IONIZATION CONSTANTS OF WEAK ACIDS AND WEAK BASES

Ostwald's Dilution Law

The dissociation of weak acids or weak bases in water is depicted as an equilibrium process. For instance, the dissociation of acetic acid (CH_3COOH) and ammonia (NH_3) in water can be represented as follows:

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

$$NH_3 + H_2O \rightleftharpoons NH_4^-(aq)$$

In general, for a weak acid HA, its dissociation in water is represented by the equilibrium:

$$HA + H_2O \rightleftharpoons A^-(aq) + H_3O^+(aq)$$

Applying the law of chemical equilibrium, the equilibrium constant (K) is expressed as:

$$K = \frac{[A^-][H_3O^+]}{[HA][H_2O]}$$

As the concentration of water ($[H_2O]$) is large and remains nearly constant, we can multiply both sides by $[H_2O]$ to obtain a new constant Ka, called the dissociation constant of the acid:

$$K_a = \frac{[A^-][H_3O^+]}{[HA]}$$

Given the value of K_a and the concentration (c) of the weak acid (HA), the concentration of H_3O^+ in the solution can be calculated using the equilibrium equation:

$$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

At equilibrium:

Initial concentration:	C	0	0
Concentration at equilibrium:	$(C-c\alpha)$	αc	αc

(where α is the degree of ionization).

The equation for Ka is derived as: $Ka = \frac{\alpha 2c2}{c(1-\alpha)}$

For a <<< 1, $K_a = a^2c$, and $\alpha = (\frac{K_a}{c})^{1\backslash 2}$ or $a = (K_a \times V)^{1/2}$

where V is the volume of the solution in liters containing 1 mole of the electrolyte, and $c = \frac{1}{V}$.

This relationship is known as Ostwald's dilution law.

Similarly, the dissociation of a weak base in water is represented by the equilibrium:

$$BOH \rightleftharpoons B^+(aq) + OH^-(aq)$$

The dissociation constant of the weak base, Kb, is given by:

$$K_b = \frac{[B+][OH\ \ ]}{[BOH]}$$

For a weak base, $Kp = \alpha^2c$, and the degree of ionization for the base (a) is calculated as:

$$\sqrt{\frac{K_b}{c}} \quad \text{or} \quad \left(\frac{K_b}{c}\right)^{1/2}$$

With $c_a = [OH^-]$.

This allows for the determination of the equilibrium concentration of species and the degree of ionization for both acids and bases, aiding in the calculation of the pH of the solution.