Key Concepts in Chemical Equilibria

Generic Equilibrium:

$$aA + bB \underset{k_{-1}}{\overset{k_1}{\rightleftarrows}} cC + dD$$

At equilibrium rate forward = rate reverse

$$k_1(\mathcal{A}_A)^a(\mathcal{A}_B)^b = k_{-1}(\mathcal{A}_C)^c(\mathcal{A}_D)^d$$

$\mathcal{A}_A$ = "activity" of compound (or element) A, $\mathcal{A}_A = \gamma_A[A]$ (for solutions). For unit activity coefficient:

$$k_1[A]^a[B]^b = k_{-1}[C]^c[D]^d$$

Rearranging:

$$K_{eq} = \frac{k_1}{k_{-1}} = \frac{[C]^c[D]^d}{[A]^a[B]^b} = \frac{[products]^x}{[reactants]^y}$$

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IMPORTANT!

1. In order for a system (reaction) to be at equilibrium, the K_{eq} expression MUST be satisfied!!!
2. If the K_{eq} exp. is satisfied, the system is in equilibrium!

Golden Rules of Equilibria:

1. K_{eq} is dimensionless and constant at a given temperature.
2. When writing equilibrium constant expressions, omit solids, pure liquids, and solvents.
3. Always use smallest integer coefficients when balancing equations and writing K_{eq}.
4. When a balanced reaction is reversed, $K_{reverse} = 1/K_{forward}$
5. When adding reactions, K_{eq} for the net reaction is the *product* of the K_{eq}'s for the individual reactions.
6. At equilibrium, the concentrations of reactants and products MUST satisfy the equilibrium constant expression!!

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Using K_{eq} to predict "direction" of reaction:

- When given a set of conditions (concentrations) ask:
  1. Is the system already in equilibrium?
  2. If yes, you're done! If no, what does the system need to do to reach equilibrium?

Le Chatelier's Principle:

- Start with system in equilibrium, what happens if we perturb equilibrium?

Autoprotolysis of water:

$$H_2O(1) + H_2O(1) \rightleftarrows H_3O^+(aq) + OH^-(aq)$$

$$K_w=[H_3O^+][OH^-] = 1.00x10^{-14}$$

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Key Concepts in Acid-Base Equilibria

Acid/Base Strength:

- "Strength" = measure of efficiency of production of H^+ (or OH^-), extent of dissociation.
- Know strong acids/bases assume everything else is weak! (H_2SO_4, HCl, HNO_3, $HClO_4$, NaOH, KOH, LiOH)

Solution acidity and pH:

- Because water is amphiprotic, "pure" water will contain a small amount of OH^- and H^+
- pH is a measure of “[H^+]”: pH = -log[H^+]
- K_a for an acid and K_b for its conjugate base are related!
- pH and pOH are related!
- ICE table approach to determining pH of weak acid/base solutions

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