College Chemistry

The following learning targets represent the major concepts studied and assessed in this course.

Semester 1:

Unit 1: Essential Ideas

- Provide examples of the importance of chemistry in everyday life.
- Describe the basic properties of each physical state of matter.
- Apply the law of conservation of matter.
- Define and give examples of atoms and molecules.
- Identify properties of and changes in matter as physical or chemical.
- Describe the properties and units of length, mass, volume, density, temperature, and time.
- Perform basic unit calculations and conversions in the metric and other unit systems.
- Correctly represent uncertainty in quantities using significant figures; apply proper rounding rules to computed quantities.
- Use dimensional analysis to carry out unit conversions for a given property and computations involving two or more properties.

Unit 2: Atoms, Molecules, and Ions

- Use postulates of Dalton's atomic theory to explain the laws of definite and multiple proportions.
- Outline milestones in the development of modern atomic theory.
- Describe the three subatomic particles that compose atoms.
- Define isotopes and give examples for several elements.
- Write and interpret symbols that depict the atomic number, mass number, and charge of an atom or iron
- Calculate average atomic mass and isotopic abundance.
- Symbolize the composition of molecules using molecular formulas and empirical formulas.
- Represent the bonding arrangement of atoms within molecules using structural formulas.
- Explain the relation between mass, moles, and numbers of atoms or molecules and perform calculations deriving these quantities from one another.

Unit 3: Electronic Structure and Periodic Properties of Elements

- Explain the basic behaviour of waves, including travelling waves and standing waves.
- Use appropriate equations to calculate related light-wave properties such as period, frequency, wavelength, and energy.
- Describe the Bohr model of the hydrogen atom and use the Rydberg equation to calculate energies of light emitted or absorbed by hydrogen atoms.
- Understand the general idea of the quantum mechanical description of electron in an atom, and that it uses the notion of three-dimensional wave functions, or orbitals, that define the distribution of probability to find an electron in a particular part of space.
- List and describe traits of the four quantum numbers that form the basis for completely specifying the state of an electron in an atom.
- Derive the predicted ground-state electron configurations of atoms.
- Relate electron configurations to element classifications in the periodic table.
- Describe and explain the observed trends in atomic size, ionization energy, and electron affinity of the elements.
- Predict the general properties of elements based on their location within the periodic table.
- Identify metals, nonmetals, and metalloids by their properties and/or location on the periodic table.
- Define ionic and molecular compounds.
- Predict the type of compound formed from elements based on their location within the periodic table.
- Determine formulas for simple ionic compounds.

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Unit 4: Chemical Bonding and Molecular Geometry

- Explain the formation of cations, anions, and ionic compounds.
- Predict the charge of common metallic and nonmetallic elements, and write their electron configurations.
- Describe the formation of covalent bonds.
- Define electronegativity and assess the polarity of covalent bonds.
- Derive names for common types of inorganic compounds using a systematic approach.
- Draw Lewis structures depicting the bonding in simple molecules.
- Use formal charges to identify the most reasonable Lewis structure for a given molecule.
- Explain the concept of resonance and draw Lewis structures representing resonance forms for a given molecule.
- Predict the structures of small molecules using valence shell electron pair repulsion theory.
- Explain the concepts of polar covalent bonds and molecular polarity.

Unit 5: Advanced Theories of Bonding

- Describe the formation of covalent bonds in terms of atomic orbital overlap.
- Define and give examples of σ and π bonds.
- Explain the concept of atomic orbital hybridization and determine the hybrid orbital associated with various molecular geometries.
- Describe multiple covalent bonding in terms of atomic orbital overlap.
- Relate the concept of resonance to π-bonding and electron delocalization.
- Outline the basic quantum-mechanical approach to deriving molecular orbitals from atomic orbitals.
- Describe traits of bonding and antibonding molecular orbitals.
- Write molecular electron configurations for first and second row diatomic molecules.

<u>Semester 2:</u>

Unit 6: Composition of Substances and Solutions

- Calculate formula masses for covalent and ionic compounds.
- Describe the fundamental properties of solutions.
- Calculate solution concentrations using molarity.
- Perform dilution calculations using the dilution equation.
- Define the concentration units of mass percentage, volume percentage, mass-volume percentage, parts-per-million, and parts-per-billion.
- Perform computations relating a solution's concentration and its components' volumes and/or masses using these units.

Unit 7: Stoichiometry of Chemical Reactions

- Derive chemical equations from narrative descriptions of chemical reactions.
- Write and balance chemical equations in molecular, total ionic, and net ionic formats.
- Define three chemical reactions types and classify chemical reactions based on their descriptions or chemical equations.
- Use balanced chemical equations to derive stoichiometric factors relating amounts of reactants and products
- Explain the concepts of theoretical yield and limiting reactants.
- Derive the theoretical yield for a reaction under specified conditions.
- Calculate the percent yield for a reaction.
- Perform stoichiometric calculations using typical titration and gravimetric data.

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Unit 8: Gases

- Define and convert among the units of pressure measurements.
- Use the ideal gas law, and related gas laws, to compute the values of various gas properties under specified conditions.
- Use the ideal gas law to compute densities and molar masses.
- State Dalton's law of partial pressures and use it in calculations involving gaseous mixtures.
- State Graham's law and use it to compute relevant gas properties.
- State the postulates of kinetic-molecular theory and use them to explain the gas laws.
- Describe the physical factors that lead to deviations from ideal gas behavior and explain how they are represented in the van der Waals equation.
- Define compressibility (Z) and describe how its variation with pressure reflects non-ideal behavior.

Unit 9: Thermochemistry

- Define energy, distinguish types of energy, and describe the nature of energy changes that accompany chemical and physical changes.
- Define and distinguish specific heat and heat capacity, and describe the physical implications of both.
- Perform calculations involving heat, specific heat, and temperature change.
- Calculate and interpret heat and related properties using typical calorimetry data.
- State the first law of thermodynamics.
- Write and balance thermochemical equations.
- Calculate enthalpy changes for various chemical reactions.
- Explain Hess's law and use it to compute reaction enthalpies.
- Use the Born-Haber cycle to compute lattice energies for ionic compounds.
- Use average covalent bond energies to estimate enthalpies of reaction.

Unit 10: Liquids and Solids

- Describe the types of intermolecular forces possible between atoms or molecules in condensed phases.
- Identify the types of intermolecular forces experienced by specific molecules based on their structures.
- Explain the relation between the intermolecular forces present within a substance and the temperatures associated with changes in its physical state.
- Distinguish between adhesive and cohesive forces.
- Describe the roles of intermolecular attractive forces in each of these properties/phenomena.
- Explain the relation between phase transition temperatures and intermolecular attractive forces.
- Describe the processes represented by typical heating and cooling curves, and compute heat flows and enthalpy changes accompanying these processes.
- Explain the construction and use of a typical phase diagram
- Use phase diagrams to identify stable phases at given temperatures and pressures, and to describe phase transitions resulting from changes in these properties.
- Define and describe the bonding and properties of ionic, molecular, metallic and covalent network crystalline solids.
- Describe the main types of crystalline solids: ionic solids, metallic solids, covalent network solids, and molecular solids.
- Explain the ways in which crystal defects can occur in a solid.
- Describe the arrangement of atoms and ions in crystalline structures.
- Compute ionic radii using unit cell dimensions.
- Explain the use of X-ray diffraction measurements in determining crystalline structures.