Summary of formulas and constants used in biochemistry

Constants

$$R = 0.008314\ kJ \cdot mol^{-1} \cdot K^{-1}$$
$$T\ in\ K = T\ in\ {}^{\circ}C + 273.15$$

Free energy

$$\Delta G = \Delta H - T\Delta S$$

Free energy and concentration:

$$aA + bB \rightleftarrows cC + dD$$
$$\Delta G = \Delta G^{\circ\prime} + RTln\left(\frac{[C]^c[D]^d}{[A]^a[B]^b}\right)$$
$$\Delta G^{\circ\prime} = -RTln\left(K_{eq}\right) = -RTln\left(\frac{[C]^c_{eq}[D]^d_{eq}}{[A]^a_{eq}[B]^b_{eq}}\right)$$

The standard state condition is defined as all products and reactants at 1 M, 25C, 1 atm pressure, pH 7.0.

Binding

For the reaction:

$$M + X \rightleftarrows M \cdot X$$
$$K_{eq} = K_{association} = K_a = \frac{[M \cdot X]}{[M][X]}$$

You can write this reaction as a dissociation reaction as well (generally preferred by biochemists)

$$M \cdot X \rightleftarrows M + X$$
$$K_{eq} = K_{dissociation} = K_D = \frac{[M][X]}{[M \cdot X]}$$

Written this way, K_D has units of concentration and thus measures the concentration at which the reaction will be 50% bound and 50% unbound.

$$\theta = \frac{[MX]}{[M] + [MX]} = \frac{1}{1 + K_D/[X]}$$

pH:

Note: K_a is an *acid* constant, and thus a K_D (dissociation constant).

$$M \cdot H \overset{K_a}{\rightleftarrows} M + H^+$$

$$K_a = \frac{[M][H^+]}{[M \cdot H]}$$

$$pH = -log_{10}\left([H^+]\right);\ pK_a = -log_{10}\left(K_a\right)$$

$$\theta = \frac{[M \cdot H]}{[M] + [M \cdot H]} = \frac{1}{1 + K_a/[H^+]} = \frac{1}{1 + 10^{(pH - pK_a)}}$$

Cooperative binding

For the cooperative binding reaction:

$$MX_n \rightleftarrows [M] + n[X]$$

$$\theta_n = \frac{[MX_n]}{[M] + \Sigma_{i=1}^{i=n}[MX_i]}$$

$$\theta = \frac{1}{1 + \left(\frac{K_D}{[X]}\right)^n}$$

where n is the number of cooperating sites.

Enzyme activity

For a reaction

$$aA + bB \rightleftarrows C$$

The rate of the forward reaction is given by:

$$d[C]/dt = k \times [A]^a \times [B]^b$$

Michaelis-Menten kinetics

$$E + S \rightleftarrows^{k_1}_{k_{-1}} ES \overset{k_{cat}}{\rightarrow} P$$

$$V_0 = \left(\frac{1}{1 + \frac{K_M}{[S]_0}}\right) k_{cat}[E]_{tot}$$

$$V_{max} = k_{cat}[E]_{tot}$$

$$K_M = \frac{k_{-1} + k_{cat}}{k_1}$$