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 $\Delta G°$ and K

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

IONIC EQUILIBRIUM

Ostwald's Dilution Law

Applicable for weak electrolytes

$\therefore \; K_c = C\alpha^2$ 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

$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

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

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

$pK_w = pK_a + pK_b = 14$

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 :**
  $K_h = \frac{K_w}{K_b}; pH = \frac{1}{2}[pK_w - pK_b - \log C]$
  e.g., NH_4Cl, $CuSO_4$
- **Salt of Strong Base and Weak Acid :**
  $K_h = \frac{K_w}{K_a}; pH = \frac{1}{2}[pK_w + pK_a + \log C]$
  e.g., CH_3COONa, Na_3PO_4
- **Salt of Weak Acid and Weak Base :**
  $K_h = \frac{K_w}{K_a \times K_b}; pH = \frac{1}{2}[pK_w + pK_a - pK_b]$
  e.g., CH_3COONH_4, $AlPO_4$

pH Concept

$pH = -\log[H^+]$
or $pH = -\log[H_3O^+]$
or $[H^+] = 10^{-pH}$

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

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

For mixture of two weak acids; $[H^+] = \sqrt{K_{a_1}C_1 + K_{a_2}C_2}$

For mixture of two weak bases; $[OH^-] = \sqrt{K_{b_1}C_1 + K_{b_2}C_2}$