Chemical Process

- Based on the direction of their occurrence Chemical reactions are two types.
- **Irreversible reactions:** in these reactions reactants are converted into products and products cannot be converted into reactants.
- There are unidirectional as they occur in one direction. i.e. Reactants → products.
- These are denoted by single arrow mark.
- These reactions almost go for completion i.e. reactants are almost completely convert into products.
- Precipitation – ionic reactions, explosive reactions, strong acid – strong base neutralisation reactions, combustion- reactions are irreversible.

  Eg :1) $2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$

  2) $NH_4NO_{2(s)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$

  3) $C_2H_5OH_{(l)} \rightarrow 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$

  4) $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

  5) $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

  6) $H_{2(g)} + F_{2(g)} \rightarrow 2HF_{(g)}$

  7) $H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$

Reversible reactions :

- A reaction is said to be reversible, if both the forward and the backward reactions are taking place simultaneously under the given experimental conditions.
- Reactants giving rise to products is known as forward reaction.
- Products giving rise to reactants is known as reverse reaction (or) backward reaction.
- Reversible reactions are represented by writing a pair of half headed – arrows pointing in opposite directions in between the reactants and products.

  Reactants $\rightleftharpoons$ products
- A reverse reaction does not go to completion.
- Most of the reversible reactions are carried in the closed vessels.

  Eg : 1) $H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$

  2) $PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$

  3) $2NO_{2(g)} \Leftrightarrow N_2O_{4(g)}^{-}$

  4) $N_{2(g)} + O_{2(g)} \Leftrightarrow 2NO_{(g)}$

  5) $2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_{3(g)}$

  6) $CaCO_{3(s)} \Leftrightarrow CaO_{(s)} + CO_{2(g)}$

  7) $CH_3COOH_{(l)} + C_2H_5OH_{(l)} \Leftrightarrow CH_3COOC_2H_{5(l)}\ H_2O_{(l)}$

Equilibrium State :

- The stage or state at which the rate of forward reaction is equal to the rate of the reverse reaction in a reversible reaction is known as the equilibrium stage or state.
- The chemical equilibrium is considered as dynamic equilibrium because the forward and the reverse reactions continue to take place simultaneously at this stage also.
- Equilibrium is established in

i) a reversible reaction ii) in a closed vessel

- In the beginning in a reversible reaction the rate of forward reaction is more since the concentration of reactants is more.
- As time proceeds the rate of forward reaction decreases as the concentrations of reactants decreases.
- In the beginning in a reversible reaction the rate of backward reaction is absolutely zero because the concentration of products is zero.
- AS time proceeds the rate of backward reaction increases since the concentrations of products also increases.
- At one stage the rate of forward reaction becomes equal to rate of backward reaction and no further change occurs in the concentration of reactions or products.
- At equilibrium, the concentration of reactants and products may not be equal but they remain constant.

Characteristics of chemical equilibrium :

- The rate of the forward reaction is equal to the rate of the reverse reaction.
- The concentrations of the reactants and the products remain unchanged with time.
- The observable properties such as pressure, concentration, density, colour also remain unchanged with time.
- The attainment of chemical equilibrium can be recognised by the constancy in some macroscopic potteries like pressure, concentration, density, color etc.
- The equilibrium is dynamic in nature. Both the forward reaction and the reverse reaction continue to take place simultaneously with equal rates.
- A catalyst does not alter the state of equilibrium or the composition of the chemical substances of the reaction at the equilibrium. It only speeds up the attainment of the equilibrium.
- Chemical equilibrium can be established from either side of the reversible reaction.
- Chemical equilibrium can be homogeneous or heterogeneous and also ionic or molecular.
- The factors such as pressure, concentration temperature presence of inert gas influence the position of the equilibrium.
- At equilibrium, the value of Gibbs free energy change (□G) is zero (□G = 0).
- At equilibrium, □S is maximum.
- The equilibrium does not tell us how long it takes for a reaction to attain equilibrium.
- Once equilibrium is reached, it continues forever until the conditions like pressure, temperature, concentration etc, are altered.
- At equilibrium the concentration of reactants may be equal or less or more than the concentration of products.