

## Summary of formulas and constants used in biochemistry

### Constants

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

### Free energy

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

### Free energy and concentration:

$$aA + bB \rightleftharpoons cC + dD$$
$$\Delta G = \Delta G^{\circ'} + RT \ln \left( \frac{[C]^c [D]^d}{[A]^a [B]^b} \right)$$
$$\Delta G^{\circ'} = -RT \ln (K_{eq}) = -RT \ln \left( \frac{[C]_{eq}^c [D]_{eq}^d}{[A]_{eq}^a [B]_{eq}^b} \right)$$

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

### Binding

For the reaction:

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

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

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

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).

$$\begin{aligned}M \cdot H &\xrightleftharpoons{K_a} M + H^+ \\K_a &= \frac{[M][H^+]}{[M \cdot H]} \\pH &= -\log_{10}([H^+]); \quad pK_a = -\log_{10}(K_a) \\\theta &= \frac{[M \cdot H]}{[M] + [M \cdot H]} = \frac{1}{1 + K_a/[H^+]} = \frac{1}{1 + 10^{(pH - pK_a)}}\end{aligned}$$

## Cooperative binding

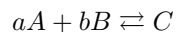
For the cooperative binding reaction:

$$\begin{aligned}MX_n &\rightleftharpoons [M] + n[X] \\\theta_n &= \frac{[MX_n]}{[M] + \sum_{i=1}^n [MX_i]} \\\theta &= \frac{1}{1 + \left(\frac{K_D}{[X]}\right)^n}\end{aligned}$$

where  $n$  is the number of cooperating sites.

## Enzyme activity

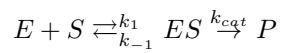
For a reaction



The rate of the forward reaction is given by:

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

### Michaelis-Menten kinetics



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

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

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