

CHEM 125 (4 credits): Introduction to Chemical Structure and Properties

Description:

CHEM 125 is the introductory chemistry course. Students study atoms and their electron configuration, building a progressive and linked understanding of bonding, ionic and molecular geometry. Since chemical properties are dependent on electron distribution, students develop an understanding of molecular orbitals in molecules. Structure, geometry and orbital configuration ultimately determines the chemical and physical properties of molecules. Hence students learn about conformations and stereochemistry of simple acyclic and cyclic molecules, which are common in the biological world. Students obtain a chemical understanding of simple to increasingly complicated structures, including biological macromolecules such as nucleic acids and proteins, as well as zeolites and semiconductors. A beginning understanding of chemical reactivity is developed with a mechanistic understanding of acid base reactions. Prerequisites: ACT Math Score 23, SAT Math Score 575 or concurrent enrollment in CHEM 121.

Goals and Objectives for 125:

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 compounds
 - 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