IONIC EQUILIBRIUM

Ionic equilibrium arises when there is a balance between unionized molecules and ions in a solution containing weak electrolytes. An illustrative example is the equilibrium represented by the equation:

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

During this equilibrium, both reactants and products coexist, ensuring that the conversion of reactants to products is always below 100%. Equilibrium reactions encompass the decomposition of covalent (non-polar) reactants or the ionization of ionic compounds into their ions within polar solvents.
This section delves into the exploration of ionic equilibrium within ionic solutions.

Electrolyte

Electrolytes are materials that possess the capacity to conduct electricity, either when in a molten state or when dissolved in a solution.
Examples of electrolytes include HCl, NaCl, KCl, and CH_3COOH.

Arrhenius Theory of Electrolytic Dissociation

Upon dissolving an electrolyte in a solvent, it undergoes spontaneous dissociation into oppositely charged particles known as ions to a significant degree. This dissociation is exemplified by reactions such as:

$$AB \rightleftharpoons A^+ + B^- \text{ and } X_2Y \rightleftharpoons 2X + (Y^{-2}).$$

Key Observations:

1. The overall electrical neutrality of the electrolyte solution ensures that the total charge on cations equals the total charge on anions.
2. Electrolytic ionization or dissociation results in the generation of ions and unionized molecules within the solution.

Degree of Dissociation

The degree of dissociation (α) represents the proportion of one mole of the electrolyte that has undergone dissociation under specific conditions. The magnitude of α is contingent upon factors such as temperature, the dilution level of the electrolyte, and the characteristics of both the electrolyte and the solvent.

It is mathematically expressed as: $\alpha = \frac{\text{No. moles ionized}}{\text{Total no.Moles}}$.

Ostwald's Law of Dilution

Ostwald's Law of Dilution pertains to the practical application of the law of mass action. Consider a weak binary electrolyte denoted as AB, containing C moles in 1 liter. The equilibrium for the dissociation reaction $AB \rightleftharpoons A^+ + B^-$ is described by the following concentrations:

- Initial Concentration: C 0 0
- Concentration at equilibrium: $C(1-\alpha)$ $C\alpha$ $C\alpha$

The equilibrium constant (K_{eq}) for this reaction is expressed as:

$$K_{eq} = \frac{[A+][B-]}{[AB]} = \frac{C\alpha \cdot C\alpha}{C(1-\alpha)} = \frac{C\alpha^2}{(1-\alpha)}$$

This equation, $K_{eq} = \frac{C\alpha^2}{(1-\alpha)}$, is recognized as Ostwald's Dilution Law. Alternatively, it can be presented as $K_{eq} = \frac{\alpha^2}{V(1-\alpha)}$, where V is the volume of the solution in liters containing 1 mole of the electrolyte.

In instances where α has a very small value for a weak electrolyte, rendering it negligible in comparison with unity, the approximation $1-\alpha \approx 1$ holds.

Consequently, $K_{eq} = \alpha^2 C$, and $\alpha = \sqrt{\frac{K_{eq}}{C}}$

or $\alpha = \sqrt{Keq \times V}$ (as $\frac{1}{C} = V$).