Chemical Reactions

Chemical reaction and its types

1. Chemical reaction is a process in which a chemical substance gets converted into another substance with new and changed properties.

2. Chemical reactions are of two types:

(i) Simple chemical reaction: Usually occurs in one step and can be explained in detail. For example: Burning of fuel

(ii) Complex chemical reaction: Usually occurs in multiple steps and cannot be explained in detail. For example: Biochemical reactions

3. Chemical reactions are responsible for the formation of new substances that are very important in our lives.

4. A chemical reaction occurs because unstable atoms tend to attain maximum stability by completing their octet or achieving noble gas electronic configuration.

Valence electrons

1. The electrons which take part in a chemical reaction are called valence electrons.

2. Valence electrons may be present in the last orbit or in the penultimate orbit.

3. Valence electrons may be gained orlost or can be shared between two or more atoms during chemical reactions.

4. When atoms acquire noble gas configuration, they become stable and do not react further at ordinary conditions.

A chemical reaction can be characterised by:

1. Evolution of gas
2. Change of colour
3. Change of state
4. Formation of precipitate

- **Catalysis** is the process in which the rate of a chemical reaction is either increased or decreased by a chemical substance known as a **catalyst**.
  Negative catalyst or inhibitor is a substance that slows down the rate of reaction. It retards the efficiency of a catalyst.

- Photochemical reactions are the reactions that proceed with absorption of light energy. Example-**Photosynthesis**
- **Some chemical reactions proceed only when the reactant molecules are brought together in close contact with each other. The intimate contact can be brought by**

1. **grinding the reactants together**
2. dissolving the reactants in water

- Certain chemical reactions proceed only when an electric current is passed through reactants in fused state or in aqueous solution.
  Example: Acidulated water decomposes into hydrogen and oxygen only when electric current is passed.
- Certain chemical reactions proceed only when reactants are heated together while certain chemical reactions proceed when reactants are exposed to sunlight or diffused sunlight or when reactants are subjected to a pressure higher than atmospheric pressure.

- Catalysis is the process in which the rate of a chemical reaction is either increased or decreased by a chemical substance known as a catalyst.
- Catalytic reactions can be represented as:

$$\text{Reactants} \xrightarrow{\text{catalyst}} \text{Products}$$

- Enzymes also acts as a catalyst in living beings as they accelerate a biochemical reaction without gettinh consumed in it.

Types of reactions

- **Combination reaction**
  - Two or more reactants combine to form one single product.
  - **Examples**

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

CaO s + H2O l → Ca(OH)2 aqCalcium oxide Water Calcium hy

Calcium oxide Water Calcium hydroxide

(Quick lime) (Slaked lime)

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

Carbon Oxygen Carbon dioxide

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

Hydrogen Oxygen Water

(Quick lime) (Slaked lime) C s + O2 g → CO2 gCarbon Oxygen Carbon dioxide 2H2 g + O2 g → 2H2O lHydrogen

- **Exothermic reaction** – Heat gets released in the reaction. Most combination reactions are exothermic. For example,

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

Calcium oxide Water Calcium hydroxide

(Quick lime) (Slaked lime)

- **Endothermic reaction** – Heat is absorbed in the reaction. Very few combination reactions are endothermic. For example,

$$\frac{1}{2}N_2\ (g) + O_2\ (g) \rightarrow NO_2\ (g)$$ 12N2 g + O2 g → NO2 g

- **Decomposition reaction**
  - A single reactant breaks into several simple products.
  - **Examples**

$$\underset{\text{Ferrous sulphate}}{2\,FeSO_4} \xrightarrow{\Delta} \underset{\text{Ferric oxide}}{Fe_2O_3} + SO_2 + SO_3$$ 2FeSO4 Ferrous sulphate$\rightarrow$ Δ Fe2O3Ferric oxide+SO2 +SO3CaCO3Limestone $\rightarrow$ Δ CaOCa

$$\underset{\text{Limestone}}{CaCO_3} \xrightarrow{\Delta} \underset{\text{Calcium oxide}}{CaO} + CO_2$$

$$\underset{\text{Silver chloride}}{2\,AgCl} \xrightarrow{\Delta} 2\,Ag + Cl_2$$
Silver
2AgClSilver chloride$\rightarrow$ Δ 2AgSilver+Cl2

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  - All decomposition reactions are **endothermic [they absorb heat**].

- **Displacement reactions:**
  - In displacement reactions, a more reactive metal can displace a less reactive metal from their compounds in aqueous solutions. (However, a less reactive metal cannot displace a more reactive metal.)

Example:

$$CuSO_4 + Zn \rightarrow ZnSO_4 + Cu$$ CuSO4 + Zn $\rightarrow$ ZnSO4 + Cu Copper Sulphate Zinc Zi
Copper Sulphate Zinc Zinc Sulphate Copper
(Blue) (Colourless) (Red)
(Blue) (Colourless) (Red)

$$Fe\ (s) + CuSO_4\ (aq) \rightarrow Cu\ (s) + FeSO_4\ (aq)$$ Fe s + CuSO4 aq $\rightarrow$ Cu s + FeSO4 aqIron Copper sulphate Copper Iron sulph
Iron Copper sulphate Copper Iron sulphate

- **Double displacement reaction**
  - Exchange of ions occurs between two compounds.
  - Example

Na_2SO_4 (aq) + $BaCl_2$ (s) → $BaSO_4$ (aq) + 2 NaCl (s) Na2SO4 aq + BaCl2 s → BaSO4 aq + 2NaCl s

Sodium sulphate Barium chloride Barium sulphate Sodium chloride
Sodium sulphate Barium chloride Barium sulphate Sodium chloride

- When the aqueous solution of two compounds react by exchanging their respective ions, such that one of the products formed is insoluble salt and appears in the form of a precipitate, then the reaction is said to be **precipitation reaction**.
- When an acid solution reacts with a base and the two exchange their respective ions, such that only salt and water are products, then the reaction is called **neutralisation reaction**.
- When two compounds react with each other and displace their ions, in such a manner that one of the product formed either decomposes into gaseous compounds or is formed in gaseous state, then the reaction is called **gas-forming reaction**.

- Chemicals that are used to check acidic or basic nature of substances are called **indicators**. One of the most commonly used indicators is litmus solution (a natural indicator). Acids turn blue litmus paper to red and bases turn red litmus paper to blue.

- Turmeric paste and China rose are also natural indicators. China rose indicator becomes dark pink when an acidic substance is added to it and turns to green when a basic substance is added to it. Turmeric paste remains yellow in acidic solutions but turns to red in basic solutions.

- Substances that are neither acidic nor basic in nature are called neutral substances. Neutral substances do not affect the colour of indicators.

- Ant sting contains formic acid. The effect of this acid is neutralised by rubbing moist baking soda (sodium hydrogen carbonate) or calamine solution that contains zinc carbonate.

- Milk of Magnesia (magnesium hydroxide) is an antacid used to neutralise the effect of excess of acid produced in our stomach.

- **Chemical properties:**

Metals	Non-metals
These react with oxygen to produce metal oxides, which are basic in nature.	These react with oxygen to form non-metallic oxides, which are acidic in nature.

Chemical properties

- **Reaction with oxygen**
- **Combine with oxygen to form oxides**
- $2Cu + O_2 \rightarrow 2CuO$

- $4Al + 3O_2 \rightarrow 2Al_2O_3$
- Most metal oxides are insoluble in water.
- If soluble, they form alkali.
- $Na_2O + H_2O \rightarrow 2NaOH$
  $K_2O + H_2O \rightarrow 2KOH$

- Sodium, potassium react very easily with O_2. So, they are kept immersed in kerosene.
- Mg, Al, Zn, Pb form thin layers of oxides.
- **Reaction with water**
- Produce metal oxide + H_2
- If oxide is soluble, then metal hydroxide is formed.

$2K + 2H_2O \longrightarrow 2KOH + H_2$ } That's why they are not put in water

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$ } Violent reactions

$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$ (Less violent)

Mg → Doesn't react with cold H_2O

- Al, Zn, Fe do not react with H_2O, but react with steam.

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

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

- **Chemical properties:**

Metals	Non-metals
These react with acids to produce metal salts and hydrogen gas.	These do not react with acids.
Some metals react with bases to produce hydrogen gas.	Reactions of non-metals with bases are complex.

Reaction with Acids

- Metal + Dilute acid → Metal salt + H_2
- H_2 doesn't evolve in the case of HNO_3 as it is a strong oxidising agent. It oxidises H_2.
- Cu does not react with acids like dilute H_2SO_4 and dilute HCl.
- **Aqua regia**
  - Freshly-prepared concentrated HCl and concentrated HNO_3 in 3:1 ratio

    - It can dissolve gold and platinum.

Reaction with Bases

- Metals react with bases to produce hydrogen gas.
- Reactions of non-metals with bases are complex.