6. EQUILLIBRIUM

Definition

Chemical reaction reach a state of dynamic equilibrium in which the rate of forward reaction and backward reaction are same and there is no net change in composition.

Physical Equilibrium

Equilibrium set up in a physical process like evaporation of water etc.

(s) ⇆ (l)

(l) ⇆ (g)

(s) ⇆ (g)

Chemical Equilibrium

Equilibrium attained in a chemical reaction

$3H_2 + N_2 \leftrightarrows 2NH_3$

- Possible only in a closed system.
- Both reaction occur at same rate
- All measurable property remains constant

Homogeneous

Reactant and product are in same phase.

Example: $N_{2(g)} + 3H_{2(g)} \leftrightarrows 2NH_{3(g)}$

Hetrogeneous

Reactant and product are in different phase.

Example: $CaCO_{3(s)} + 3H_{2(g)} \leftrightarrows CaO_{(s)} + CO_{2(g)}$

Law of chemical Equilibrium /Equilibrium Law

$aA + bB \leftrightarrows cC + dD$

$$K_c = \frac{[C]^C\ [D]^d}{[A]^a\ [B]^b}$$

Here Kc is equilibrium constant

Direction of reaction

$Q_c > K_c$

Reaction goes from left to right

$Q_c < K_c$

Reaction goes from right to left

$Q_c = K_c$

No net reaction occurs

Relation between equilibrium constant K_p and K_c

$K_p = K_c(RT)^{\Delta ng}$

Factor's affecting Chemical Equilibrium

- Le Chatlier's Principle
- Effect of concentration: change in concentration →, equilibrium shift forward/backward.
- Effect of pressure: change in equilibrium will shift in the direction having smaller number of moles.
- Effect of temperature
  For exothermic → low temperature favours formation of reactants.
  For Endothermic → High temperature favours formation of products.
- Effect of inert gas → No change
- Effect of catalyst → No change

Acids and Base

Acids: Liberates H_2 on reacting with metals
Turns blue litumus into red
Base: Taste bitter and feel soapy
Turns red litmus into blue

Acidic $\Rightarrow [H_3O^+] > [OH^-]$

Basic $\Rightarrow [H_3O^+] < [OH^-]$

Neutral $\Rightarrow [H_3O^+] = [OH^-]$

Ionic product of water

$2H_2O \leftrightarrows H_3O^+ + OH^-$

$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}\ M^2$

$[OH^-] = [H^+] = 10^{-7}$ M at 298 K

$pK_w = pK_a + pK_b = 7 + 7 = 14$

pH Concept

pH = -log[H⁺]
pH = -log[H₃O⁺]

Ionic Equilibrium

Ostwald's Dilution Law

Applicable for weak electrolytes

$$\therefore K_c = C\alpha^2 \text{ or } \alpha = \sqrt{\frac{K_c}{C}}$$

$$\text{So, } \alpha = \frac{1}{\sqrt{c}} \text{ or } \alpha \sqrt{v}$$

Where V is the volume of solution at infinite dilution

Hydrolysis of salts

Salts of strong base and strong acid does not undergo hydrolysis. eg. NaCl, KCl
Salt of weak base and Strong Acid

$$K_h = \frac{k_w}{K_b}; P^H = \frac{1}{2}[pK_a - pK_b - \log c]$$

Salt of weak Acid and weak base

$$K_h = \frac{K_w}{K_a \times K_b}; p^H = \frac{1}{2}[pK_w - pK_a - pK_b]$$

Solubility Product (Ksp)

$aA \leftrightarrows cC + dD$

$K_{sp} = [C]^c[D]^d$