Dougherty Valley HS • AP Chemistry [Keep for Reference]
Acid-Base Equilibria
BLUFFER'S GUIDE

1. $H_2O \rightleftharpoons H^+ + OH^-$ $K_w = [H^+][OH^-] = 10^{-14}$
   $pH = -\log[H^+]$ $pH+pOH = 14$ $[H+] = 10^{-pH}$
   Convert between pH, pOH, $[H^+]$, & $[OH^-]$

2. Acid Ionization Constant (K_a):

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

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

   Example: $HF + H_2O \rightleftharpoons H_3O^+ + F^-$

   $K_a = [F^-][H_3O^+]/[HF]$

3. Typical question: Given K_a and the starting concentrations of acid, find concentrations (or pH) of $[H^+]$ at equilibrium.

   Example: K_a for acetic acid = 1.8×10^{-5}.
   Find the pH of 0.100M acetic acid.

4. Polyprotic Acids: H_3PO_4, H_2SO_4, $H_2C_2O_4$, etc.
   The 1st dissociation is strong for H_2SO_4.
   When using Hess's Law with a polyprotic acid:
   $K_{overall} = K_{a1} \times K_{a2}$
   Calculating pH, use K_{a1}

5. Bronsted-Lowry Definitions.
   Acids = H+ donors; Bases = H+ acceptors
   Conjugate acid-base pairs.

6. Base Ionization Constant (K_b):

   $B + H_2O \rightleftharpoons BH^+ + OH^-$

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

   Example: $F^- + H_2O \rightleftharpoons HF + OH^-$

   $K_b = [HF][OH^-]/[F^-]$

7. Salt solns can have pH's ≠ 7 (hydrolysis)
   ions from weak acids → basic solutions
   $C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^-$
   ions from weak bases → acidic solutions
   $NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+$

8. $K_a \times K_b = K_w = 10^{-14}$
   only applies for **conjugate** acids & bases!

   Example: K_a $HC_2H_3O_2 = 1.8 \times 10^{-5}$
   K_b $C_2H_3O_2^- = 10^{-14} / 1.8 \times 10^{-5}$

9. Percent ionization =
   $[H^+]_{eqilibrium} / [HA]_{initial} \times 100$

10. Acid Strength-know the 6 strong acids: HCl, HBr, HI, HNO_3, $HClO_4$, and H_2SO_4 (removal of the first H^+ only)

    (a) binary acids - acid strength increases with increasing size and electronegativity of the "other element". (NOTE: Size predominates over electronegativity in determining acid strength.)
    Examples: $H_2Te > H_2O$ & $HF > NH_3$

    (b) Oxoacids - Acid strength increases with increasing:
    (1) electronegativity
    (2) number of bonded oxygen atoms
    (3) oxidation state of the "central atom".

    Example: $HClO_4$ or $[O_3Cl(OH)]$
    is very **acidic**
    NaOH is very **basic**
    Acid strength also increases with ***decreasing*** radii of the "central atom".
    Example:
    HOCl (bond between Cl and OH is covalent--making HOCl **acidic**)
    HOI (bond between I and OH is ionic--making HOI **basic**)

11. Lewis Acids and Bases:
    (This applies to coordinate covalent bonds.)
    Lewis Acid--electron pair acceptor
    Lewis Base--electron pair donor
    "Have Pair…Will Share" – Lewis Base

    In complex ion formation, metal ions are Lewis acids, and ligands are Lewis bases.
    Example: $Cu^{2+} + 4NH_3 \rightleftharpoons Cu(NH_3)_4^{2+}$
    Cu^{2+} acts as an acid; NH_3 acts as a base.

12. Strong Bases: amide ion, NH_2^-
    hydride ion, H^-, methoxide ion, CH_3O^-

Based on a handout by William Bond, Snohomish HS