydrochloric acid (Acid)}}{HCl} + \underset{\text{Sodium hydroxide (Base)}}{NaOH} \xrightarrow[\text{reaction}]{\text{Neutralisation}} \underset{\text{Sodium chloride (Salt)}}{NaCl} + \underset{\text{Water}}{H_2O}$$

- **Reaction with metallic oxides :** Metal oxide reacts with acid forming salt and water.

$$\underset{\text{Calcium oxide}}{CaO_{(s)}} + \underset{\text{Hydrochloric acid}}{2HCl_{(aq)}} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_{2(aq)}} + \underset{\text{Water}}{H_2O}$$

- **Reaction with water :** Acids when dissolve in water give H_3O^+ or H^+ ions.
  $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

Uses of acids :

- Sulphuric acid is used in the manufacture of fertilizers, paints, explosives, synthetic fibres, dyes, drugs, etc. and is also used in petroleum refining.
- Nitric acid is used in the manufacture of fertilizers like ammonium nitrate, explosives like TNT, artificial silk, dyes and plastics.
- Hydrochloric acid is used in textile, food, leather and dye industries.

Bases : The substances which have bitter taste, soapy touch and turn red litmus to blue are *bases*.
According to Arrhenius concept, bases are substances which when dissolved in water furnish hydroxyl (OH^-) ions.

Classification of bases :

- **Based on the strength of bases :**
  - **Strong bases :** Bases which completely ionise in aqueous solution to furnish high concentration of OH^- ions, are called *strong bases*. *e.g.,* Sodium hydroxide (NaOH), potassium hydroxide (KOH), etc.
  - **Weak bases :** Bases which partially ionise in aqueous solution to furnish low concentration of OH^- ions, are called *weak bases*. *e.g.,* Ammonium hydroxide (NH_4OH), calcium hydroxide [$Ca(OH)_2$], etc.
- **Based on the acidity of bases :** On the basis of acidity (number of replaceable OH^- ions present in a base), bases can be classified as :
  - **Monoacidic bases :** NH_4OH, NaOH, etc.
  - **Diacidic bases :** $Ca(OH)_2$, $Mg(OH)_2$, etc.

General properties of bases :

- **Physical properties :**
  - They are bitter in taste.
  - They are soapy to touch.
  - Bases turn the colour of red litmus to blue, methyl orange from orange to yellow and phenolphthalein from colourless to pink.
  - Like acids, the solutions of bases in water also conduct electricity.
- **Chemical properties :**
  - **Reaction with acids :** Bases react with acids to form salts and water.

$$\underset{\text{Sodium hydroxide (Base)}}{2NaOH_{(aq)}} + \underset{\text{Sulphuric acid (Acid)}}{H_2SO_{4(aq)}} \longrightarrow \underset{\text{Sodium sulphate (Salt)}}{Na_2SO_{4(aq)}} + \underset{\text{Water}}{2H_2O_{(l)}}$$

  - **Reaction with metals :** Some bases such as NaOH, KOH react with active metals to liberate hydrogen gas along with the formation of salts.

$$\underset{\text{Sodium hydroxide (Base)}}{2NaOH_{(aq)}} + \underset{\text{Zinc (Metal)}}{Zn_{(s)}} \longrightarrow \underset{\text{Sodium zincate (Salt)}}{Na_2ZnO_{2(aq)}} + \underset{\text{Hydrogen (Gas)}}{H_{2(g)}}$$

  - **Reaction with non-metal oxides :** Bases react with non-metallic oxides to produce salts and water.
    $2NaOH_{(aq)} + CO_{2(g)} \longrightarrow Na_2CO_{3(aq)} + H_2O_{(l)}$
  - **Reaction with heavy metal salts :** Metal salts react with aqueous solution of bases to produce precipitates of insoluble metallic hydroxides.
    $ZnSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + \underset{\text{White ppt.}}{Zn(OH)_2\downarrow}$

- **Reaction with water :** Bases when dissolved in water produce OH^- ions.

  $NaOH_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + OH^-_{(aq)}$

  Note : A base which dissolves in water is called an alkali. Thus, all alkalies are bases but all bases are not alkalies.

Uses of bases :

- Potassium hydroxide (caustic potash) is used in alkaline batteries and soft soaps.
- Calcium hydroxide is used in manufacture of bleaching powder, softening of hard water, etc.
- Ammonium hydroxide is used for removing grease stains from clothes.

Salts : Salts are the ionic compounds which contain a positive ion (or cation) other than H^+ ion and negative ion (or anion) other than OH^- ion. *e.g.*, K_2SO_4, NaCl, $NaNO_3$, etc.

Classification of salts :

- **Normal salts :** These salts are formed when all replaceable hydrogens of an acid are replaced by metal ions thus, they do not generally contain any replaceable hydrogen atom. *e.g.*, NaCl, Na_2SO_4, etc.
- **Acidic salts :** These salts are formed when a polybasic acid is partially neutralised by a base and salts still have some acidic H^+ ions. *e.g.*, $NaHCO_3$, $NaHSO_3$, etc.
- **Basic salts :** These salts are formed by partial neutralisation of polyacidic bases with acids and salts still have some basic OH^- ions. *e.g.*, Mg(OH)Cl, etc.
- **Families of salts :** The salts are classified into different families either on the basis of the acid or on the basis of the base from which they have been obtained.
  - **Sulphate family :** Na_2SO_4, K_2SO_4, $MgSO_4$, $CaSO_4$, etc.
  - **Nitrate family :** $NaNO_3$, KNO_3, $Cu(NO_3)_2$, etc.
  - **Chloride family :** KCl, NaCl, $CaCl_2$, $AlCl_3$, etc.

Concept of pH : The concentration of H^+ ion *i.e.*, $[H^+]$ in aqueous solution is very small, so it is very difficult to express the acidity or alkalinity of an aqueous solution. So, pH scale is used to measure the strength of acids and bases.

- **In pH scale :**
  - All substances having pH values between 0 and 7 are acidic in nature.
  - All substances having pH values between 7 and 14 are basic in nature.
  - All substances having pH value equal to 7 are neutral.
- **pH of salt :**
  - Salt of a strong acid and a strong base is neutral with pH value equal to 7.
  - Salt of a strong acid and a weak base is acidic with pH value less than 7.
  - Salt of a strong base and a weak acid is basic with pH value more than 7.
- **Importance of pH in everyday life :** pH plays an important role in everyday life as :
  - **In humans and plants :** Most of the reactions taking place in our body are in the pH range of 7.0 to 7.8. If pH falls below 7.0 or rises above 7.8, the survival of living organisms becomes difficult. For healthy growth of plants, the soil should have a specific pH which is neither highly alkaline nor highly acidic.
  - **In digestive system :** Hydrochloric acid is produced in our stomach which helps in the digestion of food. But if the amount of acid produced is beyond the required limit, it causes pain and irritation in the stomach. This pain can be cured by antacids containing weak bases (like magnesium hydroxide). This base neutralises the excess acid produced.
  - **Tooth decay caused by acids :** If the pH in our mouth falls below 5.5, the dissolution of calcium phosphate (tooth enamel) starts *i.e.*, tooth decay begins.
  - **Self defence of animals and plants through chemical warfare :** Sting of honey-bee or yellow ant injects methanoic acid (or formic acid) due to which we feel pain. To get relief, a solution of mild base, such as baking soda is used. Stinging hair

of nettle leaves inject methanoic acid, causing burning pain.

Common salt (Sodium chloride, NaCl) : Sea water is one of the main source of common salt. To extract the salt from sea water, it is allowed to evaporate in shallow tanks under the influence of sun and wind.

- **Properties of common salt :**
  - It is a colourless crystalline substance with melting point 820°C.
  - At low temperature (0 to –20°C), it exists as a dihydrate, $NaCl \cdot 2H_2O$.
  - It is slightly hygroscopic in nature.
  - It is soluble in water.
- **Uses of common salt :**
  - It is essential constituent of our diet.
  - It is used to make freezing mixture (when mixed with ice) *e.g.*, in making ice-creams.
  - It is used as raw material for caustic soda, bleaching powder, baking soda and washing soda.

Sodium hydroxide (caustic soda) : Sodium hydroxide is prepared by electrolysis of an aqueous solution of sodium chloride (brine). This method is called '*chlor-alkali*' *process*. The complete reaction can be represented as,

$$2NaCl_{(aq)} + 2H_2O_{(l)} \xrightarrow{\text{On passing electricity}} 2NaOH_{(aq)} + Cl_{2(g)} + H_{2(g)}$$

The sodium hydroxide solution is formed near the cathode.

- **Uses :** It is used
  - for making soaps and detergents.
  - for degreasing metals.
  - in making of artificial fibres.
  - in petroleum refining.
  - as a laboratory reagent.

Bleaching powder ($CaOCl_2$) : It is prepared by the action of chlorine gas on dry slaked lime $Ca(OH)_2$.

$$\underset{\text{Slaked lime}}{Ca(OH)_2} + Cl_2 \longrightarrow \underset{\substack{\text{Bleaching}\\ \text{powder}}}{CaOCl_2} + H_2O$$

The chlorine used in the above reaction is the by-product produced during the electrolysis of brine. Manufacturing of bleaching powder, is generally carried out in 'Hasenclever plant'.

- **Uses :** It is used
  - in textile industry for bleaching cotton and linen.
  - in paper industry for bleaching wood pulp.
  - in laundry for bleaching washed clothes.
  - for disinfecting drinking water.

Baking soda ($NaHCO_3$) : When an aqueous solution of sodium chloride (brine) saturated with ammonia is allowed to react with carbon dioxide, baking soda is produced along with ammonium chloride.

$$NaCl + H_2O + CO_2 + NH_3 \longrightarrow NH_4Cl + \underset{\text{Baking soda}}{NaHCO_3}$$

This process is known as '*Solvay process*'.

- **Uses :** It is used
  - as an antacid.
  - as an additive in food and drinks.
  - in fire - extinguishers.

Washing soda ($Na_2CO_3 \cdot 10H_2O$) : The preparation of washing soda is carried out through following steps :

Step-I : Manufacture of sodium hydrogen carbonate :

$$NaCl + H_2O + NH_3 + CO_2 \longrightarrow \underset{\substack{\text{Sodium}\\ \text{bicarbonate}}}{NaHCO_3} + NH_4Cl$$

Step-II : Thermal decomposition of sodium hydrogen carbonate : When dry crystals of sodium hydrogen carbonate are heated strongly, they decompose to form anhydrous sodium carbonate (soda ash).

$$2NaHCO_{3(s)} \xrightarrow{\text{Heat}} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$$

Step-III : Recrystallisation of sodium carbonate : Sodium carbonate thus obtained is recrystallised to form crystals of washing soda.

$$\underset{\substack{\text{Anhydrous}\\ \text{sodium}\\ \text{carbonate}}}{Na_2CO_{3(s)}} + 10H_2O_{(l)} \longrightarrow \underset{\text{Washing soda}}{Na_2CO_3.10H_2O_{(s)}}$$

- **Uses :** It is used
  - for softening of hard water.
  - for washing purposes in laundry and as cleaning agent for domestic purposes.
  - in textile industries and also in petroleum refining.
  - in the manufacturing of borax.

Plaster of Paris : It is prepared by heating gypsum ($CaSO_4 \cdot 2H_2O$) at 373 K in a kiln.

$$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow[373\ K]{\text{Heat}} \underset{\text{Plaster of Paris}}{CaSO_4 . \frac{1}{2} H_2O} + 1\frac{1}{2} H_2O$$

The temperature during the heating should not be allowed to rise above 373 K. Otherwise, whole of its water is lost and anhydrous calcium sulphate ($CaSO_4$) is obtained.

- **Uses :** It is used
  - for making moulds for toys, pottery, ceramics, etc.
  - for making statues, models and other decorative materials.
  - as fire proofing materials.
  - in medical science as plasters for setting broken and fractured bones.

Water of crystallisation : It is the fixed number of water molecules present in one formula unit of a salt. *e.g.*, Gypsum ($CaSO_4.2H_2O$) has two molecules of water of crystallisation.

In hydrated copper sulphate ($CuSO_4.5H_2O$), there are five molecules of water of crystallisation.

Chapter

3 Metals and Non-metals

QUICK RECAP

Elements : An element is a substance that is made entirely from one type of atoms.

Examples : Hydrogen (H), Helium (He), Oxygen (O), etc.

Based on their properties they are classified into two categories called metals and non-metals.

- **Metals :** Those elements which possess lustre when freshly cut, are malleable, ductile and good conductors of heat and electricity are known as *metals*. They may also be defined as those elements which lose electrons and form positive ions. Thus, metals are electropositive elements.

  Examples : Sodium (Na), Potassium (K), Calcium (Ca), etc.
- **Non-metals :** Those elements which do not possess lustre and are neither good conductors of heat and electricity nor malleable and ductile but are brittle, are known as *non-metals*. They may also be defined as elements which gain electrons and form negative ions. Thus,

non-metals are electronegative elements.
Examples : Hydrogen (H), Oxygen (O), Nitrogen (N), Chlorine (Cl), etc.

Physical properties of metals :

- Metals in their pure state have shining surface *i.e.*, possess metallic lustre.
- Metals are generally hard. The hardness varies from metal to metal. Stronger the metallic bond, harder is the metal.
- Metals are generally malleable. The ability of metals to be beaten into thin sheets is called *malleability*.
- Metals are generally ductile. The ability of metals to be drawn into wires is called *ductility*. Gold is the most ductile metal.
- Metals are good conductors of heat and possess high melting points. But some exceptions are there *e.g.*, lithium, sodium, potassium, caesium and gallium are metals with low melting points. Infact, gallium and caesium have so low melting points that they melt even on keeping them on the palm.
- Metals are good conductors of electricity. The order of electrical conductivity of some metals is found to be as follows :

$$\underset{\text{Silver}}{Ag} > \underset{\text{Copper}}{Cu} > \underset{\text{Gold}}{Au} > \underset{\text{Aluminium}}{Al} > \underset{\text{Tungsten}}{W} > \underset{\text{Mercury}}{Hg}$$

- Metals are sonorous *i.e.,* they produce sound by striking on hard surface.
- Metals have high density due to closely packed atoms. But lithium, sodium, potassium are metals with low densities.
- They have high tensile strength. Due to this property, iron is used in the construction of bridges, buildings, railway lines, etc.
- All metals are solids except mercury which is liquid.

Physical properties of non-metals :

- Non-metals do not possess any lustre, but iodine is a non-metallic solid with lustre.
- They are soft and brittle. The only exception is diamond, an allotropic form of carbon, which is a non-metal but is the hardest substance known.
- They are neither malleable nor ductile.
- They are bad conductors of heat and electricity. Exception is graphite which is an allotropic form of carbon and is a non-metal but good conductor of electricity.
- They are non-sonorous, *i.e.,* they do not produce any sound when hit with a hard object.
- They have low melting and boiling points except diamond and graphite which have high melting points.
- They have low densities.
- They have low tensile strength *i.e.,* these are easily broken.
- They may be solids, liquids or gases at room temperature.
  - Carbon, sulphur, phosphorous and iodine are solid non-metals.
  - Bromine is a liquid non-metal.
  - Hydrogen, oxygen, nitrogen, chlorine, helium and neon are gaseous non-metals.

Chemical properties of metals :

- **Reaction with oxygen :** Almost all the metals react with oxygen or air to form metal oxides which are basic in nature.
  Metal + Oxygen $\longrightarrow$ Metal oxide
  - When copper is heated in air, it combines with oxygen to form copper (II) oxide which is a black in colour.
    $2Cu + O_2 \longrightarrow 2CuO$
  - Iron reacts with oxygen to give a mixture of FeO and Fe_2O_3.

$$3Fe + 2O_2 \xrightarrow{\text{Heat}} \underset{\text{Iron (II, III) oxide}}{FeO.Fe_2O_3} \text{ or } \underset{\text{Ferrosoferric oxide}}{Fe_3O_4}$$

- **Reaction with water :** Highly reactive metals such as sodium and potassium (placed at the top of the reactivity series) react violently even with cold water with formation of hydrogen gas and energy is released.
  $2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}$ + heat energy
  Calcium reacts with water less violently while magnesium reacts with water only on heating.
  $Ca_{(s)} + 2H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + H_{2(g)}$
  $Mg_{(s)} + 2H_2O_{(l)} \xrightarrow{\text{Heat}} Mg(OH)_{2(aq)} + H_{2(g)}$
- **Reaction with acids :** Metals placed above hydrogen in the reactivity series react with dilute acids such as HCl and H_2SO_4 to displace

hydrogen from acids forming corresponding metal salt with the evolution of hydrogen gas.

Metal + Acid(dil.) $\longrightarrow$ Metal salt + Hydrogen gas

$2Na_{(s)} + 2HCl(dil.) \longrightarrow 2NaCl_{(aq)} + H_{2(g)}$

$Mg_{(s)} + H_2SO_4(dil.) \longrightarrow MgSO_{4(aq)} + H_{2(g)}$

- Hydrogen gas is not evolved when a metal reacts with nitric acid because nitric acid is a strong oxidising agent.
- Gold and platinum are noble metals which do not react with any strong acid like HCl, HNO_3 and H_2SO_4, but these can be dissolved in aqua regia (a mixture of conc. HCl and conc. HNO_3 in the ratio of 3 : 1) due to the formation of nascent chlorine which reacts with these metals to form metal chlorides.

$\underbrace{3HCl + HNO_3}_{\text{Aqua regia}} \longrightarrow \underbrace{NOCl}_{\text{Nitrosyl chloride}} + 2H_2O + \underbrace{2Cl}_{\text{Nascent chlorine}}$

$Au + 3Cl \longrightarrow AuCl_3$; $Pt + 4Cl \longrightarrow PtCl_4$

Aqua regia is highly corrosive and fuming liquid.

- **Reaction with salt solutions :** More reactive metals can displace less reactive metals from the aqueous solutions of their salts. These reactions are known as *metal displacement reactions*. Generally,

Metal *A* + Salt solution of *B* $\longrightarrow$ Salt solution of *A* + Metal *B*

Examples :

$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$

Reactivity series : It is the series in which metals are arranged in the order of their decreasing reactivity as shown :

Potassium (K)	Most reactive
Sodium (Na)	
Calcium (Ca)	
Magnesium (Mg)	
Aluminium (Al)	
Zinc (Zn)	
Iron (Fe)	
Lead (Pb)	
[Hydrogen (H)]	
Copper (Cu)	
Mercury (Hg)	
Silver (Ag)	
Gold (Au)	Least reactive

Reactivity decreases

- **Characteristics of the reactivity series :**
  - Metals are arranged in this series on the basis of the ease with which atoms of these metals give up their electrons to form ions.
  - Higher the metal in the series, greater is its tendency to form ions in solution.
  - Metals are placed in a decreasing order of reactivity, *i.e.,* the most reactive metals are placed at the top and as we move down, the reactivity of metals decreases.
  - The series also shows which metal will displace the other in a solution. Metals placed above will displace the metals placed below in the series.

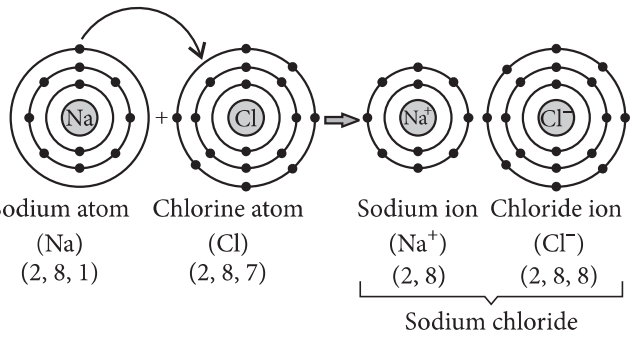
Ionic compounds : A chemical bond formed between two atoms by complete transfer of electrons from one atom to another so as to complete their octets and hence, acquire the stable nearest noble gas configuration, is called *ionic bond*. The compounds thus formed are known as *ionic compounds*.

- **Formation of ionic compounds :** During formation of ionic compounds, metal atom looses electrons and these electrons are accepted by non-metal atom. In this way, cations and anions are formed which are held together by ionic bonds.

This can be understood by taking an example of formation of sodium chloride.

$\underset{(2,8,1)}{\dot{N}a} + \underset{(2,8,7)}{:\dot{\underset{\cdot\cdot}{Cl}}:} \longrightarrow \underset{(2,8)}{[Na]^+} \underset{(2,8,8)}{[:\dot{\underset{\cdot\cdot}{Cl}}:]^-}$ or NaCl

The transfer of electrons may be represented as:



Properties of ionic compounds :

- **Physical state :** Ionic compounds are generally solids and exist in the form of crystals as ions are bonded by strong attractive forces. These crystals differ in their shapes and lustre.

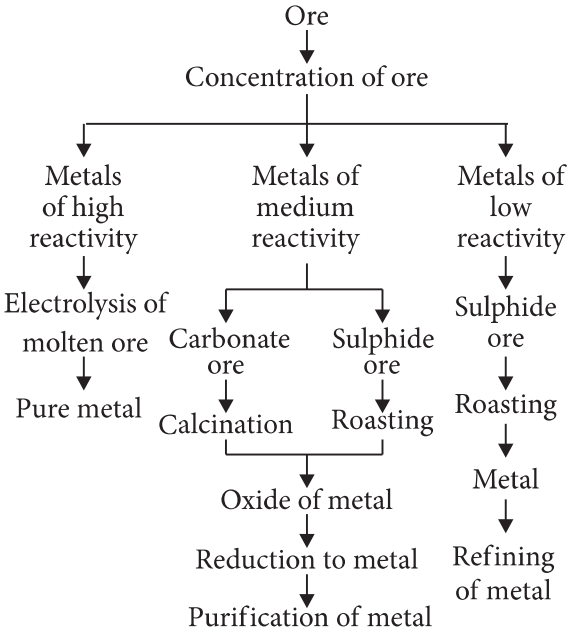
- **Melting and boiling points :** Their melting and boiling points are very high as they have strong forces of attraction.
- **Solubility :** Ionic compounds are generally soluble in water and insoluble in solvents such as kerosene, petrol, etc.
- **Electrical conductivity :** Ionic compounds conduct electricity in the aqueous solution as well as in the molten state but not in the solid state.

Occurrence of metals : The major source of metals (whether in the free state or in the combined state) is the earth's crust. Some metals are found in the sea water in the form of their soluble salts. Percentage of some metals in earth's crust is as follows :
Al(7%), Fe(4%), Ca(3%), Na(2.7%), K(2.5%), Mg(2%) and Ti(0.6%).

- **Minerals and Ores :** The elementary state or the compounds, in the form of which the metals occur in nature are called *minerals*. The earthy, sandy and rocky impurities associated with the mineral are called *gangue* or *matrix*. Also, the mineral from which the metal can be extracted conveniently and economically is called an *ore*.

Extraction of metals : Getting a metal out of its ore is called *extraction of the metal*.

Metallurgy : Various steps involved in the extraction of a metal from its ore followed by refining of the metal is called '*metallurgy*'. The steps involved are summarised as follows :



The three major steps involved in the extraction of a metal from its ore are :
(i) concentration or enrichment of ore
(ii) conversion of concentrated ore into metal
(iii) refining of impure metal.

- **Concentration or enrichment of ore :** It is done by removing gangue. The methods for removing gangue are gravity separation, froth floatation process, electromagnetic separation and chemical separation.
- **Conversion of concentrated ore into metal :**
  - **Extraction of highly reactive metals :** The highly reactive metals like Na, Mg, Ca, etc. are extracted by electrolytic reduction of their molten chlorides or oxides. Electrolytic reduction is brought about by passing electric current through the molten state. Metal gets deposited at the cathode.
    At cathode : $Na^+ + e^- \longrightarrow Na$
    At anode : $2Cl^- \longrightarrow Cl_2 + 2e^-$
  - **Extraction of metals of medium reactivity :** The metals with moderate reactivity like zinc, iron, lead, copper, etc. are generally present as oxides, sulphides or carbonates. These sulphides and carbonates first need to get converted to oxides as it is easier to get metal from their oxides.
    This can be done by two processes :
    - **Roasting :** In this process, the sulphide ores are converted into oxides by heating strongly in presence of excess of air.
      $2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{\text{Roasting}} 2ZnO_{(s)} + 2SO_{2(g)}$
      Zinc sulphide (Zinc blende ore)
    - **Calcination :** In this process, the carbonate ores are converted into oxides by heating strongly in the absence or limited supply of air.
      $ZnCO_{3(s)} \xrightarrow{\text{Heat}} 2ZnO_{(s)} + CO_{2(g)}$
      Zinc carbonate (Calamine ore)

    The metal oxides are then reduced to corresponding metals by using

reducing agents like carbon or by using displacement reactions with highly reactive metals such as aluminium, sodium, calcium, etc.

$$ZnO_{(s)} + C_{(s)} \xrightarrow{Heat} Zn_{(s)} + CO_{(g)}$$

$$3MnO_{2(s)} + 4Al_{(s)} \xrightarrow{Heat} 3Mn_{(l)} + 2Al_2O_{3(s)}$$

The reduction of metal oxides to metal using aluminium as the reducing agent is called *aluminothermy*. The reaction is highly exothermic. The heat evolved is so high that the metal is obtained in the molten state.

$$Fe_2O_{3(s)} + 2Al_{(s)} \xrightarrow{Ignited} 2Fe_{(l)} + Al_2O_{3(s)}$$

This reaction is known as *thermite reaction* and used for welding the broken parts of iron machinery, railway tracks, girders, etc.

– **Extraction of metals with low reactivity :** The oxides of these metals can be reduced to metals by heating alone.

$$2HgS_{(s)} + 3O_{2(g)} \xrightarrow{Heat} 2HgO_{(s)} + 2SO_{2(g)}$$

Mercury sulphide (Cinnabar ore)

$$2HgO_{(s)} \xrightarrow{Heat} 2Hg_{(l)} + O_{2(g)}$$

▸ **Refining of impure metal :** The process of purifying impure metals is called *refining of metals*. The most widely used method is electrolytic refining. In this process, the impure metal is made the anode and a thin strip of pure metal is made the cathode. A solution of the metal salt is used as an electrolyte. On passing the current through the electrolyte, the impure metal from the anode dissolves into the electrolyte and pure metal from the electrolyte is deposited on the cathode. The soluble impurities go into the solution, whereas, the insoluble impurities settle down at the bottom of the anode as such in the form of *anode mud*.

Corrosion : The process of slowly eating up of metals due to their conversion into oxides, carbonates, sulphides, sulphates, etc. by the action of atmospheric gases and moisture is called '*corrosion*'. In general, more reactive the metal, more easily it gets corrode. Metals like potassium, magnesium, aluminium, zinc, iron, etc. undergo corrosion easily while noble metals like gold and platinum do not get corroded easily. Corrosion of iron is known as *rusting* which causes a big loss to the economy of the country.

▸ **Prevention of corrosion :** Rusting of iron can be prevented by painting, oiling, greasing, galvanising, chrome plating, anodising or making alloys.

– A thin layer of tin metal or chromium metal is deposited on iron objects by electroplating to prevent rusting.

– Galvanisation is a method of protecting iron from rusting by coating them with a thin layer of zinc.

– **Alloying :** An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal. *e.g.*,
stainless steel (Fe + Cr + Ni),
brass (Cu + Zn), bronze (Cu + Sn), etc.

Chapter

4

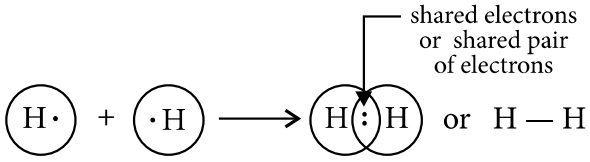
Carbon and its Compounds

QUICK RECAP

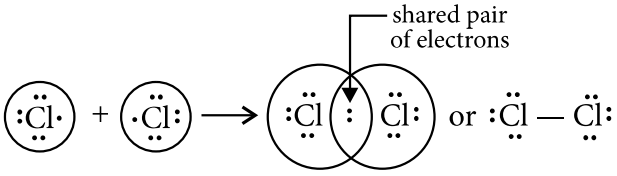
Covalent bond : A chemical bond formed between two atoms by mutual sharing of valence electrons, so that each atom acquires the stable electronic configuration of the nearest noble gas, is known as *covalent bond*.

Formation of covalent bonds :

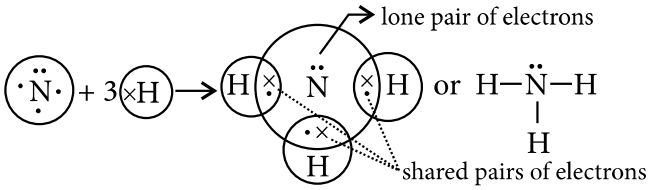
- **Formation of hydrogen molecule :**



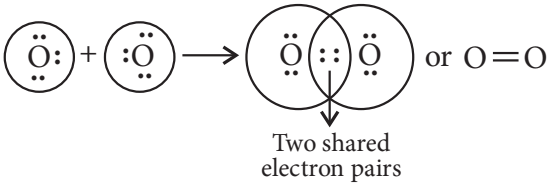
- **Formation of chlorine molecule :**



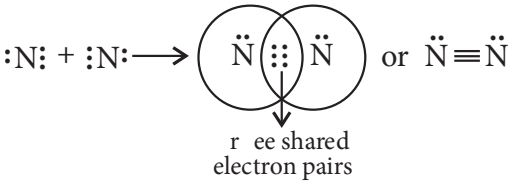
- **Formation of ammonia molecule :**



- **Formation of oxygen molecule :**



- **Formation of nitrogen molecule :**



Characteristics of covalent compounds :

- Covalently bonded molecules are seen to have strong bonds within the molecules, but intermolecular forces are small, resulting the low melting and boiling points.
- Covalent compounds are generally poor conductors of heat and electricity.

Covalency : The number of electrons contributed by each atom for sharing is, known as *covalency*.

Covalent bonding in carbon : It is difficult for carbon to lose or gain four electrons because of the following reasons :

- It cannot gain four electrons to form C^{4-} ion having neon gas (2, 8) configuration because this anion would be highly unstable due to the large amount of energy required to overcome the forces of repulsion between the four electrons being added and the six electrons already present in carbon atom.
- It cannot lose four electrons to form C^{4+} ion having helium gas (2) configuration because this cation would be highly unstable due to the large amount of energy required to remove four electrons from the carbon atom.
- Carbon overcomes this problem by sharing its valence electrons with other atoms, *i.e.*, by forming covalent bonds.

Allotropes of carbon : Carbon occurs in different forms in nature :

- **Diamond :** Each carbon atom is bonded to four other carbon atoms, forming a rigid three-dimensional structure.
- **Graphite :** In graphite, each carbon atom is bonded to three other carbon atoms in the same plane giving a hexagonal array. These hexagonal arrays are placed in layers one above the other. Graphite is smooth and slippery and very good conductor of electricity.
- **Fullerenes :** Fullerenes are another class of carbon allotropes. They are spheroidal in shape and contain even number of carbon atoms ranging from 60-350 or above.

Versatile nature of carbon : Carbon is versatile element because it shows following characteristics :

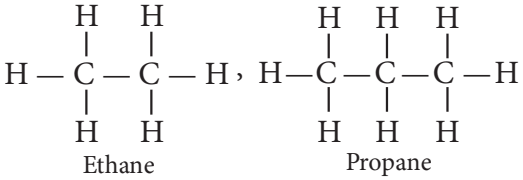
- **Catenation :** The unique property of self-linking of carbon atoms through covalent bonds to form long straight or branched chains or rings of different sizes is, called *catenation*. Due to this property, carbon forms a large number of organic compounds.
- **Tetra-covalency of carbon :** Carbon has a covalency of four. It is capable of forming bonds with four other atoms of carbon or atoms of other monovalent elements. Due to small size of carbon, these compounds are exceptionally stable.
- **Tendency to form multiple bonds :** Due to small size of carbon atom, it can form multiple bonds with carbon, oxygen, sulphur and nitrogen atoms.
- **Isomerism :** If a molecular formula represents two or more structures having different properties, the phenomenon is called *isomerisms*. Isomerism also leads to huge number of carbon compounds.

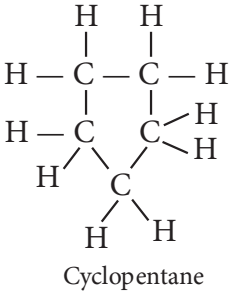
Hydrocarbons : The compounds which contain only carbon and hydrogen are called hydrocarbons. These are categorised as :

- **Saturated hydrocarbons :** The compounds in which carbon atoms are linked together

with only single covalent bonds, are called *saturated hydrocarbons*.

Example :

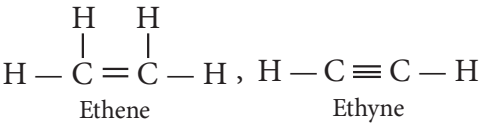


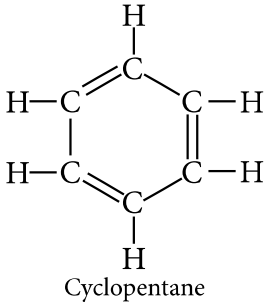


Since carbon – carbon single bonds are very strong therefore, saturated hydrocarbons are usually not very reactive. Also, saturated hydrocarbons contain the maximum number of hydrogen atoms. Saturated hydrocarbons are called alkanes.

- **Unsaturated hydrocarbons :** The compounds in which one or more double or triple bonds are present between carbon atoms are called *unsaturated hydrocarbons*. Unsaturated hydrocarbons with double bonds, are called *alkenes* while with triple bonds, are called *alkynes*.

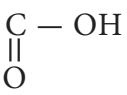
Examples :





Unsaturated hydrocarbons are more reactive than saturated hydrocarbons.

Functional group : A functional group can be defined as an atom or a group of atoms present in a molecule which largely determines its chemical properties.

Hetero atom	Name of Functional groups	Formula of functional group
Cl/Br	Halo (chloro/ bromo)	–Cl, –Br Substitutes for hydrogen atom
O	1. Hydroxyl	—OH
	2. Aldehydic	
	3. Ketonic	
	4. Carboxylic	

Homologous series : A homologous series is defined as a group of compounds having the same functional group, similar chemical properties in which the successive members differ by a $—CH_2$ group or 14 mass unit.

- **Characteristics of homologous series :**
  - All compounds in the series can be represented by a general formula. *e.g.*, for alcohol it is $C_nH_{2n+1}OH$, for alkane C_nH_{2n+2}, for alkene C_nH_{2n}, and for alkynes C_nH_{2n-2}, where, $n = 1, 2, 3....$.
  - Two successive members of homologous series differ by $—CH_2$ unit.

n	$C_nH_{2n+1}OH$	
1	CH_3OH	$—CH_2$
2	C_2H_5OH	$—CH_2$
3	C_3H_7OH	$—CH_2$
4	C_4H_9OH	

  - All compounds in the series have similar chemical properties.
  - All members of the series, show a gradual change in their physical properties.
  - Physical properties generally increase as the molecular mass increases.

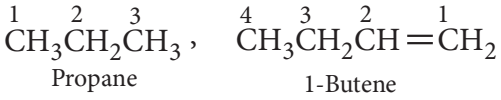
Nomenclature of carbon compounds : Naming a carbon compound can be done by following rules :

- Select the longest possible chain of carbon and number them.
- The functional group present in the organic compound is indicated either by a prefix or a suffix.

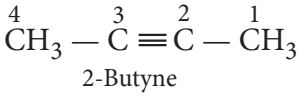
Prefix ⇒ The word comes before the name of the compound.
Suffix ⇒ The word comes after the name of the compound.

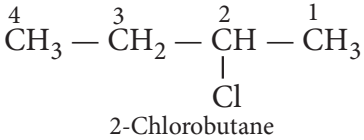
Functional group	Prefix	Suffix
Chlorine	Chloro	—
Bromine	Bromo	—
Alcohol	—	ol
Aldehyde	—	al
Ketone	—	one
Carboxylic acid	—	oic acid
Double bond	—	ene
Triple bond	—	yne

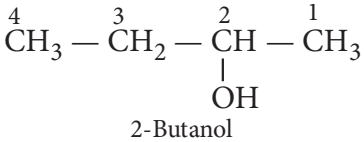
- If a suffix is to be added, the final '*e*' from the name of the alkane is omitted.
- If the carbon chain is unsaturated, the final '*ane*' from the name of the carbon chain is replaced by either '*ene*' (if the carbon chain contains a double bond) or by '*yne*' (if the carbon chain contains a triple bond).
- The position of the functional group on the carbon chain is given by the lowest possible numerical prefix.
- **Examples :**

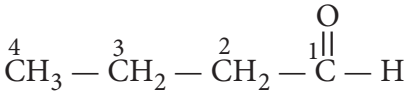

Propane

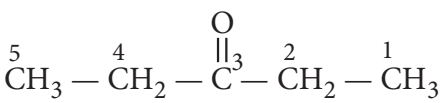
1-Butene

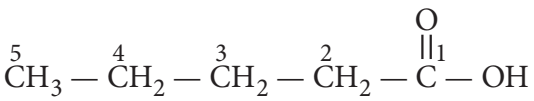

2-Butyne


2-Chlorobutane


2-Butanol

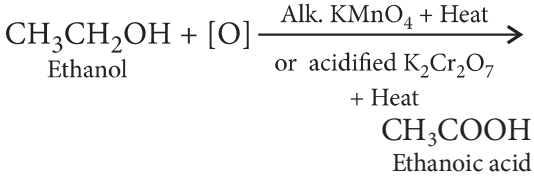

Butanal


3-Pentanone

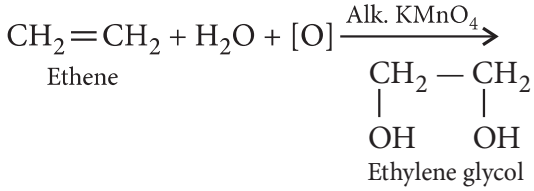

Pentanoic acid

Chemical properties of carbon compounds :

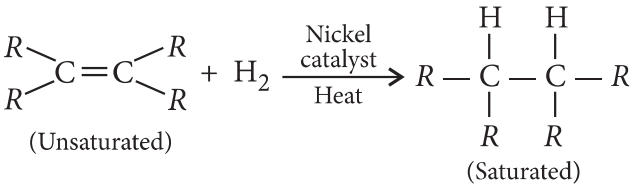
- **Combustion :** On combustion, all the allotropic forms of carbon and organic compounds are oxidised to carbon dioxide with release of a large amount of heat and light. *e.g.*, $C + O_2 \longrightarrow CO_2 + \text{heat}$
  $CH_3CH_2OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + \text{heat}$
  Saturated hydrocarbons burn in excess of air with a clean blue flame but unsaturated hydrocarbons burn with yellow flame with lots of black smoke.
- **Oxidation :** The process in which oxygen is added and hydrogen is removed form a substance is called *oxidation*. The substances which are capable of adding oxygen to other substances are called *oxidising agents*.
  - **Oxidation of ethanol to ethanoic acid :**

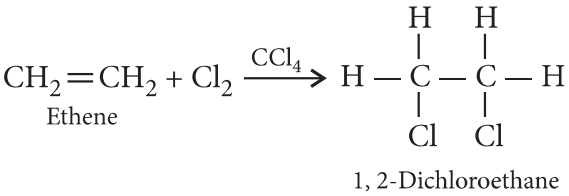

Ethanol — Ethanoic acid

  Here, alkaline $KMnO_4$ or acidified potassium dichromate are oxidising agents.
  - **Oxidation of ethene :**


Ethene — Ethylene glycol

  Here, alkaline $KMnO_4$ is acting as an oxidising agent.
- **Addition reactions :** Those reactions in which atoms or group of atoms are simply added to a double or triple bond without the elimination of any atom or molecule, are known as *addition reactions*.


(Unsaturated) — (Saturated)


Ethene — 1, 2-Dichloroethane

- **Substitution reactions :** The reactions which involve the displacement or substitution of an atom or a group of atoms in an organic compound by another atom or group of atoms, are known as *substitution reactions*.
  Saturated hydrocarbons are fairly unreactive and inert in the presence of most of the reagents. However, in presence of sunlight, hydrocarbons undergo rapid substitution reactions. *e.g.,*

$$\underset{\text{Methane}}{CH_4} + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{Chloromethane}}{CH_3Cl} + HCl$$

$$\underset{\text{Chloroform}}{CHCl_3} + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\substack{\text{Carbontetra}\\\text{chloride}}}{CCl_4} + HCl$$

Some important carbon compounds :

Ethanol

- It is the most important compound of alcohol family with molecular formula, C_2H_5OH.
- **Physical properties :**
  - Ethanol is a colourless liquid, having pleasant smell.
  - It has boiling point of 351 K (or 78°C) and freezing point of 156 K (or –114°C).
  - It is lighter than water.
  - Ethanol is neutral towards litmus.
  - It is miscible with water in all proportions.
- **Chemical properties :**
  - **Reaction with sodium :** Ethanol reacts with sodium resulting in the evolution of hydrogen gas.

$$2Na + 2CH_3CH_2OH \longrightarrow \underset{\text{Sodium ethoxide}}{2CH_3CH_2ONa} + H_2\uparrow$$

  - **Reaction with conc. sulphuric acid :** Ethanol reacts with conc. H_2SO_4 to give corresponding alkene with the removal of water molecule.

$$CH_3CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

    Conc. sulphuric acid is considered as a dehydrating agent.
- **Uses :**
  - It is used in making beer, wine, whisky and other alcoholic drinks.
  - It is used in making chloroform, iodoform, ether, acetic acid, acetaldehyde, etc.
  - It is used as a solvent for resins, fats, oils, etc.
  - It is used as an antiseptic to sterilise wounds and syringes in hospitals.
  - It is used in the manufacture of dyes, drugs and detergents.

Ethanoic Acid

- It is the second member of the homologous series of carboxylic acid with molecular formula, CH_3COOH. A 5-8% solution of acetic acid in water is called '*vinegar*'.
  100% acetic acid, obtained by melting glacier like crystals is called *glacial acetic acid*.
- **Physical properties :**
  - Ethanoic acid is a colourless, pungent smelling liquid.
  - It has melting point of 290 K and boiling point of 391 K.
  - It is miscible with water in all proportions.
- **Chemical properties :**
  - Ethanoic acid is acidic in nature. It turns blue litmus to red. It is weaker acid than hydrochloric acid (HCl).
  - **Esterification reaction :** Ethanoic acid reacts with ethanol in presence of an acid catalyst to form ester. This reaction is called *esterification reaction*.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow{\text{Acid}} \underset{\substack{\text{Ethyl acetate}\\\text{(Ester)}}}{CH_3-\overset{\overset{O}{\|}}{C}-O-CH_2CH_3}$$

    This ester again in presence of an alkali, give back the alcohol and sodium salt of carboxylic acid. This process is known as *saponification*. It is used in making soaps.

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$$

  - **Reaction with a base :** Ethanoic acid reacts with a base such as sodium hydroxide to yield salt and water.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + NaOH \longrightarrow \underset{\substack{\text{Sodium}\\\text{ethanoate}\\\text{(Salt)}}}{CH_3COONa} + H_2O$$

– **Reaction with carbonates and hydrogen carbonates :** Ethanoic acid reacts with carbonates and hydrogen carbonates to yield a salt, carbon dioxide and water.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$
(Salt)

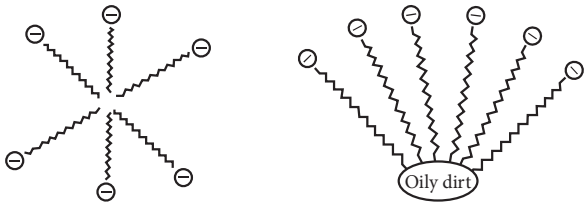
$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$
Sodium acetate (Salt)

▶ **Uses :**
- It is used as vinegar in cooking and as preservative in pickles.
- It is used in manufacture of dyes, perfumes, plastics, rubber, etc.
- It is used as a solvent in laboratory and industry.
- It is used as a laboratory reagent for carrying out chemical reactions.

Differences between soaps and detergents :

Soaps	Detergents
These are sodium or potassium salts of fatty acids *e.g.*, $C_{15}H_{31}COOH$ (palmitic acid), $C_{17}H_{35}COOH$ (stearic acid) and oleic acid ($C_{17}H_{33}COOH$)	These are ammonium or sulphonate or sulphate salts of long chain hydrocarbons containing 12-18 carbon atoms.
These have —COONa group.	These have $-\overset{+}{N}R_4$, $-SO_3Na$ or $-SO_4Na$ group.
These do not work well with hard water, acidic water and saline water but work well with soft water.	These work well with hard water, acidic water and saline water.
These are biodegradable.	Some detergents having branched hydrocarbon chains are non-biodegradable.
They take time to dissolve in water.	They dissolve faster in water.

Cleansing action of soaps and detergents :
Soaps and detergents consist of a large hydrocarbon tail with a negatively charged head. The hydrocarbon tail is hydrophobic (water-hating or water-repelling) and negatively charged head is hydrophilic (water-loving).
In aqueous solution, water molecules being polar in nature, surround the ions and not the hydrocarbon part of the molecule.
When a soap or detergent is dissolved in water, the molecules associate together as clusters called *micelles*.



Micelle formed by detergent molecules in water.
The hydrocarbon tails stick to the oily dirt.

The tails stick inwards and the heads outwards.
In cleansing, the hydrocarbon tail attaches itself to oily dirt. When water is agitated (shaken vigorously), the oily dirt tends to lift off from the dirty surface and dissociate into fragments. This gives opportunity to other tails to stick to oil. The solution now contains small globules of oil surrounded by detergent molecules. The negatively charged heads present in water prevent the small globules from coming together and form aggregates. Thus, the oily dirt is removed.
In the past, detergents caused pollution in rivers and water bodies. The long carbon chain present in detergents used earlier, contained lots of branching. These branched chain detergent molecules were degraded very slowly by the microorganisms present in sewage discharge, septic tanks and water bodies. Thus, the detergents persisted in water for long time and made water unfit for aquatic life. Nowadays, the detergents are made up of molecules in which branching is kept at minimum. These are degraded more easily than long branched chain detergents.

Chapter

5

Periodic Classification of Elements

QUICK RECAP

- **Need for classification :** It is very difficult to study each and every element individually and also very difficult to know its properties and uses. Therefore, they have been classified into groups on the basis of their similarities in properties.
- **Early attempts at the classification of elements :**
  - **Dobereiner's triads :** According to this law, "when the elements are arranged in groups of three in increasing order of atomic masses, the middle element of a group has the atomic

mass and properties roughly the average of the other two elements." These elements show similarity in their properties.

e.g., :

Elements :	Li	Na	K
Atomic mass :	7	23	39

Average atomic mass of 1st and 3rd elements $= \frac{7+39}{2} = 23$

– **Limitations :** Only a limited number of elements could be arranged in such triads.

▸ **Newland's law of octaves :** It states that when elements are arranged in the order of increasing atomic masses, the properties of the eighth element are the repetition of the properties of the first element like the eighth note on a musical scale. Therefore, Li, Na and K resemble each other.

– **Limitations :** All the elements discovered at that time could not be classified into octaves. This law worked well with lighter elements only.

Mendeleev's periodic table : This table had been designed on the basis of a law called Mendeleev's periodic law which states that the properties of elements are periodic function of their atomic masses.

▸ **Groups :** The vertical columns of the periodic table are called '*groups*'. There are eight groups in this table.

Group →	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**		
Oxide Hydride	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4		
Periods ↓	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**Transition series**		
1	H 1.008									
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998			
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453			
4 First series Second series	K 39.102 Cu 63.54	Ca 40.08 Zn 65.37	Sc 44.96 Ga 69.72	Ti 47.90 Ge 72.59	V 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe 55.85	Co 58.93	Ni 58.71
5 First series Second series	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.40	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.75	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru 101.07	Rh 102.91	Pd 106.4
6 First series Second series	Ca 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.49 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Os 190.2	Ir 192.2	Pt 195.09

- **Periods :** The horizontal rows of the periodic table are called '*periods*'. There are six periods in this table.
- **Achievements of Mendeleev's periodic table :**
  - He classified all the 63 elements discovered at that time on the basis of similarities in their properties.
  - He left gaps for yet to be discovered elements.
  - He predicted the properties of undiscovered elements and thus, helped in the discovery of these elements later on.
  - He named them by prefixing a Sanskrit numeral eka (one), divi (two), tri (three), etc. to the name of the preceding similar element in the same group, *e.g.*, eka-boron, eka-aluminium, etc.
- **Limitations :**
  - Increasing order of atomic masses could not be maintained in all cases *e.g.*, cobalt with higher atomic mass was placed before nickel. Similarly, tellurium with higher atomic mass was placed before iodine.
  - This table did not provide place for noble gases which were discovered later.
  - There was no separate place for isotopes in Mendeleev's periodic table, although they differ in atomic masses.
  - He could not assign a correct position to hydrogen.

Modern periodic law : This law states that the properties of elements are a periodic function of their atomic numbers. This means that when elements are arranged in increasing order of their atomic numbers the properties of elements are repeated after certain regular intervals. This repetition of properties of elements after certain regular interval is known as '*periodicity in properties*'. This periodicity in properties of elements is due to periodicity in their outer electronic configurations. Infact, elements having similar outer-electronic configurations show similar chemical properties.

Modern periodic table : In the modern periodic table, the elements are arranged in increasing order of their atomic numbers. This table was prepared on the basis of electronic configurations of elements.

- **Position of elements in modern periodic table :** Modern periodic table consists of eighteen columns called '*groups*' and seven horizontal rows called '*periods*'. These groups are numbered from 1-18 and periods are numbered from 1-7.
- **Description of groups :**

Family of Elements	Group
Normal or representative elements	1 and 2 (left) 13 - 18 (right)
Alkali metals	1
Alkaline earth metals	2
Boron family	13
Carbon family	14
Nitrogen family or pnicogens	15
Oxygen family or chalcogens	16
Halogens	17
Inert gases or noble gases	18
Transition elements	3, 4, 5, 6, 7, 8, 9, 10, 11, 12

- **Description of periods :** The number of elements in any period is fixed by the maximum number of electrons that can be accommodated in that particular shell which is given by the formula, '$2n^2$' where 'n' is the number of the given shell starting from the nucleus.

Shell	'n'	Period	No. of Elements
K	1	First	2[$_1$H, $_2$He]
L	2	Second	8[$_3$Li, $_4$Be, $_5$B, $_6$C, $_7$N, $_8$O, $_9$F, $_{10}$Ne]

Metals | Metalloids | Non-metals

The zigzag line separates the metals from the non-metals.

s-block elements (Representative elements) — IA, IIA

d-block elements (Transition elements) — IIIB to IIB

p-block elements — Representative elements (IIIA to VIIA) and Noble gases (0, 18)

Periods (No. of elements)	IA 1	IIA 2	IIIB 3	IVB 4	VB 5	VIB 6	VIIB 7	VIII 8	VIII 9	VIII 10	IB 11	IIB 12	IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17	0 18
1 (2) ($_1H$-$_2He$)	1 H Smallest atomic size																	2 He Highest ionisation potential
2 (8) ($_3Li$-$_{10}Ne$)	3 Li Lightest solid metal	4 Be											5 B Lightest solid non-metal	6 C Maximum catenation	7 N	8 O	9 F Highest electro negative	10 Ne
3 (8) ($_{11}Na$-$_{18}Ar$)	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4 (18) ($_{19}K$-$_{36}Kr$)	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br Liq. non-metal	36 Kr
5 (18) ($_{37}Rb$-$_{86}Rn$)	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te Most stable element	53 I Sublime on heating	54 Xe
6 (32) ($_{55}Cs$-$_{86}Rn$)	55 Cs Lowest electro-negative; lightest liq. metal	56 Ba	57 La	72 Hf	73 Ta	74 W Highest m.pt., b.pt. metal	75 Re	76 Os Heaviest solid metal	77 Ir	78 Pt (Noble Metals)	79 Au (Noble Metals)	80 Hg Lowest m.pt. metal	81 Tl	82 Pb	83 Bi	84 Po	85 At Heaviest solid non-metal	86 Rn Heaviest gaseous non-metal
7 (32) ($_{87}Fr$-$_{118}Og$)	87 Fr Liquid element of radio-active nature	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

f-block elements (Inner-transition elements)

Lanthanide series →	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinide series →	90 Th	91 Pa	92 U	93 Np	94 Pu Most poisonous element	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

M	3	Third	8[$_{11}$Na, $_{12}$Mg, $_{13}$Al, $_{14}$Si, $_{15}$P, $_{16}$S, $_{17}$Cl, $_{18}$Ar]
N	4	Fourth	18[$_{19}$K to $_{36}$Kr]
O	5	Fifth	18[$_{37}$Rb to $_{54}$Xe]
P	6	Sixth	32[$_{55}$Cs to $_{86}$Rn]
Q	7	Seventh	32[$_{87}$Fr to $_{118}$Og]

- In order to avoid the periodic table becoming too lengthy, two series of 14-elements each, have been placed at the bottom of the periodic table.
  - First series contains elements of atomic numbers 58–71 called '*Lanthanide series*'.
  - Second series contains elements of atomic numbers 90–103 called '*Actinide series*'.

Trends in the Modern periodic table : The physical and chemical properties of an element mainly depend upon its outer electronic configuration. Since the outer electronic configuration changes as we go from left to right in a period therefore, within the same period, elements show a gradation both in their physical as well as chemical properties.

These properties which show a regular gradation on moving from top to bottom within the same group or from left to right along a period are called '*atomic properties*'. *e.g.*, valency, atomic size, metallic or non-metallic character, etc.

- **Valency :** Valency is defined as the combining capacity of an element. It depends upon the number of valence electrons (electrons present in outermost shell of the atom).
  - **Variation of valency in a period :** On moving from left to right in a period, the number of valence electrons increases from 1 to 8 although in the first period, it increases from 1 to 2. *e.g.*,

$$\underset{2,8,1}{Na} \longrightarrow \underset{2,8}{Na^+} + e^- \quad \text{(Valency = 1)}$$

$$\underset{2,8,2}{Mg} \longrightarrow \underset{2,8}{Mg^{2+}} + 2e^- \quad \text{(Valency = 2)}$$

$$\underset{2,8,7}{Cl} + e^- \longrightarrow \underset{2,8,8}{Cl^-} \quad \text{(Valency = 8 – 7 = 1)}$$

In other words, in a period, the valency of an element is either equal to the number of electrons in the valence shell or eight minus the number of electrons in the valence shell.

  - **Variation of valency in a group :** All the elements in a group have same number of valence electrons. Therefore, the valency of all the elements in a group is fixed.
    e.g., : group 1 elements have valency 1, group 17 elements have valency 1, group 18 elements have valency 0.
- **Atomic size :** If an atom is considered to be a sphere, the atomic size is given by the radius of the sphere, known as *atomic radius*. The atomic radius is defined as the distance between the centre of the nucleus and the outermost shell which contains electrons, in an isolated atom. It is expressed in angstrom (Å) or in picometers (pm).
  - **Variation of atomic radii in a period :** On moving from left to right in a period, the atomic radius decreases due to increase in nuclear charge which tends to pull the electrons closer to the nucleus and reduces the size of the atom. Example :

	Li	Be	B	C	N	O	F	Ne
Atomic radius (pm) :	152	111	88	77	75	74	72	160
								Biggest

(van der Waals radius)

  - **Variation of atomic radii in a group :** On moving down the group, the atomic radii of elements increase gradually because new shells are being added. This increases the distance between outermost shell and the nucleus so that the atomic size increases in spite of the increase in nuclear charge. Example :

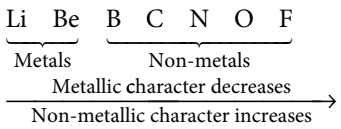
	Li	Na	K	Rb	Cs
Atomic radius (pm) :	152	186	231	246	262

- **Metallic and non-metallic character :** Group 1 to group 12 are metals. Group 13

to 18 consists of non-metals, metalloids and metals.

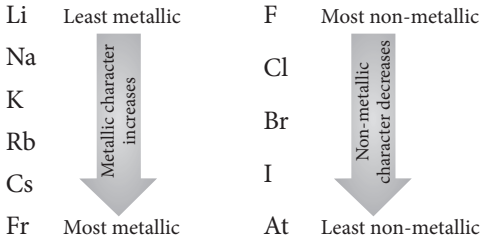
- Metals tend to lose electrons while forming bonds hence, they are electropositive in nature.
- Non-metals tend to form bonds by gaining electrons hence, they are electronegative in nature.
- **Metalloids :** Those elements which resemble both metals and non-metals *i.e.*, border line elements are called metalloids or semi-metals *e.g.*, boron, silicon, germanium, arsenic, tellurium and polonium.
- **Variation in a period :** On moving from left to right in a period, the metallic character decreases whereas the non-metallic character increases.

Example :



- **Variation in a group :** On moving down in a group, the metallic character increases.

  Reversely, on moving down a group, the non-metallic character decreases.



Chapter

6

Life Processes

QUICK RECAP

Living organisms : All the plants and animals (including human beings) are alive or living organisms. All living organisms have some common characteristics which make them different from non-living things.

Characteristics of Living Organisms

- They can move by themselves.
- They need food, air and water.
- They can grow.
- They can reproduce and can have young ones.
- They respire (release energy from food).
- They excrete (get rid of waste materials from their body).
- They can respond to changes around them and they are sensitive.

Nutrition: It is defined as the process of intake of nutrients such as carbohydrates, fats, proteins, etc., and their utilisation by an organism in various biological activities.

Modes of nutrition

Autotrophic

- A kind of nutrition in which the organisms prepare (or synthesise) their own organic food utilising only the inorganic raw materials present in their surroundings.
- It is found in green plants.

Heterotrophic

- A kind of nutrition in which the organisms derive energy from the intake and digestion of the organic substances prepared by autotrophs and other organic sources.

Saprotrophic

- A kind of nutrition in which the organisms derive their nutrients from dead and decaying organic matter (such as rotten leaves, rotten bread, dead animals, household wastes, non-living organic matter present in the soil, etc.).

Parasitic

- A type of nutrition in which the organisms (or parasites) derive their nutrients or food from other living organisms without killing them.
- Parasitic mode of nutrition is observed in several fungi, bacteria, a few plants like *Cuscuta* and some animals like *Plasmodium* and roundworms.

Holozoic

- In this type of nutrition, an organism takes the complex organic food materials into its body by the process of ingestion. The ingested food is digested and then absorbed into the body cells of the organisms.
- Human beings and most of the animals have holozoic mode of nutrition.

Flow chart: Modes of nutrition

Nutrition in Plants: The process by which green plants make their own food (like glucose) from carbon dioxide and water by using sunlight energy in the presence of chlorophyll, is called **photosynthesis**. The process of photosynthesis can be represented as:

$$\underset{\text{Carbon dioxide (From air)}}{6CO_2} + \underset{\text{Water (From soil)}}{6H_2O} \xrightarrow[\text{(Photosynthesis)}]{\text{Light energy + Chlorophyll}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

- The process of photosynthesis takes place in the green leaves of a plant because they contain green pigment called chlorophyll in special cell organelles called **chloroplasts**. Hence, site of photosynthesis in the leaves of green plants is chloroplast.They have green coloured **grana** embedded in liquid hyaline **stroma**.
- The food prepared by the green leaves of a plant is in the form of a simple sugar called **glucose.** It is then sent to different parts of the plants. The extra glucose is changed into another food called **starch.** This starch is stored in the leaves of the plant. Glucose and starch belong to a category of foods called carbohydrates.
- The plants take carbon dioxide required for photosynthesis from air through tiny pores called **stomata** present on the surface of leaves.
- Water required for photosynthesis is absorbed from soil by the roots of plants.
- **Mechanism of photosynthesis:** The first step of photosynthesis initiates when light falls on green leaves. The pigment chlorophyll present in the chloroplasts absorbs visible light and after absorption creates such condition that water breaks into hydrogen protons (H^+),

electrons (e^-) and evolves molecular oxygen (O_2). This is called **photolysis**. This O_2 goes into the atmosphere. The electrons and protons released by the photolysis of water are used up in the production of **assimilatory power** in the form of **NADPH** and **ATP**. Photolysis of water, evolution of molecular oxygen (O_2) and synthesis of assimilatory power has been assigned as the **light reaction** of photosynthesis. This step occurs in the granum part of the chloroplast.

- The assimilatory power, generated in the light reaction of photosynthesis, is used up in the next step where carbon dioxide (CO_2) of atmosphere is utilised in the production of carbohydrate.
- This step was discovered in detail by **Calvin**, **Benson** and **Bassam**. It is a cyclic process, which occurs in the stroma part of chlorophyll, that is totally enzymatic process and has been termed as the **dark reaction** of photosynthesis.
- The important factors which affect the process of photosynthesis are : light, temperature, carbon dioxide and water.

Nutrition in animals : Depending upon the food habit, holozoic animals are classified into 3 categories :

- **Herbivores:** These animals eat only algae or plant materials. The common herbivorous animals are cow, rabbit, goat, camel, deer, etc.
- **Carnivores :** These animals eat only flesh of other animals. The common carnivorous animals are lion, tiger, frog, snake, etc.
- **Omnivores :** These animals eat both plants and other animals as food. The common omnivorous animals are man, sparrow, crow, bear, etc.
- There are five steps in the process of nutrition in animals. These are :
  - **Ingestion :** The process of taking food into the body is called ingestion.
  - **Digestion :** The process in which the food containing large, insoluble molecules is broken down into small, water soluble molecules (which can be absorbed by the body) is called digestion.
  - **Absorption :** The process in which the digested food passes through the intestinal wall into blood stream is called absorption.
  - **Assimilation :** The process in which the absorbed food is taken in by body cells and used for energy, growth and repair, is called assimilation.
  - **Egestion :** The process in which the undigested food is removed from the body is called egestion.
- **Nutrition in *Amoeba:*** *Amoeba* shows holozoic mode of nutrition and obtains its food through phagocytosis. It engulfs the microscopic food particle by forming pseudopodia (temporary protoplasmic processes.) The food particle gets surrounded by pseudopodia to form **food vacuole**.
- **Nutrition in human beings :** Human beings are heterotrophic, holozoic, omnivorous organisms. The human digestive system consists of an alimentary canal and many digestive glands. The alimentary canal of human beings consists of following parts:
  - **Mouth :** Mouth gives passage for ingestion of food. It is guarded by two soft movable lips and opens into a chamber or cavity called **buccal cavity**.
  - **Buccal (or Oral) cavity :** It is a large space bounded above by the palate, below by the throat and on the sides by the jaws. The throat supports the muscular tongue which forms the floor of this cavity and helps in ingestion of food. Both upper and lower jaws are provided with teeth. Each jaw has two pairs of incisors, one pair of canines, two pairs of premolars and three pairs of molars. Thus, each jaw possesses total 16 teeth and a human adult has 32 permanent teeth. The full **dental formula** (arrangements of teeth) of humans is represented as – I 2/2, C 1/1, Pm 2/2, M 3/3. The **incisors** are sharp and have cutting edges. The **canines** are pointed and occur next to the incisors. The **premolars** and **molars** are called the grinding teeth. Teeth cut the food

into small pieces. The buccal cavity has three pairs of salivary glands located at different locations. The **parotid glands** lie on the sides of the face, **sublingual glands** lie under the front part of the tongue and **submaxillary glands** lie at the angles of the lower jaw. These salivary glands secrete saliva through their ducts. Saliva contains water, salts, mucin and an enzyme **ptyalin.** Ptyalin is salivary amylase which splits starch and glycogen into maltose.

- **Pharynx:** It is about 12 cm long funnel-shaped vertical canal which serves as a passage way for the food from the buccal cavity to the oesophagus.
- **Oesophagus:** This is a long and tubular structure which serves to carry the food from pharynx to the stomach. The wall of oesophagus is highly muscular. It exhibits **peristaltic movement,** *i.e.*, contraction and expansion movement of walls, so that the partially digested food is pushed forward in the tract.
- **Stomach:** This is a wide C-shaped or J-shaped muscular sac present on the left side of the abdomen. Partially digested food reaches the stomach from the buccal cavity through pharynx and oesophagus.
- The food is stored in the stomach for variable duration. Wall of the stomach undergoes periodic muscular contraction so that the food gets churned and mixes thoroughly with the gastric juice. Stomach possesses three types of glands which secrete hydrochloric acid, protein digestive enzyme and mucus. All these secretions are collectively called **gastric juice.** The hydrochloric acid makes the medium acidic. Protein-digesting enzyme **pepsin** acts in acidic medium which breaks down proteins into peptones. Gastric juice also contains some **gastric lipase** which partially breaks down lipids.
- **Small intestine:** This is the **longest part** of the alimentary canal. It is a narrow tube of about 6 metres which lies coiled in the abdomen. Partially digested and churned food from the stomach enters into the small intestine which receives secretions from the liver and pancreas, through a common duct. The **bile duct** carries bile secreted by liver and stored in the gall gladder. Bile contains **bile salts** (**sodium glycocholate** and **sodium taurocholate**) which bring about the emulsification of fat. **Pancreatic duct** comes from the pancreas which is both an endocrine as well as exocrine gland. The exocrine region secretes sodium bicarbonate and many digestive enzymes whereas the endocrine region of pancreas secretes hormones, **insulin** and **glucagon**. The bicarbonate ions make the medium alkaline which is favourable for the action of pancreatic enzymes. The **pancreatic amylase** causes breakdown of starch, **pancreatic lipase** breaks down lipids and **trypsin** causes digestion of protein. The small intestine also secretes digestive juice which contains a mixture of several enzymes. All these enzymes act upon different types of food. Internally, the wall of small intestine is raised into numerous projections called the **villi.** The villi greatly increase the absorptive surface area of the inner lining of intestine. Presence of villi and blood capillaries in the absorptive surface enhance the capacity of absorption by the wall of the intestine. The absorbed food goes into the blood and moves along with the blood stream. This food reaches to the cells where it is utilised. Utilisation of food is also a part of nutrition and is termed as **assimilation**.
- **Large intestine:** It is arranged around the mass of small intestine in the form of a question mark. The greater part of large intestine is **colon** which is followed by **rectum**. The undigested food is collected as faeces in the rectum which leads to the anus.

- The wall of large intestine absorbs most of the water from the undigested food making it almost solid. This undigested food is passed out from our body through anus as faeces. This act of expelling the faeces is called **egestion** or **defecation**.

Respiration: Most living organisms need oxygen (of air) to obtain energy from food. This oxygen reacts with the food molecules (like glucose) present in the body cells and burns them slowly to release energy. The process of releasing energy from food is called **respiration.** Respiration is essential for life because it provides energy for carrying out all the life processes.

- **Breathing** is the process by which air rich in oxygen is taken inside the body of an organism and air rich in carbon dioxide is expelled from the body (with the help of breathing organs).
- **Cellular respiration** is much more complex process that occurs inside the living cells. It is the oxidation of respiratory substrate (mainly glucose) in the cells resulting in the release of carbon dioxide and energy (in the form of ATP). Cellular respiration may be of two types:
  - **Aerobic respiration :** The oxidative breakdown of respiratory substrates with the help of atmospheric O_2 is known as **aerobic respiration.** During this process, the respiratory substrate is completely broken down into carbon dioxide and water by the process of oxidation. In most of the eukaryotic organisms, some part of aerobic respiration (glycolysis) occurs in the cytoplasm and the major part (Krebs' cycle) occurs inside the mitochondrium. In cytoplasm, the glucose is broken down to pyruvic acid (a three carbon compound) by the process called **glycolysis**. In presence of oxygen this pyruvic acid enters into mitochondrium where it is completely broken down resulting in the production of energy rich compound, ATP. The equation of aerobic breakdown of glucose is :

$$\text{Glucose} \xrightarrow[\text{In cytosol, no } O_2 \text{ is required}]{\text{Glycolysis}} \text{Pyruvic acid} \xrightarrow[\text{In mitochondrium, } O_2 \text{ is required}]{\text{Krebs' cycle}} CO_2 + H_2O + \text{Energy}$$

  - **Anaerobic respiration:** Oxidation of respiratory substrates in absence of oxygen is termed as anaerobic respiration. It involves incomplete breakdown of respiratory substrates in which the end products like ethanol or lactic acid are formed and CO_2 is released. This respiration occurs in certain microorganisms such as bacteria and yeast. The overall equation is as follows:

$$\text{Glucose} \xrightarrow[\text{In cytosol, no } O_2 \text{ is required}]{\text{Glycolysis}} \text{Pyruvic acid} \xrightarrow{\text{In absence of } O_2} C_2H_5OH + CO_2 + \text{Energy}$$

(Ethyl alcohol)

Respiratory system in human beings : The respiratory system in human beings includes external nostrils, nasal cavities, internal nostrils, pharynx, larynx, trachea and a pair of lungs which provide the surface for the exchange of gases.

- The air enters through the nostrils and reaches into a pair of nasal cavities, separated from the oral cavity by a bony palate and separated from each other by a nasal septum. The nasal cavities are lined with ciliated pseudostraified columnar epithelium rich in gland cells so that the inspired air gets warmed, moistened and becomes dust free. It is also lined with olfactory epithelium which acts as organ of smell. The nasal chambers open into pharynx through internal nares.
- The **pharynx** is a short vertical tube located at the back of the buccal cavity which provides passage into which the internal nares and buccal cavity both open to pass the air into it. The pharynx provides passage into trachea or wind pipe through a slit-like aperture, called **glottis**. The glottis always remains open except during swallowing when the epiglottis (leaf like cartilagenous flap) closes it to check the entry of food into it.
- The **trachea** or wind pipe is a thin-walled tube that extends downward through the neck and divides into two major bronchi. One enters

the right lung, and the other, the left lung. Trachea has cartilaginous rings to prevent it from collapsing in between breathes.

- Lungs provide the surface for the exchange of gases. Each individual has a pair of **lungs.** The lungs lie in the thoracic cavity. The thoracic cavity is separated from the abdominal cavity by a muscular portion called **diaphragm**. Each lung is enclosed in two membranes, the **pleura**. Within the lungs, the major bronchi further divide into secondary bronchi which sub divide into smaller tertiary bronchi and finally into still smaller bronchioles. Each bronchiole divides into alveolar ducts which enter the alveolar sacs. The alveolar sacs are also called **alveoli**. Alveoli have very thin walls composed of simple moist non-ciliated squamous epithelium. It is closely surrounded by a network of blood capillaries.
- The pathway of air into lungs is as follows: External nares → Nasal cavities → Internal nares → Pharynx → Glottis → Larynx → Trachea → Bronchi → Bronchioles → Alveolar ducts → Alveoli.
- Breathing in humans involves the movements of rib cage and diaphragm. This happens as follows:

Mechanism of Breathing

Breathing in: When we breathe in (or inhale), then (i)the muscles between the ribs contract causing the rib cage to move upward and outward, and (ii) the diaphragm contracts and moves downward. The upward and outward movement of rib cage, as well as the downward movement of diaphragm, both increase the space in the chest cavity and make it larger. As the chest cavity becomes larger, air is sucked in from outside into the lungs. The lungs get filled up with air and expand.	**Breathing out:** When we breathe out (or exhale), then (i) the muscles between the ribs relax causing the rib cage to move downward and inward, and (ii) the diaphragm relaxes and moves upward. The downward and inward movement of rib cage as well as the upward movement of diaphragm, both decrease the space in our chest cavity and make it smaller. As the chest cavity becomes smaller, air is pushed out from the lungs.

Flow chart : Mechanism of breathing

- **Exchange of gases between alveoli and blood:** In this exchange, the blood takes up oxygen from the alveolar air and releases CO_2 to the alveolar air. Such an exchange occurs because the concentration of O_2 is more in alveolar air. The blood has higher concentration of CO_2 as compared to alveolar air. Thus, the CO_2 moves from blood to alveolar air due to simple diffusion. This exchange of gases results in the oxygenation of blood. The oxygenated blood then returns from the lung by pulmonary veins to the left side of the heart. The heart supplies the oxygenated blood to the body tissues.
- In tissues, the exchange of gases occurs between the oxygenated blood and the tissue cells. The concentration of O_2 is more in the blood and less in the tissue cells. So, the O_2 moves from blood to the tissues by the physical process of diffusion. Similarly, CO_2 concentration is more in tissues and less in the blood. So, the CO_2 moves from tissues to the blood. This process is called **internal respiration.**

- **Respiration in Fish :** The fish has special organs of breathing called **'gills'.** The fish uses the oxygen which is dissolved in water. It breathes by taking in water through its mouth and sending it over the gills. When water passes over the gills, the gills extract dissolved oxygen from it. The extracted oxygen is absorbed by the blood and carried to all the parts of the fish. Carbon dioxide produced by respiration is brought back by the blood into the gills for expelling into the surrounding water.
- **Respiration in other organisms :** Earthworm absorbs oxygen needed for respiration through its **moist skin** as it has good blood supply.
- *Amoeba* and *Paramecium* breathe through their **cell membranes**.

- In insects like grasshopper, cockroach, housefly and mosquito, the tiny holes called **spiracles** on their body and the air tubes called **tracheae** are the respiratory organs.
- **Respiration in plants :** Plants use oxygen of air for respiration and release carbon dioxide.

Respiration in plants differs from that in animals in three respects:

- All the parts of a plant (like root, stem and leaves) perform respiration individually. On the other hand, an animal performs respiration as a single unit.
- During respiration in plants, there is a little transport of respiratory gases from one part of the plant to the other. On the other hand, respiratory gases are usually transported over long distances inside an animal during respiration.
- The respiration in plants occurs at a slow rate. On the other hand, the respiration in animals occurs at a much faster rate.

- Plants have a branching shape, so they have quite a large surface area in comparison to their volume. Therefore, diffusion alone can supply all the cells of the plants with as much oxygen as they need for respiration.

Diffusion in plants

Stem
The stems of herbaceous plants have stomata where the exchange of respiratory gases takes place.

Leaves
The leaves of plants have tiny pores called stomata. The exchange of respiratory gases in the leaves takes place by the process of diffusion through stomata.

Roots
The roots of plants take the oxygen required for respiration from the air present in between the soil particles by the process of diffusion.

- **Transportation :** It is a life process in which a substance synthesised or absorbed in one part of the organism is carried to other parts of its body.
- **Transportation in human beings :** In human beings, there are two circulatory systems through which the materials are transported to relevant organs and tissues. They are: Blood vascular system and lymphatic system.
- **Blood vascular system :** A vascular system is that which has tubes full of fluid to be transported from one place to another. This system comprises of **heart,** the organ which pumps and receives the **blood,** and **blood vessels,** which are tubes through which the blood flows.
- **Blood :** Blood is a red coloured liquid (connective tissue) because it contains a red pigment called **haemoglobin**.

Main components of blood

Plasma
The liquid part of blood is called **plasma**. Plasma contains about 90 percent water and dissolved substances such as proteins, digested food, common salt, waste products (like carbon dioxide and urea) and hormones. Red blood cells, white blood cells and platelets are immersed in this liquid.

Red blood cells
Red blood cells are red in colour due to the presence of a red pigment called haemoglobin inside them. These cells carry oxygen from the lungs to all the cells of the body. It is actually the haemoglobin present in red blood cells which carries oxygen in the body. Red blood cells are circular in shape and lack nuclei.

White blood cells
White blood cells fight infection and protect us from diseases hence, they are called soldiers of the body. Some white blood cells can eat up the germs (like bacteria) which cause diseases. Other white blood cells make chemicals known as '**antibodies**' to fight against infection. These cells are irregular in shape. All the white blood cells have a nucleus though the shape of nucleus is different in different types of white blood cell.

Platelets
Platelets are the tiny fragments of special cells formed in the bone marrow. They do not have nuclei. Platelets help in the coagulation of blood (or clotting of blood) in case of cut or wound.

– **Blood clotting:** In the region of injury, the platelets rupture and release a substance called **thromboplastin.** It converts protein **prothrombin** into **thrombin**. **Vitamin K** is essential for the formation of prothrombin in liver. Thrombin then changes soluble **fibrinogen** protein into **fibrin**. The latter undergoes rapid polymerisation to form long fibres. The fibres form a network over the damaged (injured) region, entrap blood corpuscles and form a blood clot.

Functions of blood

- Circulation of blood is responsible for transportation of soluble digested food from the small intestine to various parts of the body where they are stored or assimilated.
- Blood carries soluble excretory materials, such as urea to organs of excretion.
- Blood carries hormones from the endocrine glands to target organs.
- Circulation of blood helps to maintain a constant body temperature by distributing the excess heat from the deeply seated organs.
- Blood transports oxygen from the lungs to all parts of the body.
- Blood carries carbon dioxide produced by the tissues to the lungs for breathing out.
- Blood has a property of clotting which prevents excessive blood loss.
- The white blood cells act as soldiers of the body by killing the bacteria and other germs.
- The blood acts as a buffer and maintains a constant solute potential and pH.

– **Blood vessels :** There are three kinds of blood vessels in human body – arteries, veins and capillaries.

(i) **Arteries** are the blood vessels which carry blood away from the heart for distribution to the body. The walls of arteries are thick that enables them to dilate but not rupture when the heart contracts and forces blood into them. Thus, the blood passing through narrow lumen of arteries is aerated and has a considerable pressure.

(ii) **Veins** are thin walled blood vessels which bring blood from the body back to the heart. They are larger and hold more blood than the arteries. The blood passing through wide lumen of veins is non-aerated (except in pulmonary veins) and has low pressure.

(iii) **Capillaries** are thin walled and extremely narrow blood vessels which occur at the terminals of artery and vein. The wall of capillaries are permeable to water and dissolved substances so that the exchange of materials between the blood and body cells can take place.

▸ **Human heart:** The heart is a hollow, muscular organ, that contracts regularly and continuously pumps blood to various parts of the body. Its average weight is about 300 gm in males and about 250 gm in females. It is situated between the two lungs in the middle of the thoracic cavity. It is surrounded by a two layered sac, the **pericardium.** The pericardial fluid is secreted in the pericardial cavity between the pericardium and heart which reduces the friction between the heart wall and surrounding tissues when the heart is beating.

– **Structure of the heart:** The heart is divided by septa into two halves: the right and the left. Each half consists of two communicating chambers upper smaller or **atrium** and lower larger **ventricle**. Thus, the heart has four chambers: The two upper chambers, called atria and two lower chambers, called left and right ventricles. There are valves between left atrium and left ventricle and between right atrium and right ventricle. These valves provide one-way passage and prevent the return of blood. The walls of heart are composed of special muscles called **cardiac muscles.**

– One complete contraction (**systole**) and relaxation (**diastole**) of the heart is called a **heart beat**.

– The sequence of events which takes place during the completion of one heart beat is called the **cardiac cycle.**

Steps of cardiac cycle

Joint Diastole

During the time when the muscles of all four chambers of the heart are relaxed, the blood return to the heart under low pressure and enters the two atria. Blood from large veins, called **vena cava**, pours into right atrium. This blood comes from head, upper body parts and lower body parts where oxygen has been used up and the blood is free from oxygen, *i.e.*, deoxygenated. At the same time, the pulmonary vein from lungs pours oxygenated blood into the left atrium. Thus, **the oxygenated blood enters the left atrium.**

Atrial Systole

As the right and left atria fill with blood, pressure in them rises so that the valves between left atrium and left ventricle (**bicuspid valve)** and between right atrium and right ventricle (**tricuspid valve)** open and the atria contract. Atrial contraction forces pumping of deoxygenated blood from right atrium into the right ventricle through tricuspid valve and oxygenated blood from left atrium into left ventricle through bicuspid valve.

Ventricular Systole

Almost immediately the ventricles contract. This is called **ventricular systole.** During contraction of ventricles, the deoxygenated blood from right ventricle flows to the lungs through pulmonary artery and the oxygenated blood from left ventricle is distributed to all the parts of the body through the largest artery, called **aorta.**

- **Pulse:** Every time the heart beats, blood is forced into arteries. This blood makes the arteries expand a little. The expansion of an artery each time the blood is forced into it, is called **pulse**. Each heartbeat generates one pulse in the arteries, so the pulse rate of a person is equal to the number of heartbeats per minute. The pulse rate of an adult person while resting is 70 to 72 per minute.
- **Blood pressure:** The pressure at which blood is pumped around the body by the heart is called **blood pressure**. The blood pressure of a person is always expressed in the form of two values called **'systolic pressure'** and **'diastolic pressure'**. The maximum pressure at which the blood leaves the heart through the main artery (aorta) during contraction phase, is called the **systolic pressure.** The minium pressure in the arteries during the relaxation phase of heart is called the **diastolic pressure.** The normal blood pressure values are : Systolic pressure : 120 mm Hg6, Diastolic pressure : 80 mm Hg. This is usually written as 120/80.
- The blood circulation in human heart is **double circulation.** One circulation involves the entry of blood into the heart from all body parts. This blood is deoxygenated which goes to lungs for oxygenation. The second circulation involves entry of oxygenated blood from lungs into the heart and then its distribution to all parts of the body. Double circulation is made possible because the human heart is divided into two halves. One half pumps deoxygenated blood to the lungs and the other half pumps oxygenated blood to the rest of the body.

Lymphatic system : A system of tiny tubes called lymph vessels (or lymphatics) and lymph nodes (or lymph glands) in the human body which transport the liquid called lymph from the body tissues to the blood circulatory system is called **lymphatic system.** The lymphatic system consists of the following parts: (i) lymph capillaries, (ii) lymph vessels, (iii) lymph nodes (or lymph glands), and (iv) lymph.

- Lymph capillaries are tiny tubes which are present in the whole body (just like blood capillaries). Lymph capillaries are closed ended. Since the pores in the walls of the lymph capillaries are somewhat bigger, so even large protein molecules present in the tissue fluid can enter lymph capillaries. The lymph capillaries join to form larger lymph vessel. The lymph vessels have lymph nodes at intervals. The lymph nodes contain special

type of cells called **lymphocytes**. These cells are involved in the cleaning of lymph and protecting the body from disease. The lymph vessels are connected to large veins of the blood circulatory system. Lymph is a light yellow liquid which is somewhat similar in composition to blood plasma. It flows in only **one direction** - from body tissues to the heart. Since lymph is derived from the tissue fluid which remains outside the cells of the body, so it is also called **extracellular fluid**.

Functions of lymphatic system

- Lymph takes part in the nutritive process of the body. For example, it puts into circulation large protein molecules by carrying them from the tissues into the blood stream (which could not be absorbed by blood capillaries due to their large size). Lymph also carries digested fat for the nutritive process.
- Lymphatic system protects the body by killing the germs drained out of the body tissues with the help of lymphocytes contained in the lymph nodes and by making antibodies.
- Lymph helps in removing the waste products like fragments of dead cells, etc.

Transportation in plants : Transport system in plants is less elaborate as compared to animals. It is because plants are less active and require less supply of materials either from outside or synthesised by the plants themselves. There are two kinds of transportation in plants-

(i) Transportation of water and minerals
(ii) Transportation of food and other substances.

- **Transportation of water and minerals.** The main water conducting tissue in higher plants is **xylem.** Xylem consists of vessels and tracheids. A xylem vessel is made of many hollow, dead cells (called **vessel elements**), joined end to end. The end walls of the cells are dissolved so that a long, open tube is formed. These vessels run from the roots of the plant right up through the stem and reach the leaves. These vessels do not contain cytoplasm or nuclei. Their walls are made of cellulose and lignin (a very hard and strong substance), so they also provide strength to the stems and help to keep the plant upright.

Tracheids are dead cells with lignified walls but they do not have open ends. They have pits in their thick cell walls. Pits are thin areas of the cell wall where no lignin has been deposited. Water flows from one tracheid to another through pits.

3 interconnected processes for transportation of water and minerals

Absorption of water and minerals

The water and minerals are absorbed by land plants from the soil where they are present in the form of soil solution. The main water absorbing organs are root hairs and mineral absorbing organs are root epidermal cells at root apex. The water is absorbed actively by water potential difference between soil solution and root hairs. Water molecules move from higher water potential to lower water potential and then migrate from cell to cell passing from epidermis to cortex, from cortex to endodermis and from endodermis to **xylem vessels** and **tracheids** from where they move upward by the process called ascent of sap.

Ascent of sap

According to root pressure theory, the roots absorb water and exert a pressure, the root pressure which pushes the water upward. The root pressure develops in the tracheary element of xylem as a result of metabolic activities of roots. The root pressure theory is applicable in small herbs but not in tall trees.

Transpiration

The loss of water in the form of vapours from the living tissues of aerial parts of the plant is termed as **transpiration.** It mainly occurs by the process of diffusion through stomata. The stomata are tiny pores present on the surface of leaf. Each stoma has two small, green-coloured, kidney-shaped guard cells which regulate the opening and closing of stomatal apertures. Loss of water through transpiration generates a transpirational pull. Transpiration pull and cohesion-tension theory explain the upward movement of water in tall trees. According to this theory, the main force responsible for upward movement of water is transpiration pull generated in the leaves which pulls the water column filled in the xylem tracheids and vessels.

- **Transportation of food and other substances :** The main food conducting tissue in plants is **phloem**. It is a complex permanent tissue, running parallel to the xylem strands. It consists of sieve tube elements and companion cells.
  - **Sieve tubes** are living cells which contain cytoplasm but no nucleus. The sieve tube cells do not have lignin in their walls. Each sieve tube cell has a companion cell next to it. The companion cell has a nucleus and many other organelles. Companion cells supply the sieve tubes with some of their requirements.
  - The sugars and other metabolites are transported through phloem. The phloem elements remain in close contact with the mesophyll cells of leaves. Soluble carbohydrates (food molecules) enter the phloem elements from mesophyll cells of the leaf. Once the food molecules enter the phloem, they are transported upward, downward in lateral directions.
  - The upward movement of organic solutes takes place from the leaves to developing buds, flowers and fruits for consumption and storage. The upward movement also occurs during the germination of seeds. The food materials, stored mainly in the cotyledons and endosperm, are translocated upward to the growing apex. The nutrients are transported in sieve tubes in a dilute aqueous solution. Such a transport of food from leaves to other parts of the plant is termed as **translocation** which takes place by utilising energy.

Excretion : The two important homeostatic processes occurring in organisms which help to maintain the steady state are: excretion and osmoregulation. The biological process of removal of toxic wastes from the body of an organism is called **excretion**. **Osmoregulation** is a process that maintains the amount of water and proper ionic balance in the body fluids. It maintains a constant osmotic condition in the body by regulating the water content and solute concentration of body fluids, particularly of sodium, potassium and chloride ions.

Excretion in animals: The protozoans, lose waste matter by simple diffusion through the cell membrane into the surrounding water. Some excretion and osmoregulation occurs by way of contractile vacuoles.

- In earthworm, the excretion and osmoregulation occurs through tubular structures constituting **nephridia**.
- The insects, centipedes, arachnids and millipedes have **malpighian tubules** for excretion.
- The molluscs and vertebrates have **kidneys** for excretion and osmoregulation.

Excretion in human beings : Excretory system in human beings consists of a pair of **kidneys,** a pair of **ureters,** a **urinary bladder** and a **urethra.** The two kidneys are located towards the back of the lower part of the abdominal cavity, one on either side of the backbone. Left kidney is slightly larger and placed a little higher than the right kidney. The blood from aorta enters into kidneys *via* renal arteries and returns to the posterior vena cava *via* renal veins. Urine formed in the kidneys passes by a pair of ureters to the bladder where it is stored until it is released *via* urethra.

- Each kidney is made up of a large number of excretory units called **nephrons**. The nephron has a cup-shaped bag at its upper end which is called **Bowman's capsule**. The lower end of Bowman's capsule is tube-shaped and it is called tubule. The Bowman's capsule and the tubule taken together make a nephron. One end of the tubule is connected to the Bowman's capsule and its other end is connected to a urine-collecting duct of the kidney.
- The Bowman's capsule contains bundle of blood capillaries which is called **glomerulus** (plural glomeruli). One end of the glomerulus is attached to the renal artery which brings the dirty blood containing waste into it. The other end of glomerulus comes out of Bowman's capsule as a blood capillary, surrounds the tubule of nephron and finally joins a renal vein.

- The function of glomerulus is to filter the blood passing through it. Only the small molecules of substances present in blood like glucose, amino acids, salts, urea and water ,etc., pass through the glomerulus and collect as filtrate in the Bowman's capsule. The large molecules like proteins and blood cells cannot pass out through the glomerulus capillaries and hence remain behind in the blood.
- The function of tubule of nephron is to allow the selective reabsorption of the useful substances like glucose, amino acids, salts and water into the blood capillaries. But the waste material like urea remains behind in the tubule. It does not get reabsorbed into blood capillaries.
- The condition when a person's kidneys stop working is called **kidney** or **renal failure**. Complete failure of the kidneys allows the urea and other waste products to build up in the blood. Even the amount of water in the body is not regulated. The best long term solution for kidney failure is the kidney transplant. If a kidney transplant is not possible due to some reasons, then the patient with kidney failure is treated periodically on a kidney machine by a procedure called **dialysis**.
- Dialysis is used for cleaning the blood of a person by separating the waste substance (urea) from blood. The blood from an artery in the patient's arm is made to flow into the dialyser of a dialysis machine made of long tubes of selectively permeable membrane (like cellulose) which are coiled in a tank containing dialysing solution. This solution contains water, glucose and salts in similar concentrations to those in normal blood. As the patient's blood passes through the dialysing solution, most of the wastes present in it pass through the selectively permeable cellulose tubes into the dialysing solution. The clean blood is pumped back into a vein of the patient's arm.

Excretion in plants : The plants remove their waste products by different methods. The main waste products of plants are carbon dioxide, water vapour and oxygen. Carbon dioxide and water vapour are produced as wastes during respiration whereas oxygen is produced as a waste during photosynthesis. The gaseous wastes of respiration and photosynthesis in plants (carbon dioxide, water vapour and oxygen) are removed through the 'stomata' in leaves and 'lenticels' in stems and released in air.

Methods of disposal of plant wastes

- Excess salt is removed through hydathodes along with guttation water.
- Many breakdown products are recycled in the synthesis of new metabolic products.
- Most of the toxic waste products are stored within dead permanent tissues such as **heartwood** (non functional part of xylem in the trunk and branches), leaves or bark which are removed periodically.
- Some waste substances are eliminated through petals, fruits and seeds.
- Some excretory products such as **latex, gums, essential oils,** etc., are stored in special type of tissues and glands. For example, laticiferous tissue collects latex (which is the source of natural rubber), resin ducts store resin (the resin of pine trees yields turpentine), mucilaginous ducts store mucilage, oil glands store essential oils, etc.

Chapter

7

Control and Coordination

QUICK RECAP

- All movements in living organisms occur in response to changes in the environmental factors. All living organisms respond and react to environmental factors (stimuli) such as light, heat, cold, sound, smell, taste, pressure, etc., and this response involves **coordination** of many organs in our body.
- **Coordination in animals:** Unicellular organisms respond to environmental stimuli by moving towards or away from it. Such response is termed as **taxis**. Movement towards the source of stimulus is positive taxis and movement away from stimulus is negative taxis. In lower multicellular organisms, coordination takes place through nervous system.
  - **Coelenterates** – diffused nervous system is present which is made up of epidermal and gastrodermal nerve net of nerve cells.
  - **Flatworms** – ladder type nervous system is present which is made up of ganglionated nerve ring and nerve cords.

- **Annelids** – Central nervous system (CNS) is present which comprises of circumpharyngeal nerve ring and a nerve cord.
- **Insects** - CNS consist of circum-oesophageal nerve ring and nerve cord.
- In higher animals, control and coordination is provided by **nervous** and **endocrine** system.

Control and coordination in humans: There are two systems of coordination of activities in humans : nervous system and endocrine system.

- Both the systems of coordination, consist of a number of organs working together in a systematic way.

Human Nervous System: Human nervous system is the most complex system. The main parts of the nervous system are: **brain**, **spinal cord** and **nerves**. The sense organs can be considered to be other organs of the nervous system because they help in the functioning of the nervous system. We receive a variety of information from the environment around us through the sense organs. There are five sense organs in our body : eyes, ears, nose, tongue and skin. The sense organs contain receptors. A **receptor** is a cell (or a group of cells) in a sense organ which is sensitive to a particular type of stimulus. Different sense organs contain receptors for detecting different stimuli.

- The common types of receptor are photoreceptors (detect light, present in eyes), phonoreceptors (detect sound, present in ears), olfactory receptors detect smell, present in nose), gustatory receptors (detect taste, present in tongue) and thermoreceptors (detect heat or cold, present in skin).
- **Neurons** are the structural and functional unit of nervous system. Neuron is the longest cell in human body.

Components of Neuron

Cell body

The cell body of a neuron is also called **cyton** which is broad, rounded, pyriform or stellate part of the neuron. It has abundant cytoplasm, called **neuroplasm** which contains **Nissl's granules** and a relatively large, spherical **nucleus** and is mainly concerned with metabolic maintenance and growth. It also receives nerve impulses from dendrites and transmits them to axon.

Dendrites

These are several short, tapering, much branched protoplasmic processes stretching out from the cell body of a neuron. Here sensation (information) is acquired which then travels as an electric impulse towards the cell body.

Axon

It is a single, very long, cylindrical nerve fibre of uniform diameter arising from the cell body. At its terminal end, axon is highly branched. Axon terminals are often knob-like and these may end in nerve fibres that form synapses with dendrites of other neurons. The axon conducts nerve impulses away from the cell body.

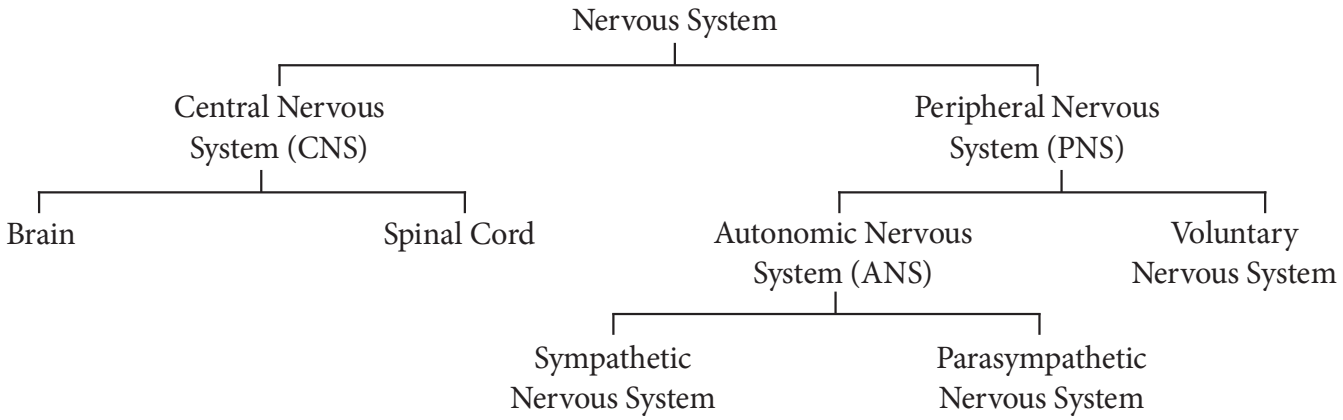
Types of neuron

Sensory (receptor) : Transmits impulse from sensory cells to CNS.

Motor (effector) : Transmits impulse from CNS to muscle cells.

Relay or **Connector** : Serves as link between sensory and motor neurons.

- The classification of human nervous system into various parts is given in the following chart:



Flow Chart : Main parts of human nervous system

- **Central nervous system :** The central nervous system (CNS) consists of the brain and the spinal cord.
- **Peripheral nervous system :** All the nerves of the body together make up the peripheral nervous system (PNS). **Voluntary peripheral nervous system** is under the control of will. It consists of nerves that arise directly from CNS connecting different body parts for voluntary (conscious) control of the brain. **Autonomic nervous system** or **involuntary peripheral nervous system** on the other hand, is not under the control of human will. It develops from branches of some cranial and spinal nerves

CNS

Brain

- Brain is the highest coordinating centre in the body. The brain is located inside the skull of our body (at the top of the spinal cord). It is protected by a bony box in the skull called **cranium**. It is surrounded by three membranes called **meninges,** which help to protect it . The space between the membranes (or meninges) is filled with a **cerebro-spinal fluid** which protects the brain from mechanical shocks. Pairs of cranial nerves arise from the brain.
- The brain is broadly divided into three regions: **forebrain, midbrain** and the **hindbrain**. The forebrain consists mainly of **cerebrum**. The midbrain does not have any further divisions. It consists of two fibre tracts called **crura cerebri** which connect hindbrain with forebrain. The hindbrain consists of three parts called **pons, cerebellum** and **medulla**.
- The cerebrum (or forebrain) is the main thinking part of the brain. It is the site of our faculties such as learning, reasoning, intelligence, personality and memory. All our thoughts, sensations, actions and movements are controlled by the cerebrum.
- The midbrain controls reflex movements of the head, neck and trunk in response to visual and auditory stimuli. It also controls the reflex movements of the eye muscles, changes in pupil size and shape of the eye lens.
- Pons varolii takes part in regulating respiration. Cerebellum helps in maintaining posture and balance of the body.
- Medulla oblongata controls various involuntary actions such as heart beat (blood circulation), breathing, blood pressure and peristaltic movements of alimentary canal. Medulla is also the controlling centre for reflexes such as swallowing, coughing, sneezing, secretion of saliva and vomiting.

Spinal cord

Spinal cord is a cylindrical structure that begins in continuation with the medulla oblongata of brain and extends downwards upto early part of lumbar region. It then extends to the end of vertebral column as fibrous connective called **filum terminale**.

It is enclosed in a bony cage called **vertebral column**. Spinal cord is also surrounded by membranes called **meninges**. As many as 31 pairs of nerves arise from the spinal cord. The spinal cord is concerned with spinal reflex actions and the conduction of nerve impulses to and from the brain.

Spinal cord performs two important functions: it conducts sensory and motor impulses to and from the brain and it acts as a centre for the reflex actions. Thus, it reduces brain's work.

called **visceral nerves**. The autonomic nervous system (ANS) is subdivided into two parts:

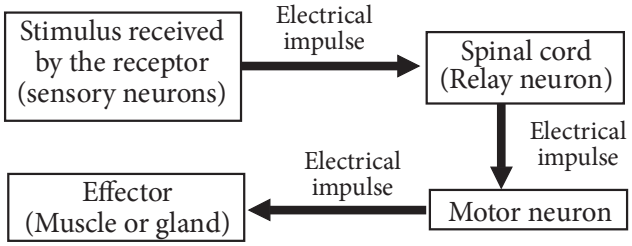
(i) Sympathetic nervous system

(ii) Parasympathetic nervous system

Peripheral nervous system consists of three types of nerve

- **Cranial nerves** arise from the brain and spread to various parts of the head. They are 12 pairs in number. Cranial nerves I, II and VIII are sensory nerves; cranial nerves III, IV, VI, XI and XII are motor nerves ; and cranial nerves V, VII, IX and X are mixed nerves (containing both sensory and motor nerve fibres).
- 31 pairs of **spinal nerves** arise from the spinal cord along most of its length and spread throughout the body (except, head region). They are all mixed nerves as they carry both sensory and motor nerve fibres.
- Many activities of the internal organs such as heart, kidney, lungs, urinary bladder, blood vessels, glands etc., are controlled by specific set of nerves called **visceral nerves** which mostly arise from spinal cord but a few from the brain also. These form the autonomic nervous system.

- **Reflex action and reflex arcs :** The simplest form of response in the nervous system is reflex action. This is a rapid, automatic response to a stimulus which is not under the voluntary control of the brain. It is described as an involuntary action which aims to protect ourselves. A knee jerk, movement of diaphragm (during respiration), coughing, yawning, blinking of eyes and sneezing are all reflex actions. Coughing is a reflex action which clears our windpipe. The pupils of our eyes get smaller in bright light. This protects the retina of our eyes from damage due to too much light.



Flow chart : Depicting a reflex action

The pathway taken by nerve impulses in a reflex action is called the **reflex arc**. Reflex arcs allow rapid response.

Human Endocrine System : Endocrine system is comprised of endocrine glands and the hormones released by them.

- **Hormones :** These are the chemical substances which coordinate the activities of living organisms and also their growth. The various characteristics of hormones are:
- They are secreted in small amounts by the endocrine glands.
- They are poured directly into the blood and carried throughout the body by circulatory system.
- They have their effects at the sites different from the sites where they are made. So, they are also called chemical messengers.
- They act on specific tissues or organs (called target organs).
- They coordinate the activities of the body and also its growth.
- **Endocrine glands :** A gland is a structure (cell, tissue or organ) which secretes certain useful chemicals or substances in the body. There are two types of gland in the body: **exocrine gland** and **endocrine gland**. Exocrine glands are the glands having ducts whereas endocrine glands are ductless glands.

Table: Endocrine glands – Their hormones and functions

Endocrine glands	Hormones secreted	Principal functions
1. Hypothalamus	(a) Releasing hormones (RH)	Stimulate anterior/ intermediate pituitary to secrete hormones.
	(b) Inhibiting hormones (IH)	Inhibit the secretion of hormones from anterior / intermediate pituitary gland.

2. Pituitary gland • It has three lobes. It is attached to the lower surface of the brain.		
(i) Anterior lobe • It produces six hormones.	(a) Growth hormone (GH) or Somatotropic hormone (STH)	Controls the overall development or growth of the body, muscles, bones and tissues. Lack of this hormone (hypoactivity) causes **dwarfness**. Its excessive secretion (hyperactivity) causes excessive growth of bones making the person very tall **(gigantism)**.
	(b) Thyroid stimulating hormone (TSH)	Controls the growth and functioning of the **thyroid gland**. Stimulates the thyroid gland to produce **thyroxine**.
	(c) Adrenocorticotropic hormone (ACTH)	Stimulates the adrenal cortex to secrete cortisol hormone.
	(d) Gonadotropic hormone (i) Follicle stimulating hormone (FSH)	In males, it stimulates the process of **spermatogenesis** (sperm formation). In females, it stimulates the follicle cells in the ovaries to develop into **mature eggs**.
	(ii) Luteinising hormone (LH)	In males, it stimulates the secretion of male hormone, **testosterone** (sex hormone in males). In females, it stimulates the secretion of **oestrogen** and **progesterone** (sex hormones in females).
	(e) Prolactin hormone (PRL)	Stimulates mammary gland development during pregnancy and milk production after child birth in females.
(ii) Intermediate lobe	Melanocyte stimulating hormone (MSH)	Stimulates the synthesis of melanin in the skin.
(iii) Posterior lobe	(a) Oxytocin	Stimulates contraction of smooth muscles at the time of child birth. It also helps in milk ejection (lactation) from the mammary glands.
	(b) Vasopressin or Antidiuretic hormone (ADH)	Regulates water and electrolyte balance in body.
3. Pineal gland • It lies between the two cerebral hemispheres of the brain.	Melatonin	Regulates circadian rhythm.

4. Thyroid gland • It is situated in the neck region on the ventral side of the body. It has two lateral lobes, one on either side of the trachea.	(a) Thyroxine or T_4 and Triiodothyronine or T_3	T_3 and T_4 stimulate the rate of cellular oxidation and metabolism.
	(b) Calcitonin	Calcitonin lowers calcium level by suppressing release of calcium ions from the bones, when calcium level is high in blood.
5. Parathyroid gland • These are four small oval bodies which lie embedded in the lobes of the thyroid gland.	Parathyroid hormone (PTH) or parathormone.	Regulates calcium and phosphate levels in the blood. When blood calcium level is below normal, it mobilises the release of calcium into the blood from bones. It has an action opposite to that of calcitonin on calcium metabolism.
6. Thymus gland • It is situated in the upper chest near the front side of the heart. • It undergoes gradual atrophy in the adult.	Thymosin	Stimulates the development and differentiation of lymphocytes (white blood cells).
7. Adrenal gland • In human beings, a pair of adrenal glands are present, one on top of each kidney, so, also called suprarenals. Each adrenal gland has an outer part called the **cortex** and an inner part, **medulla**.		
(i) Adrenal cortex • It secretes 3 groups of steroid hormones.	(a) Glucocorticoids	Regulate the metabolism of protein, fats and carbohydrates in the body and the level of blood sugar.
	(b) Mineralocorticoids (Aldosterone)	Regulate water and mineral balance in body.
	(c) Sexcorticoids	Stimulate the development of secondary sexual characters both in males and females.
(ii) Adrenal medulla • It secretes 2 hormones.	Adrenaline (Epinephrine) and Noradrenaline (Nor-epinephrine)	Both these hormones together control emotions, fear, anger, blood pressure, heart beat, respiration and relaxation of smooth muscles.

8. Pancreas • It is a compound gland in the abdominal region located posterior to the stomach. Its endocrine part is **Islets of Langerhans**, which secretes 2 hormones.	(a) Insulin	Regulates the conversion of glucose to glycogen, *i.e.*, it lowers blood glucose level.
	(b) Glucagon	Regulates the conversion of glycogen back to glucose, *i.e.*, it increases blood glucose level.
9. Ovaries • These are a pair of glands present in the lower abdominal region in females.	(a) Oestrogen (b) Progesterone	Plays an important role in ovulation. It is responsible for development of secondary sexual characteristics in females like mammary glands, voice, hair pattern, etc. Helps in the preparation of uterus for the reception of fertilised ovum. Also helps in the maintenance of pregnancy.
10. Testes • These are extra-abdominal in position. • The **interstitial** or **Leydig's cells** present in testes produce the male hormone.	Testosterone	Stimulates spermatogenesis, regulates the growth, development and functioning of accessory sex organs and controls the secondary sexual characteristics in males, such as enlargement of penis and scrotum, growth of facial and pubic hair and enlargement of larynx that causes deepening of voice.

- **Feedback mechanism:** The timing and amount of hormones released by various glands are controlled by the 'feedback mechanism' which is in-built in our body. For example, if the sugar level in the blood rises too much, they are detected by the cells of pancreas which respond by producing and secreting more insulin into blood. And as the blood sugar falls to a certain level, the secretion of insulin is reduced automatically.

Control and coordination in plants: Plants coordinate their behaviour against environmental changes by using hormones. The hormones in plants coordinate their behaviour by affecting their growth. And the effect on growth of the plant can result in the movement of its part like shoot (stem) or root, etc. The plants respond to various stimuli very slowly by growing. Hence, in most of the cases, the response of a plant to a stimulus cannot be observed immediately. It usually takes a considerable time to observe the effect of a stimulus on a plant.

- **Plant hormones (or Phytohormones):** The plant hormones coordinate the activities of the plant by controlling one or the other aspect of the growth of the plant. So, they are also known as plant growth substances. The growth of a plant can be divided into three stages: **cell division**, **cell enlargement** and

cell differentiation (or cell specialisation), and these stages have particular locations in a plant. There are 5 major types of phytohormone. These phytohormones with their functions are discussed in the given table:

Table: Plant hormones and their functions

Plant hormones	Functions
Auxins	These promote cell enlargement and cell differentiation in plants. These promote stem and fruit growth. These regulate important plant growth movements, *i.e.*, tropisms. These induce parthenocarpy (*i.e.*, the formation of seedless fruits without fertilisation) in number of plants.
Gibberellins	These promote cell enlargement and cell differentiation in plants in the presence of auxins. These also promote growth in stems and fruits. Rossette plants (*i.e.*, plants that show profuse leaf development but reduced internode growth) show bolting and flowering when treated with gibberellins. These also induce parthenocarpy in many plants.
Cytokinins	These promote cell division in plants. These play vital role in the morphogenesis in plants. These help in breaking the dormancy of seeds and buds. These delay the ageing in leaves. These promote the opening of stomata. These also promote fruit growth.
Ethylene	It promotes growth and ripening of fruits. It helps in breaking the dormancy in buds and seeds. It stimulates the formation of separation layer (abscission zone) in leaves, flowers and fruits. It promotes yellowing and senescence of leaves.
Abscisic acid (ABA)	It promotes the dormancy in seeds and buds and thus inhibits growth. It also promotes the closing of stomata and thus affects wilting of leaves. It also promotes the falling of leaves (abscission) and senescence in leaves.

Plant movements : Plants do not show locomotion (movement of the entire body). However, movements of the individual parts or organs of a plant (like shoot, root, leaves, etc.) are possible when they are subjected to some external stimuli like light, force of gravity, chemical substances, water and touch, etc. These movements of the plant parts are usually caused by an unequal growth in their two regions by the action of plant hormones, under the influence of the stimulus. When a plant part shows movement, it remains attached to the main body of the plant.

Types of plant movements

Nastic movements
Movement independent of growth.

Tropic movements
Movements due to growth.

Phototropism
Phototropism is the directional movement or orientation of the plant part in response to light stimulus. If the plant part moves towards light, it is called as positive phototropism. Alternatively, if the plant part moves away from light, it is called as negative phototropism. Example. (i) Stem or shoot of a growing plant moves towards light and thus shows positive phototropism. (ii) Roots of a plant move away from light and thus show negative phototropism.

Seismonastic movements
Such movements occur in response to touch (shock). These movements are very quick and are best seen in 'touch-me-not' plant (*Mimosa pudica*), also called '*Chhui-mui*' or '*Lajwanti*' or 'sensitive plant'.

Geotropism
Geotropism is the directional movement or orientation of the plant part in response to gravity. If the plant part moves in the direction of gravity, it is called as positive geotropism. Alternatively, if the plant part moves against the direction of gravity, it is termed as negative geotropism. Example : (i) Roots of a plant move downward in the soil in the direction of gravity and thus show positive geotropism. (ii) The stem or shoot of a plant shows movement against the direction of gravity and thus shows negative geotropism.

Nyctinastic movements
The movements involving the diurnal variations in the position of flowers and leaves of many plants in day and night are called nyctinastic or sleep movements. Nyctinastic movements include photonastic movements and thermonastic movements.

Photonastic movements
If the diurnal variations in the position of plant parts (*e.g.*, flowers and leaves) are caused by the light stimulus, such non-directional movements are called photonastic movements. Example is dandelion flower.

Thermonastic movements
If the diurnal variations in the position of plant parts (*e.g.*, flowers and leaves of plants) are caused by the change in temperature of the surroundings, such non-directional movements are called thermonastic movements.

Chemotropism
It is the directional movement or orientation of the plant part in response to chemical stimulus. If the plant part moves towards the chemical stimulus, it is called positive chemotropism. On the other hand, if the plant part moves away from the chemical stimulus, it is called negative chemotropism. Example: During the process of fertilisation, growth of pollen tube towards the ovule in the ovary is an example of positive chemotropism.

Hydrotropism
It is the directional movement or orientation of the plant part in response to water stimulus. If the plant part moves towards the water stimulus, it is called as positive hydrotropism. On the other hand, if the plant part moves away from the water stimulus, it is called as negative hydrotropism. Example:Bending of roots of the plant towards water signifies positive hydrotropism.

Thigmotropism
It is the directional response of plant parts to the touch of an object. It is often seen in plants having tendrils. Tendrils are positively thigmotropic which means that they grow towards things they happen to touch. Examples: Bitter gourd, bottle gourd, grape vine, etc.

Flow chart : Types of plant movement

Chapter

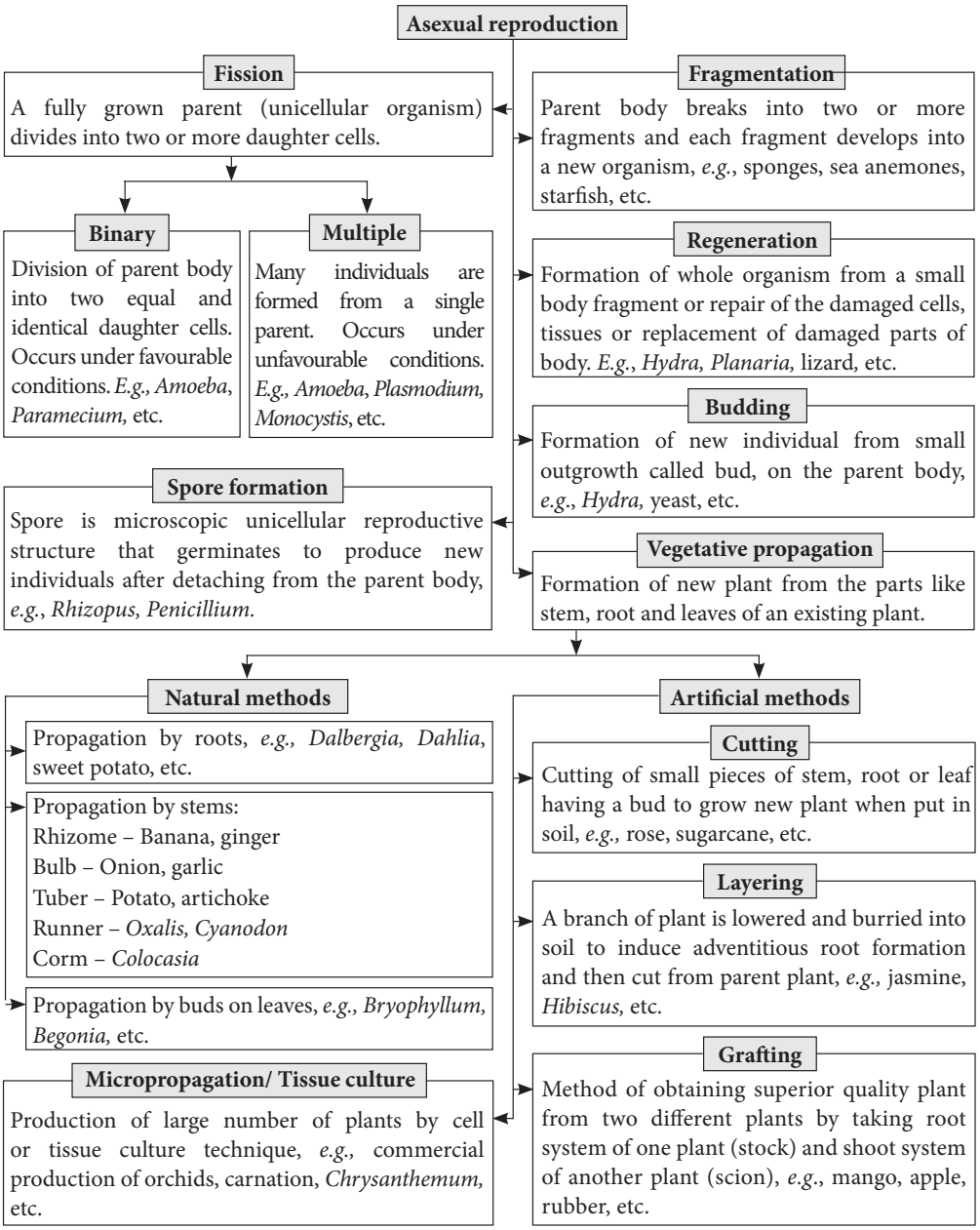
8

How do Organisms Reproduce?

QUICK RECAP

- **Reproduction** is the production of new organisms from the existing organism of a species that ensures continuity of population of that species.
- **Types of reproduction :** Living organisms reproduce by two ways-asexual reproduction and sexual reproduction.

- **Asexual reproduction :** It involves the production of an offspring from a single parent without the fusion of gametes.
- **Basic features of asexual reproduction :**
  - Only one organism is involved; different sexes are not involved.
  - All the cell divisions during this type of reproduction are either mitotic or amitotic.
  - New individuals produced are genetically identical to the parents.
  - It is a rapid mode of multiplication.
  - No gametes are formed and hence no fertilisation takes place.



Flow chart: Types of asexual reproduction

- **Sexual Reproduction :** It may be defined as the production of offspring (new individuals) by the fusion of two gametes (usually one from male parent and the other from female parent) to form a diploid zygote which develops into a mature organism.
- Advantages of sexual reproduction over asexual reproduction are : (i) Fusion of male and female gametes coming from male and female organisms. Since the fusing gametes come from two different and sexually distinct individuals, the offsprings exhibit diversity of characters, and (ii) Meiosis during gametogenesis provides opportunities for new combination of genes. It plays a prominent role in the origin of new species and leads to variation required for evolution.
- **Sexual reproduction in flowering plants :** The reproductive part of angiosperms is called flower.
- Sepals are green while petals are coloured. They form the non-essential parts of flower.
- Stamens and carpels are the essential reproductive parts of the flower.
- **Stamen** (androecium) is the male reproductive part of the plant made up of filament and anther. Anther produces the pollen grains that contain male gametes.
- **Carpel** (gynoecium) is the female reproductive part made up of stigma, style and ovary. Stigma is responsible for receiving pollen during pollination. **Style** is the middle part of carpel. It is an elongated tubular structure which connects stigma with ovary. The basal swollen part of carpel is **ovary**. Each ovule has an embryo sac that bears a haploid egg (female gamete).
- The process of transfer of pollen grains from the anther of a flower to the stigma of the same flower or another flower is known as **pollination**. It is of two types - **self pollination** that takes place in same flower (bisexual)or between two flowers of the same plant and **cross pollination** which takes place between two flowers of different plants of same species. Insects **(entomophily)**, wind **(anemophily)**, water **(hydrophily),** birds **(ornithophily)**, etc., are the various pollinating agents.
- After pollination, pollen grain on the stigma germinates and grows a pollen tube downwards through style to the ovary. Two non-motile male gametes are formed inside the tube during its growth through the style.
- After reaching the ovary, pollen tube enters the ovule through the micropyle. The tip of the tube finally pierces the micropylar end of the embryo sac and ruptures releasing two male gametes into the embryo sac. During the act of fertilisation, one male gamete fuses with the egg to form the diploid zygote. The process is called **syngamy** (or generative fertilisation). The diploid zygote finally develops into an embryo. The other male gamete fuses with the two polar nuclei to form the triploid (3n) primary endosperm nucleus. The process is called **triple fusion** (or vegetative fertilisation). This mechanism involving two acts of fertilisation in an embryo sac is called **double fertilisation**.
- The ovary of flower develops into a fruit. Ovule gets converted into a seed on maturation.
- Seeds germinate under suitable conditions such as optimum moisture, air and warmth, etc., into a seedling and eventually into a new plant.
- **Sexual reproduction in human beings :** Human beings are unisexual and there is a distinct sexual dimorphism. The reproductive systems of males and females consist of many organs which are distinguishable into primary and secondary sex organs. The primary sex organs are gonads, which produce gametes (or sex cells) and secrete sex hormones. The secondary sex organs include the genital ducts and glands which help in transportation of gametes and reproductive process.
- The period of sexual maturity during adolescence when reproductive organs become functional is called **puberty.**
- Puberty is characterised by :
- Development of secondary sex organs and secondary sex characters in both male and female.

▶ **In males :**
- Enlargement of penis and scrotum.
- Broadening of the shoulders and increased muscle development.
- Enlargement of larynx and thickening of vocal cords producing deepening of the voice.
- Growth of pubic hair and extra hair on the face, in the armpits and on the chest.

- **In female :**
- Growth of breasts and external genitalia (vulva).
- Growth of pubic hair and extra hair in armpits.
- Hair on beard, moustache and chest are lacking.
- Broadening of pelvis.
- Initiation of menstruation and ovulation.

Male reproductive system

Testes

- One pair, present outside the abdominal cavity within scrotal sacs which keep the testicular temperature 2° - 3° C lower than that of normal body temperature. It is the site of production of male gametes called sperms and also secretes a hormone called testosterone.

Vas deferens

- Long, tubular structure present in pair that carries sperms to the seminal vesicles that temporarily store sperm. Vas deferens along with seminal vesicle opens into ejaculatory duct which leads to urethra.

Urethra

- Common pathway for the flow of urine and semen, arises from the urinary bladder and is joined by ejaculatory duct. Runs through the penis and opens outside through male genital pore.

Penis

- Long, thick muscular organ having erectile tissues. Tip of penis is called **glans penis** (soft and highly sensitive), covered by foreskin.
- It is a copulatory organ which transfers semen into vagina of female sexual intercourse.

Accessory reproductive glands

- **Seminal vesicles :** One pair, sac like, present between rectum and urinary bladder and secrete mucus and alkaline watery fluid that contains fructose (source of energy for sperms) which helps in the movement of sperms.
- **Prostate gland :** Single, large, surrounds urethra, secretes milky fluid into urethra that helps sperms to swim.
- **Bulbourethral or Cowper's glands :** One pair, very small, present at both sides of urethra, secrete mucus to lubricate the end of penis and secrete alkaline fluid that neutralises the acids from the urine.

Flow chart : Male reproductive system

Female reproductive system

Ovaries

- Paired, almond shaped, present in the lower abdominal cavity near kidneys, connected by ligament to the uterus.
- They are primary sex organs and perform two functions – production of female gametes (eggs or ova) and secretion of female sex hormones (estrogen and progesterone). A mature ovary contains a large number of ova in different stages of development.
- The formation of ova begins in female fetus before birth. At birth, each ovary contains about 2-3 lakhs immature ova.
- One mature ovum is released from either of the ovary (ovulation) at the interval of every 28 days during reproductive phase of a woman.

Fallopian tubes (Oviducts)

- Paired tubes originating from uterus, on either side, extend upto the ovary of their respective sides.
- Its terminal part is funnel-shaped with finger-like projections called **fimbriae** lying near ovary. Fimbriae direct the ovum released from ovary into the Fallopian tube.

Uterus

- Single, inverted pear-shaped, highly muscular, hollow structure present in the pelvic cavity, lying between urinary bladder and rectum.
- Development of fetus occurs inside it, hence called **womb**. The narrower lower part of uterus is called cervix, which leads into vagina.

Vagina

- About 7-10 cm long tube where penis discharges sperms.
- Vagina acts as the passage for menstrual flow and also acts as birth canal during parturition (child birth).

Flow chart : Female reproductive system

Menstrual cycle : Sexual cycle begins in a female when she attains puberty. It occurs under the control of sex hormones and repeats every 28 days. It is marked by bleeding or **menstrual flow**. A single egg is released from either of the two ovaries and the inner wall of uterus, **endometrium**, becomes ready to receive it after fertilisation. If the ovum gets fertilised by the sperm, a zygote is formed and an embryo starts developing. Till the birth of the child, neither any egg is released from ovary nor menstruation takes place.

- In the absence of fertilisation, the egg is expelled through vagina along with the bleeding caused by the breaking of endometrium. This is called **menstruation**. Menstruation usually occurs 14 days after ovulation and lasts for 3-5 days. After menstruation is over, the endometrium gets repaired and uterus once again becomes ready to receive the next embryo.
- The first menstruation in a female's life is called **menarche**. The sexual cycle in a woman continues upto the age of 45 to 55 years. The ovaries do not release any further egg after that and this stage is called **menopause**.

Fertilisation : Fertilisation is internal in human beings. The sperms produced in testes of male are transferred into the vagina of female during the intercourse. The ovum

released from ovary during ovulation is swept into the adjacent Fallopian tube where fertilisation takes place. Only one sperm can enter into the ovum. Fusion of nucleus of sperm and nucleus of ovum marks the completion of fertilisation. It results in the formation of **single-celled zygote**.

- **Post fertilisation changes** : The zygote then undergoes repeated mitotic divisions to form a blastula on the 7th day that descends into uterus and gets implanted.
- Specialised tissues of fetus and uterine wall of the mother form a structure called **placenta**. It is a mechanical and physiological connection between an embryo and uterine wall of the mother through which nutrients and other useful substances enter fetus from mother's blood and waste products are expelled into mother's blood.
- The complete development of fetus, from the initial stage of conception till the birth of the young one, is called **gestation.** It is completed in about 280 days or 40 weeks from the first day of the last menstruation. Gestation is followed by **parturition** (birth of child). Parturition is the expulsion of fully formed young one from the mother's uterus after the gestation period is over. It starts with contraction of uterine wall under the influence of oxytocin hormone. Relaxin hormone from the ovary widens the pelvis and vagina for child birth.

- **Reproductive health :** Reproductive health is a total well-being in all aspects of reproduction, *i.e*., physical, emotional, social and behavioural.
- Some of its problems and strategies are :
  - Increasing population and methods to check it
  - Knowledge of reproductive organs, sex education and sexually transmitted diseases (STDs)
  - Awareness about birth control devices
  - Care of mother and child
  - Prevention of sex abuse and sex-related crimes.

- **Population control** : Continuous increase in population may cause scarcity of food, other natural resources, proper housing and medical care, etc. Frequent pregnancies also deteriorate mother's health therefore, regulation of conception is required. Preventive measures to avoid the pregnancy are called **contraception**. Some of the contraceptive methods are :
  - **Barrier method :** Physical devices that prevent the entry of sperms into vagina during copulation. They also protect individuals from STDs.
    (a) Condoms or *Nirodh* – Thin rubber tube worn over the penis.
    (b) Femidom – Thin rubber tube that fits inside vagina.
    (c) Diaphragm or Cervical cap – Rubber cover that fits over the cervix in vagina.
  - **Chemical methods :** Spermicide creams and jellies are applied in vagina to immobilise or kill the sperms. Oral contraceptive pills contain hormones like estrogen and progesterone that prevent ovulation.
  - **Intrauterine contraceptive devices (IUCDs) :** These are contraceptive devices made of copper, plastic or stainless steel. These include Copper-T(CuT), Lippes loop, etc. A CuT is inserted into uterus by a doctor or a skilled nurse. They prevent implantation in uterus.
  - **Natural methods :** These include rhythm method (avoid copulation around the time of ovulation) and coitus interruptus (withdrawal of penis before ejaculation).
  - **Surgical methods (Sterilisation) :**
    (a) Vasectomy : Procedure done on males involving removal of a small portion of the vas deferens and ligation of two cut ends with threads to prevent the sperms from coming out.
    (b) Tubectomy : Procedure done on females involving removal of a small portion of the Fallopian tubes and ligation of cut ends with threads to prevent the egg (ovum) to enter the uterus.

- Female to male ratio is declining due to sex determination done by amniocentesis or radio imaging techniques that are legally banned by government.
- Abortion is the **medical termination of pregnancy (MTP)** before the fetus becomes viable. It is suggested by doctor incase of complicated pregnancies which are dangerous for the mother or fetus or both. However, this method is widely misused by people who do not want a female child.

Sexually Transmitted Diseases : These are infectious (communicable) diseases caused by bacteria, protozoa and viruses **which spread from an infected person to a healthy person by sexual contact.** Human beings suffer from over 30 different kinds of sexually transmitted diseases (STDs). The common STDs are:

- **Gonorrhoea** is caused by a bacterium *Neisseria gonorrhoeae.* Infection results in inflammation of the mucous membrane of the urinogenital tract, rectum, throat and eye. The victim feels burning sensation and pain during urination. It spreads by sexual contact and through infected clothes. Penicillin and ampicillin are used for its cure.
- **Syphilis** is caused by bacterium, *Treponema pallidum* which affects the mucous membrane of genital, rectal and oral regions and causes lesions. Infection occurs by sexual intercourse, and occasionally by kissing or close body contact. Antibiotics such as penicillin and tetracycline are used to cure it.
- **AIDS (Acquired Immuno-Deficiency Syndrome) :** The disease AIDS is caused by HIV virus. It is a fast spreading incurable disease which weakens the body's immune system. It spreads by unprotected sex, use of contaminated needles, transfusion of infected blood, etc. Few drugs like zidovudine or azidothymidine are used to prolong patients life.

Healthy Pregnancy : Malnutrition and stress during pregnancy are the major causes of ill health of pregnant women. Therefore it is advisable that cigarette, LSD, marijuana and alcohol should be avoided by the expecting mothers as they cause harmful effects on the fetus including mental retardation. Proper spacing between subsequent pregnancies should also be maintained for mothers to regain their health.

Chapter

9

Heredity and Evolution

QUICK RECAP

- **Genetics :** The science primarily concerned with precise understanding of biological properties which are transmitted from parent to offspring is called **genetics**. The term 'genetics' was coined by **W. Bateson** in 1905.
- **Heredity :** A recognisable feature of a human being (or any other organism) like height, complexion, shape of hair, colour of eyes and shape of nose and chin, etc., is called 'character' or 'trait'.
- The transmission of characters (or traits) from the parents to their offspring is called **heredity.** In most simple terms, heredity means continuity of features from one generation to the next.
- The hereditary information is present in the sex cells (or gametes) of the parents. Thus, gametes constitute the link between one generation and the next, and pass on the paternal (father's) and maternal (mother's) characters or traits to the offspring.

Variations : The offspring are never a true copy of their parents. In fact, no two individuals are exactly alike and the members of any one species differ from one another in some characters (or traits) or the other. These differences are known as variations, *i.e.*, the differences in the characters (or traits) among the individuals of a species is called variation.

Accumulation of variations : Variations appear during reproduction whether asexual or sexual.

- Minor variations may arise during asexual reproduction due to small inaccuracies in DNA copying.
- Sexual reproduction generates even greater diversity. This is so because sexual reproduction involves two parents (father and mother) and every offspring receives some characters of father and some of mother. Different offsprings receive different combinations of characters of their parents and show distinct variations among themselves as well as from their parents.

During sexual reproduction variations arise due to -

- Chance separation of chromosomes during gamete formation (gametogenesis)
- Crossing over during meiosis
- Chance coming together of chromosomes during fertilisation
- Mutations, *i.e.*, alterations in the genetic material

- The significance of a variation shows up only if it continues to be inherited by the offspring for several generations.
- The great advantage of variation to a species is that it increases the chances of its survival in a changing environment.

Gene as unit of heredity : Chromosome is a thread-like structure in the nucleus of a cell and is formed of DNA which carries the genes.

- A gene is a unit of DNA on a chromosome which governs the synthesis of one protein that controls a specific characteristic (or trait) of an organism. The term 'gene' was coined by **Johannsen** in 1909. However Mendel called them **factor**. Genes work in pairs and are represented by letters. Genes controlling the same characteristics are given the same letters. For example, the gene for tallness is represented by the letter T whereas the gene for dwarfness is represented by the letter t.
- Genes for controlling the same characteristic of an organism can be of two types : dominant or recessive. The gene which decides the appearance of an organism even in the presence of an alternative gene is known as a **dominant gene** and the dominant gene is represented by a capital letter. The gene which can decide the appearance of an organism only in the presence of another identical gene is called as **recessive gene**. The corresponding recessive gene is represented by the corresponding small letter. Genotype is the description of genes present in an organism.

Mendel's experiments : Mendel selected garden pea (*Pisum sativum*) for series of hybridisation experiments because it has some special features.

Special features of garden pea plant are:

- It is easy to grow.
- It has a short life cycle and, therefore, it is possible to study number of generations in less time.
- Garden pea plant has distinct, easily detectable contrasting variants of features. Mendel, in fact, noted **seven pairs** of such contrasting characters in garden pea plant.
- The plant has bisexual flowers wherein artificial cross fertilisation could be easily achieved.
- Each pea plant produces many seeds in one generation.

- The characters which always appear in two opposing conditions are called **contrasting characters**. There were seven contrasting characters noted by Mendel in garden pea. These are listed in the given table:

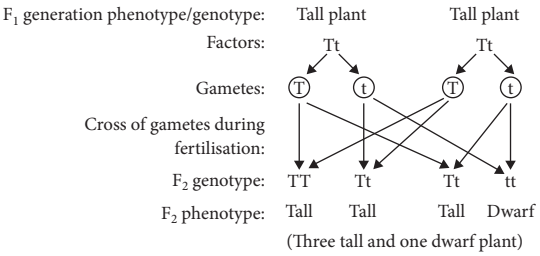
	Character	Contrasting Traits	
		Dominant	**Recessive**
1.	Plant height	Tall	Dwarf
2.	Position of flower on the stem	Axial	Terminal
3.	Colour of unripe pod	Green	Yellow
4.	Shape of pod	Inflated	Constricted
5.	Shape of seed	Round (smooth)	Wrinkled
6.	Colour of seed	Yellow	Green
7.	Colour of flower	Violet	White

Mendel conducted breeding experiments in three steps:

- Selection of pure parent plants (*i.e.*, plants producing similar traits in every generation).
- Production of first generation of plants by cross breeding (hybridisation).
- Raising of second and subsequent generations by self-fertilisation of hybrids.

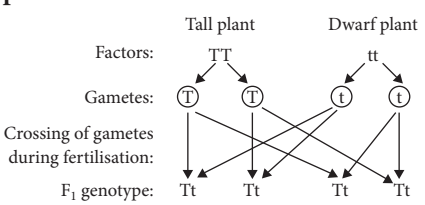
Monohybrid inheritance and law of segregation : A breeding experiment dealing with a single character is called **monohybrid cross**.

- Mendel first crossed pure-bred tall pea plants with pure-bred dwarf pea plants and found that only tall pea plants were produced in the first generation or F_1 generation.
- Mendel then crossed the tall pea plants of the first generation (F_1 generation) and found that tall plants and dwarf plants were obtained in the second generation (or F_2 generation) in the ratio of 3 : 1 (monohybrid ratio).
- **Illustration of Mendel's monohybrid F_1 cross :**



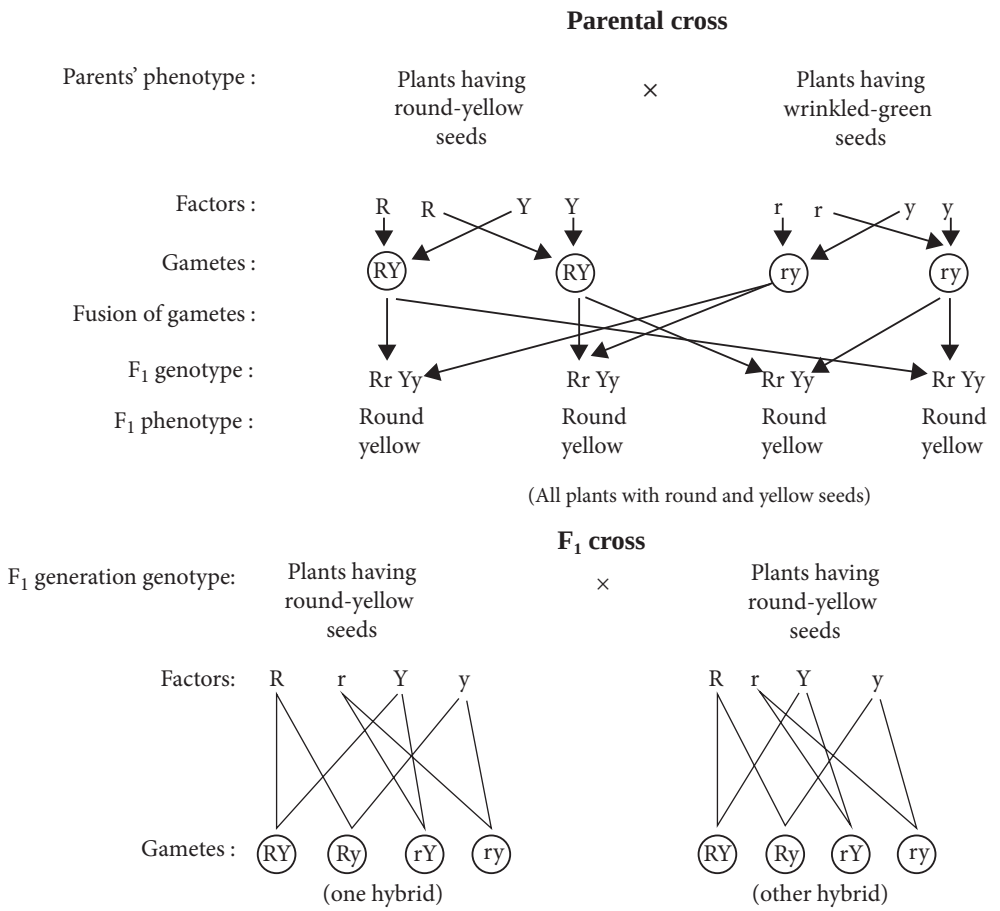
(Three tall and one dwarf plant)

- Mendel said that the trait of dwarfness of one of the parent pea plant had not been lost, it was merely concealed or suppressed in the first generation to re-emerge in the second generation. He called the repressed trait of dwarfness as recessive trait and expressed trait of tallness as the dominant trait.
- This phenomenon of appearance of only one of two contrasting traits in F_1 generation, is termed as **dominance**.
- Mendel also noted that all the pea plants produced from the hybrid tall parents of F_1 generation, were either tall or dwarf. There were no plants with intermediate height (or medium height) in-between the tall and dwarf plants.
- This is because there is no mixing or blending of traits and they are inherited independently.
- Mendel formulated his first law of inheritance which is called the **law of segregation**. According to this law, the characteristics (or traits) of an organism are determined by internal 'factors' which occur in pairs. Only one of a pair of such factors can be present in a single gamete.
- **Illustration of Mendel's monohybrid parental cross :**



(All tall plants)

- **Dihybrid inheritance and law of independent assortment :** A breeding experiment dealing with two characters at the same time is called a **dihybrid cross**.
- Mendel considered shape as well as colour of the seeds simultaneously. He selected pure line plants and then cross pollinated flowers raised from seeds of round shape and yellow colour with those from wrinkled seeds and green colour. He observed that in F_1 generation all seeds had the features of only one parental type, *i.e.*, round shape and yellow colour. He raised plants from F_1 generation seeds and allowed the flowers to self pollinate to produce the seeds of F_2 generation.
- **Illustration of Mendel's dihybrid cross :**
  - In F_2 generation, Mendel observed the appearance of four types of combinations. These included **two parental types** (round and yellow seeds, and wrinkled and green seeds) and **two new combinations** (round and green seeds and wrinkled and yellow seeds).
  - Based on dihybrid cross, Mendel postulated that inheritance of factors controlling a particular trait in an organism is independent of the other. This is called **law of independent assortment.** Hence, at the time of reproduction, two pairs of factors of each of the two traits in a dihybrid cross segregated independently during gamete formation and randomly formed combinations in the F_2 generation.



Fusion of gametes (shown in the table)

	RY	Ry	rY	ry
RY	RRYY Round yellow	RRYy Round yellow	RrYY Round yellow	RrYy Round yellow
Ry	RRYy Round yellow	RRyy Round green	RrYy Round yellow	Rryy Round green
rY	RrYY Round yellow	RrYy Round yellow	rrYY Wrinkled yellow	rrYy Wrinkled yellow
ry	RrYy Round yellow	Rryy Round green	rrYy Wrinkled yellow	rryy Wrinkled green

F_2 ratio : Round yellow = 9, Round green = 3, Wrinkled yellow = 3, Wrinkled green = 1
So, the ratio is 9 : 3 : 3 : 1.

Mechanism of heredity : Deoxyribonucleic acid (DNA) present in the chromosomes of cell is the hereditary material. It is the information source in the cell for making proteins.

- **Structure of DNA :** It was first isolated by the scientist **Frederick Meisher** from the nucleus of the pus cells in 1869. He named it as '**nuclein**' or nucleic acid because of its acidic nature. Later, it was experimentally proved by the scientists **Griffith** (1928); **Avery**, **McLeod** and **McCarty** (1944) that DNA is the carrier of the genetic information from one generation to another generation.
- DNA is a macromolecule or polymer made up of very large number of 'nucleotide' units and hence is termed polynucleotide. Each nucleotide unit in a DNA molecule is made up of three components :

Components of DNA

- **Deoxyribose sugar :** A pentose sugar
- **Nitrogenous base:** In a DNA molecule, nitrogenous bases are of two types: Purines in a DNA molecule are – **Adenine (A)** and **Guanine (G).** Pyrimidines in a DNA molecule are – **Cytosine (C)** and **Thymine (T).**
- **Phosphate group:** It contains one phosphorus atom and four specifically linked oxygen atoms.

- A dominant factor or allele controls the synthesis of a fully functional structural protein or enzyme to produce its morphological or physiological effect. A recessive factor, on the other hand, produces defective, incomplete and less efficient structural protein or enzyme. It is, therefore, unable to express its effect in the presence of dominant factor. Effect of recessive factor only becomes apparent when it occurs in a pair.

Basic features of the mechanism of inheritance

- Characters (traits) are controlled by genes which are present on chromosomes.
- Each gene controls one character.
- There may be two or more forms (alleles) of the gene.
- One form may be dominant over the other form.
- An individual has two (similar or dissimilar) forms of the gene.
- The two forms of the gene separate at the time of gamete formation so that each gamete has only one form of the gene.
- The two forms of the gene are brought together in the zygote after fusion of male and female gametes.

Sex determination : The process by which the sex of a person is determined is called **sex determination**.

- Human beings have genetic or chromosomal sex determination.
- Humans have separate sexes where a specific pair of chromosomes in each diploid cell determines the sex of the individual. They are called **sex chromosomes.**
- All other chromosomes are termed **autosomes** as these have genes which control the somatic (body) characters.
- A male individual contains one X chromosome and one Y chromosome, *i.e., XY.* Male produces two different kinds of gametes (sperms); half of the sperms have X chromosome and other half have

Y chromosome. Therefore, male is called **heterogametic.**

- A female individual contains two X chromosomes, *i.e.,* XX. Female, therefore, produces only one type of gamete (ova). So, female is called **homogametic.**
- The sex of the child is determined at the time of fertilisation when male and female gametes fuse to form zygote. If a sperm carrying Y chromosome fertilises an egg or ovum which has X chromosome, then the offspring will be a boy (male). This is because the offspring will have XY combination of sex chromosomes. If a sperm carrying X chromosome fertilises an ovum having X chromosome, then offspring will be a girl (female).
- In some of the animals, sex determination is also controlled by the environmental factors. For example, in some reptiles, the temperature at which the fertilised egg is incubated before hatching, plays an important role in determining the sex of the offspring.

Acquired and inherited traits :

- **Acquired trait :** A trait (or characteristic) of an organism which is 'not inherited' but develops in response to the environment is called an acquired trait. These traits cannot be passed on to the future generations. Only those traits can be transmitted to future generations in which changes have occurred in the genes (or DNA) present in the reproductive cells (or gametes) of parent organisms.
- **Inherited trait :** A trait (or characteristic) of an organism which is due to the expression of a gene (or DNA) is called an inherited trait. Inherited traits actually mean the characteristics which we receive from our parents.

Origin of life : According to **big bang theory**, the universe originated by a big bang (thermonuclear explosion) of a dense entity about 15 billion years ago.

- Numerous scattered pieces of cosmic material (**nebulae)** slowly condensed and became organised into **galaxies.**
- Our galaxy is called **Akash Ganga** (The Milky Way). **Sun** is one of the millions of stars in our galaxy.
- Our solar system (including Earth) was formed about 4.5 billion (4500 million) years ago from a huge, spinning cloud of solar nebula.
- Many theories have been advanced to explain origin of life on Earth. These include theory of special creation, theory of spontaneous generation, cosmozoic or interplanetary theory and naturalistic theory.
- **Naturalistic theory** or **abiogenic theory** or **chemical theory of origin of life** is the most accepted one. It was independently put forward by the **A.I. Oparin** (1923) and **J.B.S. Haldane** (1929). According to this theory, life originally arose from the inorganic molecules of the primitive Earth (abiogenesis), but on today's Earth life comes only from the pre-existing life (biogenesis).
- Major support to this theory was provided by laboratory experimental work of **S.L. Miller** and **H.C. Urey** in 1953.

Evolution : Evolution is the sequence of gradual changes which took place in the primitive organisms over millions of years due to which new species are produced.

- Some of the important evidences of evolution are given below :
- **Morphological evidences :**
  - **Homologous organs :** The organs which have the same basic structure (or same basic design) but different functions are called homologous organs. For example, the forelimbs of a lizard, a bird and a human being show similarity in basic structure and also develop in similar fashion. However, these organs perform entirely different functions.
  - **Analogous organs :** The organs which have different basic structure but have similar appearance and perform similar functions are called analogous organs. For example, the wings of an insect and a bird have different structures but perform similar functions.

- **Vestigial organs :** The organs which occur in reduced form and are useless to the possessor, but were fully developed, functional organs in the ancestors or related forms are called vestigial organs. For example, vermiform appendix of the large intestine and nictitating membrane in the eye of human beings.

- **Embryological evidence : Embryology** refers to the study of development of an embryo of an organism from fertilised egg to young one. The early embryos of all vertebrates resemble in shape and structure which suggests that they have evolved from a common ancestor. (ontogeny recapitulates phylogeny - Ernst Haeckel).
- **Palaeontological evidence**
  - **Fossils :** The remains (or impressions) of dead animals or plants that lived in the remote past are known as fossils.

    Fossils help in establishing evolutionary relationships among different plant and animal groups. For example, the discovery of *Archaeopteryx* fossil showing characters of both reptiles and birds provided a clue that birds have evolved from reptiles.

    Fossils also provide us evidence of instances wherein a change useful for one function to start with, can become useful later for quite a different function. For example, feathers were developed initially to provide insulation in cold weather but later these became useful for the function of flight in birds. This speculation is based on the evidence from fossil records of a small dinosaur, who had feathers but it could not fly using them, thus, suggesting that evolution of feathers had nothing to do with flight.
- **Darwin's theory of evolution : Charles Robert Darwin** gave the theory of evolution in his famous book '**The Origin of Species**'.
- The theory of evolution proposed by Darwin is known as '**The Theory of Natural Selection**. It suggests that the best adapted organisms are selected by nature to pass on their characteristics to the next generation. Darwin's theory of evolution applies to plants as well as animals. It can be described as follows:
  - Within any population, there is natural variation. Some individuals have more favourable variations than the others.
  - Even though all species produce a large number of offspring, populations remain fairly constant naturally.
  - This is due to the struggle between members of the same species and different species for food, space and mate.
  - The struggle for survival within populations eliminates the unfit individuals. The fit individuals possessing favourable variations survive and reproduce. This is called natural selection (or **survival of the fittest**.)
  - The individuals having favourable variations pass on these variations to their progeny from generation to generation.
  - These variations when accumulate over a long time period, lead to the origin of a new species.
- **Natural selection** is the process of evolution of a species whereby characteristics which help individual organisms to survive and reproduce are passed on to their offspring, and those characteristics which do not help are not passed on.
- Though Darwin's theory was widely accepted, but it was criticised on the ground that it could not explain 'how the variations arise'. **Genetic variation** is the raw material of evolution. So, the Darwin's theory was modified accordingly. These days, the most accepted theory of evolution is the **Synthetic Theory of Evolution** in which the origin of species is based on the interaction of 'genetic variation' and 'natural selection'.

Artificial selection : Artificial selection is the process by which man selects trait(s) useful to him for improving the qualities of domesticated plants and animals.

E.g., plant breeders have produced several useful varieties of plants like wheat, rice, sugarcane, cotton, pulses, vegetables and ornamental plants by artificial selection. Several crop plants like broccoli, kohlrabi, cabbage, cauliflower, kale, etc., are produced from a common wild cabbage species by selective breeding.

- **Speciation :** A **species** is a population of organisms consisting of similar individuals which can breed together and produce fertile offspring. The process by which new species develop from the existing species is known as **speciation**.
  - The important factors which could lead to the rise (or formation) of a new species are the following:
    - **Geographical isolation** of a population caused by various types of barriers (such as mountain ranges, rivers and sea). This isolation leads to reproductive isolation due to which there is no flow of genes between separated groups of population.
    - **Genetic drift** caused by drastic changes in the frequencies of particular gene by chance alone.
    - **Variations** caused in individuals due to natural selection.
- **Evolution and progress :** Evolution should not be equated with `progress'. There is no real progress in the concept of evolution. Evolution, infact results in the generation of diversity and shaping of this diversity by environmental selection. The only progressive trend that appears in the evolution is the development of more and more complex designs over a period of time. For instance, one of the simplest forms of bacteria still inhabit the most inhospitable habitats such as hot springs, deep sea thermal vents and the ice of Antarctica. Thus, human beings are not the pinnacle of evolution, but simply yet another species in the spectrum of evolving life.
- **Human evolution :** Human evolution has been studied by using various tools of tracing evolutionary relationships such as excavating (digging Earth), carbon-dating, studying fossils as well as determining DNA sequences. The study reveals there is a great diversity of human forms and features across the planet. For a long time, people used to talk about `human races'. The human races were identified on the basis of their skin colour and named as white, black, yellow and brown.

  In fact, there is no biological basis for dividing human beings into different `races', it is now proved that all human beings belong to a single species, *Homo sapiens*. The earliest members of *Homo sapiens* have been traced back to Africa. A couple of hundred thousand years ago, some of our ancestors left Africa while others continued living there while the residents spread across Africa. The migrants slowly spread across the planet from Africa to West Asia, then to Central Asia, Eurasia, South Asia, East Asia. Like all other species on the planet, they had come into being as an accident of evolution and were trying to live their lives the best they could.

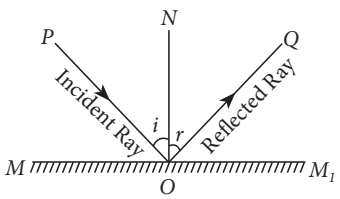
Chapter

10

Light-Reflection and Refraction

QUICK RECAP

Reflection : When light falls on a surface and gets back into the same medium, it is called reflection.



- In reflection, the frequency, speed and wavelength do not change but a phase change may occur depending on the nature of reflecting surface.

Laws of reflection

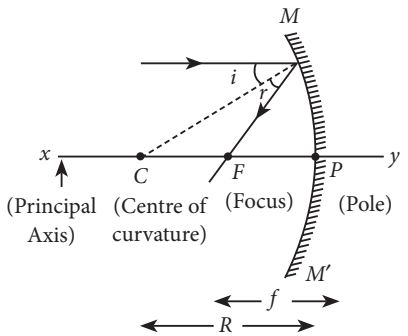
- The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.
- The angle of reflection (r) and the angle of incidence (i) are equal.

Plane mirror : A plane mirror always forms an erect, virtual, size to size image at the same distance as the object is, but at the back of the mirror.

- Its magnification is +1.
- It forms a laterally inverted image.
- When a plane mirror is turned by an angle θ, the reflected ray will turn by an angle of 2θ.
- The radius of curvature of a plane mirror is infinity. Its focal length is therefore infinity.
- To see full size image of a person, he needs a mirror of length half his height.

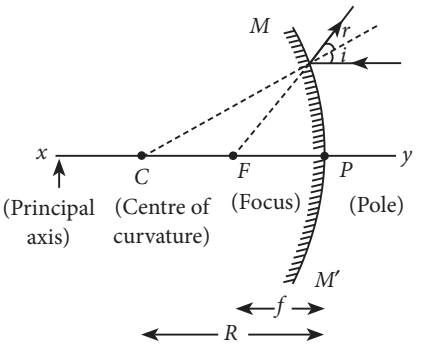
Spherical mirror : A reflecting surface which is of the form of a sphere in which inner or outer surface is reflecting.

- **Concave mirror :** If the outer surface is silvered and reflection takes place from inner surface, the mirror is called concave mirror.



Concave Mirror

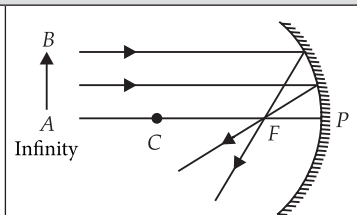
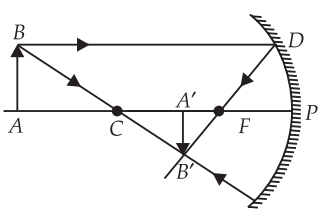
- **Convex mirror :** If the inner surface is silvered and reflection takes place from outer surface, the mirror is called convex mirror.

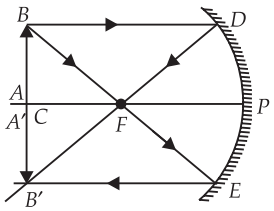
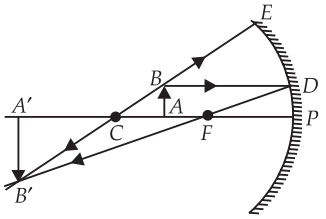
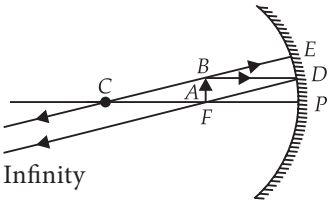
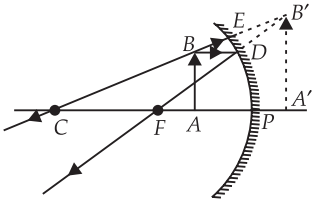


Convex Mirror

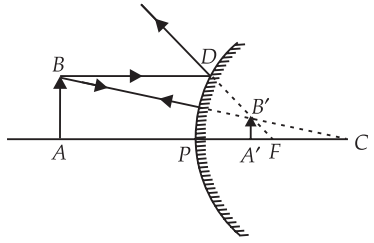
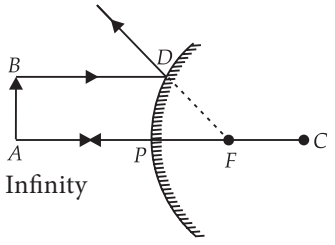
- **Rules to draw the ray diagram :** Any two of the rules are used in order to draw the ray diagram.
  - The rays of light passing parallel to the principal axis will converge at the focus after reflection.
  - The rays of light passing through the focus will emerge parallel to the principal axis after reflection.
  - The rays of light passing through the centre of curvature will all retrace their path after reflection.
  - The rays of light falling at the pole gets reflected at the same angle on the other side of principal axis.

- **Image formation by spherical mirrors :**

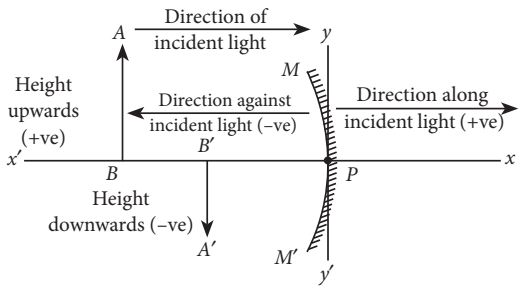
Concave mirror			
Ray diagram	**Object position**	**Image position**	**Nature of image**
(a) 	At infinity	At the focus *F*	Real, inverted and point-sized
(b) 	Between infinity and the centre of curvature *C*	Between *F* and *C*	Real, smaller than the object and inverted

(c)		At *C*	At *C*	Real, same size and inverted
(d)		Between *C* and *F*	Between *C* and infinity	Real, enlarged and inverted
(e)		At *F*	At infinity	Real, infinitely large and inverted
(f)		Between the pole *P* and *F*	Behind the mirror	Virtual, enlarged and erect

Convex mirror

Ray diagram		Object position	Image position	Nature of image
(a)		Between infinity and the pole	Behind the mirror between the focus and the pole	Virtual, smaller and erect
(b)		At infinity	Behind the mirror at the focus *F*	Virtual, point-sized and erect

- **Sign conventions :**



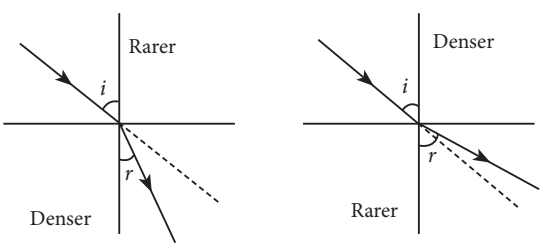
- **Mirror formula :** $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$

  Where f, u and v are the focal length, object distance and image distance respectively.
- **Magnification :** It is defined as the ratio of size of image to the size of object.

  $$m=\frac{\text{Size of object } (h_I)}{\text{Size of image } (h_0)}=-\frac{v}{u}$$

  Magnification is always (+ve) for convex mirror while it depends on position of object for concave mirror.
- **Uses of concave mirror :** It is used
  - as a shaving mirror.
  - in a reflecting type astronomical telescope.
  - in search light, headlight of automobile.
- **Uses of convex mirror :** It is used
  - as rear view mirrors in automobiles.
  - as a device to check theft in shops.
  - to bring view of corners which are not directly visible.

Refraction : Bending of light when it passes obliquely from one medium to another medium is called refraction.



- **Laws of refraction :** The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.
- The ratio of the sine of the angle of incidence to the sine of angle of refraction is a constant, *i.e.*, $\frac{\sin i}{\sin r}$ = constant, for the light of a given colour and for a given pair of media.

Refractive index : $\frac{\sin i}{\sin r}$ is called refractive index (n) of one medium with respect to another medium. It has no unit.

- **Absolute refractive index :** The ratio of speed of light in vacuum or air to the speed of light in the medium is called the absolute refractive index.

  $$n=\frac{\text{Speed of light in air } (c)}{\text{Speed of light in medium } (v)}$$

- **Relative refractive index :** The relative refractive index is defined as the ratio of refractive index of medium 2 to the refractive index of medium 1.

  $$n_{21}=\frac{c/v_2}{c/v_1}=\frac{n_2}{n_1}$$

- **Relative refractive index of two media :**

  For air-water interface, $n_{wa}=\frac{\sin i}{\sin r_1}$ ...(i)

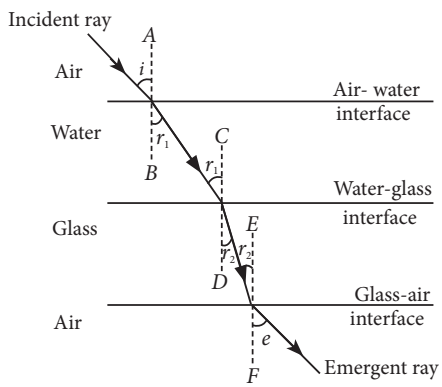
  For water-glass interface, $n_{gw}=\frac{\sin r_1}{\sin r_2}$ ...(ii)

  For glass-air interface, $n_{ag}=\frac{\sin r_2}{\sin e}$ ...(iii)

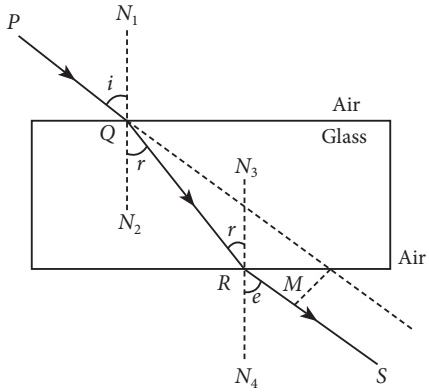
  From eqns. (i), (ii) and (iii)

  $$n_{wa}\times n_{gw}\times n_{ag}=\frac{\sin i}{\sin r_1}\times\frac{\sin r_1}{\sin r_2}\times\frac{\sin r_2}{\sin e}=1$$

  $\therefore \quad \angle i=\angle e$

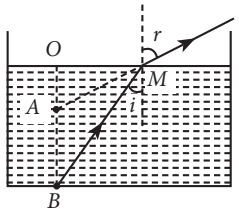


- **Lateral displacement :** The perpendicular distance (M) between the original path of incident ray and the emergent ray coming out of a glass slab is called lateral displacement of the emergent ray of light.



Lateral displacement is
- directly proportional to the thickness of the slab.
- directly proportional to the incident angle.
- directly proportional to the refractive index of the glass slab.
- inversely proportional to the wavelength of incident light.

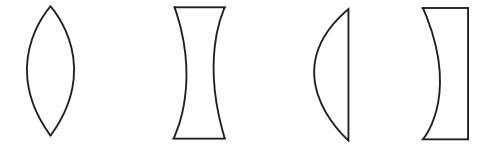
- **Apparent position of object :** Due to refraction, the original depth of a tank cannot be known. The apparent depth of the tank is $1/n$ times the original depth of the tank.



$$n = \frac{\text{real depth}}{\text{apparent depth}} = \frac{OB}{OA}$$

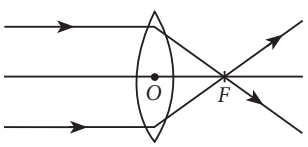
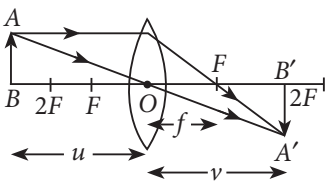
- The bottom of the tank, filled with water appears to be raised.
- A coin placed at the bottom of water filled glass tumbler appears to be raised.
- When a straight rod, partly immersed in water, viewed from the sides, it appeared to be broken.
- A lemon kept in a bowl viewed from side, it appears larger than its actual size.
- The part of the rod inside water appears thick, if viewed from side.

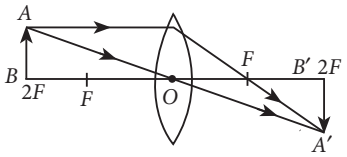
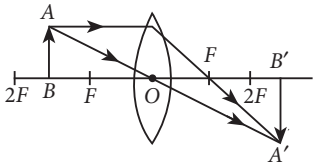
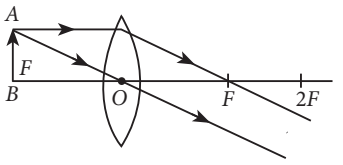
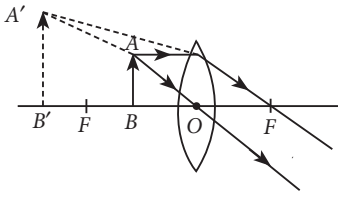
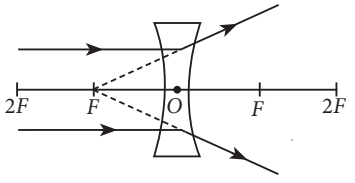
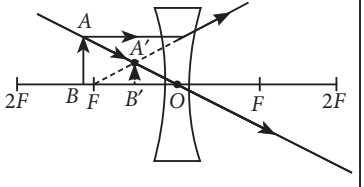
Lens : A piece of transparent medium bounded by at least one spherical surface is called lens.



Convex or converging lens | Concave or diverging lens | Plano-convex lens | Plano-concave lens

- **Image formation by lenses :**

Convex lens				
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 u = –ve, v = +ve and f = +ve	At infinity	At F	Real, inverted and highly diminished
(b)	 u = –ve, v = +ve and f = +ve	Between infinity and $2F$	Between F and $2F$	Real, inverted and diminished

(c)	 u = –ve, v = +ve and f = +ve	At 2F	At 2F	Real, inverted and same sized
(d)	 u = –ve, v = +ve and f = +ve	Between F and 2F	Beyond 2F	Real, inverted and enlarged
(e)	 u = –ve, v = +ve and f = +ve	At F	At infinity	Real, inverted and enlarged
(f)	 u = –ve, v = –ve and f = +ve	Between F and O	On the same side of the lens	Virtual, erect and enlarged
Concave lens				
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 u = –ve, v = –ve and f = –ve	At infinity	At F	Virtual, erect and highly diminished
(b)	 u = –ve, v = –ve and f = –ve	Between infinity and O	Between F and O	Virtual, erect and diminished

- **Lens formula and magnification :**

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

This formula gives the relationship between object distance (u), image distance (v) and the focal length (f).

The ratio of the height of the image and the height of the object is magnification of lens.

$$m = \frac{\text{Size of image } (h')}{\text{Size of object } (h)} = \frac{v}{u}$$

Magnification of inverted image is taken as (–)ve and for erect image, it is taken as (+)ve.

- **Power of a lens :** The ability of a lens to converge or diverge is called power (P) of the lens.

$$P = \frac{1}{f}$$

The SI unit of power is dioptre.
1 dioptre = 1 m^{-1}

Power of a convex lens is taken as (+)ve while the power of concave lens is taken as (–)ve.

- **Lenses in combination :** When two or more lenses are used in combination, the diverging or converging power varies.

The equivalent focal length in combination is given as $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

The power of the combination, $P = P_1 + P_2$
The magnification of combination,
$m = m_1 \times m_2 \times m_3 \ldots\ldots m_n$

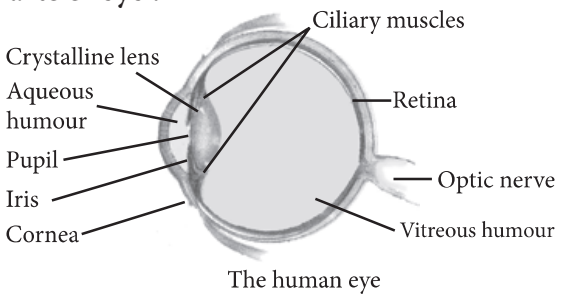
Chapter

11

The Human Eye and the Colourful World

QUICK RECAP

- **Human eye :** A natural optic device works on the principle of refraction of light through a natural convex lens.
- **Parts of eye :**



The human eye

- **Cornea :** Light coming from different objects enters the eye through cornea.
- **Iris :** Controls the size of the pupil.
- **Pupil :** Regulates and controls the amount of light entering the eye.
- **Eye-lens :** A convex lens made of a transparent, soft and flexible tissue.
  - It forms real and inverted image on the retina.
- **Ciliary muscles :** Change the focal length of the eye-lens.

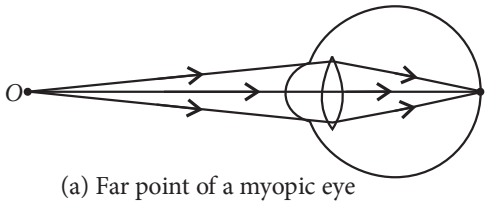
- **Retina :** The light-sensitive screen on which the image is formed.
- **Rods and cones :** Light-sensitive cells present in retina.
  Rods → respond to the intensity of light.
  Cones → respond to colours.
- **Aqueous humour :** The viscous liquid filled between the eye-lens and cornea.
- **Vitreous humour :** The viscous liquid filled between eye-lens and retina to support the back of the eye.

Range of vision of a normal human eye :

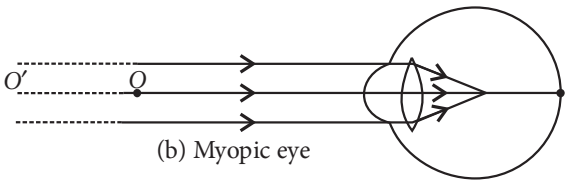
- **Accommodation :** The ability of an eye lens to change its focal length or converging power to get a clear view of any object is called accommodation.
- **Power of accommodation :** The maximum variation in the power of the lens so that the far-off and nearby objects are viewed clearly.
  - For a normal vision, it is about 4 dioptres.
- **Near point of eye :** The nearest point upto which an eye can see the object clearly without strain.
  - It is about 25 cm for a normal eye.
- **Far point of eye :** The farthest point upto which an object can be seen clearly.
  - It is infinity for a normal eye.

Defects of vision, causes and their corrections:

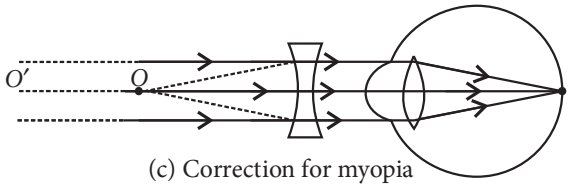
- **Myopia (near-sightedness) :** Inability of eye in viewing long distant objects.
  - The far point of an eye is less than infinity.
  - Image is formed in front of retina.
- **Causes :**
  - Excessive curvature of eye-lens.
  - Elongation of eye-ball.
- **Correction :** It is corrected by using concave lens which diverges and shifts the image to the retina.



(a) Far point of a myopic eye

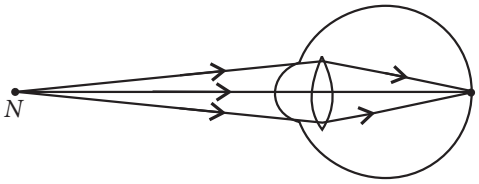


(b) Myopic eye

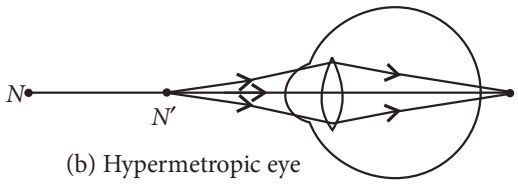


(c) Correction for myopia

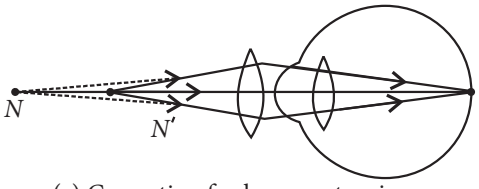
- **Hypermetropia (far-sightedness) :** Inability of eye in viewing nearby objects.
  - Near point of the eye is more than 25 cm.
  - Image is formed behind the retina.
- **Causes :**
  - Low converging power of eye-lens.
  - Smaller size of eye-ball.
- **Correction :** It is corrected by using a convex lens which converges and shifts the image to the retina from beyond.



(a) Near point of a hypermetropic eye



(b) Hypermetropic eye

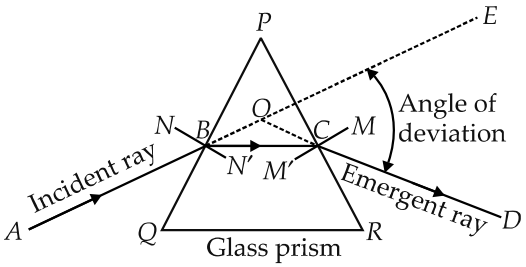


(c) Correction for hypermetropic eye

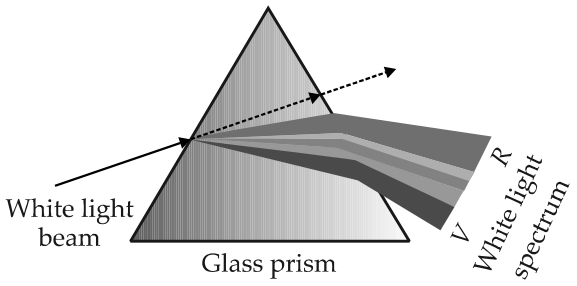
- **Presbyopia :** Gradual decrease in the power of accommodation of the eye lens with ageing.
  - The eye becomes both myopic and hypermetropic.
- **Causes :**
  - Weakening of ciliary muscles.
  - Diminishing flexibility of the eye-lens.
- **Correction :** It can be corrected by using bi-focal lens.

Refraction of light through a glass prism :

- Refraction of light occurs both, when a ray of light enters the prism as well as when it leaves the prism.
- The incident ray and the emergent ray are not parallel to each other.

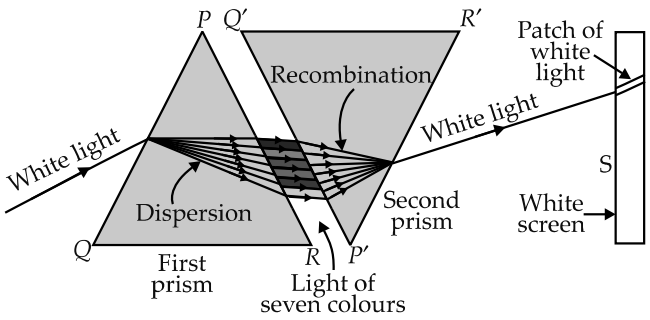


- **Angle of deviation :** The angle between the emergent ray and the incident ray.
- **Spectrum of white light :** The band of seven colour components of white light obtained on screen by passing a beam of white light through a glass prism.
  - Seven colours of the spectrum is denoted by the acronym VIBGYOR, *i.e.*, $V \rightarrow$ Violet, $I \rightarrow$ Indigo, $B \rightarrow$ Blue, $G \rightarrow$ Green, $Y \rightarrow$ Yellow, $O \rightarrow$ Orange and $R \rightarrow$ Red
- **Dispersion of light :** Splitting up of white light into its seven constituent colours on passing through a transparent medium.
  - It occurs due to the variation in the speeds of different colours.
  - Speed of red colour is maximum.
  - Speed of violet colour is minimum.
  - Red colour is deviated the least.
  - Violet colour is deviated the most.

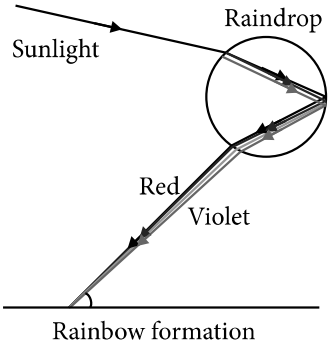


Dispersion of white light by the glass prism

- **Recombination of spectrum :** Seven coloured lights of the spectrum can be recombined to give back white light by placing two prisms, one upside down.



- **Rainbow :** A natural spectrum produced by the dispersion of sunlight by raindrops in the atmosphere.
  - Water droplets act as small prisms.
  - Water droplets refract and disperse the incident sunlight, then reflect internally and finally, refract it again when it comes out of the raindrop.



Atmospheric refraction : Refraction of light caused by earth's atmosphere due to the variation in optical densities of air layers.

- **Effects :**
  - Twinkling of stars
  - Stars seem higher than they actually are
  - Advanced sunrise and delayed sunset

Scattering of light : Phenomenon of change in the direction of propagation of light.

- Very fine particles scatter mainly blue colour.
- Large sized particles scatter light of longer wavelength.
- Shorter is the wavelength, greater will be the scattering.
- **Effects :**
  - Tyndall effect
  - Blue colour of the sky
  - White colour of clouds
  - Reddening of the sun at sunrise and sunset

Chapter

12

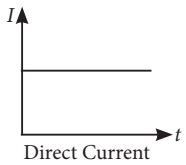
Electricity

QUICK RECAP

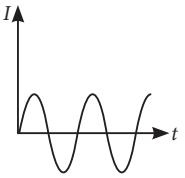
- **Charge :** Electrons have a negative charge of 1.6×10^{-19} C, while protons have an equal positive charge of 1.6×10^{-19} C.
- **Electric current :** The quantity of electric charge flowing through a conductor in one second.

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

- SI unit of current $= \dfrac{1 \text{ coulomb (C)}}{1 \text{ second (s)}}$
  $= 1$ ampere (A)
- Small units of current are
  $1 \text{ mA} = 10^{-3}$ A (mA = milliampere)
  $1 \mu\text{A} = 10^{-6}$ A (μA = microampere)
- Current may be direct, varying or alternating current.



Direct Current



Alternating Current

Electric potential : The work done in bringing a unit positive charge from reference point to a point against any electric field.

$$V = \frac{\text{Work done } (W)}{\text{Charge } (q)}$$

- SI unit of electric potential

$$= \frac{1 \text{ joule (J)}}{1 \text{ coulomb (C)}} = 1 \text{ volt (V)}$$

Electric potential difference : The amount of work done in bringing unit positive charge from one point to another point in an electric field.

$$V_{AB} = V_B - V_A = \frac{W_B}{q} - \frac{W_A}{q}$$

- It has the same SI unit as electric potential.

Electric potential energy : The work required to be done to bring the charges to their respective location against the electric field with the help of a source of energy.

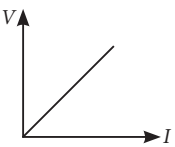
- This work done gets stored in the form of potential energy of charges.

Symbols of electrical components : The symbols of the components that are used in making an electric circuit.

Component	Symbol
1. Electric cell	
2. Battery	
3. Lamp	
4. Electric bulb	
5. Key (open)	
6. Key (closed)	
7. Wire crossing	
8. Resistor	
9. Rheostat	
10. Ammeter	
11. Voltmeter	
12. Galvanometer	
13. AC source	

Ohm's law : Under similar physical conditions, the current flowing through a conductor is directly proportional to the difference in potential applied across its ends, *i.e.*, $I \propto V$ or $V = IR$, where R is the resistance offered.

Graphical representation :



Slope $\frac{V}{I}$ is a measure of resistance offered (R).

- The opposition caused to the flow of current is called resistance.
- The SI unit of resistance is ohm.

$$R = \frac{1 \text{ volt}}{1 \text{ ampere}} = 1 \text{ ohm } (\Omega)$$

Factors affecting resistance :

- **Length of the conductor :** The resistance of a conductor is directly proportional to the length of the conductor.
  $R \propto l$
- **Area of cross-section of the conductor :** The resistance of a conductor is inversely proportional to the area of the conductor.
  $R \propto 1/A$
- **Material of the conductor :** Two resistance made up of the same length and same area of cross-section but of different materials have different resistances.

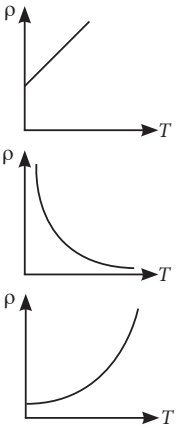
$$R \propto \frac{l}{A}\ ; R = \rho\frac{l}{A} \text{ or } \rho = \frac{RA}{l}$$

- Resistivity, $\rho = \frac{\text{ohm m}^2}{\text{m}} = \text{ohm m } (\Omega \text{ m})$
- **Temperature :** With rise in temperature, the resistance of metals increases and decreases

with decrease in temperature. Certain alloy like nichrome, manganin whose resistance vary negligible with temperature.

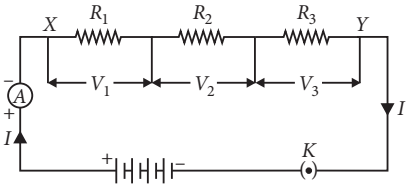
Effect of temperature on resistivity :

- Resistivity of a conductor increases linearly with increasing temperature.
- Resistivity of a semi-conductor decreases with increase in temperature.
- Resistivity increases with rise in temperature in insulators.

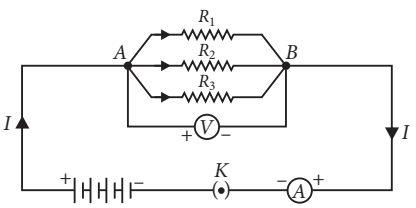


Combination of resistances :

- **Resistors in series :** When resistors are placed in series.



  - The current through them will be the same.
  - The sum of the potential difference, or voltage across them is the total potential difference, *i.e.*,
    $V = V_1 + V_2 + V_3 = I(R_1 + R_2 + R_3)$
  - The equivalent resistance is given by,
    $R_S = R_1 + R_2 + R_3$
- **Resistors in parallel :** When resistors are connected in parallel.



  - The potential difference across their ends is the same.
  - The sum of current through them is the current drawn from the source of energy or cell.

$$I = I_1 + I_2 + I_3 \text{ or } \frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

  - The equivalent resistance is given by,
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Heating effect of electric current :

- When electric current flows through the resistive element, the flowing charges suffer resistance. Work has to be done to overcome this resistance which is converted into heat energy. The complete sequence is, electrical energy does work which converts into heat energy.
- **Joule's law of heating :** When a current I flows through a resistor R, heat is produced. The heat produced H depends directly on the square of the current, resistance and the time t for which the current is allowed to pass through the resistor, $H = I^2Rt$
  This is called Joule's law of heating.

Electrical power : The rate at which electrical energy is consumed or dissipated is called electrical power.

$$\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{W}{t}$$

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

- Power is expressed in joule/second or watt.
- Practical unit of electrical power is horse power (h.p.).
  1 h.p. = 746 W

Electrical energy :

- Electrical energy = Electrical power × time
- Commercial unit of energy is kilowatt hour (kW h).
- 1 kW h = 3.6×10^6 J

Electrical fuse : It is a safety device connected in series with the electric circuit. It is a wire made of a material whose melting point is very low.

- Fuse wires are made of copper or tin-lead alloy.
- When large current flows through a circuit and hence through fuse wire large amount of heat is produced. Due to this heat the fuse wire and the circuit is broken so that current stops flowing through the circuit. This saves the electric circuit from burning.

Chapter

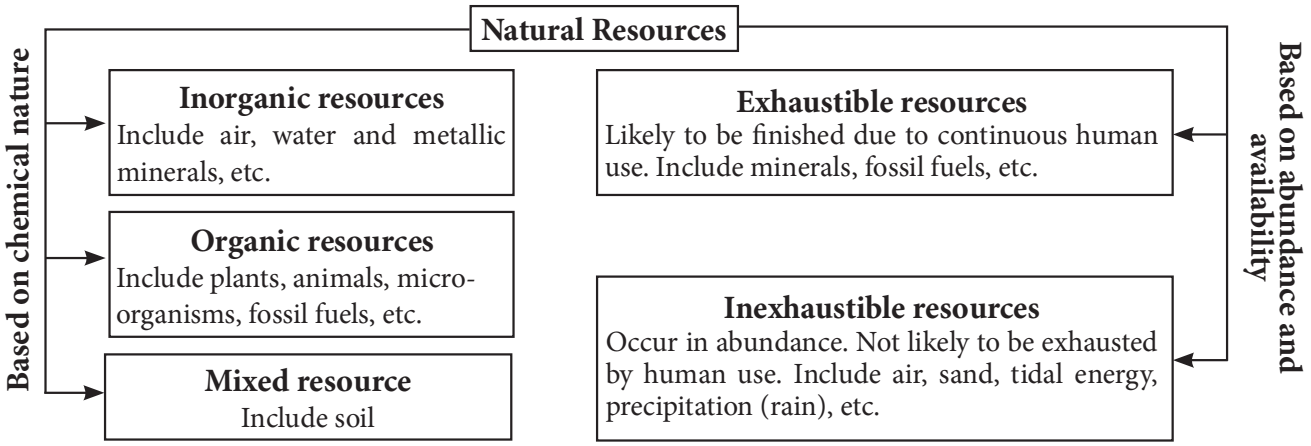
16

Management of Natural Resources

QUICK RECAP

Natural resources : They are those living or non-living substances available in the nature which are being exploited for supporting and meeting human requirements.

- Some of the important natural resources are: forests, wildlife, flora, fauna, water, air, soil, fossil fuels (like coal and petroleum), metal ores, etc.



Flow chart : Classification of natural resources

- **Exhaustible resources :** They are of two types:
  - **Renewable resources :** These are maintained by natural recycling and reproduction or can be replenished if managed wisely. Some of them are ground water, forests, crops, wildlife, etc.
  - **Non-renewable resources :** These get exhausted with use because they are not recycled or replenished. They include metallic minerals and fossil fuels (coal, natural gas and petroleum). In nature, formation of these resources has taken several thousand years but man is using them at a much faster rate.
  - A system of controlling the usage of natural resources in such a way so as to avoid their wastage and enabling their usage in the most effective way is called **management of natural resources.** Natural resources are a 'tool' of development for human beings but it should be **sustainable development** to maintain food webs, food chains, material cycling as well as to preserve biodiversity.
  - We need to manage our natural resources because of the following reasons:
    - The resources of the Earth are limited and because of rapid increase in human population the demand for resources is increasing day by day. Proper management can ensure that the natural resources are utilised properly so that they fulfil the needs of present generation and also last for the future generations.
    - Proper management of natural resources takes into consideration for long-term perspective and prevent their exploitation for short-term gains.
    - Proper management can ensure equitable distribution of natural resources so that everyone can benefit from the development of natural resources.
    - Proper management will also takes into consideration the damage caused to the environment during the extraction or use of the natural resources and would find means to minimise this damage.
- **Conservation of natural resources:** Two main categories of conservation are: Conservation of natural resources may be defined as the judicial utilisation of natural resources for the benefit of all life so that it may yield sustainable results for the present generation as well as for future generations.
- **Categories of conservation:** Two main categories of conservation are:
  - ***In situ* conservation :** When conservation of natural resources is done in their natural habitats, it is called *in situ* conservation. For example, national parks, wildlife sanctuaries, natural monuments, cultural landscapes and biosphere reserves.
  - ***Ex situ* conservation:** When conservation of natural resources is done outside their habitats, it is called *ex situ* conservation. For example, botanical gardens, zoos, seed banks, pollen storage, tissue culture, etc.

Forests and Wildlife : A large area of land on which trees and other plants grow naturally is called as forest. **Forests** are **biodiversity hotspots** as they provide a habitat for a wide range of microorganisms, flora, fauna, etc. The wild animals like tiger, elephant, deer, birds, etc., which live in a forest constitute **wildlife**.

Uses of Forest

Economic functions
- Forest provide wood for timber, paper, sports goods, railway sleepers, etc.
- Forest provide fuel in the form of wood for cooking food and keeping warm.
- Forest provide spices, medicines, tannin, gum, resin, dyes, drugs, etc. Forests provide habitat to wildlife and numerous human tribes.

Protective functions
- Forest anchor the soil by the roots trees inhabiting them.
- Reduce atmospheric pollution by absorbing CO_2 and other toxic gases, collecting suspended particulate matter and absorbing excess noise in an area.
- Forest provide habitat to wildlife and numerous human tribes.

Regulative functions
- Regulate climate by balancing humidity and temperature.
- Replenish water table by allowing seepage of water through the soil.
- Regulate water cycle.
- Maintain balance between CO_2 and O_2 gases present in atmospheric air.

Flow chart : Uses of forest

Major stakeholders of forests: The products obtained from forests are utilised by everyone but some are more dependent on them for their basic needs. A person with an interest or concern in something is called as a stakeholder.

- The four main stakeholders of forests are:
  - Local people who live in and around the forests and are dependent to some extent on forest products to lead their life.
  - The Forest Department of the Government which owns the forest land and controls the resources from the forest.
  - The forest and nature enthusiasts who work towards conserving and keeping the forests in their pristine form (original condition).
  - The industrialists who use various forest products for their factories, such as wood for making paper and furniture and *tendu* leaves for making *bidis*, etc.

Earlier, forests were used in sustainable manner by local people but when, in India, British took the control of forests, they exploited the forest products ruthlessly. Little care and management was done by Indian Government for such areas after independence. Forests became the areas where only trees like *Pinus*, teak and *Eucalyptus* were grown that led to the monoculture of plants which thereby led to loss of biodiversity. As a result, there was scarcity of fodder plants, medicinal herbs, supply of fruits and nuts became acute. Monoculture of few plants is useful for few industries and for the Forest Department as it is a source of income for them.

Deforestation : This is defined as the destruction, reduction or removal of forest cover by human activities.

Deforestation

Causes
- Timber, fuel and industrial demand of wood
- Overgrazing by livestock
- Shifting cultivation
- Forest fires
- Urbanisation
- Construction of dams, reservoirs, roads, etc.

Effects
- Global warming
- Weather changes
- Scarcity of timber wood and fuel wood
- Soil erosion, floods, droughts, etc.
- Increase in pollution
- Loss of biodiversity

Flowchart : Causes and effects of deforestation

Conservation of forests : Conservation of forests refers to the development, management and full protection of existing forest cover so as to make them available for present and future generations.

- Following measures can help in forest conservation:
  - Afforestation - Plantation of exotic species to develop forests in all the available land.
  - Social forestry - Kind of afforestation where group of people raise quick growing multipurpose trees and shrubs on village common lands, road sides, etc.
  - Agroforestry - Kind of afforestation where multipurpose trees, shrubs, horticultural and fodder plants are grown in crop fields.
  - Urban forestry - Plantation of multi-purpose trees, shrubs, etc., in open urban lands.
- **Conservation of reserve forests :** Some areas are protected from villagers, cattle and industrialists from exploitation. These reserve forests may have no human activity or some human activity depending upon the designation given by Government such as national park, sanctuary, bioreserve, etc.

People's participation in forest management

- **Chipko movement** started in 1970s in a small hilly village of the upper reaches of Himalayas. Tribal people of Tehri-Garhwal district of Uttarakhand (then in U.P.) realised the importance of forests and decided against giving its products to the people of other areas. They stood against the destruction caused by greedy contractors. In December 1972, the women of Advani village in Tehri-Garhwal protested against the felling of trees. In March 1973, a sports goods factory was prevented from cutting ten Ash trees near the village Mandel in Chamoli district. The local people prevented the same by hugging the marked trees. Thus, the movement came to be known as Chipko. In 1974, a group of women led by Gaura Devi successfully prevented felling of trees near village Reni. The movement became famous in 1978 when the women of Advani village in Tehri-Garhwal faced police firing and later courted arrest. The Chipko Movement spread slowly to all nearby areas under the leadership of **Shri Sunderlal Bahuguna** of Silyara in Tehri region and **Shri Chandi Prasad Bhatt** of Gopeshwar.
- **A Bishnoi community** in Rajasthan, takes wildlife protection as a religious act. In 1731, Amrita Devi Bishnoi sacrificed her life along with 363 others for protection of **6** *Khejri* trees in Khejrali village near Jodhpur in Rajasthan. Government of India has instituted '**Amrita Devi Bishnoi National Award for Wildlife Conservation'** in her memory.
- **Sal forests of West Bengal** were in highly degraded condition so in 1972, the West Bengal Forest Department with the help of forest officer A.K. Banerjee involved the local villagers in the revival of the forest. The villagers were promised 25% of final harvest along with fuel wood and fodder at nominal charges. By 1983, the Sal forests had revived.

Importance of wildlife

- Wildlife maintains the ecological balance of nature.
- It helps in maintaining biodiversity.
- Wildlife serves as a source for domestication of animals and cultivation of crop plants.
- Many valuable products such as drugs, silk, lac, honey, leather, feather, musk, ivory, etc., are obtained from wildlife.

Threat to wildlife : Hunting of wild animals for recreation, food, safety or for profit through sale of their products has led to a remarkable decrease in their population. Population of wild animals has considerably decreased due to – deforestation; setting up of dams and reservoirs; filling or drainage of wetlands; pollution; urbanisation and industrialisation, etc.

- Some animals are always in great demand for their highly priced articles (*e.g.*, skin, wool, fur, ivory, horn, musk, etc.).

- Forests are destroyed and converted into deserts due to overgrazing by domestic animals and cause a threat to wildlife.

Endangered flora and fauna : All those species of plants (flora) and animals (fauna) which are liable to become extinct (a species which has completely vanished from Earth) are called **endangered species**. IUCN **(International Union for Conservation of Nature and Natural Resources)** maintains a **Red Data Book** which provides global index about already declined biodiversity, helps in identification and documentation of endangered species and highlights conservation priorities.

Wildlife conservation : Wildlife can be conserved by undertaking following measures:

- Natural habitats of wild animals must be protected by identification and safeguard of feeding, resting, breeding and nursing habitats of each species.
- The wild animals must be allowed to grow in natural habitats in protected areas by preventing poaching, maintaining habitats and their requirements. Protected areas include:
  - **Biosphere reserves** are multipurpose protected areas meant for conservation of representative wildlife, traditional lifestyle of tribal people and their domesticated animals.
  - **National parks** are areas for protection of wildlife maintained by the Central Government where cultivation, grazing, hunting or other activities are not allowed.
- **Sanctuaries** (*i.e.,* protected natural habitats where specific wild animals are protected and hunting is not allowed but other activities are allowed). Sanctuaries are maintained by state governments.
- Wildlife is also protected through a number of legislative bodies and acts:
  - **Wildlife (Protection) Act, 1972** has been adopted by all states of India.
  - **Special Projects for Endangered Species** have been initiated such as Project tiger (Initiated on 1st April, 1973), Gir Lion project (1972), Crocodile breeding project (1974), Rhinos conservation (1987), Snow Leopard project, Project elephant (1992).
  - **Convention on International Trade in Endangered Species** (CITES) regulates International trade of wild flora and fauna (1976).
  - **Man and Biosphere (MAB) programme** of UNESCO was started in 1971 to study biosphere.

Water : Water is the basic necessity for all forms of life including human beings, animals as well as plants. The various sources of water available to humans are groundwater (*e.g.*, well) and surface water (*e.g.*, lakes, river, stream). Rain is a very important source of water. Rainwater fills the lakes, ponds and also flows into rivers. Some rainwater also seeps into the ground to recharge water table and becomes available as groundwater.

Dams : In order to make proper use of river water, dams are constructed across the rivers to regulate the flow of water. Dams are useful for the society in the following ways:

- Water from a dam is used for irrigation in fields through a network of canals.
- Water from a dam is supplied to the people in towns and cities through pipelines after suitable treatment.
- The flowing water from the dam is used for generating electricity.
- Various problems associated with construction of dams are as follows:
  - Due to the construction of high-rise dams, a large number of human settlements are submerged in the water of the large reservoir formed by the dam and many people are rendered homeless.
  - The construction of high-rise dams on the rivers contributes to deforestation and loss of biodiversity. This is because a

vast variety of flora and fauna (plants and animals) get submerged in the water of reservoir formed by the dam and disturb the ecological balance.
- Dam construction requires huge amount of money without proportionate benefits.
- So, before taking a decision to construct high rise dams on rivers, or raising the heights of dams its necessary to consider it is long term effects on social life and environment carefully.

Water pollution : The pollution of river water is caused by the dumping of untreated sewage and industrial wastes into it. The contamination of river water can be usually confirmed by two factors: (i) the presence of *Coliform* bacteria in river water, and (ii) measurement of pH of river water.

Rainwater harvesting : It is the technique used to collect and store rain water for future use by making special water harvesting structures.

	Region	Ancient water harvesting structure
1.	Rajasthan	*Khadins,* Tanks, *Nadis*
2.	Maharashtra	*Bandharas, Tals*
3.	Madhya Pradesh and Uttar Pradesh	*Bhundhis*
4.	Bihar	*Ahars* and *Pynes*
5.	Himachal Pradesh	*Kulhs*
6.	Jammu region	Ponds
7.	Tamil Nadu	*Eris* (Tanks)
8.	Kerala	*Surangams*
9.	Karnataka	*Kattas*

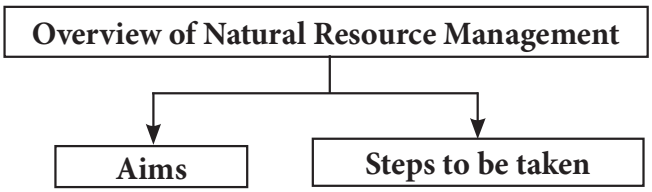
- The main purpose of rain water harvesting is not to hold rain water on the surface of the Earth but to make rain water percolate under the ground so as to recharge ground water.
- In present day ecological context, rain water harvesting comprises of water storage and ground water recharging. The rain water collected from roof top of a house, apartment complex, commercial building, a factory of catchment areas is filtered and then stored in proper tanks. Properly stored rain water is either used for human consumption, irrigation or can be channelised through a drain pipe into a well to raise the water table.

Coal and Petroleum : Coal and **petroleum** are fossil fuels found in Earth's crust. They are non-renewable and exhaustible resources.
- **Coal** is a combustible organic rock that releases enormous energy on burning. It is formed of biomass containing carbon, hydrogen and sulphur.
- **Petroleum** occurs in the form of liquid-oil. It has been formed from degradation of plant and animal remains over million of years. It occurs in the form of mineral oil in sedimentary rocks.
- Fossil fuels can be conserved b y:
  - Avoiding direct use of coal for the purpose of burning. Coal may be converted into liquid fuel and compressed natural gas (CNG) through coal gasification.
  - Wastage during extraction and transportation should be avoided. Techniques should be developed to recover maximum fossil fuels that lie in deep mines and wells.
  - Oil wells and coal mines should be well protected from fire to avoid wastage, pollution and loss of life and property.
  - Alternate sources of energy, such as hydroelectric, nuclear, wind power, solar and biogas plants should be used.
  - Over-consumption of oil in automobiles should be checked as fossil fuel reserves are very limited.
  - Use of public transport is an efficient way of using fossil fuels to conserve them.

3R's to save the environment :
- **Reduce (Reduction in use of raw materials)** means that we use less of the natural resources by avoiding their wastage. For example, we can

reduce the wastage of electricity by switching off lights and fans when not being used.

- **Recycle (Recycling of waste materials)** means that we should collect the used and discarded items of paper, plastic, glass and metals and send them to the respective industries for using them as raw materials.
- **Reuse (Reuse of waste materials)** means that, if possible, we should use the same things again. For example, the plastic and glass jars in which we buy various food items like jams and pickles, etc., can be used later on for storing things like salt, spices, sugar, tea-leaves and pulses, etc.
- The process of 'reuse' is better than that of 'recycling' because some energy is used to recycle old objects but no energy is required during reuse. However, the items which can be reused are very limited.



- To maintain essential biological processes.
- Sustainable use of resources for present and future availability.
- Preservation of biodiversity.

- Conservation of water by economic use of water.
- Conservation of energy by development of alternative and renewable sources of energy.
- Conservation of soil by using agricultural practices that conserve soil.
- Promoting environmental education and awareness.

Chapter

14 Sources of Energy

QUICK RECAP

- **Energy :** A physical quantity having ability to do work.
- **Sources of energy :** Substances that provide energy.
  - Sun is the ultimate source of energy.
- **Good source of energy :** A good source of energy should
- have high calorific value.
- be convenient to transport, store and use.
- be economical.
- have a proper ignition temperature.
- have a moderate and steady rate of combustion.
- **Conventional sources of energy :** The traditional sources of the energy which are familiar to most of the people and non renewable, *e.g.*, fossil fuels.
- **Fossil fuels :** Fuels that were formed from the decomposition of the pre-historic dead plants and animals inside the Earth.
- **Coal**
  - A complex mixture of compounds of carbon, hydrogen, oxygen and small amount of nitrogen and sulphur.
  - A sedimentary rock formed from peat.
  - Used as a domestic and industrial fuel.

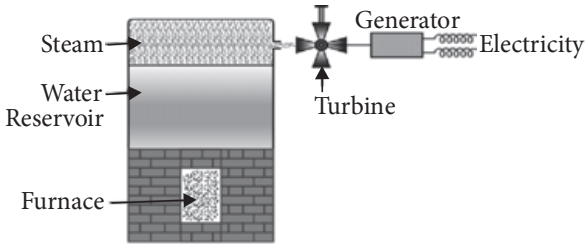
- Its destructive distillation leads to the formation of coke (98% carbon).
- Leaves residue on burning.

▸ **Petroleum**
- A complex mixture of several hydrocarbons mixed with water, salt and earth particles.
- Leaves no residue.
- Its fractional distillation leads to the formation of petroleum gas, gasoline, diesel etc.

▸ **LPG (Liquified petroleum gas)**
- Liquified under pressure.
- Major component is butane.
- Leaves no residue.
- High calorific value (50 kJ/g).

▸ **Natural gas**
- Consists of mainly methane (CH_4), *i.e.*, about 97%.
- Formed under the Earth by the decomposition of matter lying under water carried out by anaerobic bacteria.
- Its compressed form is CNG.
- High calorific value (50 kJ/kg)

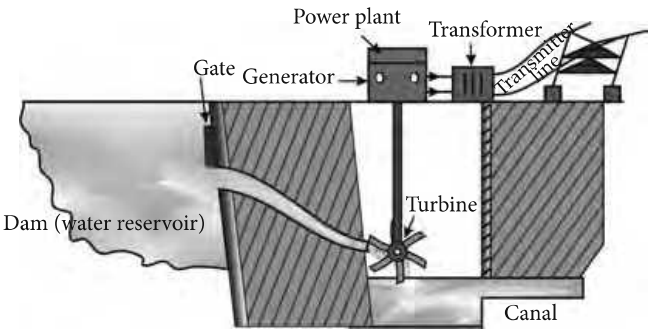
▸ **Thermal power plant**
- Produces electricity by burning fossil fuels.
- Usually set up near coal fields or oil fields for the convenience of transportation.



Thermal Power Plant

▸ **Disadvantages**
- Causes pollution and global warming.

▸ **Hydro power plants**
- **Principle :** Potential energy of water stored in a dam is converted into kinetic energy of falling water and then, kinetic energy is converted into the electrical energy.



Hydro Power or Hydro Electric Power Plant

▸ **Advantages :** Hydroelectricity is
- pollution free.
- cheapest source of energy.
- renewable source of energy.

▸ **Disadvantages**
- Large eco-systems are destroyed as the land is submerged under the water of reservoir of a dam.
- Large areas of fertile land, flora and fauna as well as human settlements get submerged.
- Hydroelectric dams cannot be constructed everywhere.

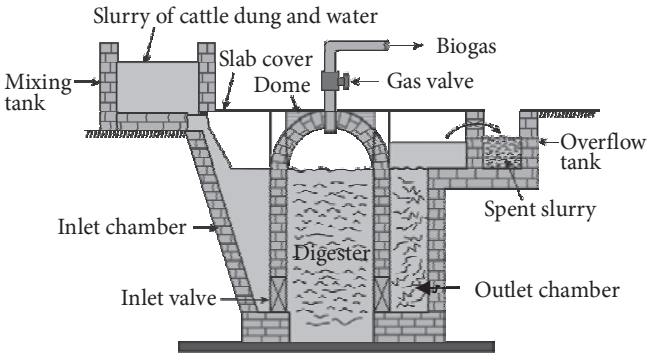
Improvements in the technology for using conventional sources of energy :

▸ **Bio-mass**
- Organic matter which is used as a fuel to produce energy.
- Includes wood, agricultural wastes, cow dung, dead parts of plants etc.
- A renewable source of energy.
- Used for the production of bio-gas and charcoal.

▸ **Bio-gas**
- Consists of methane (75%), carbon dioxide (23%) and other gases (2%).
- Produced by the anaerobic degradation of animals like cow-dung (or plant wastes) in the presence of water.
- Also known as "gobar gas".

▸ **Bio-gas plant**

The plant has a dome-like structure built with bricks. A slurry of cow-dung and water is fed to the digester from the mixing tank. Anaerobic degradation of bio-mass produces bio-gas.



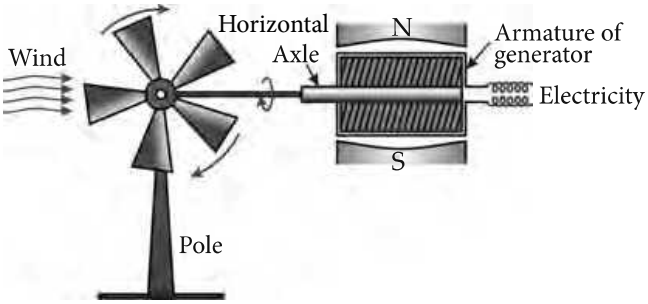
Biogas Plant

Wind energy :
- Wind is caused by unequal heating of the atomspheric air near the surface of the Earth.
- Moving air (wind) possesses kinetic energy which is used for doing work.

▸ **Traditional Uses :** It is used for
- drying clothes.
- winnowing.
- grinding grains, pumping out water from wells etc.

Windmill : It converts kinetic energy into mechanical or electrical energy.

▸ **Construction :** It consists of a wheel with blades cut into its outer rim. The wheel rotates about an axle mounted on a pole. The wind energy is used to rotate the wheel about its axle.



▸ **Principle :** When wind strikes the blades, a pressure difference is created between different regions which produces a turning effect and the blades rotate.

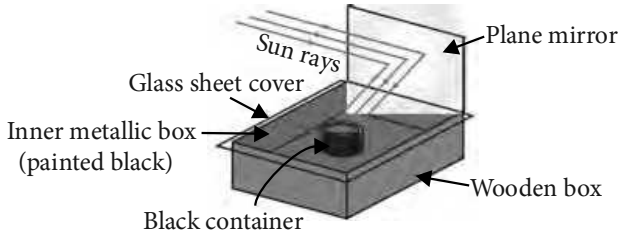
▸ **Advantages**
- Environment -friendly
- Renewable source of energy
- Economical

▸ **Disadvantages**
- Wind energy cannot be used to operate all types of machines.
- High level of maintenance is required.
- Wind energy farms can be established only where the minimum velocity of wind is 15 km h^{-1}.

Alternative or non-conventional sources of energy :

▸ **Solar energy**
- The heat and light received by the Earth from the Sun is solar energy.
- Nuclear fusion is the source of solar energy.
- It helps in photosynthesis, blowing of wind, rainfall, snowfall etc.

▸ **Solar cooker**
- A heating device by which solar energy is directly harnessed.
- Works on the phenomenon of thermal conversion.
- It consists of an insulated wooden or metallic box.
- Its inner walls are painted black to increase heat absorption.
- Covered with a glass sheet which reduces heat loss by radiation.



Solar Cooker

▸ **Advantages**
- Cheap and easy to operate.
- Reduces the consumption of firewood and LPG.
- Does not cause pollution.

▸ **Disadvantages**
- Works only during daytime.
- Takes long time in cooking the food items.
- Cannot be used for baking and frying.

▸ **Solar cell :** It is a device which converts solar energy directly into electricity.
- Usually made of semiconductors like silicon (Si) and gallium arsenide (GaAs).
- A typical cell develops a voltage of 0.5V – 1V and can produce about 0.7 W of electricity.

- Large number of solar cells are connected to get a large potential difference, *i.e.*, solar cell panel.

Energy from the Sea :

- **Tidal energy**
  - Enormous movement of water between the high tides and low tides, generates large amount of energy, *i.e.*, tidal energy.
  - Can be harnessed by constructing a tidal barrage or dam.
  - Used to produce electricity by a turbine.
- **Wave energy**
  - Waves are produced due to the blowing of wind on the surface of ocean.
  - Turbines are so arranged that they are rotated by the moving waves and generate electricity.

Ocean thermal energy :

- The temperature between the upper and lower layers of the sea or ocean is different because of the absorption of heat energy of the sun by the surface of water.
  - The difference in temperature (*i.e.*, 20°C or more) is exploited to produce electric energy in ocean thermal energy conversion plant (OTEC).
  - A low melting point fluid like ammonia or CFC is used to run the turbine of the generator.
  - OTEC system can be operated for 24 hours throughout the year.

Geothermal energy :

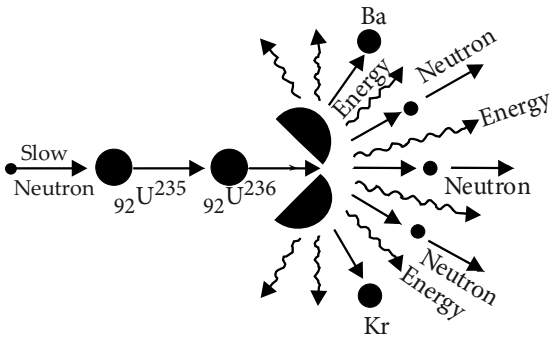
- Energy harnessed from the heat of the earth's crust is geothermal energy.
- Can be converted continuously into electricity for 24 hours throughout the year.
- Cause no pollution.
- Conversion of geothermal energy into electricity is not expensive.

Nuclear energy :

- A physical reaction which involves changes in the nucleus of an atom is known as nuclear reaction.
- Energy released during a nuclear reaction is called nuclear energy.

Types of nuclear reactions :

- **Nuclear fission :** The phenomenon of splitting up of a heavy nucleus, on bombardment with slow speed neutrons, with the release of two or more fast moving neutrons and a large amount of energy is known as nuclear fission. *i.e.*,



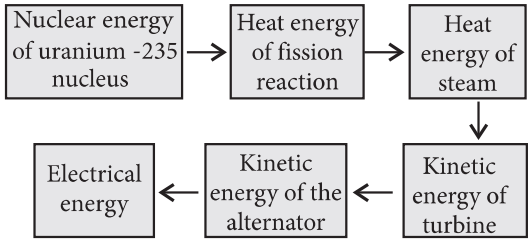
Nuclear Fission

The energy (E) obtained due to loss of matter of mass m is given by the Einstein's equation,

$$E = mc^2$$

where m is the mass of matter lost and c is the velocity of light, $c = 3 \times 10^8$ m s^{-1}.

- **Nuclear power plant :** A nuclear power plant is a type of power station that generates electricity using heat from nuclear reactions.



- **Nuclear fusion :** A process in which two lighter nuclei combine together to form a stable heavier nucleus with a simultaneous release of a very large amount of energy is called nuclear fusion.

e.g., the fusion of two nuclei of heavy hydrogen or deuterium ($_1^2H$) is

$$_1^2H + {}_1^2H \longrightarrow {}_4^2He + {}_0^1n + 17.4\ MeV$$

  - Source of energy in the stars is nuclear fusion reaction.
  - Also known as "thermonuclear fusion" reaction.
- **Advantages of nuclear energy**
  - It produces a large amount of useful energy from a very small amount of nuclear fuel.

- It does not produce smoke.
- It does not produce greenhouse gases.

▶ **Disadvantages of nuclear energy**

- Wastage of nuclear reactions is radioactive which keeps on emitting harmful nuclear radiations for thousands of years.
- Risk of accidents in nuclear reactors leads to the leakage of radioactive materials.
- Installation of nuclear power plants is very expensive and availability of uranium is limited.

Environmental consequences : The use of each and every source of energy disturbs the environment in one way or the other. In reality, no source of energy can be said to be pollution free, *e.g.*

- the use of fossil fuels causes air pollution.
- the production of hydroelectricity causes ecological imbalance etc.

▶ In any given situation, the source we would choose depends on the factors such as

- the ease of extracting energy from that source.
- the efficiency of the technology available.
- the environmental damage that will be caused by using that source.

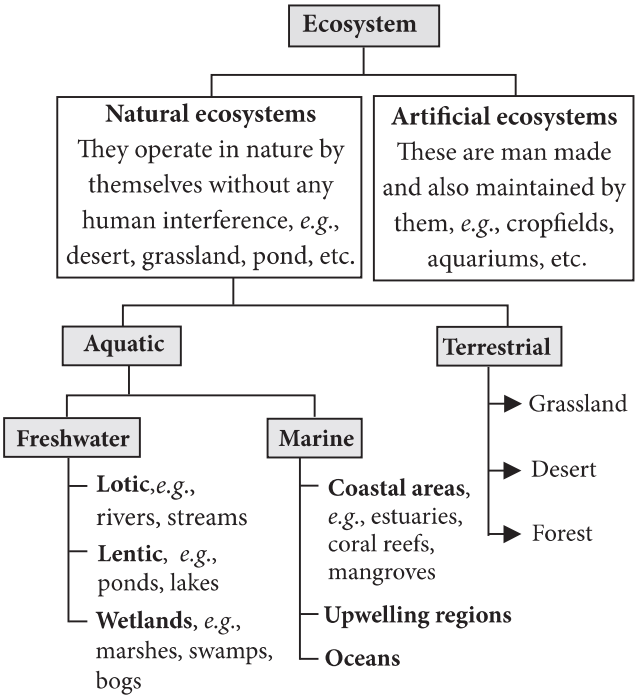
Chapter

15

Our Environment

QUICK RECAP

- **Environment :** It is the sum total of external factors and conditions that affect organisms without becoming an integral part of them. It includes everything surrounding the organism, *i.e.,* both non-living (abiotic) and living (biotic) components. The **abiotic components** are the physical factors such as climatic factors (*e.g.,* temperature, light, wind, humidity, precipitation, water, etc.) and edaphic factors (*e.g.,* soil texture, substratum, topography, background, minerals, pH, etc.). The **biotic components**, on the other hand, include all kinds of living organisms.
- **Ecosystem and its components:** An ecosystem is self-supporting unit of living organisms (plants, animals and decomposers), and their non-living environment (soil, air and water).



Flow chart : Types of ecosystem

- **Abiotic components of ecosystem :** These include inorganic substances, organic compounds and climatic factors.
  - **Inorganic substances:** These substances, *e.g.,* carbon, nitrogen, oxygen, calcium, phosphorus, etc., and their compounds (water, carbon dioxide, etc.) constitute the main abiotic components. These occur either in the form of compounds dissolved in water, in the soil or in free state in the air.
  - **Organic compounds:** These include carbohydrates, proteins, lipids, nucleic acids, etc. These are present in living organisms and dead organic matter. The dead organic matter is broken down by the action of decomposers (*e.g.*, bacteria, fungi on decayed matter) into inorganic substances for their recycling.
  - **Climatic factors:** These include light, temperature, humidity, wind, rainfall, water, etc., and also **edaphic factors** (*e.g.*, soil and substrate, topography, mineral, pH, etc.)
- **Biotic components of ecosystem :** The biotic community (or living community) of an ecosystem includes three types of organisms:
  - **Producers (or autotrophs)** are organisms which synthesise their own food. All the green plants and some blue-green algae are producers.
  - **Consumers (or heterotrophs)** are organisms which are dependent on others for food directly or indirectly. All the animals are consumers. Consumers can be further divided into three groups: herbivores, carnivores and omnivores. Those animals which eat only plants are called **herbivores.** Herbivores are **primary consumers**. *E.g.,* cow, buffalo, goat, sheep, horse, deer, camel, etc.
  - Those animals which eat only the flesh of other animals are called **carnivores**. The small carnivores which feed on herbivores are called **secondary consumers.** The large carnivores which feed upon the small carnivores are called **tertiary consumers.** *E.g.,* lion, tiger, vulture, etc.
  - Those animals which eat both, plants and animals, are called **omnivores.** *E.g.,* dog, crow, sparrow, bear, mynah and ant.
  - **Decomposers (or saprotrophs)** are those which consume the dead remains of other organisms. Certain bacteria and fungi are decomposers and they replenish the soil and increase its fertility.

Food chains : The sequential interlinking of organisms involving transfer of food energy from the producers, through a series of organisms with repeated eating and being eaten is called the **food chain**. In ecosystem, different food chains may have two, three, four or maximum five trophic levels. A food chain may end at the:

- herbivore (primary consumer) level
- primary carnivore (secondary consumer) level
- secondary carnivore (tertiary consumer) level or
- tertiary carnivore (quaternary consumer) level.

- The distinct sequential steps in the food chain where transfer of energy occurs are referred to as different trophic levels. For example, green plants (producers) form **the first trophic level**. The plant eaters (herbivores), belong to the **second trophic level** and the

flesh eaters (carnivores), represent **the third trophic level**.

- A food chain is always straight and proceeds in a progressive straight line. In a food chain, there is unidirectional flow of energy from sun to producers and subsequently to series of consumers.
- The quantum of available energy in a food chain successively decreases at each trophic level as a result of energy which is wasted as heat in metabolic reactions such as respiration, excretion, etc.

Food web : In nature, food chains do not operate in isolation. It is so because in natural environment, each organism is generally eaten by two or more kinds of organisms which, in turn, are eaten by several other organisms. Thus, instead of straight line food chain, the relationship between organisms forms a sort of interlocking pattern due to alternate pathways, called a **food web**.

- Food web is a network of food chains which become interlinked at various trophic levels forming a number of feeding connections amongst various organisms in a biotic community.
- Food webs provide stability to ecosystem, keep a check on the population of species of animals and plants having high reproductive rates and help in development of ecosystem.

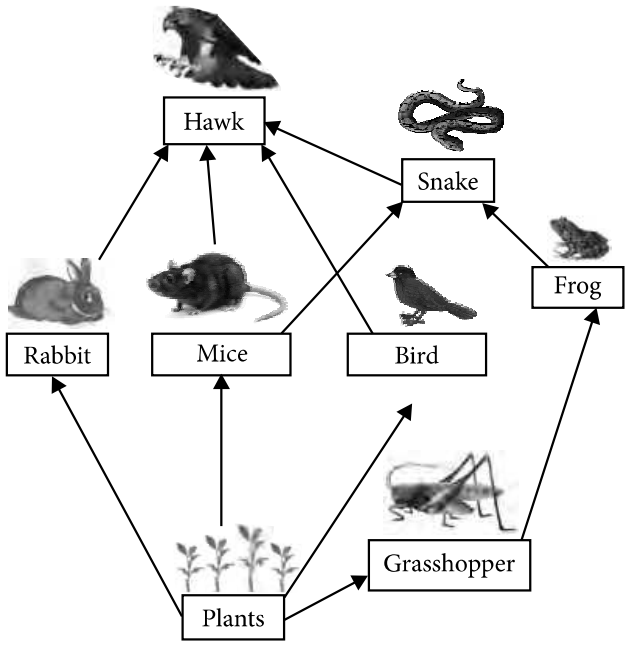


Fig.: Food web

Ecological pyramids : An ecological pyramid is a graphic representation of an ecological parameter (numbers or biomass or amount of accumulated energy) at different trophic levels in a food chain in an ecosystem. Ecological pyramids can be of three types on the basis of ecological parameters.

- **Pyramid of numbers : It** is the graphic representation depicting the arrangement of number of individuals of different trophic levels in a food chain of an ecosystem. The shape of pyramid of numbers may be **upright** (*e.g.*, in pond ecosystem and in grassland ecosystem) or **inverted** (*e.g.*, in parasitic food chain) depending upon whether the number of organisms gradually decreases or increases at successive trophic levels from producers onwards to top consumers.

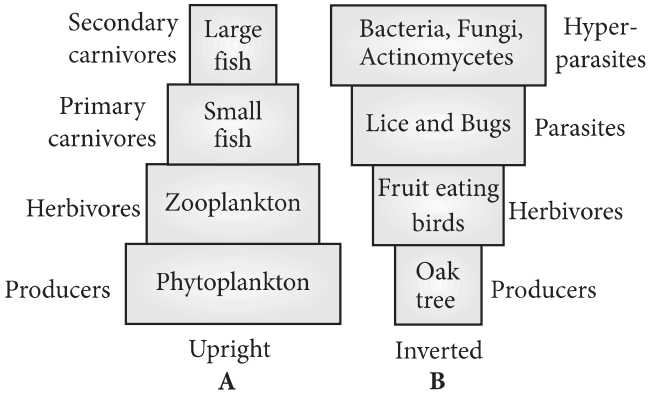


Fig.: Pyramid of numbers (A) in pond ecosystem; (B) in parasitic food chain

- **Pyramid of biomass:** A pyramid of biomass is the graphic representation of biomass (total amount of living organic matter in an ecosystem) per unit area at different trophic levels. Pyramid of biomass may also be **upright** (*e.g.*, in a grassland ecosystem) or **inverted** (*e.g.*, in a pond ecosystem) depending upon whether the biomass of organisms gradually decreases or increases at successive trophic levels from producers onwards to top carnivores.

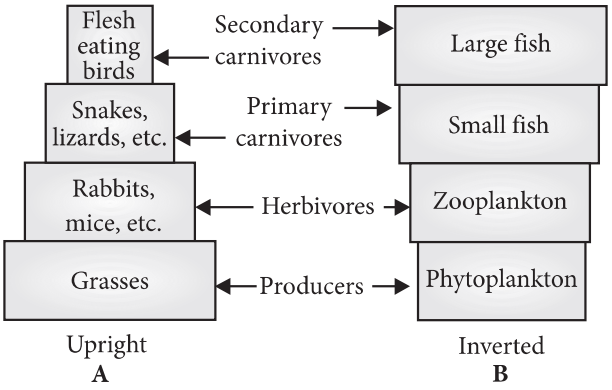


Fig.: Pyramid of biomass (A) in a grassland ecosystem; (B) in a pond ecosystem

- **Pyramid of energy:** A pyramid of energy is a graphic representation of amount of energy per unit area at different trophic levels of a food chain in an ecosystem. The pyramid of energy is **always upright** because the available energy is the highest at producer level. According to second law of thermodynamics, there is gradual decrease in available energy at successive trophic levels.

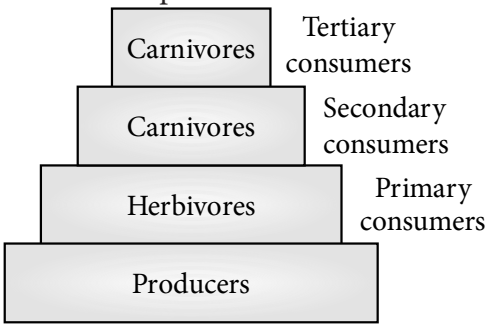


Fig.: Pyramid of energy

Flow of energy in an ecosystem : In an ecosystem, energy comes from the sunlight which is further converted from one form to another. Energy gets continuously transferred from one trophic level to the other by repeated food consumption in a food chain. Loss of energy occurs as heat at each step of energy transfer (trophic level) in the environment. At each trophic level, organisms utilise energy in respiration, reproduction, growth, etc.)

- **Ten percent law** states that during transfer of energy from one trophic level to the next level, only about 10% energy is available to the higher trophic level and the remaining 90% is lost in respiration and heat. This limits the trophic levels to 3 or maximum of 4 or 5 in food chain.

Types of waste : In our daily lives, we generate a lot of useless materials and discard them. The useless left over or discarded materials are termed as **wastes**. The waste materials can be **gaseous** (*e.g.*, automobile exhausts, smoke from chimneys of industries and house), **liquid** (*e.g.*, effluents from industries, sewage water) or **solid** (*e.g.*, kitchen waste, cow dung, human excreta, trash and rubbish, etc.)

- **Solid wastes :** These accumulate in the environment due to human activities and are the main sources of soil pollution. They can be categorised into two types: biodegradable and non-biodegradable wastes.
  - **Biodegradable wastes** can be easily degraded by natural means *i.e.*, by the action of microorganisms such as bacteria and fungi, complex organic matters can be converted into simpler, harmless substances in due course of time. However, biodegradable wastes can also act as pollutants when their quantity becomes large *i.e.*, they start accumulating as they are not broken down into simpler substances by the action of microorganisms at the pace at which they are generated. These affect the human life in various ways:
  - Flies breed on heaps of solid wastes containing biodegradable substances. These carry the germs and spread diseases such as diarrhoea, typhoid, tuberculosis, cholera, conjunctivitis, etc.
  - These biodegradable wastes may also block the drains, creating pools of water which become the breeding sites of mosquitoes. The latter are the carriers of diseases like malaria, chikungunya, etc.
  - **Non-biodegradable wastes** cannot be degraded by natural means, *i.e.*, by the action of microorganisms, into simpler, harmless substances in due course of time. Some harmful effects of non-biodegradable wastes are :

(i) Some of the non-biodegradable substances, such as pesticides (*e.g.*, D.D.T.), industrial chemicals, heavy metals and

radioactive substances are very harmful. This is so because these enter the food chains and their concentration goes on increasing from one trophic level to the next. This phenomenon is known as **biomagnification** which results in many harmful effects in human beings and other animals.

(ii) Excessive use of fertilisers and pesticides, and dumping of industrial chemical wastes affect the soil fertility and subsequently reduces the crop yield. The soil, thus, may become acidic or alkaline.

– **Modes of solid waste disposal :**

(i) In urban areas, majority of the solid wastes are buried in low lying areas to level the uneven surface of land. This method of waste disposal is commonly called **land filling.**

(ii) Number of solid wastes (*e.g.*, paper, plastics, metals, etc.) can be recycled by sending them to respective recycling units. This is known as **recycling of wastes**.

(iii) **Preparation of compost :** Household waste should be segregated and the biodegradable wastes such as fruit peel and vegetables, left-over food, fallen dead leaves of plants, etc., should be converted to **compost** and used as manure.

(iv) **Incineration** is the process of burning of substances at high temperature (usually more than 1000°C) and ultimately converting them into ashes. It is carried out in an incinerator. Household wastes, chemical and hospital wastes are generally disposed off by incineration process.

(v) Biodegradable wastes can be used in biogas plants to generate biogas (55% methane + 45% CO_2)and manure.

Greenhouse effect and global warming : The atmospheric cover around the Earth acts as glass wall of a greenhouse. The clouds, dust particles, gases and water vapours, present in the atmosphere, filter and scatter large quantity of solar radiation falling on Earth. Only about 48% of solar radiation actually reaches the surface of Earth and only 1% of it is absorbed by plants. Most of the remaining radiation is used up in warming the surface of Earth.

- The solar radiation absorbed by Earth's surface is emitted back as infrared radiations into the atmosphere. Part of infrared radiations pass through the atmosphere.
- Most of the remaining infrared radiations are absorbed by greenhouse gases and re-emitted in all directions. It is called **greenhouse flux.** It is due to greenhouse flux that mean annual temperature of Earth is about 15°C.
- The gases in the atmosphere, responsible for keeping Earth's surface warm, are carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs) and nitrous oxide (N_2O). These gases are called **green - house gases.**
- The phenomenon of rise of average atmospheric temperature due to continuous increase in concentration of greenhouse gases in the atmosphere is called **global warming.** The reasons for global warming are :
  - Man is adding large amounts of **carbon dioxide** (CO_2) to the atmosphere each year by burning fossil fuels in homes, industries and automobiles, biomass burning associated with agricultural practices, etc.
  - **Methane** is being added to the atmosphere by marshes, paddy fields, cattle sheds and biogas plants.
  - **Chlorofluorocarbons** (CFCs) are emitted into the atmosphere by refrigerators and air conditioners. Consequently, there is slow rise in the atmospheric temperature.

Ozone depletion : Ozone is a triatomic molecule made up of three atoms of oxygen (O_3). Very little quantity of ozone is present in the lower part of atmosphere, called **troposphere**. However, good amount of ozone is present in the upper part of atmosphere, called **stratosphere.**

- Though ozone is present throughout the stratosphere, its concentration is maximum 23-25 km above equator and 11-18 km

above poles. This rich zone of ozone in the stratosphere is called **ozone layer** or ozone shield because this region intercepts high energy ultraviolet (UV) radiations to reach the Earth's surface.

- In the stratosphere, ozone is being photodissociated and generated simultaneously by the absorption of harmful ultraviolet (UV) radiations coming from the Sun.

$$\underset{\text{Ozone}}{O_3} \underset{}{\overset{\text{UV radiations from Sun}}{\rightleftharpoons}} \underset{\text{Oxygen molecule}}{O_2} + \underset{\text{Oxygen atom}}{[O]}$$

- The two reactions (photodissociation of O_3 and its generation) are in equilibrium thereby maintaining steady concentration of ozone in the stratosphere (18-50 km above sea level).
- The thinning of ozone layer is known as **ozone depletion**. Ozone shield is important for the survival and existence of life on Earth but it is being depleted by air pollutants like chlorofluorocarbons (CFCs), methane (CH_4) and oxides of nitrogen (NO_x).
- Chlorofluorocarbons (CFCs) are synthetic, harmful chemicals which are widely used in refrigerators and air conditioners as coolants, in fire extinguishers, in aerosol sprayers and as propellants. Once released in the air, these harmful chemicals produce active chlorine (Cl and ClO radicals) in the presence of UV radiations.
- These radicals, through chain reactions, convert ozone into oxygen. Due to this, the ozone layer in the upper atmosphere (*i.e.*, stratosphere) becomes thinner.
- The thinning of ozone layer allows more UV radiations to pass through it which then strike the Earth. UV radiations reaching the Earth have following harmful effects on man, animals and plants:
  - In humans UV radiations may cause sun burn, skin cancer, eye cataract, etc.
  - Damage to immune system in human beings and animals and hence lowering the body's resistance to diseases.
  - Increased mortality of developing embryos in the mother's uterus.
  - In plants, UV radiations may interfere with the process of photosynthesis. Decreased photosynthesis would increase the concentration of CO_2 in the atmosphere which will result in global warming.

Chapter

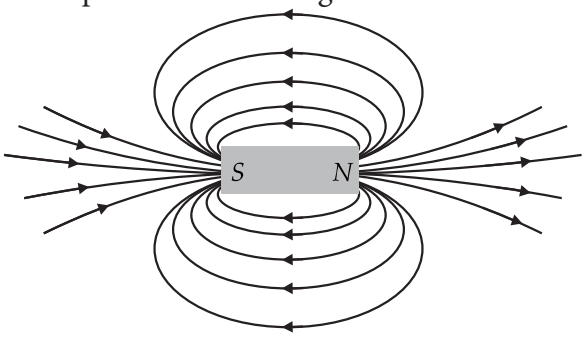
13

Magnetic Effects of Electric Current

QUICK RECAP

- **Magnet :** A piece of iron or other material which has its component atoms so ordered that the material exhibits properties of magnetism and aligning itself in an external magnetic field.
- Properties of a magnet
  - Attracts material like iron, nickel and cobalt.
  - Attraction is maximum at its poles.
  - Always aligns itself in north-south direction.
- **Magnetic field :** Space around a magnet where its influence can be experienced by another magnet.
- **Magnetic field lines :** Curved imaginary lines used to show the magnetic field in a given region.

- Magnetic fields are closed continuous curves directed from north pole to south pole outside the magnet but from south pole to north pole inside the magnet.



Field lines around a bar magnet

- Tangent at any point on the magnetic field line gives the direction of magnetic field at that point.
- Magnetic fields are closer together at the poles and far apart at the centre.
- Never intersect each other as magnetic field cannot have two directions at one point.

Magnetic field due to a straight conductor carrying current : The magnetic field due to a straight conductor carrying current is in the form of concentric magnetic lines of force, whose centre lies on the conductor. These magnetic lines of force lie in a plane perpendicular to the plane of linear conductor.

- Strength of magnetic field produced by a straight current-carrying wire at a given point is
  - directly proportional to the current passing through it.
  - inversely proportional to the distance of that point from the wire.

$$i.e.,\ B \propto \frac{I}{r}\begin{cases} B \rightarrow \text{magnetic field} \\ I \rightarrow \text{current} \\ r \rightarrow \text{distance between wire and point of observation} \end{cases}$$

S.I. unit of magnetic field is tesla (T).

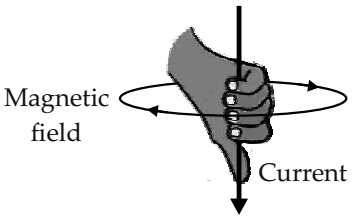
$$1 \text{ tesla} = \frac{1 \text{ newton}}{1 \text{ ampere} \times 1 \text{ metre}} = 1 \text{ N m}^{-1} \text{ A}^{-1}$$

C.G.S. unit of magnetic field is gauss (G).

1 tesla = 10^4 gauss

Right-hand thumb rule :

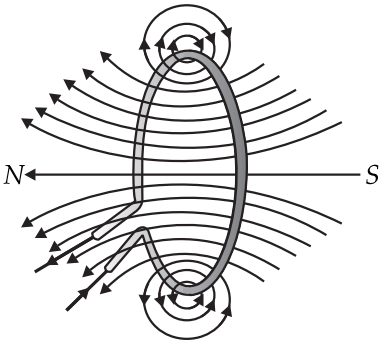
- The straight thumb of right hand points in the direction of electric current.
- The direction of the curl of fingers represents the direction of magnetic field.



Right-hand thumb rule

Magnetic field due to a circular coil carrying current:

- The magnetic field lines are nearly circular and concentric.
- Field lines are in the same direction in the space enclosed by the coil.
- Field lines are nearly straight and parallel at the centre.
- Direction of magnetic field at the centre is perpendicular to the plane of the coil.
- Magnetic field is maximum at its centre.

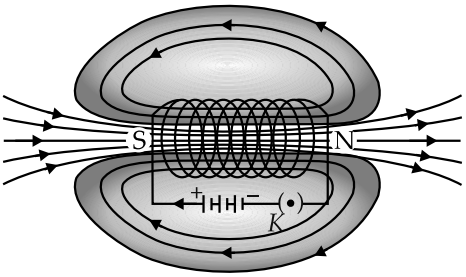


Magnetic field lines of the field produced by a current-carrying circular loop

- Strength of magnetic field can be increased by
  - increasing the number of turns of wire in the coil.
  - increasing the current flowing through the coil.
  - decreasing the radius of the coil.

Magnetic field due to a current carrying solenoid : An insulated copper wire wound on a cylindrical cardboard tube such that its length is greater than its diameter is called a solenoid.

- Magnetic field lines are
  - Almost uniform inside the solenoid and are directed from south pole to north pole.
  - Non-uniform outside the solenoid and are directed from north pole to south pole.



Field lines of the magnetic field through and around a current-carrying solenoid

- Strength of magnetic field can be increased by
  - increasing the number of turns in the solenoid.
  - increasing the strength of current.
  - using soft iron rod as core.

Force on a current-carrying conductor in a magnetic field : When a current-carrying wire is placed in a magnetic field, it experiences a magnetic force that depends on

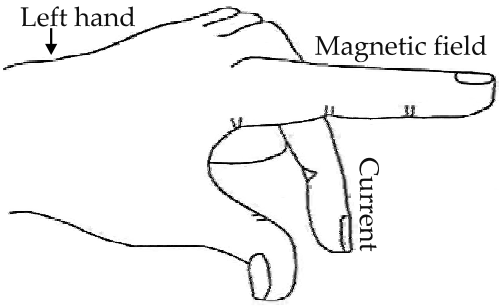
- Current flowing in the conductor
- Magnetic field
- Length of the conductor
- Angle between the element of length and the magnetic field.

i.e.,

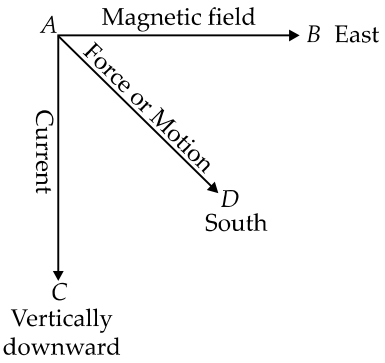
$F = BIl \sin\theta$

$F \rightarrow$ Force
$B \rightarrow$ Magnetic field
$I \rightarrow$ Current
$l \rightarrow$ Length of the conductor
θ = angle between element of length and magnetic field

Fleming's left-hand rule : The direction of the force experienced by a current-carrying conductor placed in a magnetic field is determined by Fleming's left-hand rule, *i.e.*,



Fleming's left-hand rule

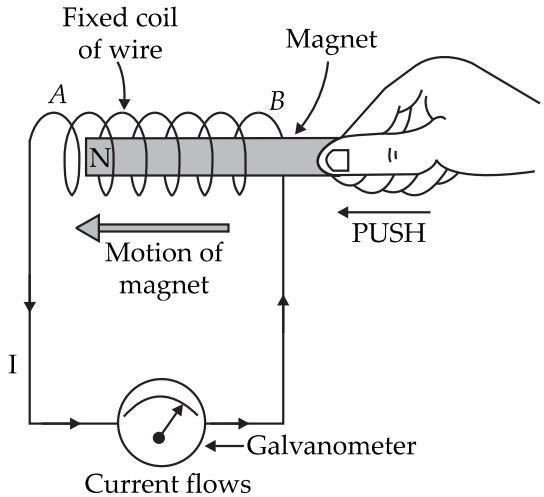


Pictorial diagram of Fleming's left-hand rule

Electric motor :

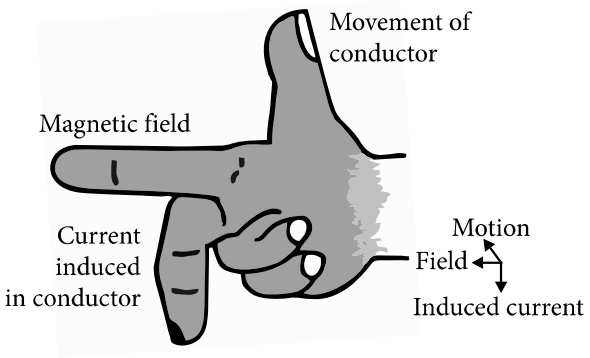
- Device which converts electrical energy into mechanical energy.
- Works on the principle that a current-carrying conductor placed perpendicular to the magnetic field, experiences a force.

Electromagnetic induction : The phenomenon in which electric current is generated by varying magnetic fields is called electromagnetic induction.



As a magnet is pushed into the fixed coil, a current is produced in the coil

Fleming's right-hand rule : Direction of induced current in a conductor is determined by Fleming's right-hand rule.



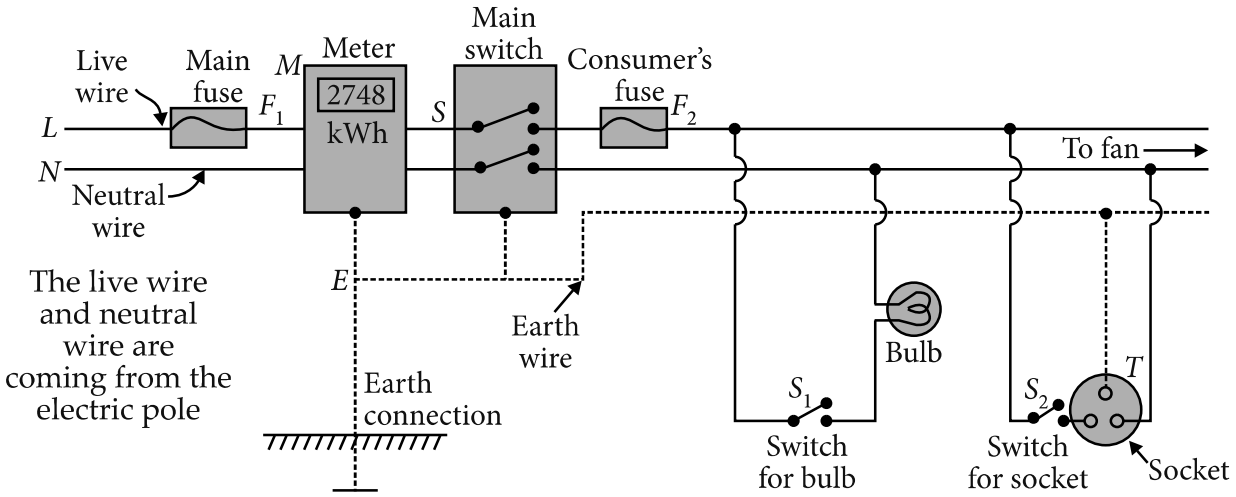
Fleming's right-hand rule

Electric generator :

- A device which converts mechanical energy into electrical energy.
- Works on the principle of electromagnetic induction.

Domestic electric circuits :

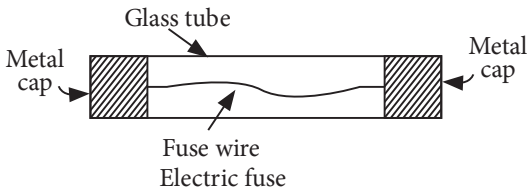
- To supply electric power from one place to another place, through the three wires *i.e.*, phase wire or live wire (insulation of red colour), neutral wire (insulation of black color) and earth wire (insulation of green color).
- 15 A current rating is used for appliances with higher power ratings.
- 5 A current rating is used for appliances with lower power ratings.
- Each appliance has equal potential difference as they are connected parallel to each other.



Domestic electric wiring from electric pole to a room

Electric fuse : A safety device used to save the electrical appliances from burning when large amount of current flows in the circuit.

- Made of a material of low melting point.
- Works on the principle of heating effect of current.



Overloading : The condition at which a large number of higher current-flowing through the circuit and at the same time the appliances are switched on then the total current drawn through the circuit may exceed its rated value.

Short-Circuiting : The condition when the live wire comes in direct contact with the neutral wire, a high current flows.