UNIT – I: CHEMICAL SUBSTANCES—NATURE AND BEHAVIOR

CHAPTER-1

CHEMICAL REACTIONS AND EQUATIONS

Topic-1 **Chemical Reaction and Equations**

Concepts Covered • *Chemical reaction and examples,* • *Skeletal and balanced chemical equation,* • *Steps to balance a chemical equation.*

Revision Notes

A chemical reaction

- A chemical reaction is a process in which the original substance(s) loses its nature and identity and forms new substance(s) with different properties.
- Breaking of the chemical bonds and formation of new chemical bonds is responsible for the occurrence of a chemical reaction.
- The substances which take part in a chemical reaction are called Reactants.
- The substances which are formed in a chemical reaction are called Products.
- **Examples of chemical reaction:**
  - **(i)** Digestion of food
  - **(ii)** Respiration
  - **(iii)** Rusting of iron
  - **(iv)** Burning of magnesium ribbon
  - **(v)** Formation of curd
- A chemical reaction can be identified by either of the following observations:

S. No.	Characteristics	Examples
1.	Change in state	The combustion reaction of candle wax is characterized by a change in state from solid to liquid and gas.
2.	Change in colour	The chemical reaction between citric acid and purple coloured potassium permanganate solution is characterized by a change in colour from purple to colourless.
3.	Evolution of gas	The chemical reaction between zinc and dilute sulphuric acid is characterized by hydrogen gas. $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$
4.	Change in temperature	The reaction between quicklime and water to form slaked lime is characterized by an increase in temperature.
5.	Formation of a precipitate	When an aqueous solution of sodium sulphate is mixed with the aqueous solution of barium chloride, barium sulphate comes in the form of white precipitate
		$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(\downarrow) + 2NaCl(aq)$

Chemical equations

- A chemical equation is the symbolic representation of a chemical reaction in the form of symbols and formulae.
- It is a way to represent the chemical reaction in a concise and informative way.
- For example,

$$\underset{\text{(Reactants)}}{\text{Magnesium} + \text{Oxygen}} \rightarrow \underset{\text{(Product)}}{\text{Magnesium oxide}}$$

  This equation is called word equation.
- The word equation can be written into chemical equation by writing symbols and formulae of the substance in place of their name.

$$2Mg + O_2 \rightarrow 2MgO$$

Writing a chemical equation

(i) The symbols of elements and the formulae of reacting substances (reactants) are written on the left hand side of the equation, with a plus (+) sign between them.

(ii) The symbols and formulae of the substances formed (products) are written on the right hand side of the equation, with a plus sign (+) between them.

(iii) An arrow sign (→) is put between the reactants and the products.

(iv) The physical states of the reactants and products are also mentioned in a chemical equation.

- **Skeletal chemical equation:** A chemical equation which simply represents the symbols and formulas of reactants and products taking part in the reaction is known as skeletal chemical equation for a reaction.

For example: For the burning of Magnesium in the air, $Mg + O_2 \rightarrow MgO$ is the skeletal equation.

- **Balanced Equation:** The equation in which atoms of various elements on both sides of a chemical equation are equal in accordance with the **law of conservation of mass.**

The example of balanced chemical equation :

(i) $CO(g) + 2H_2(g) \xrightarrow{340\ atm} CH_3OH(l)$

(ii) $6CO_2(g) + 6H_2O(l) \xrightarrow[chlorophyll]{sunlight} \underset{Glucose}{C_6H_{12}O_6(aq)} + 6O_2(g)$

- The process of equalizing the atoms of various elements both on either sides of an equation is called the balancing of chemical equation. This is known as hit and trial method. Let us understand this with the help of an example given below:

Key Word

Law of conservation of mass: It states that, "The matter can neither be created nor destroyed in a chemical reaction. " OR "
the total mass of reactants = total mass of products".

Example 1

Balancing a chemical equation :

Step 1. Write the chemical equation and draw boxes around each formula.

$$Fe + H_2O \rightarrow Fe_3O_4 + H_2$$

Step 2. Count the number of atoms of each element on both the sides of the arrow :

	Element	No. of atoms at reactant side	No. of atoms at product side
1.	Fe	1	3
2.	H	2	2
3.	O	1	4

Step 3. Equalize the number of the atoms of element which has the maximum number of atoms (oxygen).

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

Step 4. Try to equalize all the atoms of elements on reactant and product side by adding coefficient in front of it.

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

Now, all the atoms of elements are equal on both sides.

Step 5. Write the physical states of reactants and products.

$$3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$$

Solid state = (*s*), Liquid state = (*l*), Gaseous state = (*g*), Aqueous state = (*aq*)

Step 6. Write necessary conditions of temperature, pressure or catalyst at above or below the arrow.

Topic-2 Types of Chemical Reactions

Concepts Covered • ***Combination reaction,*** • ***Decomposition reaction,*** • ***Displacement reaction,*** • ***Double displacement reaction,*** • ***Redox reaction,*** • ***Oxidation and reduction reaction,*** • ***Exothermic and endothermic reaction.***

Revision Notes

- **Types of Chemical Reactions**

I. Combination Reaction: The reaction in which two or more reactants combine to form a single product.

e.g., (i) Burning of coal

$C(s) + O_2(g) \rightarrow CO_2(g)$

(ii) Formation of water

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

(iii) $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + Heat$

(Quick lime) (Slaked lime)

Exothermic Reactions: Reaction in which heat is released along with formation of products.

e.g., (i) Burning of natural gas.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + Heat$

(ii) Respiration is also an exothermic reaction.

$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(aq) + 6H_2O(l) + energy$

(Glucose)

II. Decomposition Reaction:

The reaction in which a compound splits into two or more simpler substances is called decomposition reaction.

$A \rightarrow B + C$

(a) Thermal decomposition: When decomposition is carried out by heating.

e.g., (i) $2FeSO_4(s) \xrightarrow{Heat} Fe_2O_3(s) + SO_2(g) + SO_3(g)$

(Ferrous sulphate) Green colour — (Ferric oxide) Red-brown colour

(ii) $CaCO_3(s) \xrightarrow{Heat} CaO(s) + CO_2(g)$

(Lime stone) (Quick lime)

(b) Electrolytic Decomposition: When decomposition is carried out by passing electricity.

e.g., $2H_2O(l) \xrightarrow[current]{Electric} 2H_2(g) + O_2(g)$

(c) Photolytic Decomposition: When decomposition is carried out in presence of sunlight.

e.g., (i) $2AgCl(s) \xrightarrow{Sunlight} 2Ag(s) + Cl_2(g)$

(ii) $2AgBr(s) \xrightarrow{Sunlight} 2Ag(s) + Br_2(g)$

Endothermic Reaction: The reactions which require energy in the form of heat, light or electricity to break reactants are called endothermic reactions.

III. Displacement Reaction: The chemical reactions in which more reactive element displaces less reactive element from its salt solution.

e.g., (i) $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$

(Iron) (Copper sulphate) (Ferrous sulphate) (Copper)

The iron nail becomes brownish in colour by deposition of Cu and blue colour of $CuSO_4$ changes into dirty green colour due to formation of $FeSO_4$.

(ii) Zinc displaces copper forming zinc sulphate. Zn is more reactive than copper.

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

(Zinc Sulphate)

IV. Double Displacement Reaction: A reaction in which new compounds are formed by mutual exchange of ions between two compounds.

$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$

(Sodium sulphate) (Barium chloride) (Barium sulphate) (Sodium chloride)

White precipitate of $BaSO_4$ is formed, so it is also called precipitation reaction.

V. Oxidation and Reduction:

Oxidation: Loss of electrons

Reduction: Gain of electrons

Mnemonics

Concept: Types of decomposition reaction
Mnemonics: PET
Interpretations:
Photolytic reaction, **E**lectrolytic reaction, **T**hermal reaction

Concept: Oxidation and reduction reaction
Mnemonics: OIL RIG
Interpretations:
Oxidation **I**s **L**oss of electrons, **R**eduction **I**s **G**ain of electrons

Concept: Types of chemical reactions
Mnemonics: ROC.D^3
Interpretations:
Reduction, **O**xidation, **C**ombination, **D**ecomposition, **D**isplacement, **D**ouble Displacement

Oxidation: It is a process of gaining oxygen during a reaction by an atom, molecule or ion.

$$2Cu + O_2 \xrightarrow{Heat} 2CuO$$

Reduction: It is the gain of electrons or a decrease in the oxidation state of an atom by another atom, an ion or a molecule.

$$CuO + H_2 \longrightarrow Cu + H_2O$$

In this reaction, CuO is reduced to Cu and H_2 is oxidised to H_2O. In other words, one reactant gets oxidised while the other gets reduced. Such reactions are called oxidation-reduction reactions or redox reactions.

VI. Important equation

Redox (Oxidation and Reduction) Reaction :

Oxidation (HCl isoxidized)

$$MnO_2(s) + 4HCl(conc.) \longrightarrow MnCl_2(aq)_2 + Cl\ (g) + 2H_2O$$

Reduction(MnO_2 is reduced)

VII. Some usually asked equations in exams for balancing :

- $2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$
  (Carbon monoxide) (Oxygen) (Carbon dioxide)
- $ZnCO_3 \xrightarrow{Heat} ZnO + CO_2$
- $2FeSO_4(s) + \longrightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$
- $Pb(NO_3)_2 + 2KI \longrightarrow 2KNO_3 + PbI_2$
  (Lead nitrate) (Potassium iodide) (Potassium nitrate) (Lead Iodide)
- $CaO(s) + H_2O \longrightarrow Ca(OH)_2 + Heat$
  (Quick lime) (Slaked lime)
- $NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$
  (Sodium chloride) (Silver nitrate) (Silver chloride) (Sodium nitrate)
- $Ca + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2\uparrow$
- $2Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2\uparrow$
- $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$
- $Zn + 2HCl \longrightarrow ZnCl_2 + H_2\uparrow$
- $Zn + 2NaOH \xrightarrow{Heat} Na_2ZnO_2 + H_2\uparrow$
- $Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2\uparrow$
- $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$
- $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$
- $4Zn + 10\,HNO_3 \longrightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$

Effects of oxidation reactions in everyday life :

1. **Corrosion:** Corrosion is a process in which metals are deteriorated by action of air, moisture, chemicals, etc. It is a redox reaction where metal gets oxidised to metal oxide and oxygen gets reduced to oxide ion.
   Examples:
   (a) Corrosion of iron is called rusting. Iron objects when left in moist open air for sometime get coated with a reddish brown powder. The process is known as rusting.
   (b) Green coating on Copper articles and black coating on silver ornaments are another example of corrosion.
   Effects of corrosion :
   (a) Rusting causes damage to ships, car bodies, bridges, railings.
   (b) Corrosion is a wasteful process because it leads to wastage of tonnes of various metals every year and lot of money is spent to repair or replace it.
   Prevention of Rusting:
   (a) The iron articles should be painted.
   (b) The machine parts should be oiled and greased.
   (c) Galvanised iron pipes should be used for water supply.
   (d) Iron can be coated with chromium to prevent rusting.

Mnemonics

Concept: Preventive ways of rusting	**Interpretations:**
Mnemonics: POGG	**P**ainting **O**iling **G**reasing **G**alvanising

2. **Rancidity :** Rancidity is the process of slow oxidation of oil and fat, present in the food materials resulting in the production of foul odour and taste in them. When cooked food items are placed for a long time, they become rancid and unsuitable for the consumption.

Rancidity can be prevented by the following ways :

(a) Storing the food in refrigerator.

(b) Storing the food in air-tight container.

(c) Addition of anti-oxidants to food.

(d) Storing the food in flush bags with gas, such as nitrogen to prevent the oxidation process.

CHAPTER-2

ACIDS, BASES AND SALTS

Topic-1 Acids and Bases

Concepts Covered • **Definition of acids and bases,** • **Properties of acids and bases,** • **Indicators and its type,** • **pH scale and importance of pH in everyday life.**

Revision Notes

Acids

- Acids are the substances that furnish H^+ ions in aqueous solution. Acids are sour in taste. They turn blue litmus red.
- The example includes Sulphuric acid (H_2SO_4), Acetic acid (CH_3COOH), Nitric acid (HNO_3) etc.
- If in an aqueous solution, concentration of acid is low, it is called **dilute solution** and if concentration of acid is high, it is called **concentrated solution**.
- Those acids which dissociates into ions completely are called strong acids, e.g., H_2SO_4, HCl.
- Those acids which do not dissociate into ions completely are called weak acids, e.g., citric acid, acetic acid.

> **Note:**
> Although we talk of 'taste' of acids and bases, it is not advisable to taste any acid or base. Most of them are harmful. Similarly touching the solutions of strong acids and bases should be avoided. They may harm the skin.

Some Naturally occurring acids :

Natural source	Acid	Natural source	Acid
Vinegar	Acetic acid	Sour milk (Curd)	Lactic acid
Orange	Citric acid	Lemon	Citric acid
Tamarind	Tartaric acid	Ant sting	Methanoic acid
Tomato	Oxalic acid	Nettle sting	Methanoic acid

Bases

- Bases are those chemical compounds which are bitter in taste, soapy in touch, turn red litmus blue and give OH^- ions in aqueous solution.
- The examples include Sodium hydroxide (NaOH), Potassium hydroxide (KOH), etc.
- The substances / bases which ionise completely to furnish OH^- ions are called strong bases, e.g., KOH, NaOH, etc.
- The bases which ionise only partially are called weak bases, e.g., $Mg(OH)_2$, $Cu(OH)_2$, etc.
- Both acids and bases conduct free electric current in their aqueous solution due to the presence of free ions.
- Strength of an acid or base depends on the number of H^+ ions or OH^- ions produced by them respectively. More the H^+ ions produced by an acid, stronger is the acid. More the OH^- ions produced by a base, stronger is the base.
- Chemical compounds can cause harm to our body, some are very lethal, and therefore, we cannot rely on physical tests such as taste and appearance. In laboratory, to test whether a compound has acidic character or basic character, indicators are used.
- **Indicators:** These are the substances which change their colour / smell in different types of substances.

Types of Indicators:

	S. No.	Indicator	Smell/Colour In Acid Solution	Smell/Colour In Basic Solution
Natural Indicator	1.	Litmus	Red	Blue
	2.	Red cabbage leaf extract	Red	Green
	3.	Flowers of hydrangea plant	Blue	Pink
	4.	Turmeric	No change	Red
Synthetic Indicator	1.	Phenolphthalein	Colourless	Pink
	2.	Methyl orange	Red	Yellow
Olfactory Indicator	1.	Onion	Characteristic smell	No smell
	2.	Vanilla essence	Retains smell	No smell
	3.	Clove oil	Retains smell	Loses smell

Chemical Properties of Acids and Bases:

1. Reaction of Metals with:

Acids	Bases
Acid + Metal → Salt + Hydrogen gas	Base + Metal → Salt + Hydrogen gas
e.g., $2HCl + Zn \rightarrow ZnCl_2 + H_2\uparrow$ (Zinc chloride)	e.g., $2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2\uparrow$ (Sodium zincate)

Test for H_2 gas: Hydrogen gas released can be tested by bringing a burning candle near gas bubbles, it bursts with pop sound.

2. Reaction of Metal Carbonates / Metal Hydrogen Carbonates with:

Acids	Bases
Acid + Metal Carbonate / Metal hydrogen Carbonate ↓ Salt + CO_2 + H_2O	Base + Metal Carbonate / Metal Hydrogen Carbonate ↓ No Reaction

e.g., $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

$HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$

Test for CO_2: CO_2 can be tested by passing it through lime water. Lime water turns milky.

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

When excess CO_2 is passed, milkiness disappears.

$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

3. Reaction of Acids and Bases With Each Other

When an acid reacts with base, the hydrogen ion of acid combines with hydroxide ion of base and forms water. As these ions combine together, they form water instead of remaining free, thus both neutralize each other.

Acid + Base → Salt + Water

H X + MOH →MX + HOH

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Since, in the reaction between an acid and a base both neutralize each other, it is also known as neutralization reaction.

Example : Sodium hydroxide (a strong base) reacts with hydrochloric acid to form sodium chloride and water.

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Dilution of Acid and Base

When a concentrated acid or base is diluted, a vigorous reaction takes place. The process is called dilution. It is an exothermic process as a lot of heat is produced.

The process of forming ions in aqueous solution is called ionisation. All ionic compounds like NaCl, $NaNO_3$, Na_2SO_4 form ions in aqueous solution.

Key Facts

- We add acid to water. If we add water to acid, the high concentration of acid may produce a violent exothermic reaction.
- Concentrated acids and bases are corrosive; no person should touch it with bare hand or skin. In case a few drops spill on the body, a person should wash it with plenty of water.

Common property between all acids and all bases

- Acids give hydrogen gas when they react with metal. This shows that all acids contain hydrogen.
- When acids are dissolved in water they dissociate as H^+ ions. The dissociation as hydrogen ions in aqueous solution is the common property of all acids. As a result, an acid shows acidic behavior.

  $HCl\ (aq) \rightarrow H^+(aq) + Cl^-\ (aq)$

  $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-\ (aq)$

  $CH_3COOH\ (aq) \rightarrow H^+\ (aq) + CH_3COO^-\ (aq)$
- As H^+ ion cannot exist alone so it combines with water molecules and forms H_3O^+ (hydronium) ions.

  Example :

  $HCl + H_2O \rightarrow H_3O^+ + Cl^-$

  $H^+ + H_2O \rightarrow H_3O^+$

  Thus, acids can also be defined as 'Substances which when dissolved in water ionize to produce hydrogen ions, H^+ (aq).
- Similarly, substances which when dissolved in water ionize to produce hydroxide ions, OH^- (aq).

  Examples : When sodium hydroxide is dissolved in water, it dissociates into hydroxide and sodium ion.

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

4. Reaction of acids with metal oxides :

Metal oxides react with acids to give salt and water.

Metal oxide + Acid → Salt + Water

Example : Copper oxide reacts with dil. hydrochloric acid to form copper chloride (salt) and water.

$CuO + 2HCl \rightarrow CuCl_2 + H_2O$

Copper oxide Copper chloride

Copper oxide is black in colour. When dilute hydrochloric acid is added in it, the colour of the solution becomes blue green due to formation of copper chloride.

▶ **How strong are acid or base solutions?**

- Strength of an acid or base depends on the number of H^+ ions or OH^- ions produced by them respectively.
- Based on its ability to dissociate into ions in solution, acids and bases are classified as strong acid or base and weak acid or base.

(i) Strong acids : Acid which completely dissociates in water to produce large amount of hydrogen ions are called strong acids. For example hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3) are strong acids as they get completely ionized in water to form ions.

$$HCl\ (aq) \rightarrow H^+(aq) + Cl^-\ (aq)$$

(ii) Weak acids : Acids which are partially ionized in water to produces small amount of hydrogen ions are known as weak acids. For example, acetic acid partially dissociates in water to produce small amount of hydrogen ions.

$$CH_3COOH\ (aq) \rightarrow H^+\ (aq) + CH_3COO^-(aq)$$

(iii) Strong bases : Bases which completely ionize in water to produce large amount of hydroxide ions are called strong bases. Examples include NaOH, KOH, etc.

(iv) Weak bases : Bases which partially dissociate in water to furnish lesser amount of hydroxide ions are called weak bases. Examples include ammonium hydroxide (NH_4OH) and calcium hydroxide $Ca(OH)_2$

pH

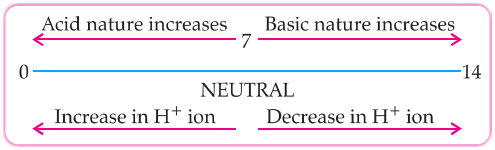
▶ A scale for measuring H^+ ion concentration in a solution.

▶ The concentrations of H^+ are generally small, therefore concentrations of H^+ are expressed in terms of pH. pH is defined as negative logarithm of H^+ concentration or H_3O^+ concentration.

$$pH = -\log [H^+] \text{ or } pH = -\log [H_3O^+]$$

- pH = 7 → neutral solution
- pH < 7 → acidic solution
- pH > 7 → basic solution
- On diluting an acid: pH increases ↑
- On diluting a base: pH decreases ↓

Key Diagram



▶ **Importance of pH in everyday life:**

- Plants and animals are pH sensitive.
- Our body works within the pH range of 7 – 7.8.
- When pH of rain water is less than 5.6, it is called **acid rain.**
- Plants require a specific pH range for their healthy growth.

Key Fact

p in pH stands for 'potentz', a German word which means power.

- pH of stomach is 1.5-3.0 due to secretion of HCl. In case of indigestion, acidity increases, which can be neutralised by antacids like milk of magnesia.
- Tooth decay starts when pH of the mouth is lower than 5.5. To protect tooth decay, toothpastes which are basic in nature are used to neutralize the excess acid.
- Many plants and animals produce certain acids to defend themselves. For example, Bee stings leave an acid into the skin, which causes pain and irritation. If a mild base like baking soda is applied on the stung area, it gives relief.

Key Word

Acid rain: Acid rain is rain or any other form of precipitation that is unusually acidic, meaning that it has elevated levels of hydrogen ions (low pH).

▶ **Important Reaction of different solutions with different indicators:**

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

Topic-2 Salts, their Properties and Uses

Concepts Covered • **Salts,** • **Types of salts,** • **Preparation and uses of Sodium Hydroxide, Bleaching powder, Baking soda, Washing soda and Plaster of Paris..**

Revision Notes

▶ **Salts:** A salt is an ionic compound that results from the **neutralisation reaction** of an acid and a base. Salts are composed of related numbers of cations and anions, so that, the product is electrically neutral.

▶ **Types of Salts:**

(i) Neutral salts : Salts produced by reaction of strong acid and strong base are neutral in nature with pH value 7. For example, sodium chloride formed by reaction between sodium hydroxide (strong base) and hydrochloric acid (strong acid).

$$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$$

(ii) Acidic salts : Salts formed by reaction between a strong acid and weak base are acidic in nature with pH value less than 7. For example, ammonium hydroxide. It is a salt of hydrochloric acid (strong acid) and ammonium hydroxide (weak base).

$$NH_4OH\ (aq) + HCl(aq) \rightarrow NH_4Cl\ (aq) + H_2O\ (l)$$

Key Word

Neutralisation reaction: The reaction in which base or basic oxide reacts with acid or acidic oxide is called neutralisation reaction.

Example : $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O$.

(iii) Basic salts : Salts formed by reaction of strong base and weak acid are basic in nature with pH value more than 7. For example, sodium carbonates. It is a salt of carbonic acid (weak acid) and sodium hydroxide (strong base).

$$H_2CO_3\,(aq) + 2NaOH\,(aq) \rightarrow Na_2CO_3 + 2H_2O\,(l)$$

- **Common Salt (NaCl):**

Preparation: $NaOH + HCl \rightarrow NaCl + H_2O$

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

Users of common salt:

(a) Used as daily food.

(b) Used as preservative.

(c) Used in manufacture of metal (Na) and gas (Cl_2) in molten state by electrolysis

- **Sodium hydroxide (NaOH)**

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

The process is called chlor - alkali process because of the products formed- Chlor for chlorine and alkali for sodium hydroxide.

Uses :

(a) Sodium hydroxide is used in making of paper, soap and detergents, for de-greasing metals, etc.

(b) Chlorine gas is used in water treatment, manufacturing of PVC, pesticides, etc.

(c) liquid hydrogen is used as rocket fuel, in hydrogenation process of oil to produce vegetable *ghee* (margarine) and in making of ammonia for fertilizers..

- **Bleaching Powder ($CaOCl_2$):**

Preparation: It is produced by the action of chlorine on dry slaked lime.

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

Properties:

(a) It has a strong smell of chlorine.

(b) Soluble in water.

(c) It loses Chlorine by the action of carbon di oxide.

Uses:

(a) Bleaching cotton and linen in textile industry.

(b) Bleaching wood pulp in paper factories.

(c) Oxidizing agent in chemical industries.

(d) Disinfecting drinking water.

- **Baking Soda** (Sodium hydrogen carbonate) ($NaHCO_3$)**:**

Preparation: $NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + \underset{\text{Baking soda}}{NaHCO_3}$

Properties:

(a) It is mild non-corrosive base.

(b) When it is heated during cooking, the following reaction takes place.

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

Uses:

(a) For making baking powder (mixture of baking soda and tartaric acid). When baking powder is heated or mixed with water, CO_2 is produced which causes bread and cake to rise making them soft and spongy.

$NaHCO_3 + H^+ \rightarrow CO_2 + H_2O$ + Sodium salt of an acid

(b) An ingredient in antacid.

(c) Used in soda acids, fire extinguishers.

- **Washing Soda ($Na_2CO_3.10H_2O$):**

Preparation: Re-crystallization of sodium carbonate gives washing soda. It is a basic salt.

$$Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3.10H_2O$$

Properties:

(a) Transparent crystalline solid.

(b) It has 10 molecules of water of crystallisation.

(c) It dissolves in water and the aqueous solution is alkaline.

(d) It liberates Carbon dioxide when treated with Hydrochloric acid and Sulphuric acid.

Uses:

(a) In glass, soap and paper industry.

(b) Manufacture of borax.

(c) It can be used as cleaning agent.

(d) It can be used for removing permanent hardness of water.

- **Plaster of Paris (Calcium sulphate hemihydrates) ($CaSO_4.½H_2O$):**

Preparation: On heating gypsum $CaSO_4.2H_2O$ at 373K, it loses water molecules and becomes Plaster of Paris (POP). It is white powder and on mixing with water it changes to gypsum.

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

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

Uses:

(a) Doctors use POP for supporting fractured bones.

(b) For making toys and material for decoration.

Important salts :

Common name	Chemical name	Chemical formula	Uses
Washing soda	Sodium carbonate decahydrate	$Na_2CO_3.10H_2O$	Manufacture of borax, caustic soda, softening of hard water.
Baking soda	Sodium hydrogen carbonate	$NaHCO_2$	Used as antacid, ingredient of baking powder.
Bleaching powder	Calcium oxychloride	$CaOCl_2$	Bleaching clothes, used as oxidising agent, disinfecting water, manufacture of chloroform.
Plaster of Paris	Calcium sulphate hemihydrate	$CaSO_4.1/2\ H_2O$	Plastering fractured bones, making toys, decorative materials, statues.

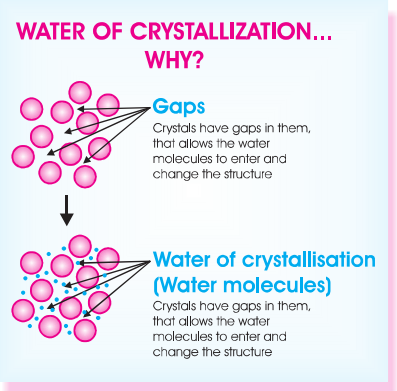
Water of crystallization

- Water molecules present in the crystal structure of salt are called water of crystallization and such salts are called hydrated salts. Water of crystallization is the fixed number of water molecule present in one formula unit of a salt.

Examples:

- **Copper sulphate pentahydrate ($CuSO_4.5H_2O$) :** It has five water molecules in one formula unit of copper sulphate (blue vitriol).
- **Sodium carbonate ($Na_2CO_3.10H_2O$) :** It has ten molecules of water as water of crystallization.
- **Gypsum ($CaSO_4.2H_2O$) :** It has two molecules of water as water of crystallization.

Key Diagram



CHAPTER-3
METALS AND NON-METALS

Topic-1 Properties of Metals and Non-Metals

Concepts Covered • Physical properties of Metals and non-metals, • Chemical properties of Metals and non-metals:, • Reaction with oxygen, • Reaction with water, • Reaction with acids, • Reaction with other metal salt solutions, • Reaction between metals and non-metals (ionic bond formation).

Revision Notes

▶ **Physical Properties of Metals and Non-metals :**

Property	Metals	Non-Metals
1. Lustre	Metals have shining surface.	They do not have shining surface. • Except Iodine.
2. Hardness	They are generally hard. • Except Sodium, Lithium and Potassium which are soft and can be easily cut with knife.	Generally soft. • Except Diamond, a form of carbon which is the hardest natural substance.
3. State	Exist as solids. • Except Mercury that exists as liquid.	Exist as solids or gases • Except Bromine that exists as liquid.
4. Malleability	Metals can be beaten into thin sheets. • Gold, Silver and Aluminium are the most malleable metals.	Non-metals are non-malleable. • They are brittle.
5. Ductility	Metals can be drawn into thin wires.	They are non-ductile.
6. Conductor of heat & electricity	Metals are good conductors of heat and electricity.	Non-metals are poor conductors of heat and electricity. • Except Graphite.
7. Density and Melting point	Generally metals have high density and high melting point. • Except Sodium and Potassium	Non metals have low density and low melting point.
8. Sonorous	Metals produce a sound on striking a hard surface.	They are not sonorous.
9. Oxides	Metallic oxides are basic in nature.	Non-metallic oxides are acidic in nature.

▶ **Chemical Properties of Metals :**

(A)Reaction of Metals with Air: Metals combine with oxygen to form metal oxide.

Metals + $O_2 \rightarrow$ Metal oxide

Examples:

(i) $2Cu + O_2 \rightarrow 2CuO$
Copper (II) oxide (black)

(ii) $4Al + 3O_2 \rightarrow 2Al_2O_3$
Aluminium oxide

(iii) $2Mg + O_2 \rightarrow 2MgO$
Magnesium oxide

Different metals show different reactivity towards O_2.

- Na and K react so vigorously with oxygen that they catch fire if kept in open. So, they are kept immersed in kerosene.
- Surfaces of Mg, Al, Zn and Pb are covered with a thin layer of oxide which prevent them from further oxidation.
- Fe does not burn on heating but iron fillings burn vigorously.
- Cu does not burn but is coated with black copper (II) oxide.
- Au and Ag do not react with oxygen.

Amphoteric Oxides: Metal oxides which react with both acids as well as bases to produce salt and water are called amphoteric oxides.

Examples: $Al_2O_3 + 6HCl \rightarrow \underset{\text{Aluminium chloride}}{2AlCl_3} + 3H_2O$

$Al_2O_3 + 2NaOH \rightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2} + H_2O$

(B)Reaction of Metals with Water: Metals react with water to produce metal hydroxide and hydrogen gas.

Metal + Water → Metal oxide + Hydrogen

Examples:

Metal oxide + Water → Metal hydroxide

$2Mg + 2H_2O \rightarrow \underset{\text{Magnesium oxide}}{2MgO} + 2H_2\uparrow$

$MgO + H_2O \rightarrow \underset{\text{Magnesium hydroxide}}{Mg(OH)_2}$

- Sodium and Potassium react vigorously with water.
- Magnesium metal reacts with hot water to produce magnesium hydroxide and hydrogen gas.

$$Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2$$

- Aluminium and zinc react with steam to produce metal oxide and hydrogen gas.
- Metals like silver, gold, copper and lead do not react with water.

(C) Reactions of Metals with Acid:

- Metal + Dil. Acid ⟶ Salt + Hydrogen gas

  e.g., $Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$
- Copper, mercury and silver don't react with dilute acids.

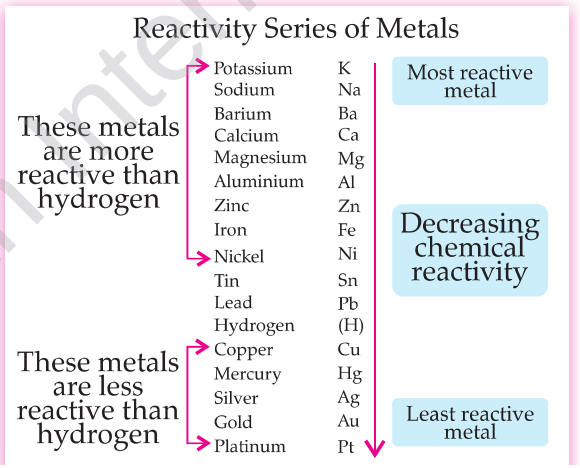
(D)Reaction of Metals with solutions of other Metal Salts:

Metal A + Salt solution B → Salt solution A + Metal B

- Reactive metals can displace less reactive metals from their compounds in solution form.

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

- **Reactivity or activity series of metals :** All the metals do not react with the same rate. Some react very fast, some react moderately whereas others react very slowly. The series of metals in decreasing order of reactivity is called **reactivity** or **activity series of metals.** The metals at the top (K at the top most) are most reactive whereas metals at the bottom (Pt at the extreme bottom) are least reactive.



Mnemonics

Concept: Activity series of metals

Mnemonics: Popular **S**cientists **C**an **M**ake **A** **Z**oo **I**n**T**he **L**ow **H**umid **C**ountry **M**ore **S**atisfactorily

Interpretations:

P: Potassium
S: Sodium
C: Calcium
M: Magnesium
A: Aluminium
Z: Zinc
I: Iron
T: Tin
L: Lead
H: Hydrogen
C: Copper
M: Mercury
S: Silver

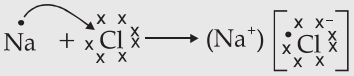
- **Reaction of Non-Metals:**
  - **Reaction with oxygen:** Non- metals react with oxygen to form acidic oxides.
    e.g., $C + O_2 \longrightarrow CO_2$
  - Reaction with water: Non-metals do not react with water because they do not release any electrons.
  - Reaction with dil. acids: No reaction.
  - Reaction with salt solutions: A more reactive non-metals will displace less reactive non-metal from its salt solution.
  - Reaction with chlorine: Non-metals react with chlorine to form their respective Chlorides.
    e.g., $H_2 + Cl_2 \longrightarrow 2HCl$
  - Reaction with hydrogen: Non-metals react with hydrogen to form their respective hydrides.
    e.g., $H_2 + S \longrightarrow H_2S$
- **Aqua Regia** is a mixture of conc. HCl and conc. HNO_3 in the ratio of 3: 1. It can dissolve gold and platinum. Aqua Regia is a strong oxidizing agent due to the formation of NOCl (Nitrosyl chloride) and chlorine produced by reaction of two acids.
- **Reaction between metal and non-metals:**
  - Reactivity of an element is the tendency to attain completely filled valence shells.
  - Atoms of metals can lose electrons from valence shells to form cations while atoms of non-metals can gain electrons in valence shell to form anions.
  - Opposite charged ions attract each other and held by strong electrostatic forces of attraction.
  - Let us understand formation of NaCl with the help of an example :

Example 1

Step 1: Atomic number of sodium (Na) is 1. Atoms in last shell are 1.
Step 2: Atomic number of chlorine (Cl) is 17. Atoms in last shell are 7.
Step 3: So, Na gives 1 atom to chlorine.
Step 4: This is complete transfer of electrons. So, it is ionic compound.

$Na \rightarrow Na^+ + e^-$
2,8,1 2, 8
(Sodium cation)

$Cl + e^- \rightarrow Cl^-$
2,8,7 2,8,8
(Chloride anion)



Topic-2 Ionic compounds, Metallurgy and Corrosion

Concepts Covered • Ionic compounds • Occurrence of Metals • Extraction of Metals • Corrosion • Alloy.

Revision Notes

- **Ionic Compounds**
  The compounds formed by the transfer of electrons from a metal to a non-metal are called ionic compounds or electrovalent compounds.
- **Properties of Ionic Compounds**
  (i) Physical nature: They are solid and hard, generally **brittle**.

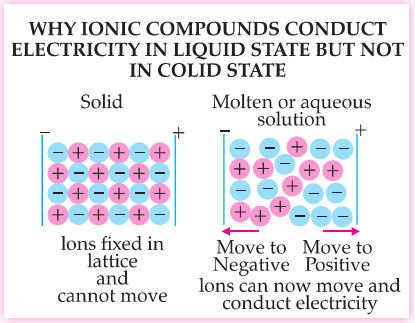
Key Word

Brittle: The property of a substance to get easily broken or cracked when hammered.

(ii) Melting and Boiling Point: They have high melting and boiling points.
(iii) Solubility: Generally soluble in water and insoluble in solvents such as kerosene, petrol, etc.
(iv) Conduction of electricity: Ionic compounds conduct electricity in molten and solution form but not in solid state.

Occurrence of Metals

- **Minerals:** The elements or compounds which occur naturally in the earth's crust are called minerals.
- **Ores:** Minerals that contain very high percentage of particular metal and the metal can be profitably extracted from it, such minerals are called ores.



Metals on the basis of reactivity, can be grouped into three categories:

- Metals at the bottom of the activity series are least reactive and are often found in free state. For e.g., Gold, silver, platinum and copper.

  These metals are very unreactive. The oxides of these metals can be reduced to metals by heating alone. For example, cinnabar (HgS) (an ore of mercury). When it is heated in air, it is first converted into mercuric oxide which is further reduced to mercury on heating.

  $2HgS(s) + 3O_2(g) \xrightarrow{\Delta} 2HgO(s) + 2SO_2(g)$

  $2HgO(s) \xrightarrow{\Delta} 2Hg(l) + O_2(g)$
- Metals at the top of the activity series are so reactive that they are not found in nature as free state. e.g., K, Na, Ca, Mg and Al.
- Metals in the middle of the activity series are moderately reactive. They are found in the earth's crust as oxides, sulphides and carbonates. e.g., Zn, Fe, Pb, etc.

  The highly reactive metals are used as reducing agents because they can displace metals of lower reactivity from their compounds.

  For example: $3MnO_2(s) + 4Al(s) \longrightarrow 3Mn(l) + 2Al_2O_3(s) + Heat$

  Thermit reaction: $Fe_2O_3(s) + 2Al(s) \longrightarrow 2Fe(l) + Al_2O_3(s) + Heat$

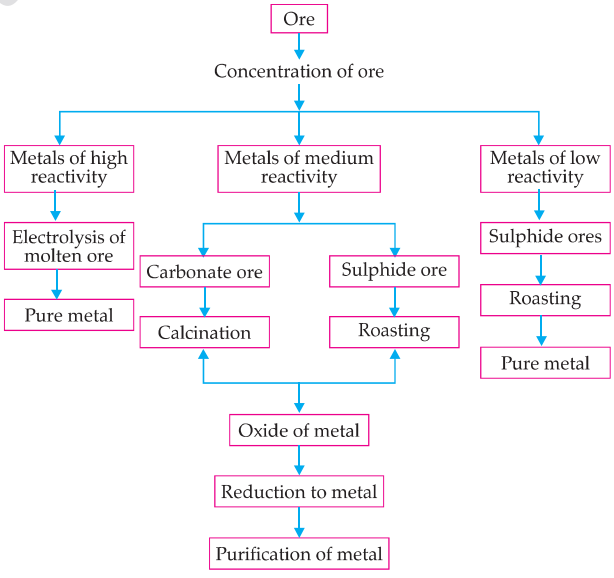
  The amount of heat evolved is so large that the metals are produced in the molten state. This reaction is used to join railway tracks or cracked machine parts.

Extraction of metals : It is the process of obtaining pure metal from its ore. Extraction of metal can be classified into three steps :

(1) Enrichment of ores or concentration of ores.

(2) Extraction of metal from the concentrated ores.

(3) Refining of metal.



- **Steps involved in extraction of metals from ores are as follows:**
- **Metallurgy:** The extraction of metals from their ores and then refining them for use is known as metallurgy.
- **Corrosion:** It is the deterioration of a metal as a result of chemical reactions between it and surrounding environment. For example,
  - Silver reacts with sulphur in air to form silver sulphide and articles become black.
  - Copper reacts with moist carbon dioxide in air and forms green coat of copper carbonate.
  - Iron acquires a coating of brown flaky substance called rust.
  - Rust is hydrated Iron (III) oxide, i.e., $Fe_2O_3.xH_2O$
- **Prevention of corrosion:** By painting, oiling, greasing, galvanizing and by making alloys.
- **Galvanization:** It is the process which involves coating of iron with zinc. The oxide thus formed is impervious to air and moisture thus protects further layers from getting corroded.
- **Alloys:** These are homogeneous mixture of metals with metals and non-metals. For example,
  - **Stainless steel:** Alloy of iron, nickel, chromium
  - **Brass:** Alloy of copper and zinc
  - **Bronze:** Alloy of copper and tin
  - **Solder:** Alloy of lead and tin
- **Amalgam:** If one of the metals is mercury, then the alloy is known as amalgam. E.g, Sodium amalgam and silver amalgam.

CHAPTER-4
CARBON COMPOUNDS

Topic-1
Carbon and its Properties, Homologous Series and IUPAC Names

Concepts Covered • *Covalent bonding in carbon compounds,* • *Versatile nature of carbon,* • *Homologous series,* • *Nomenclature of carbon compounds containing functional groups,* • *Difference between saturated and unsaturated hydrocarbons,* • *Chemical properties of carbon compounds*

Revision Notes

- **Properties of Carbon**
  - The element carbon is non-metal. Its symbol is C.
  - Carbon is a versatile element. The percentage of carbon present in earth's crust in form of mineral is 0.02% and in atmosphere as CO_2 is 0.03%.
  - All the living things, like plants and animals are made up of carbon based compounds.
  - Carbon always forms covalent bonds.
  - The atomic number of carbon is 6.
  - **Electronic configuration:**

	K	L
C (6)	2	4

- **How carbon attain noble gas configuration ?**

(i) Carbon is tetravalent in nature. It does not form ionic bond because it has 4 valence electrons, half of an octet. To form ionic bonds, carbon molecules must either gain or lose 4 electrons. It is because, that is difficult to hold four extra electron and would require large amount of energy to remove four electrons. So, carbon can form bond by sharing of its electron with the electrons of other carbon atom or with other element and attain noble gas configuration.

(ii) The atoms of other elements like hydrogen, oxygen, nitrogen and chlorine also form bonds by sharing of electrons.

(iii) The bond formed by sharing of electrons between same or different atoms is **covalent bond**.

Key Word

Covalent Bond is formed by sharing of electrons between atoms. In a covalent bond, the shared pair of electrons belongs to the valence shell of both the atoms.

- **Conditions for formation of a covalent bond:**
  - **(i)** The combining atoms should have 4 to 7 electrons in their valence shell.
  - **(ii)** The combining atoms should not lose electrons easily.
  - **(iii)** The combining atoms should not gain electrons readily.
  - **(iv)** The difference in electronegativity of two bonded atoms should be low.
- **Properties of covalent compounds:**
  - **(i) Physical state:** They are generally liquids or gases. Some covalent compounds may exist as solid.
  - **(ii) Solubility:** They are generally insoluble in water and other polar solvents but soluble in organic solvents such as benzene, toluene, etc.
  - **(iii) Melting and boiling points:** They generally have low melting and boiling points.
  - **(iv) Electrical conductivity:** They do not conduct is more apt word instead of electrical current.
- **Steps for writing the Lewis dot Structures of a covalent compound:**
  - **(i)** Write the electronic configuration of all the atoms present in the molecule.
  - **(ii)** Identify how many electrons are needed by each atom to attain noble gas configuration.
  - **(iii)** Share the electrons between atoms in such a way that all the atoms in a molecule have noble gas configuration.
  - **(iv)** Keep in mind that the shared electrons are counted in the valence shell of both the atoms sharing it.

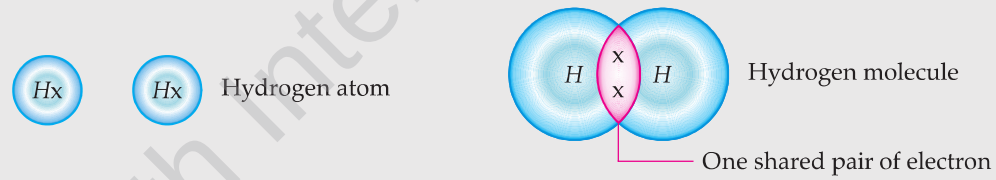
Key Word

Lewis dot structures reflect the electronic structures of the elements, including how the electrons are paired. In Lewis dot structures each dot represents an electron. A pair of dots between chemical symbols for atoms represents a bond.

Let us understand this with the help of examples:

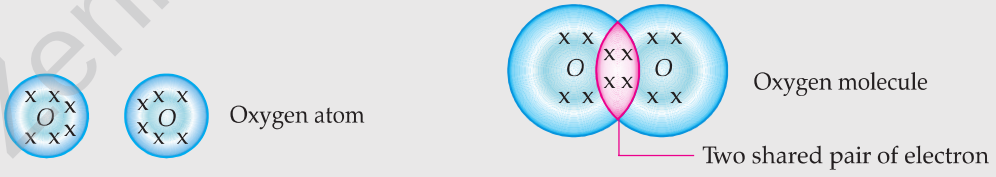
Example 1

(i) H_2



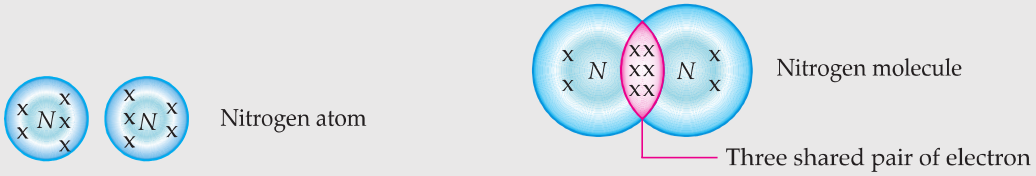
H – H: Single bond between hydrogen atoms

(ii) O_2



O = O: Double bond between oxygen atoms

(iii) N_2



N ≡ N: Triple bond between nitrogen atoms

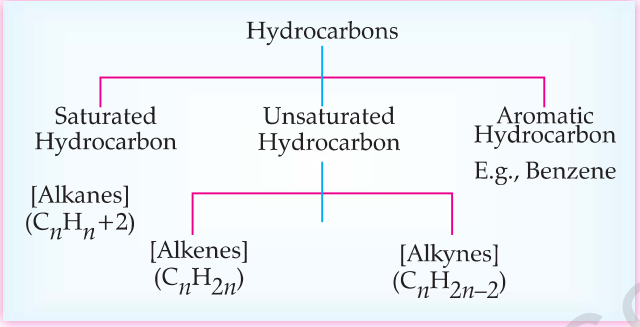
- **Versatile Nature of Carbon:** Carbon can form large number of carbon compounds. The factors that enable carbon to form large number of compounds are **catenation** and **tetravalency**.

Key Words

Catenation: It is the unique ability of elements to form long, straight or branched chains and rings of different sizes. Carbon shows maximum catenation in the periodic table.

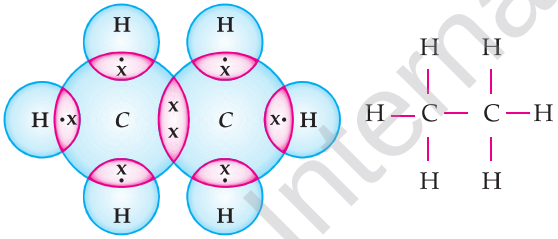
Tetravalency: It is the state of an atom in which there are four electrons available with the atom for covalent chemical bonding.

- **Hydrocarbon:** Compounds made up of hydrogen and carbon are called hydrocarbon.



- **Electron dot structure of saturated hydrocarbons:**

Ethane C_2H_6



Mnemonics

Concept: Saturated and unsaturate compounds

Mnemonics: Thank You DeSa.

Interpretation:

T: Triple bond

Y: Alkyne

D: Double bond

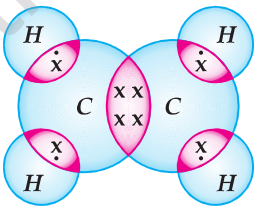
e: Alkene

S: Single bond

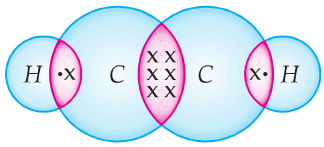
A: Alkane

- **Electron dot structure of unsaturated hydrocarbons:**

Ethene: C_2H_4



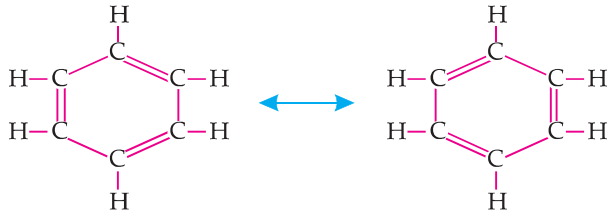
Ethyne: C_2H_2



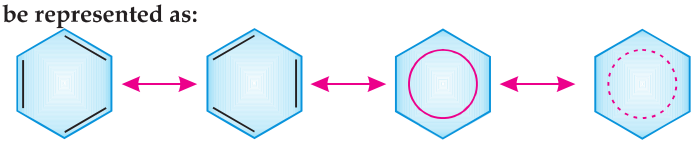
H – C ≡ C – H

- **On the basis of structures, hydrocarbons can be:**
  - (i) **Straight chain hydrocarbons:** Propane, butane, etc.
  - (ii) **Branched chain hydrocarbon:** Iso-butane, iso-pentane, etc.
  - (iii) **Cyclic hydrocarbons:** Cyclohexane C_6H_{12}, benzene C_6H_6, etc.
- **Cyclic or Closed Chain Hydrocarbons:** These are the hydrocarbons which have carbon - carbon closed chain. They are classified as:
  - (i) **Alicyclic hydrocarbons:** These are the hydrocarbons which do not have benzene ring in their structures.
  - (ii) **Aromatic hydrocarbons:** The hydrocarbons which have benzene ring in their structures. When hydrogen bonded to carbon of benzene is substituted with halogens, radicals or other functional groups, the derivatives are called aromatic compounds.

- **Benzene:** It is an aromatic hydrocarbon which has the molecular formula C_6H_6. It has alternating carbon - carbon single and double bonds.



- **Benzene can also be represented as:**



- **IUPAC name of hydrocarbon consists of two parts. It involves:**

(i) Word root: Number of carbons in the longest carbon chain.

Number of carbon atoms	Word root (Greek name)
1	Meth
2	Eth
3	Prop
4	But
5	Pent
6	Hex
7	Hept
8	Oct
9	Non
10	Dec

(ii) Suffix: It depends on the type of carbon - carbon bond, for single bond suffix is – ane; for double bond, suffix is – *ene*; and for triple bond suffix is – *yne*.

- **Types of Formula for Writing Hydrocarbons:**

(i) Molecular formula: It involves the actual number of each type of atom present in the compound.

(ii) Structural formula: The actual arrangement of atoms is written in structural formula.

(iii) Condensed formula: It is the shortened form of the structural formula.

- In hydrocarbon chain, one or more hydrogen atom is replaced by other atoms in accordance with their valencies. These are **heteroatoms.**
- These heteroatoms or group of atoms which make carbon compound reactive and decides its properties are called functional groups.

Some important functional groups in carbon compounds are:

Hetero atom	Functional group	Formula of functional group
Cl/Br	Halo (Chloro/Bromo)	— Cl, — Br, — I
Oxygen	1. Alcohol	— OH
	2. Aldehyde	— CHO
	3. Ketone	— C — (=O)
	4. Carboxylic acid	— C(=O) — OH
Double bond	1. Alkene group	> C = C <
Triple bond	2. Alkyne group	— C ≡ C —

Key Word

Heteroatoms: An atom other than carbon or hydrogen atom.

- **Isomerism:** The compounds which possess the same molecular formula but different structural formulae, are called isomers, and the phenomenon is known as isomerism. For example, butane with a molecular formula C_4H_{10} has two isomers.

- **Homologous Series:** A series of organic compounds in which every succeeding member differs from the previous one by – CH_2 or 14 a.m.u. is called homologous series. The molecular formula of all the members of a homologous series can be derived from a general formula.
- **Properties of a homologous series:** As the molecular mass increases in a series, physical properties of the compounds show a variation, but chemical properties which are determined by a functional group remain the same within a series.

Mnemonics

Concept 1: Homologous series
Mnemonics: **M**onkeys **E**at **P**eeled **B**ananas
Interpretations:
M: Methane (1C), **E: E**thane (2C), **P: P**ropane (3C), **B: B**utane (4C)
Concept 2: Reaction in saturated and Unsaturated compounds
Mnemonics: SaSUnA
Interpretations:
Sa: Saturated, **S: S**ubstitution, **Un: Un**saturated, **A: A**ddition

- **Homologous series of alkanes:** General formula: C_nH_{2n+2}, where n = number of carbon atoms. CH_4, C_2H_6, C_3H_8.
- **Homologous series of alkenes:** General formula: C_nH_{2n}, where n = number of carbon atoms. C_2H_4, C_3H_6, C_4H_8.
- **Homologous series of alkynes:** General formula: C_nH_{2n-2}, where n = number of carbon atoms. C_2H_2, C_3H_4, C_4H_6.
- **Chemical Properties of carbon compounds**

(a) Combustion: Carbon compounds burn in air to give carbon dioxide, water, heat and light.

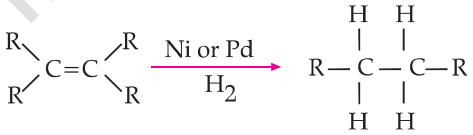
$$CH_4 + 2O_2 \xrightarrow{\text{Combustion}} CO_2 + 2H_2O + \text{Heat} + \text{Light}$$

- Carbon and its compounds are used as fuels because they burn in air releasing lot of heat energy.
- Saturated hydrocarbon generally burn in air with blue and non-sooty flame.
- Unsaturated hydrocarbon burns in air with yellow sooty flame because percentage of carbon is higher than saturated hydrocarbon which does not get completely oxidized in air.

(b) Oxidation: Alcohols can be converted into carboxylic acid in the presence of oxidizing agent like alkaline $KMnO_4$ (potassium permanganate) or acidic potassium dichromate $K_2Cr_2O_7$.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{Acidic } K_2Cr_2O_7]{\text{Alkaline } KMnO_4 \text{ Or}} \underset{\text{Ethanoic acid}}{CH_3COOH}$$

(c) Addition Reaction: Unsaturated hydrocarbons (alkene, alkyne) undergo addition reactions.



In unsaturated hydrocarbon, hydrogen added in the presence of catalyst palladium or nickel. Vegetable oils are converted into vegetable ghee using this process. It is also called hydrogenation of vegetable oils.

(d) Substitution Reaction: Saturated hydrocarbons undergo substitution reaction in the presence of sunlight.

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

Topic-2 Ethanol, Ethanoic acid, Soaps and Detergents

Concepts Covered • ***Properties and uses of ethanol and ethanoic acid,*** • ***Soap and Detergents.***

Revision Notes

- **Ethanol:** Ethanol is commonly known as alcohol. It is the second member of the alcohol series. The molecular formula of ethanol is C_2H_5OH.
  - **Chemical Properties:**

(i) Reaction with sodium: Formation of sodium ethoxide and hydrogen.

$$2CH_3CH_2OH + 2Na \rightarrow 2CH_3CH_2ONa + H_2$$

(ii) Reaction with acid: Formation of ester (ethyl ethanoate) – a sweet smelling ester. This process is called esterification.

$$CH_3COOH + C_2H_5OH \underset{}{\overset{\text{conc.}H_2SO_4}{\rightleftharpoons}} CH_3COOCH_2CH_3 + H_2O$$

- **Uses:** In preparation of soap, cosmetics, in alcoholic beverages, in medicines, in laboratory reagent.

▶ **Ethanoic acid:** The common name of ethanoic acid is acetic acid and it belongs to the group of acids called carboxylic acid. It is the second member of the series. The molecular formula of the compound is CH_3COOH.

- Vinegar — 5-8 % solution of acetic acid in water.
- Glacial acetic acid — Pure acetic acid
- **Chemical Properties of ethanoic acid**

(i) Reaction with sodium carbonate:

$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$

(ii) Reaction with sodium hydrogen carbonate:

$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$

Brisk effervescence marks the presence of carbon dioxide.

(iii) Reaction with NaOH:

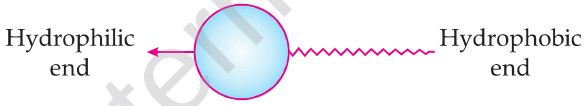
$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

(iv) Reaction with ethanol (Esterification):

$$CH_3COOH + CH_3CH_2OH \underset{}{\overset{\text{conc.}H_2SO_4}{\rightleftharpoons}} CH_3COOC_2H_5 + H_2O$$

▶ **Soap and detergents**

- Soap is sodium or potassium salt of long chain carboxylic acid. e.g., $C_{17}H_{35}COONa^+$
- On hydrolysis, **ester** gives parent alcohol and sodium salt of carboxylic acid. Alkaline hydrolysis of ester is called saponification.
- Soaps are effective only in soft water.
- Detergents are ammonium or sulphonate salt of long chain of carboxylic acid.
- Detergents are effective in both hard and soft water.
- Soap molecule has:
  (i) Ionic (hydrophilic) part
  (ii) Long hydrocarbon chain (hydrophobic) part



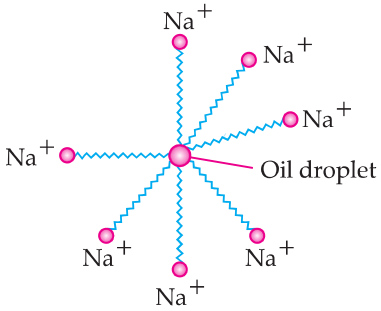
Structure of soap molecule

Key Word

Ester: Esters is generally sweet-smelling substances and is produced as a result of the reaction of an acid such as ethanoic acid and an alcohol such as ethanol in the presence of an acid catalyst. It is used in making perfumes and as flavouring agents.

▶ **Cleansing Action of Soap:** Most dirt is oily in nature. The hydrophobic end of soap molecule attaches itself with dirt and the ionic end is surrounded with molecule of water. This result in formation of a radial structure called micelles.

- Soap micelles helps to dissolve dirt and grease in water and cloth gets cleaned.



- The magnesium and calcium salt present in hard water reacts with soap molecule to form insoluble product called scum. This scum create difficulty in cleansing action.
- By use of detergent, insoluble scum is not formed with hard water and clothes get cleaned effectively.