CHEM 151 Exam IV Memorizations and Equations

Chapter 15

Characteristics of Equilibrium:

- Dynamic
- Neither reactants nor products can escape from the system (happens in a closed container)
- The rate of forward reaction = the rate of the reverse reaction
- The concentrations of the reactants and products no longer change with time (remain constant).
- The reactant concentrations do not have to equal the product concentrations at equilibrium.
- If mostly products at equilibrium, “equilibrium lies to the right”.
- If mostly reactants at equilibrium, “equilibrium lies to the left”.

Equilibrium Constant:

- K using concentrations: $aA + bB$ □ $dD + eE$

$$K = \frac{[D]^d [E]^e}{[A]^a [B]^b}$$

- K using pressures:

$$K_p = \frac{(P_D)^d (P_E)^e}{(P_A)^a (P_B)^b}$$

K_c and K_p can also be also called as K_{eq} .

- Concentrations of pure solids and liquids are always omitted in K expression.
- K changes only with temperature.

What does the numerical value of *K* mean?

- If K □ 1
  - The reaction is product favored.
  - Equilibrium lies to the right.
  - Does not mean the reaction is fast.
- If K K □ 1 1
  - The reaction is reactant-favored.
  - Equilibrium lies to the left.
  - Does not mean the reaction is slow.

The Direction of the Chemical Equation and K:

- Reversing a chemical equation will cause the value of K_{eq} to become the reciprocal.

$$K_{reverse} = \frac{1}{K_{forward}}$$

- Doubling an equation will cause the K_{eq} value to square. $K_{new} = K_{original}^{2}$
- Halving the equation will cause the K_{eq} value to become the square root. $K_{new} = K_{original}^{1/2}$

The Reaction Quotient (*Q*)

- *Q* uses the same ratio as the equilibrium expression, but for a system that is *not* at equilibrium.

  For the general equation $aA + bB \rightleftharpoons dD + eE$

  $$Q = \frac{[D]^d [E]^e}{[A]^a [B]^b}$$

The Reaction Quotient and Predicting the Direction of Change

- **If $Q < K$**
  - Large denominator; Initially more reactants than products
    - System will shift right to reach equilibrium
- **If $Q = K$**
  - The [products] and [reactants] do not change
    - System is at equilibrium
- **If $Q > K$**
  - Large numerator; Initially more products than reactants
    - System will shift left to reach equilibrium

Le Châtelier's Principle

If a system at equilibrium is disturbed, by a change in temperature, pressure, or the concentration of one of the components, the system will shift its equilibrium position so as to counteract the effect of the disturbance.

- If you add something (exception: pure solids, liquids, catalysts, noble gases), the reaction will shift to the opposite side to use it up.
- If you remove something (exception: pure solids, liquids, catalysts, noble gases), the reaction will shift to the same side make more.
- Adding or removing a solid or a liquid has no effect.
- Adding an inert gas or catalyst to the equilibrium mixture has no effect.
- If you increase the pressure (by decreasing the volume), the reaction will shift to reduce the pressure by shifting to the side with fewer # of moles of gas and vice versa. (Count only gas molecules)
- If you increase heat, the direction of shift depends on if it is an exothermic reaction or endothermic reaction.

Chapter 16

7 **Strong acids:** HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_3$, $HClO_4$

8 **Strong bases:** $LiOH$, $NaOH$, KOH, $RbOH$, $CsOH$, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$

Arrhenius Definition on Acids and Bases:

- An acid is a substance that, when dissolved in water, increases the concentration of hydrogen ions (H^+ in H_2O is same as H_3O^+) or produces H^+ ions in solution.
- A base is a substance that, when dissolved in water, increases the concentration of hydroxide ions or produces OH^- ions in solution.
  - Applies only to aqueous solutions

Bronsted-Lowry Definition on Acids and Bases:

An acid is a proton donor.

A base is a proton acceptor.

Lewis Definition on Acids and Bases:

An acid is an electron pair acceptor.

A base is an electron pair donor.

Know the names and formulas of acids and bases in the Nomenclature handout.

Conjugate Acid:

- Formed by adding a proton (H^+) to the base (E.g. H_2O is a base and H_3O^+ is its conjugate acid.).

Conjugate Base:

- Formed by removing a proton (H^+) from the acid (E.g. HNO_2 is an acid and NO_2^- is its conjugate base.).

Amphoteric Substances:

- Substances that can act as an acid or a base. (E.g. H_2O , HCO_3^-)
  - have both transferable H and atom with lone pair

Autoionzation:

- A reaction between molecules of the same substance to produce ions.

E.g. $H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

$NH_3 + NH_3 \rightleftharpoons NH_4^+ + NH_2^-$

Know this: pH = 7 neutral pH <7 is acidic pH >7 is basic

Memorize the following equations:

$K_a = \frac{[H^+][A^-]}{[HA]}$ and $K_b = \frac{[BH^+][OH^-]}{[B]}$

$$[H^+][OH]^- = 1.0\times10^{-14}$$ at 25 °C

$$pH = -\log[H^+]$$

$$pOH = -\log[OH^-]$$

$$[H^+] = 10^{-pH}$$

$$[OH^-] = 10^{-pOH}$$

$$pH + pOH = 14.00$$

$$K_a \times K_b = 1.0\times10^{-14}$$

Percent Ionization:

Percent ionization of acid =

Percent ionization of acid= $\frac{[H^+]_{equilibrium}}{[HA]_{initial}} \times 100\%$

Percent ionization of base= $\frac{[OH^-]_{equilibrium}}{[B]_{initial}} \times 100\%$

- For a given weak acid, the percent dissociation increases as the acid becomes more dilute.

Hydrolysis of ions:

- Hydrolysis is the reaction of an ion with water, usually to produce a solution that is acidic or basic.
- Cations of strong bases cannot be hydrolyzed. (E.g. Na^+)
- Anions of strong acids cannot be hydrolyzed. (E.g. Cl^-)
- Anions of weak acids hydrolyze in water to produce a basic solution. (E.g. F^-)
- Cations of weak base hydrolyze in water to produce acidic solution.(E.g. NH_4^+)

Acid-Base Properties of Salts

- Salts that contain the cation of a strong base and an anion that is the conjugate base of a weak acid are basic.(E.g. NaF)
- Salts that contain cations that are the conjugate acid of a weak base and an anion of a strong acid are acidic. (E.g. NH_4Cl)
- Salts that contain the cation of a strong base and an anion that is the conjugate base of a strong acid are neutral. (E.g. $NaCl$)

Factors Affecting Acid Strength

For Binary Acids (HX)

Acidity increases from left to right across a row and from top to bottom down a group. (E.g. HF is a stronger acid than H_2O and H_2S is a stronger acid than H_2O)

- **For Oxyacids of type H-O-Y**

  The more electronegative the Y atom, the stronger the acid (E.g. $HClO > HBrO > HIO$)

- **For a series of oxyacids**

  Acidity increases with the number of oxygens. ($HClO_4 > HClO_3 > HClO_2 > HClO$)