Prepared by the Department of Natural Sciences & Applied Technology
Date of Departmental Approval: January 21, 2016
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1. **Course Number: CHM152 and CHM152L**
   Course Title: General Chemistry II and General Chemistry II Laboratory

2. **Description:** Continuation of CHM151. Considers the study of intermolecular forces, solution properties, chemical kinetics, chemical equilibria, acid-base theory, solubility products, electrochemistry, and thermodynamics. Laboratory studies reinforce the principles and concepts studied in lecture and include the qualitative and quantitative analysis of solutions. (3 class hours/ 3 laboratory hours)

3. **Student Learning Outcomes (instructional objectives, intellectual skills):**
   Upon successful completion of this course, students are able do the following.
   - Describe the various kinds of intermolecular attractions and how they are related to physical properties such as vapor pressure, viscosity, melting point, boiling point, evaporation, condensation, melting, solidification, sublimation and deposition
   - Describe the various types of solids and relate the properties of different types of solids to the bonding or interactions among particles in these solids
   - Describe the colligative properties of solutions and carry out calculations involving the colligative properties of solutions
   - Describe the experimental factors that affect the rates of chemical reactions
   - Apply the method of initial rates to find the rate-law expression for a reaction and calculate k, the rate constant
   - Use the integrated rate-law expression for a reaction (the relationship between concentration and time)
   - Analyze kinetics data to determine the order of a reaction and to solve problems related to calculations of the rate constant, k; concentrations of reactant after time, t; half-life of reactions
   - Describe the collision theory of reaction rates, transition state theory, and the role of activation energy in determining the rate of a reaction
   - Use the Arrhenius equation to relate the activation energy for a reaction to changes in the rate constant with changes in temperature
   - Derive the reaction quotient and explain the relationship between the reaction quotient and the equilibrium constant
   - Apply LeChatelier's Principle to recognize factors that affect equilibria and predict the result when changes are introduced into systems at equilibrium
   - Describe the Bronsted-Lowry Theory and the Lewis Theory of acids and bases and calculate pH and pOH of acid base solutions
   - Use ionization constants for weak monoprotic acids and bases to determine concentrations of species in dilute solutions
   - Describe the ionization of polyprotic acids and calculate the concentrations of all species in solutions of polyprotic acids
   - Apply acid-base equilibrium concepts to salts of acids and bases
   - Explain the common ion effect and calculate the concentrations of all species in solutions containing common ions
   - Describe the process of titration; the use of acid-base indicators and how they function
   - Calculate the concentrations of all species present at various stages of titration curves for (a) strong acids and bases, (b) weak acids and strong bases, (c) strong acids and weak bases
   - Write solubility product expressions and use Ksp in chemical calculations
   - Use Ksp to calculate separation of ions by fractional precipitation and explain how simultaneous equilibria can be used to control solubility
   - Write formation expressions for complex ions and use K_f in chemical calculations

- Describe the differences between and identify the components of electrolytic cells and voltaic (galvanic) cells, and write half-reactions and overall cell reactions for electrolysis processes
- Use Faraday's Law of Electrolysis to calculate amounts of products formed, amounts of current passed, time elapsed, and oxidation state
- Apply understanding of the thermodynamic quantities enthalpy, entropy and free energy to predict the sign of an entropy change, predict spontaneity and relate equilibrium conditions to free energy
- Develop independence in designing and executing lab experiments, while practicing lab safety and accepted lab techniques, through planning how to meet lab objectives without specific step by step instructions.
- Use appropriate techniques in the laboratory, collect and analyze meaningful data, and present clearly and cogently written laboratory results (utilizing Standard American English).
- Work cooperatively in a small group setting to complete various laboratory exercises, following the written instructions provided.
- Solve problems that involve any of the topics included in the outline for this course.
- Explain some of the ways in which Chemistry can be applied to the problems of society in general.
- Effectively utilize appropriate quantities and units to describe chemical phenomena.
- Use a variety of devices and instruments in taking laboratory measurements.
- Use a scientific calculator as a tool in solving a wide variety of problems.

4. Credits: 4 credits

5. Satisfies General Education Requirement: Natural or Physical Science

6. Prerequisite: A grade of C or better in CHM101 General Chemistry I (retired) or CHM151 General Chemistry I

7. Semester Offered: Spring

8. Suggested General Guidelines for Evaluation: Course grading procedures are detailed on a student handout. Grades will be based on quizzes, hourly exams, final exam, formal laboratory reports, laboratory notebook and pre-laboratory problems.

9. General Topical Outline:

A. Intermolecular Forces, Liquids and Solids
   1. Forces Between Molecules
      a. Kinetic-Molecular Theory: Liquids and Solids
      b. Dipole-Dipole and Ion Dipole Attractions
      c. Dispersion Forces
      d. Hydrogen Bonding
   2. Properties of Liquids and Solids
      a. Evaporation of Liquids and Solids
      b. Boiling of Liquids
      c. Distillation
      d. Melting of Solids
      e. Critical Temperature and Pressure
      f. Phase Diagrams
      g. Cohesive Forces and Adhesive Forces
   3. The Structures of Crystalline Solids
      a. Types of Solids
      b. Crystal Defects
      c. The Structure of Metals
      d. The Structure of Ionic Crystals
      e. Crystal Systems

B. Colligative Properties of Solutions
   1. Lowering of the Vapor Pressure of the Solvent
   2. Elevation of the Boiling Point of the Solvent
   3. Distillation of Solutions
   4. Depression of the Freezing Point of the Solvent

5. Phase Diagram for an Aqueous Solution of a Nonelectrolyte
6. Osmosis and Osmotic Pressure

7. Determination of Molecular Masses
8. The Effect of Electrolytes on Colligative Properties

C. Chemical Kinetics
1. The Rate of Reaction
2. Factors Affecting the Reaction Rate
    a. Concentration of Reactants
    b. Nature of Reactants
    c. Temperature and Heat
    d. Catalyst
    e. State of Subdivision
3. Rate Equations
4. Order of a Reaction
5. Half-Life of a Reaction
6. Collision Theory of the Reaction Rate
7. Activation Energy and the Arrhenius Equation
8. Elementary Reactions
    a. Unimolecular
    b. Bimolecular
    c. Termolecular
9. Reaction Mechanisms

D. An Introduction to Chemical Equilibria
1. The State of Equilibrium
2. Reaction Quotients and Equilibrium Constants
3. The Relationship of Rates of Reaction and Equilibrium Constants
4. Predicting the Direction of Reaction of a Reversible Reaction
5. Calculations Involving Equilibrium Concentrations
6. Calculation of Equilibrium Concentrations
7. Techniques for Solving Equilibrium Problems
8. Effect on Equilibrium When Change of:
    a. Concentration
    b. Temperature
    c. Pressure
9. Effect of Catalyst on Equilibrium
10. Homogeneous and Heterogeneous Equilibria
11. The Distribution Law and Extraction

E. Acids and Bases
1. The Bronsted-Lowry Concept of Acids and Bases
    a. Protonic Concept of Acids and Bases
    b. Amphiprotic Species
    c. Strengths of Acids and Bases
    d. Neutralization
    e. Relative Strengths of Strong Acids and Bases
    f. Bronsted Acids
        i. In Aqueous Solution
        ii. Preparation
        iii. Monoprotic
        iv. Diprotic
        v. Triprotic
    g. Bronsted Bases
        i. In Aqueous Solution
        ii. Preparation
    h. Salts
    i. Quantitative Reactions of Acids and Bases
    j. Equivalents of Acids and Bases
2. The Lewis Concept of Acids and Bases
    a. Definitions
    b. Examples

F. Ionic Equilibria of Weak Electrolytes
1. pH and pOH
2. Ion Concentrations in Solutions of Strong Electrolytes
3 The Ionization of Weak Acids
a. Monoprotic Acids
b. Diprotic Acids
c. Triprotic Acids
4. The Ionization of Weak Bases
5. The Common Ion Effect
6. Buffer Solutions
7. Reactions of Salts with Water
a. Salt of Strong Base and Weak Acid
b. Salt of Weak Base and Strong Acid
c. Salt of Weak Base and Weak Acid
8. The Ionization of Hydrated Metal Ions
9. Acid-Base Indicators
10. Titration Curves

G. The Solubility Product Principle
1. The Solubility Product
2. Calculation of Solubility Products from Solubilities
3. Calculation of Solubilities from Solubility Products
4. The Precipitation of Slightly Soluble Electrolytes
5. Calculation of Concentrations Necessary to Form a Precipitate
6. Calculations of Concentrations Following Precipitation
7. Solubility and Crystal Size
8. Fractional Precipitation
9. Multiple Equilibria Involving Solubility
10. Dissolution by
a. Formation of a Weak Electrolyte
b. Changing an Ion into Another Species
c. Formation of a Complex Ion

H. Electrochemistry and Oxidation-Reduction
1. Galvanic Cells and Cell Potentials
a. Galvanic Cells
b. Cell Potentials
c. Standard Electrode Potentials
d. Calculation of Cell potentials
e. Effect of Concentrations on Cell Potentials
f. Relationship of the Cell Potential to the Equilibrium Constant
2. Batteries
a. Primary Cells
b. Secondary Cells
c. Fuel Cells
d. Corrosion
3. Electrolytic Cells
a. The Electrolysis of Molten Sodium Chloride
b. The Electrolysis of Aqueous Solutions
c. Electrolytic Deposition of Metals
d. Faraday's Law of Electrolysis
4. Oxidation-Reduction Reactions
a. Balancing Redox Equations by the
i. Half-Reaction Method
ii. Change in Oxidation Number Method
b. Some Half-Reactions

I. Thermodynamics
1.Spontaneous Processes
2. Entropy
3. Gibbs Free Energy
4. Free Energy and Equilibrium