

CONCEPT MAP

EQUILIBRIUM

Get well-prepared for exams with quick revision of important concepts and formulae of equilibrium.

Class XI

CHEMICAL EQUILIBRIUM

Law of Chemical Equilibrium

For the reaction, $aA_{(aq)} + bB_{(aq)} \rightleftharpoons xX_{(aq)} + yY_{(aq)}$

$$K_c = \frac{[X]^x [Y]^y}{[A]^a [B]^b}$$

K_c = equilibrium constant in terms of molar concentration

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

K_p = Equilibrium constant in terms of pressure.

$$K_p = K_x (P)^{\Delta n_g}$$

K_x = Equilibrium constant in terms of mole fraction.

Relation between different equilibrium constants (K)

Applications of Equilibrium Constant

- Predicting the extent of a reaction :
 - $K_c > 10^3$ [Forward reaction is favoured.]
 - $K_c < 10^{-3}$ [Backward reaction is favoured.]
 - $10^{-3} < K_c < 10^3$ [Both reactants and products are present in equilibrium.]
- Predicting the direction of a reaction :
 - $Q_c < K_c$ [Backward reaction is favoured.]
 - $Q_c > K_c$ [Forward reaction is favoured.]
 - $Q_c = K_c$ [Reaction is in equilibrium.]

Relation between ΔG° and K

- At equilibrium, $\Delta G^\circ = -RT \ln K$; $K = e^{-\Delta G^\circ/RT}$
 - If $\Delta G^\circ < 0$ then $K > 1$ [Forward reaction is favoured.]
 - If $\Delta G^\circ > 0$ then $K < 1$ [Backward reaction is favoured.]
 - If $\Delta G^\circ = 0$, $K = 1$ [Reaction is in equilibrium.]

For weak acid; $\text{pH} = \frac{1}{2} (\text{p}K_a - \log C)$

For weak base; $\text{pOH} = \frac{1}{2} (\text{p}K_b - \log C)$, $\text{pH} = 14 - \text{pOH}$

For mixture of two weak acids; $[\text{H}^+] = \sqrt{K_{a1} C_1 + K_{a2} C_2}$

For mixture of two weak bases; $[\text{OH}^-] = \sqrt{K_{b1} C_1 + K_{b2} C_2}$

IONIC EQUILIBRIUM

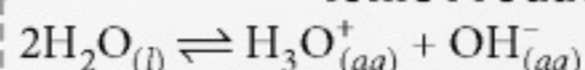
Ostwald's Dilution Law

Applicable for weak electrolytes

$$\therefore K_c = C\alpha^2 \text{ or } \alpha = \sqrt{\left(\frac{K_c}{C}\right)}$$

So $\alpha \propto \frac{1}{\sqrt{C}}$ or $\alpha \propto \sqrt{V}$ where, V is the volume of solution at infinite dilution.

Ionic Product of Water



$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ M}^2$$

$$\therefore [\text{OH}^-] = [\text{H}^+] = 1.0 \times 10^{-7} \text{ M at } 298 \text{ K}$$

$$\text{p}K_w = \text{p}K_a + \text{p}K_b = 14$$

Hydrolysis of Salts

It is a process in which a salt reacts with water to give acid and base.

- **Salt of Strong Base and Strong Acid** : Neutral solution and does not undergo hydrolysis. *e.g.*, NaCl, KCl.
- **Salt of Weak Base and Strong Acid** :

$$K_h = \frac{K_w}{K_b}; \text{pH} = \frac{1}{2} [\text{p}K_w - \text{p}K_b - \log C]$$
e.g., NH_4Cl , CuSO_4
- **Salt of Strong Base and Weak Acid** :

$$K_h = \frac{K_w}{K_a}; \text{pH} = \frac{1}{2} [\text{p}K_w + \text{p}K_a + \log C]$$
e.g., CH_3COONa , Na_3PO_4
- **Salt of Weak Acid and Weak Base** :

$$K_h = \frac{K_w}{K_a \times K_b}; \text{pH} = \frac{1}{2} [\text{p}K_w + \text{p}K_a - \text{p}K_b]$$
e.g., $\text{CH}_3\text{COONH}_4$, AlPO_4

pH Concept

$$\text{pH} = -\log[\text{H}^+]$$

$$\text{or } \text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$\text{or } [\text{H}^+] = 10^{-\text{pH}}$$