COMPETENCY 1. Demonstrate awareness, and proper use, of laboratory safety techniques.

ENABLING OBJECTIVES
1-1. Differentiate between safe and unsafe procedures, applications, and methods of disposal of chemicals.
1-2. Chose the appropriate safety equipment for specific laboratory situations.
1-3. Decide which safety and emergency procedures to follow in case of particular accidents including fires and hazardous material spills.
1-4. Demonstrate proper methods for carrying and moving chemicals and equipment.
1-5. Demonstrate the ability to understand and follow the safety codes on chemical containers.

COMPETENCY 2. Apply System Internationale, "SI", units as used in chemistry.

ENABLING OBJECTIVES
2-1. Identify the base units of the SI system and describe the standards for each.
2-2. Describe the concept of a derived quantity and its units, and identify the dimension (combination of base units) for any derived quantity, initially including area, volume and density.
2-3. Using dimension analysis, determine whether an equation is dimensionally valid, and establish the dimensions of a quantity.
2-4. Explain and give examples of the system of subdivision used in the SI system, including the use of prefixes to represent powers of ten.
2-5. Use conversion factors to convert quantities from one metric unit to another, and also between metric and English units.

COMPETENCY 3. Integrate computer use into the laboratory environment.

ENABLING OBJECTIVES
3-1. Acquire experimental data from computer interfaced hard and software.
3-2. Create spreadsheets, databases, and reports using relevant utility software.
3-3. Produce tables and graphs of data using available graphing software programs.
3-4. Conduct statistical analysis of data using relevant utility software.

COMPETENCY 4. Organize laboratory data using proper report and logbook format.

ENABLING OBJECTIVES
4-1. Maintain a current, organized, and accurate laboratory logbook.
4-2. Write a simple laboratory report which includes title, introduction, experimental design diagram, procedure, results, and conclusion.

COMPETENCY 5. Apply appropriate experimental and measurement skills and
techniques to laboratory experiences.

**ENABLING OBJECTIVES**

5-1. Select appropriate systems of measurement, using proper units, metric prefixes and number of significant digits.

5-2. Report the degree of uncertainty of a measurement, and carry out mathematical operations with measurements containing stated uncertainties.

5-3. Determine the significant digits in a recorded measurement, and carry out mathematical operations using these measurements with answers rounded off to the correct number of significant digits.

5-4. Determine the limit (decimal place) to which a measurement can be made for any measuring instrument.

5-5. Differentiate between precision and accuracy and calculate each.

5-6. Make linear measurements and determine masses of materials using various pieces of equipment.

5-7. Utilize computer laboratory interface to record measurements.

**COMPETENCY 6. Evaluate the impact of science and technology on society.**

**ENABLING OBJECTIVES**

6-1. Describe the natures of science, technology, and society and the relationships between them. Illustrate how science and technology have an impact on society and vice versa.

6-2. Apply the concepts of "problem-based learning" to solving specific issues.

6-3. Apply the "issues analysis technique" to the study of environmental problems.

**COMPETENCY 7. Categorize matter and its properties.**

**ENABLING OBJECTIVES**

7-1. Describe the general properties of matter.

7-2. Classify matter according to whether it is an element, a compound, or a mixture.

7-3. Define, calculate, and experimentally determine density for a variety of substances.

7-4. Distinguish between physical and chemical properties of matter.

7-5. Determine chemical and physical properties of substances by carrying out physical and chemical changes.

7-6. Use physical methods to separate the components of a mixture.

7-7. Write symbols for 55 common elements.

**COMPETENCY 8. Integrate the main features of atomic theory and the atomic mass scale.**

**ENABLING OBJECTIVES**

8-1. Describe the postulates of the modern atomic theory.

8-2. Relate the Laws of Conservation of Mass, Definite Composition, and Multiple Proportions to atomic theory.

8-3. Locate and describe the main components of the atom as used in
chemistry.

8-4. Define isotope, and relate atomic number, mass number, and number of atomic particles to each other, and interpret and write isotope symbols.

8-5. Calculate atomic mass from isotope abundances.

8-6. Design a relative mass scale similar to that of the atomic mass scale

COMPETENCY 9. Apply rules of chemical nomenclature to writing formulas and naming compounds.

ENABLING OBJECTIVES
9-1. Identify basic differences between atoms, molecules, and ions and classify compounds as being ionic or molecular.

9-2. Write names of ionic and binary covalent compounds from their formulas using older system of prefixes and suffixes and the newer IUPAC system.

9-3. Use ion-charge method to write formulas for ionic compounds.

9-4. Write formulas for binary covalent compounds.

COMPETENCY 10. Utilize the Periodic Table to determine properties of an element, or a set of elements.

ENABLING OBJECTIVES
10-1. Describe the events leading to the modern day arrangement of the periodic table.

10-2. Describe periodic trends of the general characteristics of metals, nonmetals, and metalloids .


COMPETENCY 11. Categorize chemical reactions and write balanced equations for reactions.

ENABLING OBJECTIVES
11-1. Write and balance chemical equations when given reactants and products.

11-2. Classify those equations that come under the heading of synthesis, decomposition, replacement, and ionic reactions.

11-3. Predict the products of chemical reactions when given the reactants.

11-4. Define oxidation and reduction, and identify any species undergoing oxidation or reduction, and identify the oxidizing and reducing agents.

11-5. Use solubility rules to predict the formation of insoluble products, and the activity series to predict the occurrence of replacement reactions.

11-6. Relate complete and incomplete combustion to oxidation.

11-7. Carry out examples of each kind of reaction, and write balanced equations for each.

COMPETENCY 12. Apply the mole concept to calculations involving masses and/or numbers of atoms, molecules, or formula units.

ENABLING OBJECTIVES
12-1. Relate Avogadro's number to the atomic mass scale.

12-2. Convert numbers of atoms and molecules to masses by using the mole,
and vice versa.
12-3. State the masses of atoms or molecules in terms of molar masses.
12-5. Distinguish between empirical and molecular formulas.
12-6. Experimentally determine the empirical formula of an ionic compound.
12-7. Calculate percentage composition of a compound from its formula, and
from experimental data.
12-8. Calculate empirical and molecular formulas from experimental data.

COMPETENCY 13. Apply stoichiometry experimentally and in calculations.

ENABLING OBJECTIVES
13-1. Calculate mass relationships based on balanced chemical equations.
13-2. Determine the limiting reactant, and the theoretical yield for chemical
reactions.
13-3. Experimentally determine the mole ratio for a chemical reaction, and
use it to determine the equation or the reaction.

COMPETENCY 14. Relate the concept of energy to chemical reactions.

ENABLING OBJECTIVES
14-1. Classify the various forms of energy.
14-2. Summarize the changes in energy that take place during a chemical
reaction.
14-3. Distinguish between exothermic and endothermic reactions.
14-4. Distinguish between heat and temperature.
14-4. State the three Laws of Thermochemistry.
14-5. Calculate AH for a reaction using specific heats and heats of formation.
14-6. Experimentally measure heat flow using a calorimeter, and use the
measurements to write a thermochemical equation for the reaction.
14-7. Calculate “q” and hE for a system according to the First Law of
Thermodynamics.

COMPETENCY 15. Predict the spontaneity of reactions.

ENABLING OBJECTIVES
15-1. Define and calculate M1 and AS for a reaction.
15-2. Use the Gibbs-Helmholtz equation to calculate the Gibbs energy
change for a reaction.
15-3 Describe how the signs of AH, AS, and AG relate to the spontaneity of a
reaction.

COMPETENCY 16. Characterize the electronic structure of the atom.

ENABLING OBJECTIVES
16-1. State and interpret the postulates of the Quantum Theory.
16-2. Relate energy differences, wavelength, and frequencies of EMR.
16-3. Describe the atomic spectrum of hydrogen in terms of the Bohr model.
16-5. Identify the four quantum numbers and relate each in terms of energy
differences and mathematical interpretation.
16-6. Write electron configurations for elements.
16-7. Use Hund’s rule to draw orbital diagrams for electrons in an atom.
16-8. Experimentally determine the wavelengths and frequencies line
COMPETENCY 17. Relate nuclear processes to nuclear power.

ENABLING OBJECTIVES
17-1. Write nuclear equations showing α, β and γ-emissions.
17-2. Relate nuclear decay to first order kinetics.
17-3. Relate E = mc² to nuclear thermochemistry.
17-4. Compare nuclear fission to nuclear fusion.
17-5. Consider use of nuclear power with reactor accidents and waste disposal.

COMPETENCY 13. Apply stoichiometry experimentally and in calculations.

ENABLING OBJECTIVES
13-1. Calculate mass relationships based on balanced chemical equations.
13-2. Determine the limiting reactant, and the theoretical yield for chemical reactions.
13-3. Experimentally determine the mole ratio for a chemical reaction, and use it to determine the equation or the reaction.

COMPETENCY 14. Relate the concept of energy to chemical reactions.

ENABLING OBJECTIVES
14-1. Classify the various forms of energy.
14-2. Summarize the changes in energy that take place during a chemical reaction.
14-3. Distinguish between exothermic and endothermic reactions.
14-4. Distinguish between heat and temperature.
14-5. State the three Laws of Thermochemistry.
14-6. Calculate AH for a reaction using specific heats and heats of formation.
14-7. Experimentally measure heat flow using a calorimeter, and use the measurements to write a thermochemical equation for the reaction.

COMPETENCY 15. Predict the spontaneity of reactions.

ENABLING OBJECTIVES
15-1. Define and calculate AH and AS for a reaction.
15-2. Use the Gibbs-Helmholtz equation to calculate the Gibbs energy change for a reaction.
15-4. Describe how the signs of AH, AS, and AG relate to the spontaneity of a reaction.

COMPETENCY 16. Characterize the electronic structure of the atom.

ENABLING OBJECTIVES
16-1. State and interpret the postulates of the Quantum Theory.
16-2. Relate energy differences, wavelength, and frequencies of EMR.
16-3. Describe the atomic spectrum of hydrogen in terms of the Bohr model.
16-5. Identify the four quantum numbers and relate each in terms of energy differences and mathematical interpretation.
16-6. Write electron configurations for elements.
16-7. Use Hund's rule to draw orbital diagrams for electrons in an atom.
APPENDIX H

16-8. Experimentally determine the wavelengths and frequencies line spectrum of selected elements.

COMPETENCY 17. Relate nuclear processes to nuclear power.

ENABLING OBJECTIVES
17-1. Write nuclear equations showing a, b and g-emissions.
17-2. Relate nuclear decay to first order kinetics.
17-3. Relate $E = mc^2$ to nuclear thermochemistry.
17-4. Compare nuclear fission to nuclear fusion.
17-5. Consider use of nuclear power with reactor accidents and waste disposal.

COMPETENCY 18. Relate ionic and covalent bonding to the electronic structure of atoms and the ionic and/or molecular compounds they form.

ENABLING OBJECTIVES
18-1. Describe the formation of cations and anions, and relate it to electronegativity and position on the periodic table.
18-2. Relate AH of ionic compounds to their lattice energies.
18-3. Write Lewis structures to show the covalent bonding in molecules and polyatomic
18-4. Determine the polarity of covalent bonds from electronegativities.
18-5. Compare bond lengths of covalent bonds.
18-6. Use bond energies to calculate AH for the formation of molecular compounds.
18-7. Experimentally determine the number of ionizable hydrogens in a compound.

COMPETENCY 19. Determine the shape of molecules and describe the distribution of the valence electrons according to atomic and molecular orbital theories.

ENABLING OBJECTIVES
19-1. Use VSEPR model to predict the geometric shape of simple molecules and polyatomic ions.
19-2. Construct models of molecules and polyatomic ions to illustrate their predicted geometric shapes.
19-3. Predict the polarity of molecules by using the VESPR model for molecules containing polar covalent bonds.
19-4. Describe covalent bonding in terms of atomic orbitals: sp, sp2, sp3 hybrid orbitals, sigma and pi bonds, and expanded octets.
19-6. Experimentally relate solubilities of solutes in solvents to their polarities.

COMPETENCY 20. Characterize the properties of chemical systems that reach equilibrium in the gaseous phase.

ENABLING OBJECTIVES
20-1. Write the expression for $K_c$ from the balanced equation for a reaction involving gases.
20-2. Calculate $K_c$ from equilibrium concentrations of all species, or from original concentrations of all species and the equilibrium concentration
APPENDIX H

of one species.

20-3. Predict the direction a chemical system will move to reach equilibrium when the value of Kc is known.

20-4. Predict the equilibrium concentration of one species when given those of all other species when the value of Kc is known.

20-5. Predict the equilibrium concentrations of all species when given their original concentrations and when the value of Kc is known.

20-6. Using LeChatelier's Principle, predict the effect of a change in the number of moles, volume, or temperature upon the position of an equilibrium.

20-7. Experimentally determine Kc for an equilibrium system.

20-8. Relate the standard free energy change for a reaction to the equilibrium constant.

COMPETENCY 21. Describe the properties of acids and bases.

ENABLING OBJECTIVES

21-1. Relate the acidic and basic properties of aqueous solutions to the dissociation of water.

21-2. Carry out calculations involving pH and pOH.

21-3. Compare strong and weak acids.

21-4. Compare strong and weak bases.

21-5. Predict acidity or basicity of salt solutions (cations and anions).

21-6. Write equations for reactions for reactions between strong acids-strong bases, strong acids-weak bases, and weak acids-strong bases.

21-7. Carry out acid-base titrations and write equations for the reactions.


COMPETENCY 22. Describe the properties of solutions and carry out calculations related to these properties.

ENABLING OBJECTIVES

22-1. Compare unsaturated, saturated, and supersaturated solutions to equilibrium conditions.

22-2. Distinguish between electrolytes and nonelectrolytes.

22-3. Carry out calculations involving solution concentrations in mole fractions, molality, and/or molarity.

22-4. Describe the factors that affect the solubility of a solute in a particular solvent.

22-5. Determine the concentration of an unknown solution by using the Spec 20 and Beer's Law.

22-6. Describe the colligative properties of solutions.

22-7. Experimentally determine the molar molar mass an unknown solute by freezing point depression and boiling point elevation.

COMPETENCY 23. Identify and characterize the factors that affect reaction rate.

ENABLING OBJECTIVES

23-1. Determine the order of a reaction when given the initial rate as a function of concentration of a reaction.

23-2. Calculate, for a first order reaction, the concentration of a reactant after
APPENDIX H

a given time when given the original concentration and the rate constant.

23-3. Calculate, for a first order reaction, the time required for the concentration to drop by a given amount when given the rate constant.

23-4. When given either the half-life or the rate constant for a first order reaction, calculate the other quantity.

23-5. Experimentally determine the order of a reaction.

23-6. Relate ozone depletion to CFCs and chlorine photochemistry.

23-7. Compare homogeneous with heterogeneous catalysts, and their affects on reaction rates.

COMPETENCY 24. Describe gases in terms of the kinetic theory of gases, apply the gas laws and the Ideal Gas Equation to problems, and compare real gases to ideal gases.

ENABLING OBJECTIVES

24-1. Define pressure and relate to kinetic theory.

24-2. Describe the effect of temperature on pressure and volume of gases.


24-4. Describe the relationship between pressure and volume of gases (Boyle's Law).

24-5. Combine Boyle's, Charles, and Avogadro's laws of gases into the ideal gas law.

24-6. Describe diffusion of gases and relate to Graham's Law.


24-8. Relate density of gases to molar volume and molar mass.

24-9. Describe the operation of mercury barometers.

24-10. Relate motion of molecules to the Boltzmann distribution and temperature.

24-11. Compare the behavior of real gases to the ideal and relate to the van der Waals equation.
COMPETENCY 1. Analyze materials development from an historical perspective.

ENABLING OBJECTIVES
1-1. Describe the history of materials development.
1-2. Differentiate the meaning of materials engineering and materials science.
1-3. Compare and contrast the various classifications of materials.
1-4. Forecast modern materials needs.

COMPETENCY 2. Apply the concepts of Atomic Structure and Molecular bonding to the development of various crystalline structures.

ENABLING OBJECTIVES
2-1. Explain the subatomic structure of atoms.
2-2. Describe the differences and similarities of the Bohr and Wave-mechanical Atomic Model.
2-3. Explain the theory of atomic bonding in solids including Covalent, Van der Waals, and Metallic bonding.
2-4. Using atomic structure and bonding theories, provide a model to illustrate various crystalline structures including body centered cubic (BCC), face centered cubic (FCC) and closed packed hexagonal (CPH).
2-5. Compare and contrast crystalline materials and amorphous materials.
2-6. Describe the effect of various crystalline structures on the properties of various materials.

COMPETENCY 3. Analyze the various theories which explain the effect of imperfections on materials properties.

ENABLING OBJECTIVES
3-1. Compare and contrast the various point defects in solids.
3-2. Describe dislocations and their effect on material strength and workability.
3-3. Explain the effect of grain size on material properties.

COMPETENCY 4. Apply the theory of diffusion to determine the influence of temperature of diffusion depth in various materials.

ENABLING OBJECTIVES:
4-1. Explain the process of inter diffusion and impurity diffusion.
4-2. Describe the various diffusion mechanisms.
4-3. Compare and contrast steady-state and non steady-state diffusion.
4-4. List the factors that influence diffusion and use these to solve related problems.
COMPETENCY 5. Using materials testing devices determine the mechanical properties of various materials.

ENABLING OBJECTIVES:
5-1. Using appropriate test equipment, determine stress-strain diagrams for various materials in tension.
5-2. Label the various regions of the stress-strain curves.
5-3. Describe the similarities and differences of stress-strain diagrams for various materials.
5-4. Explain the similarities and differences of brittle and ductile fracture.
5-5. Apply the relationship between hardness tests and other mechanical tests to predict the strength of materials.
5-6. Using safety factors, calculate the safe or working strength of various materials.
5-7. Determine from stress-strain curves the modulus of elasticity, tensile stress, fracture stress, and yield stress.

COMPETENCY 6. Use the various strengthening mechanisms to strengthen materials.

ENABLING OBJECTIVES
6-1. Illustrate the effect of dislocation density on the strength of metals.
6-2. Describe the effect of grain size reduction on the strength of metals.
6-3. Explain the effect of solid solution hardening on the strength of metals.
6-4. Use strain hardening to increase the strength of metals.

COMPETENCY 7. Using various materials that have experienced mechanical failure determine the mode of fracture.

ENABLING OBJECTIVES
7-1. Compare and contrast ductile and brittle fracture.
7-2. Describe the s-n diagram and the mechanisms of fatigue.
7-3. List the factors that affect fatigue life.
7-4. Explain the various phases of creep behavior.
7-5. Compare and contrast creep behavior to elastic and plastic deformation.
7-6. Explain the factors which affect creep behavior.

COMPETENCY 8. Analyze the structure and properties of various ceramic materials.

ENABLING OBJECTIVES
8-1. Explain the structure of various ceramic materials.
8-2. Describe the influence of structure and impurities on the properties of various ceramic materials.
APPENDIX H

8-3. Compare and contrast the stress-strain behavior of ceramic materials and metallic materials.

COMPETENCY 9. Analyze the effect of molecular structure on the properties and behavior of polymer materials.

ENABLING OBJECTIVES
9-1. Distinguish between a general hydrocarbon material and a polymeric material.
9-2. Compare and contrast linear polymers, branched polymers, and cross linked polymers, network polymers, and copolymers and describe how the structures cause unique properties in each.

COMPETENCY 10. Explain the characteristics, applications, and processing of polymers.

ENABLING OBJECTIVES:
10-1. Explain the stress-strain behavior of polymeric materials.
10-2. Compare and contrast thermoplastic and thermoset polymers.
10-3. Explain the relationship between elastic, plastic, and viscoelastic behavior in polymers.
10-4. Compare and contrast addition and condensation polymers.
10-5. Explain the effect of fillers, plasticizers, stabilizers, colorants, and flame retardants on the properties, applications, and mechanical behavior of polymers.

COMPETENCY 11. Synthesize the relationship of the behavior and properties of composite materials and metals, ceramics, and polymers.

ENABLING OBJECTIVES:
11-1. Explain the meaning and significance of the matrix and dispersed phase of composite materials.
11-2. Give examples of large and small particle composites and dispersion-strengthened composites and compare and contrast their mechanical behavior and properties.
11-3. Explain fiber reinforced composites and discuss the influence of fiber length, fiber orientation, and concentration on the strength properties of composites.
11-4. Compare and contrast the properties and structure of laminar and sandwich panel composites.