Chapter 5 Notes

5-1: The Nature of Aqueous Solutions

- 3 classes: precipitation, acid-base, and oxidation
- Will conduct electricity if solution of ions is not too low; depends on nature of solute
- Electrolytes- solutes that provide ions when dissolved in water
- Nonelectrolytes- do not provide ions in water
- Strong electrolyte- substance that is completely ionized in a solution
- Weak electrolyte- substance that is only partially ionized in a solution
- All soluble ionic compounds and only a relatively few molecular compounds are strong electrolytes
- Most molecular compounds are either nonelectrolytes or weak electrolytes
- Simple hydrogen ion does not exist in aqueous solutions; its actual form is as hydronium ion, H_3O^+
    - Interacts with surrounding water molecules to form $H_5O_2^+$, $H_7O_3^+$, etc.
    - These interactions called hydration
- For weak electrolytes, the reaction that produces ions does not go to completion; only a fraction of the solute molecules in the solution are ionized
- Double arrows in a formula indicate that the process is reversible
- For a nonelectrolyte, we simply write the molecular formula

5-2: Precipitation Reactions

- Insoluble- a solution in which very little of a solute dissolves in a solvent
- Precipitate- an insoluble solid that deposits from a solution as a result of a chemical reaction
- Precipitation reactions happen when certain cations and anions combine to produce an insoluble ionic solid, or a precipitate
- In writing formulas, strong electrolytes are represented by their separate ions [Ag^+ (aq), + NO_3^- (aq)... etc.]
- Whole formulas vs. Ionic formulas
- Spectator ions- ions that go through the reaction unchanged; not reactants
- Net ionic equation- includes only the actual participants in a reaction, with each participant denoted by the symbol or formula that best represents it
- Must be balanced for both the numbers of atoms and of all types and the electric charge
- Solubility for Common Ionic Solids:
    - Salts of group 1 cations (except for Li) and the NH4+ cation are soluble
    - Nitrates, acetates, and perchlorates are soluble
    - Salts of silver, lead, and mercury (I) are insoluble
    - Cholrides, bromides, and iodides are soluble
    - Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (except for sulfides of group 2 cations and hydroxides of Ca2+, Sr2+, and Ba2+, which are slightly soluble)
    - Sulfates are soluble except for those of calcium, strontium, and barium

(Applied in order listed)

5-3: Acid-Base Reactions

- **Acids:**
  - Identified by sour taste and ability to react with a variety of metals and carbonate minerals
  - Acid-base indicators- effect of acids or bases on colors of substances
  - Acid- a substance that provides hydrogen ions (H+) in aqueous solutions
  - Proposed by Svante Arrhenius in 1884
  - Strong acids:
    - Strong tendency for producing H+ ions
    - Completely ionized in an aqueous solution
    - Common strong acids: HCl, HBr, HI, $HClO_4$, HNO_3, H_2SO_4[a]
  - Weak acids:
    - Weak tendency for producing H+ ions
    - Incompletely ionized in an aqueous solution
    - Most acids are weak acids
    - Ionization of a weak acid is best described in terms of a reversible reaction that does not go to completion
  - Johannes Bronsted and Thomas Lowry proposed that the key process responsible for the properties of acids and bases was the transfer of an H+ ion from one substance to another
  - Proton donor- an acid in the Bronsted-Lowry acid-base theory
  - Whether you include water as a reactant in the equation for the reaction depends on your preference; if you do not, remember that H+ ion is not a free proton but is firmly bound to a water molecule and exists as an H3O+ ion
- **Bases:**
  - Identified by bitter taste, slippery feel, and effect on the colors of acid-base indicators
  - Base- compound that produces hydroxide ions, OH-, in water solution (Arrhenius theory); a protein acceptor (Bronsted-Lowry theory); an atom, ion, or molecule that can donate a pair of electrons to form a covalent bond (Lewis theory)
  - Strong base- base that dissociates completely, or very nearly so, in an aqueous solution
  - Common strong bases: LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$
  - Weak base- incompletely ionized in aqueous solution
  - Most bases are weak bases
  - Proton acceptor- a base in the Bronsted-Lowry acid-base theory
- **Acidic and Basic Solutions**
  - Although acids produce H+ ions and bases produce OH- ions, small numbers of H+ and OH- ions are present in pure water
  - An acidic solution has a greater concentration of H+ ions than pure water (1.0×10^{-7} M at 25 degrees C)
  - A basic solution has a greater concentration of OH- ions than pure water (1.0×10^{-7} M at 25 degrees C)
- **Neutralization**

    - Most important property of acids and bases is ability of each to cancel or neutralize the other
    - Neutralization reaction- an acid and a base react in stoichiometric proportions, so that there is no excess of either acid or base in the final solution; products are water and salt
    - Salt- ionic compounds in which hydrogen atoms of acids are replaced by metal ions; produced by the neutralization of acids and bases
- **Recognizing Acids and Bases:**
    - Acids contain ionizable hydrogen atoms, which are separated from other H atoms in the formula either by writing them first or by indicating where they are found in the molecule
    - A substance whose formula indicates a combination of OH- ions with cations is generally a strong base

5-4: Oxidation-Reduction Reactions: Some General Principles

- Oxidation- a reaction in which a substance gains oxygen atoms
- Reduction- substance looses oxygen atoms
- Oxidation-reduction (redox) reaction- reaction in which certain atoms undergo changes in oxidation states
- **Oxidation State Changes**
    - In oxidation process, the oxidation state of some element increases
    - In reduction process, the oxidation state of some element decreases
- **Oxidation and Reduction Half-Reactions**
    - Half reaction- one portion of an overall oxidation-reduction reaction, either the oxidation or the reduction
    - Overall reaction is sum of two half reactions
    - Oxidation- oxidation state of some element increases as electrons are lost; electrons appear on right side of half-equation
    - Reduction- oxidation state of some element decreases as electrons are gained; electrons appear on left side of half-equation
    - Oxidation and reduction half-reactions must always occur together, and total number of electrons associated with oxidation must equal total number associated with reduction
    - Redox reactions are harder to identify than acid-base reactions because electrons are hidden; electron transfer is emphasized

5-5: Balancing Oxidation-Reduction Equations

- In a chemical reaction, atoms are neither created nor lost; they are just rearranged
- Focus on 3 factors:
    - Number of atoms of each type
    - Number of electrons transferred
    - Total charges on reactants and products
- **The Half Equation Method**
    - Write and balance separate half-equations for oxidation and reduction
        - Balance atoms of all elements except H and O
        - Balance oxygen by using H20