<u>Goals for 125:</u>

1. Understand basics of atomic structure and periodic trends
    a. Atomic orbital filling
        - Write electron configurations for atoms and ions
        - Recognize shapes and sizes of atomic orbitals and determine energies of atomic orbitals
        - Relate electron location probability (electron density) based on orbital number and shape
    b. Sub-atomic particles and charges and masses
        - Determine the number of protons, neutrons and electrons in a given isotope of an atom or ion
    c. Periodic trends for atomic radii and EN
        - Predict the relative sizes of atoms and ions
        - Predict relative ionization energies
        - Rank atoms according to electronegativity

2. Understand different bonding models and motifs in a variety of chemical structures (metals, ionic compounds, molecular compounds, coordination compounds, biomolecules) and how electronic structure affects properties
    a. Metallic Bonding
        - Explain metallic bonding and apply the delocalized electron model to the properties of metals such as malleability, ductility, conduction of heat
        - Describe how the differences between metallic bonds and ion-ion interactions influence the bulk properties of metallic and ionic solids such as conductivity and malleability
    b. Ionic Bonding
        - Use Coulomb's law to determine the strength of attractive/repulsive force between two ions
        - Describe how the strength of ionic interactions affect properties such as lattice energy, melting points, bond length, solubility, etc.
        - Write simple empirical formulas based on balanced charge
    c. Lewis Structures/Molecular Bonding
        - Draw Lewis structures for molecules and ions
        - Calculate formal charge
        - Represent Lewis Structures as skeletal structures or line-bond structures
        - Draw a dipole moment on the molecule based on electronegativities of the atoms
        - Describe electron (charge) distribution between bonded atoms
        - Predict the overall polarity of a molecule based on structure and dipole moments
        - Draw resonance structures of small molecules
    d. Ligand-Metal Bonding
        - Draw Lewis structures for common ligands

- Determine the donor atom(s)
- Determine the charge on the metal
- Determine the electron count of a metal in a coordination complex

e. Molecular Orbital Theory for Molecular Bonding
- Draw the possible orbital combinations for sigma and pi bonds
- Fill the electrons in a simple diatomic MO diagram
- Use an MO diagram to predict bond order
- Identify the hybridization of an atom
- Fill electrons in MO diagrams for conjugated/aromatic systems
- Predict relative energy levels of molecular orbitals
- Use MO diagrams to explain properties such as magnetism, bond rotation, bond lengths, aromaticity, stability, etc.

3. Understand the 3D structures of a variety of chemical structures and how the structure affects the properties

a. Unit cells and packing
- Illustrate the differences between packing patterns (Cubic vs. Hexagonal)
  - Closest packing: HCP and CCP
  - Cubic packing: simple cubic and body centered cubic
- Given a unit cell:
  - Determine the number of ions or atoms in the unit cell
  - Describe the types of holes occupied in the unit cell
  - Determine the coordination number of the atoms or ions in the unit cell.
- Given a formula and coordination numbers, add atoms to a unit cell in the right placement and ratio
- Use information about the packing of atoms in a unit cell to explain properties of metallic and ionic compounds such as material density, conductivity, thermochromic behavior, etc.

b. Coordination Numbers/Geometries of Transition Metal Complexes
- Determine the coordination number of the central metal
- Determine the geometry of the complex
- Discuss factors that influence the type of geometry, such as square planar vs. tetrahedral

c. IMF and solubility and other physical properties
- Identify the different types of intermolecular interactions in a given solution
- Predict the strengths of intermolecular interactions of homogeneous and heterogeneous mixtures
- Evaluate the effect of electron density on physical properties such as solubility, melting point, location of dominating IMF, etc.

d. Isomerism in organic, biomolecules & coordination cmpds
- Identify differences between kinds of isomers

- Draw molecules in three dimensions: wedge-dash convention, Newman projection, diamond lattice projection
- Predict most stable conformation based on assessment of 6- and 7-atom interactions
- Identify relationships between geometric isomers of coordination compounds and molecular compounds
- Identify relationships between stereoisomers: enantiomers and diastereomers
- Identify chiral centers and label stereochemical configurations: R, S

e. Macromolecular structures of network solids, polymers, biomolecules
   - Identify factors that hold macromolecular structures in a specific shape
   - Identify discrete versus aggregate or extended structures
   - Distinguish between 2D and 3D macrostructures, metal network, ionic network, and molecular network
   - Identify different classes of biomolecules

4. Learn a conceptual approach for acid-base chemistry and how structure affects reactivity
   a. Lewis Acid/Base
      - Identify compounds as Lewis Acids or Bases
      - Predict products of Lewis Acid/Base Reactions
   b. Bronsted-Lowry Acidity/Basicity
      - Identify compounds as Bronsted Acids or Bases
      - Recognize the structural features that affect acid/base reactivity such as sterics, polarizability, electronegativity, resonance, etc.
      - Identify the most acidic proton on a molecule
      - Rank the strength of bases/acids based on structural features
      - Predict products of simple proton transfers
   c. Introduction to Curved Arrow Notation
      - Draw an arrows to predict electron flow for acid-base reactions
      - Show bond-making and –breaking steps using arrow notation
   d. Qualitative concepts of equilibria
      - Use pKa to predict direction of reaction
      - Identify acids and bases that are compatible with aqueous solution

5. Learn problem-solving skills through modern applications of chemistry
   a. Apply techniques learned in the analysis of small molecules to more complex systems
      - Recognize similar structural features in new molecules
      - Recognize similar bonding motifs in new molecules
      - Predict behavior of molecules based on structural features and/or bonding motifs