CHEM 105 Goals for Student Learning – Updated 9.18.2019

Textbook: *Chemistry: An Atoms-Focused Approach*, 2^{nd} ed., by Gilbert, Kirss, Foster, and Bretz

Chapter 1
Upon completion of this chapter, you should be able to:

- Describe the features of the three states of matter at the macroscopic and molecular/atomic levels.
- Define and distinguish between the following terms: element, atom, compound, molecule, homogeneous and heterogeneous mixtures
- Define and give examples of the following: physical property, extensive property, intensive property, physical change, chemical change
- Know and convert between the metric units and the prefixes specified (Giga- through femto-).
- Convert between the different volume units commonly used in chemistry.
- Understand precision and accuracy.
- Identify the number of significant figures in a given value and determine the proper number of significant figures to include in a calculated value, using proper rounding.
- Quickly perform organized dimensional analysis calculations (with multiple steps) to convert from one set of units to another.
- Use the relationship between mass, volume and density and other simple equations (from geometry, etc.) to solve problems.

Chapter 2, Sections 1-4
Upon completion of these sections, you should be able to:

- Describe the modern view of atomic structure in terms of the three types of subatomic particles. Know where these particles are located in the atom, their charges and relative masses. Understand the relative sizes of the nucleus and the atom.
- Define the following terms: isotope, atomic number, mass number.
- Calculate the average atomic mass of an element and understand the origin of the masses given on the periodic table.
- Identify the number of protons, neutrons and electrons and the overall charge of an atom and write its complete chemical symbol.
- Provide the names corresponding to element symbols and correct symbols for written element names (elements 1-88).
- Understand the arrangement of the periodic table, including the groups discussed in class (alkali metals, alkaline earth metals, halogens, noble gases), and be able to differentiate between metals, nonmetals and metalloids (or semimetals).
- Know what cations and anions are.
- Use the periodic table to predict the charges of common monoatomic ions; determine the numbers of subatomic particles in monoatomic ions and write their complete chemical symbols.

Chapter 3
Upon completion of this chapter, you should be able to:

- Understand the relative placement of the various regions of the electromagnetic spectrum in terms of wavelength, frequency and energy.
- Calculate the wavelength or frequency of light, given the other quantity.
- Understand what is meant by *quantization of energy*.
    - Calculate the energy, wavelength or frequency of a single photon.
- Describe the photoelectric effect.

    - Determine whether an electron can be ejected from a metal with a particular work function and a photon of a given energy, frequency or wavelength.
- Calculate changes in energy associated with the electronic transitions in the H atom (from Bohr's model). Understand where the lines in the H-atom emission spectrum come from.
- Understand the meaning of *wave-particle duality* and its relative importance for macroscopic and atomic-size objects.
    - Calculate the de Broglie wavelength of a particle.
    - State the Heisenberg Uncertainty Principle and understand its consequences for electronic structure. (Can we know where an electron is in an atom? Why or why not?)
- Understand, in general, the results of Schrödinger's wave equation:
    - Understand how quantization of energy applies to the electron wave.
    - Understand what orbitals are and where quantum numbers come from.
    - Explain how solutions to Schrödinger's equation can be used to determine electron (probability) density.
- Know the three quantum numbers needed to define an orbital, what values each may have, and what each one tells us about the orbital.
- Draw representations of *s*, *p* and *d* orbitals, indicating orbital shapes, relative signs, and orientations in space.
    - Locate any nodes present in each orbital, and understand their significance.
- Know the fourth quantum number needed to specify a certain electron in an orbital, what it represents, and what values it may have.
    - Write a set of four quantum numbers to describe a particular electron in an atom or ion.
- Know the ordering of the energies of atomic orbitals for multi-electron atoms.
- State the Pauli Exclusion Principle and Hund's Rule, and understand their implications for electron configurations.
- Give the lowest energy (ground-state) electron configuration and orbital "box" diagram for any atom or monoatomic ion.
- Understand how orbital size (or "radial extent") changes with increasing (or decreasing) principal quantum number, n.
- Understand and estimate the effective nuclear charge experienced by a valence electron in a given atom.
- Use your understanding of effective nuclear charge and radial extent to explain periodic trends in:
    - Atomic and ionic radii
    - First ionization energy
- Define first ionization energy and write a chemical reaction to describe the ionization process.
- Explain increases in successive (1st, 2nd, 3rd, 4th, etc.) ionization energies in terms of electronic configurations.
- Define electron affinity and write a chemical equation to describe this process.
- Use your understanding of effective nuclear charge and radial extent to explain periodic trends in electron affinity.

<u>End of Material for Exam I</u>

Chapter 4

Upon completion of this chapter, you should be able to:

- Know the names, formulas and charges for the common polyatomic ions provided on the handout.
- Write a formula for a given ionic compound; give the correct name for a compound formula. Name binary molecular compounds and provide formulas for names.
- Describe ionic and covalent bonding:
  - Predict whether a particular bond will be ionic or covalent (i.e., whether a particular compound is ionic or molecular)
  - Understand how ionic bonds are formed (starting with neutral atoms) and the driving force for this process; compare lattice energies for different ionic compounds.
  - Understand covalent bond formation.
- Draw the Lewis structure for a given atom, molecule or ion. Understand the "octet rule" and its exceptions.
- Draw equivalent or non-equivalent resonance structures for a given molecule or ion and understand their implications for the actual depiction of bonding in the molecule/ion.
- Define electronegativity; predict and explain periodic trends in electronegativities.
- Assign formal charges to atoms in Lewis structures; use formal charges (and electronegativities) to evaluate Lewis structures.
- Determine bond order and understand trends in bond length and strength among single, double, and triple bonds.
- Understand the continuum between 100% ionic and 100% covalent bonding, including polar covalent bonds and covalent character in ionic compounds.

Chapter 5, Sections 1-6

Upon completion of these sections, you should be able to:

- Understand the basis of VSEPR Theory and use it to predict electron domain geometries and molecular geometries.
- Sketch and name molecular geometries and provide estimated bond angles.
- Identify polar covalent bonds and use molecular geometries to determine whether molecules/ions are polar or nonpolar.
- Describe Valence Bond Theory and explain why it (alone) is not an acceptable bonding model.
- Explain how hybrid orbitals are formed, starting from valence electron configurations.
  - Understand why hybridization is used as a modification to Valence Bond Theory and what its limitations are.
- Predict the types of valence and/or hybrid orbitals used by atoms in molecules/ions.
- Understand what sigma and pi bonds are and in which situations each type is formed.
- Explain how atomic and/or hybrid orbitals overlap to form the bonds (both sigma and pi) in a molecule or polyatomic ion; also, be able to specify the type of orbital holding each lone pair.

Chapter 7, Sections 2.5-2.6, Section 6.3, and Sections 8.1-8.3

Upon completion of these sections, you should be able to:

- Know what a mole is and where Avogadro's number came from.
- Calculate the molar mass for a given compound.

- Use Avogadro's number and the concept of molar mass to interconvert between mass, moles, and number of atoms of an element (or number of molecules of a compound).
- Write and balance chemical equations.
- Write and balance (complete) combustion reactions, given only the formula of the compound to be burned.
- Understand and apply balanced chemical equations (stoichiometry) to:
  - Determine the mass (or number of moles) of a desired reactant or product given the mass (or number of moles) of another.
  - Identify limiting reactants and reactants in excess.
  - Calculate the mass of remaining excess reactant.
  - Determine percent yields.
- Define the following terms: *solution, solvent, solute, molarity, strong electrolyte*.
- Calculate the molar concentration of a solution.
  - Interconvert between molarity, moles solute, and volume solution.
  - Use molar concentration to work with aqueous solutions in stoichiometry problems.
- Complete calculations related to dilution, determining an unknown volume or concentration.

Projected End of Material for Exam II