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

- 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 :

- $2CO(g)$ (Carbon monoxide) + $O_2(g)$ (Oxygen) $\longrightarrow$ $2CO_2(g)$ (Carbon dioxide)
- $ZnCO_3 \xrightarrow{Heat} ZnO + CO_2$
- $2FeSO_4(s) + \longrightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$
- $Pb(NO_3)_2$ (Lead nitrate) + $2KI$ (Potassium iodide) $\longrightarrow$ $2KNO_3$ (Potassium nitrate) + PbI_2 (Lead Iodide)
- $CaO(s)$ (Quick lime) + H_2O $\longrightarrow$ $Ca(OH)_2$ (Slaked lime) + Heat
- $NaCl$ (Sodium chloride) + $AgNO_3$ (Silver nitrate) $\longrightarrow$ $AgCl$ (Silver chloride) + $NaNO_3$ (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.