Course Outline for: CHEM 1020 Introductory Chemistry

A. Course Description:

1. Number of credits: 4
2. Lecture hours per week: 3
   Lab hours per week: 2
3. Prerequisites: None
4. Corequisites: None
5. MnTC Goals: Goal 3 Natural Sciences

This laboratory science course is intended for students as preparation for CHEM 1050 or CHEM 1061. Basic principles of chemistry are discussed and applied to everyday situations. Tools and methods of investigation used by chemists are introduced through laboratory exercises.

B. Date last reviewed/updated: May 2024

C. Outline of Major Content Areas:

1. *CLASSIFYING MATTER:* Classify matter and explain how it can be altered through chemical and physical changes.
   a. Identify chemistry as the study of matter, its properties, and its changes.
   b. Describe the scientific method and compare the characteristics of a hypothesis, scientific law, and scientific theory.
   c. Identify examples and describe characteristics of the following classifications of matter: pure substance, mixture, element, compound, homogeneous mixture, heterogeneous mixture.
   d. Describe characteristics of the three phases of matter and define the following phase changes: melting, freezing, vaporization, and condensation.
   e. Identify examples and describe characteristics of physical and chemical properties and changes.
   f. Describe the law of conservation of mass.
2. *MEASUREMENT, UNITS, AND CONVERSIONS:* Use metric and English units to express measurements of length, volume, mass, and density, and perform unit conversions.
   a. Identify which digits of a number are significant, including how to deal with ambiguous zeroes.
   b. Report answers of single-step calculations using the correct number of significant figures.
   c. Convert between decimal and scientific notation.
   d. Define the following metric base units: meter, gram, liter.
   e. Use the following metric prefixes in calculations: kilo, centi, milli.
   f. Use the equivalence 1 mL = 1 cm^3 to perform conversions.
   g. Use given equivalence statements to convert between English and metric units.
   h. Perform calculations involving multiple units, such as density and speed.

i. Use the formula for density to calculate density, mass, or volume, and describe the relationship between density, mass, and volume.

3. *ATOMIC STRUCTURE:* Explain how the periodic table is organized, describe the model of the atom, and write electron configuration.
   a. Write the names and symbols of elements 1-36.
   b. Use the periodic table to identify metals, metalloids, and nonmetals.
   c. Use the periodic table to identify alkali metals, alkaline earth metals, halogens, noble gases, and transition metals.
   d. Describe the location, charge, and mass of protons, neutrons, and electrons.
   e. Define atomic number and describe its relevance to the periodic table.
   f. Define isotope and mass number.
   g. Define anion and cation.
   h. Determine the number of protons, neutrons, and electrons in atoms, isotopes, and ions.
   i. Define wavelength and frequency, and understand the conceptual relationships between wavelength, frequency, and energy (no calculations).
   j. Determine the number of orbitals and electrons in s, p, d, and f sublevels (subshells).
   k. Discuss the relationship between the periodic table and orbital blocks.
   l. Draw the orbital diagram (energy diagram) for elements 1-20.
   m. Write the full electron configuration for elements 1-20.
   n. Write the noble gas shorthand electron configuration for elements 1-20.
   o. Determine the number of valence electrons for main group elements.
   p. Determine the charge that is formed when main group elements form an ion.
4. *IONIC AND COVALENT COMPOUNDS:* Name and write chemical formulas for ionic and covalent compounds.
   a. Interpret the use of subscripts in chemical formulas.
   b. Describe the characteristics of ionic and covalent (molecular) compounds.
   c. Given a name or formula, determine whether a compound is ionic or covalent.
   d. Write the name and formula for ionic compounds, including ionic compounds that contain transition metals and the following polyatomic ions: ammonium, hydroxide, nitrate, carbonate, sulfate, and phosphate. (Given a name write the formula, or given a formula write the name).
   e. Write the name and formula for covalent compounds. (Given a name write the formula, or given a formula write the name).
   f. Describe what a diatomic molecule is and identify the seven elements found in nature as diatomic molecules.
5. *PARTICLES, MOLES, GRAMS, AND STOICHIOMETRY:* Use molar mass and Avogadro's number to relate grams, moles, and atoms, balance chemical equations, and perform stoichiometry calculations.
   a. Define molar mass and calculate the molar mass of a compound.
   b. Use molar mass to convert between grams and moles.
   c. Define Avogadro's number and use Avogadro's number to convert between moles and particles.
   d. Identify the reactants and products of a chemical equation.
   e. Balance chemical equations and interpret the use of coefficients in balanced chemical equations.

f. Identify the following types of chemical reactions: synthesis, decomposition, single displacement, double displacement, and combustion.
g. Use a balanced chemical equation to determine mole ratios.
h. Use mole ratio and molar mass to convert between amounts of reactants and products. (g → g, mol → mol, g → mol, and mol → g calculations).

6. *MOLECULAR STRUCTURE:* Use Lewis structures and VSEPR theory to determine the shape, polarity, and intermolecular forces of molecules.
   a. Define the octet rule, describe how hydrogen is an exception, and be aware that other exceptions exist.
   b. Draw Lewis structures that obey the octet rule for small molecules and polyatomic ions.
   c. Use Lewis structures to determine electron geometry, molecular geometry, and bond angles.
   d. Define electronegativity and describe its periodic trends.
   e. Define and identify polar and nonpolar bonds.
   f. Define and identify polar and nonpolar molecules.
   g. Describe and identify examples of dispersion forces, dipole-dipole forces, and hydrogen bonding.
   h. Use intermolecular forces to compare melting points and boiling points.
   i. Use the rule "like dissolves like" to determine whether two substances will mix together.
7. *SOLUTION CHEMISTRY*: Describe the properties of solutions, acids, and bases.
   a. Define solute, solvent, solution, and aqueous solution.
   b. Discuss how adding more solute makes a solution more concentrated, and adding more solvent makes a solution more dilute.
   c. Compare the characteristics of a saturated and unsaturated solution.
   d. Define and identify examples of electrolytes and nonelectrolytes.
   e. Describe the difference in the particles produced when ionic and molecular compounds (not including acids) dissolve in water.
   f. Use the formula for molarity to calculate molarity, moles, and liters.
   g. Calculate the molarity of a solution given the mass of solute and volume of solvent.
   h. Describe the characteristics of acids and bases and determine whether a substance is an acid or a base.
   i. Given a formula, identify acids and bases.
   j. Predict the products of an acid-base neutralization reaction (simple reactions between Arrhenius acids and bases that produce salt and water).
   k. Describe that an acid has a pH below 7 and a base has a pH above 7.
   l. Interpret the relationship between the concentration of an acid or base and pH.
8. *LABORATORY SKILLS* Identify common laboratory equipment, make measurements and observations, analyze data, and communicate results.
   a. Demonstrate how to work safely in a laboratory.
   b. Identify the name of common laboratory equipment.
   c. Demonstrate how to use a digital balance to measure mass, including the use of the tare button.
   d. Make measurements using equipment with graduations and record the correct number of digits.
   e. Demonstrate the ability to follow a step-by-step experimental procedure.

f. Determine the density of various substances.
g. Demonstrate using physical properties to separate a mixture.
h. Describe physical properties of elements and compounds and identify patterns.
i. Make detailed observations of chemical changes and distinguish them from conclusions.
j. Use models to demonstrate molecular shapes.
k. Make solutions and compare different concentrations.
l. Analyze data and perform calculations such as unit conversions, average, percent composition, percent yield, and percent error.
m. Explain the difference and identify examples of experimental errors and experimental mistakes.

D. Course Learning Outcomes:

Upon successful completion of the course, the student will be able to:

1. Describe the basic principles of chemical knowledge including quantitative relationships. (Goal 3a, 3b)
2. Apply chemical principles to real-world applications. (Goal 3a, 3b, 3d)
3. Perform measurements and calculations using the metric system. (Goal 3a, 3b)
4. Perform lab techniques correctly using appropriate safety procedures. (Goal 3b, 3c)
5. Accurately interpret lab data. (Goal 2a, 3b, 3c)
6. Clearly communicate lab results. (Goal 2a, 3c)

E. Methods for Assessing Student Learning:

Methods for assessment may include, but are not limited to, the following:

1. Unit/midterm exams
2. Quizzes, homework and/or lab exam
3. Laboratory experiments, which will include the following topics:
   a. Lab safety
   b. Glassware and measurement
   c. Metric system and density
   d. Stoichiometry
   e. Solutions
   f. Observations of chemical substances and phenomena
4. Comprehensive Final Exam

F. Special Information:

None.