CHAPTER 1: CHEMICAL REACTIONS AND EQUATIONS

Introduction

In our daily life many changes happen around us. Some changes only change the appearance of a substance, while some changes form a completely new substance. When a new substance is formed, the process is called a **chemical reaction**.

Examples from daily life:

- Milk turning sour when left outside in summer
- Iron objects rusting in moist air
- Grapes getting fermented
- Cooking of food
- Digestion of food in our body
- Respiration

In all these cases the **original substance changes into a new substance**, which means a chemical reaction has taken place.

Chemical Reactions

A **chemical reaction** is a process in which one or more substances called **reactants** change into new substances called **products** with different properties.

General form:

$$Reactants \rightarrow Products$$

Example:

1. $2H_2 + O_2 \rightarrow 2H_2O$

   Here:

   - **Hydrogen (H□)** and **Oxygen (O□)** = Reactants
   - **Water (H□O)** = Product

2. Mg + O_2 → MgO Magnesium + Oxygen → Magnesium Oxide
   When **magnesium ribbon is burned in air**, it burns with a

bright white flame and forms a white powder called **magnesium oxide**.

This shows that magnesium reacts with oxygen present in the air to form a new substance.

Characteristics of Chemical Reactions

When a chemical reaction occurs, one or more of these changes may be observed:

1. Change in Colour

A substance may change its colour during the reaction.

Example:

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

The **blue solution of copper sulphate turns green** due to formation of ferrous sulphate.

2. Change in Temperature

Chemical reactions may involve the **release or absorption of heat energy**.

Exothermic Reaction:
A reaction in which heat is released is called an exothermic reaction.

Example:

$C + O_2 \rightarrow CO_2 + Heat$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Heat$

Endothermic Reaction:
A reaction in which heat is absorbed is called an endothermic reaction.

Example:

$CaCO_3 + Heat \rightarrow CaO + CO_2$

$N_2 + O_2 + Heat \rightarrow 2NO$

3. Evolution of Gas

Some reactions produce gases which can be identified by bubbles or smell.

Example:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow \text{ Hydrogen}$$

gas is evolved.

4. Formation of Precipitate

A **precipitate** is an insoluble solid formed during a reaction in solution.

Example:

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

A **white precipitate of silver chloride** is formed.

5. Change in Physical State

Reactants may change from one physical state to another during the reaction.

Example:

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

Chemical Equations

A **chemical equation** is the symbolic representation of a chemical reaction using the **chemical formulas of reactants and products**.

Reactants → Substances that take part in a reaction Products
→ Substances formed after the reaction

Reactants are written on the **left side** and products on the **right side**.

Example:

Hydrogen + Oxygen → Water

$H_2 + O_2 \rightarrow H_2O$

- **Word Equation**

  A chemical reaction written in words.
  Magnesium + Oxygen → Magnesium Oxide

- **Skeletal Chemical Equation**

  Unbalanced chemical equation.
  $Mg + O_2 \rightarrow MgO$

Balanced Chemical Equation

According to the **Law of Conservation of Mass**, mass can neither be created nor destroyed in a chemical reaction.

This means the **number of atoms of each element must be the same on both sides** of the equation.

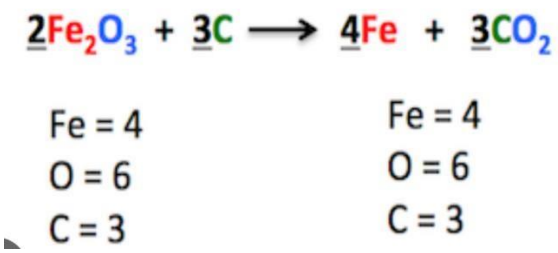
Example:

Unbalanced equation:

$Fe_2O_3 + C \rightarrow Fe + CO_2$

Balanced equation:

$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$



Here the number of atoms of Fe, H, and O are equal on both sides. Therefore it is a **balanced chemical equation**.

Steps to Balance a Chemical Equation

$Fe + H_2O \rightarrow Fe3O_4 + H_2$

Step 1: **Count atoms:** List atoms for reactants and products

Reactants	Products
Fe = 1	Fe = 3
H = 2	H = 2
O = 1	O = 4

Step 2: **Use Coefficients:** Balance the largest molecule first (usually Oxygen or Metal).

$Fe + 4H_2O \rightarrow Fe3O_4 + H_2$

Reactants	Products
Fe = 1	Fe = 3
H = 8	H = 2
O = 1	O = 4

Step 3: **Balance other atoms:** Adjust coefficients for hydrogen and iron.

$3Fe + 4H_2O \rightarrow Fe3O_4 + 4H_2$

Reactants	Products
Fe = 3	Fe = 3

H = 8	H = 8
O = 4	O = 4

Step 4: **Verify:** Ensure atoms are equal.

Physical States in Chemical Equations

To make equations more informative, physical states are written along with the formulas.

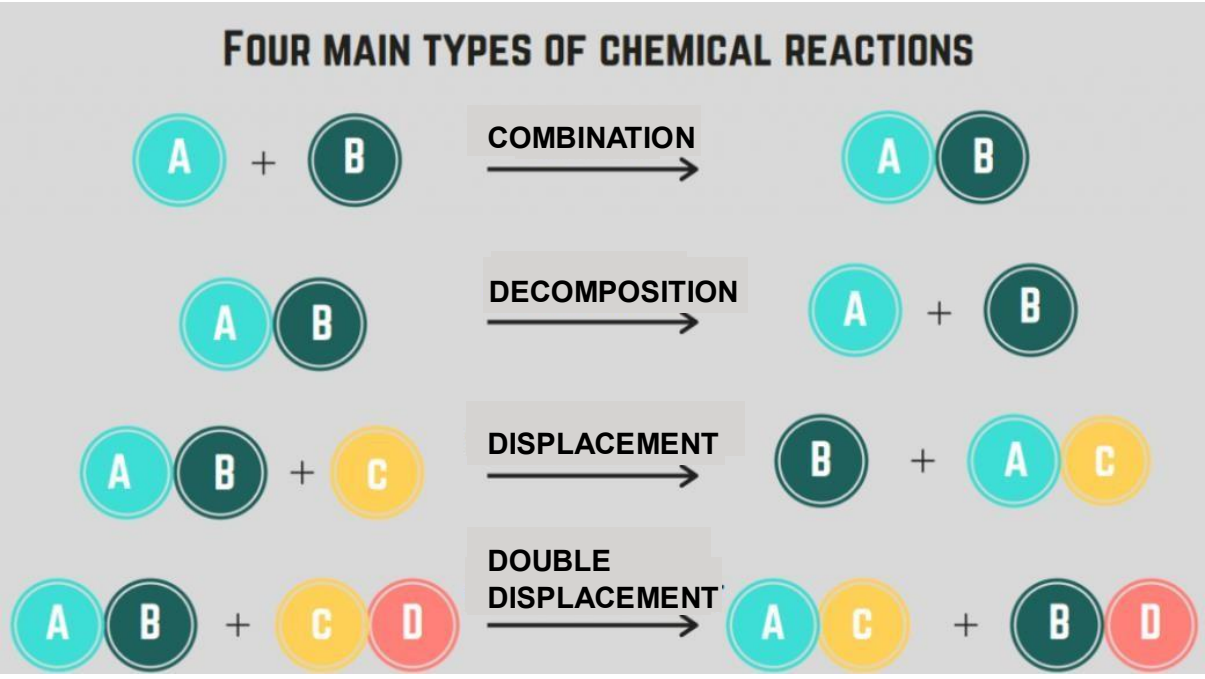
Symbols used:

- (s) → Solid
- (l) → Liquid
- (g) → Gas
- (aq) → Aqueous solution (dissolved in water)

Example:-

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

Types of Chemical Reactions



Combination Reaction

A reaction in which two or more substances combine to form a single product is called a **combination reaction**.

Example:

$$\underset{\text{(Quick lime)}}{CaO(s)} + H_2O(l) \rightarrow \underset{\text{(Slaked lime)}}{Ca(OH)_2(aq)} + \text{Heat}$$

Calcium oxide reacts vigorously with water to produce slaked lime (calcium hydroxide) releasing a large amount of heat.

This reaction releases heat and is therefore an **exothermic reaction**.

Other examples of combination reaction :-

1. Burning of coal $C(s) + O_2(g) \rightarrow CO_2(g)$

2. Formation of water from $H_2(g)$ and $O_2(g)$
   $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

3. Burning of natural gas

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

Decomposition Reaction

A reaction in which **one substance breaks down into two or more simpler substances** is called a decomposition reaction.

Example:

$$\underset{\text{(Ferrous sulphate)}}{2FeSO_4(s)} \xrightarrow{\text{Heat}} \underset{\text{(Ferric oxide)}}{Fe_2O_3(s)} + SO_2(g) + SO_3(g)$$

Decomposition reactions require **energy** such as heat, light or electricity.

Types of decomposition reactions:

- Thermal decomposition (heat)

  $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

- Electrolytic decomposition (electricity)

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

- Photolytic decomposition (light)

  $2AgCl \rightarrow 2Ag + Cl_2$ (in sunlight)

You will see that white silver chloride turns grey in sunlight. This is due to the decomposition of silver chloride into silver and chlorine by light

Displacement Reaction

A reaction in which a more reactive element replaces a less reactive element from its compound is called a **displacement reaction**.

Example:

$$\underset{\text{(Copper sulphate)}}{Fe(s) + CuSO_4(aq)} \rightarrow \underset{\text{(Iron sulphate)}}{FeSO_4(aq)} + Cu(s)$$

Here iron displaces copper from copper sulphate.

Other examples:

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

$Pb + CuCl_2 \rightarrow PbCl_2 + Cu$

Zinc and lead are more reactive elements than copper. They displace copper from its compounds.

Double Displacement Reaction

A reaction in which **two compounds exchange their ions to form new compounds** is called a double displacement reaction.

Example:

$$\underset{\text{(Sodium sulphate)}}{Na_2SO_4(aq)} + \underset{\text{(Barium chloride)}}{BaCl_2(aq)} \rightarrow \underset{\text{(Barium sulphate)}}{BaSO_4(s)} + \underset{\text{(Sodium chloride)}}{2NaCl(aq)}$$

Here a **white precipitate of barium sulphate** is formed.

The reaction in which precipitate is formed by the mixing of the aqueous solution of two salts is called **precipitation reactions**.

Neutralization Reaction: The reaction in which an acid reacts with a base to form salt and water by an exchange of ions is called **Neutralization Reaction**.

$HCl + NaOH \rightarrow NaCl + H_2O$

Oxidation and Reduction

Oxidation

Addition of oxygen or removal of hydrogen.

Example:

$2Cu + O_2 \rightarrow 2CuO$

Copper gains oxygen and becomes copper oxide.

Reduction

Removal of oxygen or addition of hydrogen.

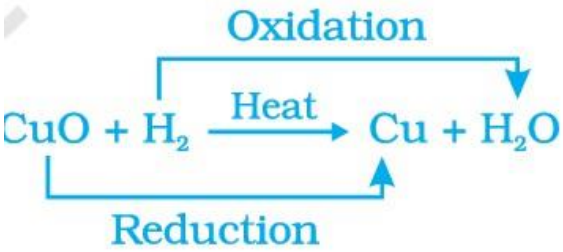
Example:

$CuO + H_2 \rightarrow Cu + H_2O$

Copper oxide loses oxygen and becomes copper.

Redox Reaction

When oxidation and reduction occur together in a reaction, it is called a **Redox Reaction**.



Some other examples of Redox Reactions:

1. **$ZnO + C \rightarrow Zn + CO$**

In this reaction, ZnO is reduced to Zn and carbon is oxidised to CO.

2. **$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$**

In this reaction, HCl is oxidised to Cl□ and MnO□ is reduced to MnCl□.

Effects of Oxidation in Everyday Life

Corrosion is the slow destruction of metal**s** when they react with moisture, air, or chemicals.

Example:

- Rusting of iron
- Black coating on silver
- Green coating on copper

Rusting causes damage to structures like bridges, vehicles, and buildings.

Rancidity is the process in which fats and oils get oxidised on exposure to air, causing the food to develop an unpleasant smell and taste.

Example:
Spoiled chips or oily food.

Prevention methods:

- Store food in airtight containers
- Refrigeration
- Adding antioxidants