Acids and Bases

Different Models

- Arrhenius: acids – produce H+ ions in solution
  bases – produce OH- ions in solution
- Bronsted-Lowry: acid – proton donor
  base – proton acceptor
  - Conjugate acid: remainder of acid molecule
  - Conjugate base: what is formed when proton is transferred to base
- Lewis: acid – e- pair acceptor
  base – e- pair donor

Dissociation Constants

Acids:

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

$K_a = [H_3O^+][A^-]/[HA]$

Bases:

$B(aq) + H_2O(l) \leftrightarrow BH^+(aq) + OH^-(aq)$

$K_b = [BH^+][OH^-]/[B]$

Acid Strength

- $HA(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + A^-(aq)$
- Strong acid – above equilibrium lies far to the right
- Strong acid -> weak conjugate base
- Weak acid – above equilibrium lies far to the left
- Weak acid -> strong conjugate base

Water: Acid & Base

- Amphoteric: can behave as either
- Autoionization: transfer of protons from one molecule to another of the same kind
  - $H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$
- Ion-product water:
  - $K_w = [H_3O^+][OH^-] = [H^+][OH^-]$
- @298K:
  - $K_w = 1.0 \times 10^{-14}$
  - in pure water: $[H^+] = [OH^-]$

The pH Scales

- pH = -log[H+]
- Note: The number of decimal places in the log is = to the number of sig. fig. in the original number.
- Ex: [H+] = 1.0 x 10^-9 M

  pH = 9.00

pH of Strong Acids

- Major species: solution components in large amounts
- 1.0 M HCl: major species – H^+, Cl^-, H_2O
- 1.0 M H^+ contributed by HCl
- H_2O produces a negligible amount of H^+

pH of Weak Acids & Weak Acid Mixtures

- Example

Percent Dissociation

- Percent dissociation =

amount dissociated/initial concentration x 100%

- Ex: 1.00 M HF yields $[H^+] = 2.7 \times 10^{-2}$ M

  % dissociation = $2.7\times10^{-2}/1.00 \times 100\% = 2.7\%$

- Percent dissociation increases as the acid becomes more dilute

Bases and their pH

- Basically the same as acids but with OH- ions
- B(aq) + H2O(l) <-> BH+(aq) + OH-(aq)
- Strong base: equilibrium lies far to the right
- Weak base: equilibrium lies far to the left

Summary for Solving Acid-Base Problems

1. List major species
2. Look for reactions that can be assumed to go to completion (e.g. strong acids)
3. For a reaction that can be assumed to go to completion:
   a) Determine concentration of products
   b) Write down major species after reaction
4. Look at each major component of the solution and decide if it's an acid or a base
5. Pick the equilibrium that will control the pH. Use known values of the dissociation constants for the various species to help decide on the dominant equilibrium.
   a) Write the equation for the reaction and the equilibrium expression.
   b) Compute the initial concentrations
   c) Define x
   d) Compute the equilibrium concentrations in terms of x.
   e) Substitute the concentrations into the equilibrium expression and solve for x.
   f) Check if approximation is valid
   g) Calculate the pH and other concentrations