

**Department:**

Chemistry

**Course Description:**

This course continues the study begun in PS 111 and is intended for students going into technological, scientific, engineering, or medical fields. The course is required in certain pre-professional programs, such as pre-medicine, pre-veterinary medicine, pre-dentistry, etc. Course topics will include crystals and solids, reaction kinetics, chemical equilibrium, solution chemistry including acid-base and complex-ion equilibria, thermodynamics, and electrochemistry. The course will also include a brief discussion of organic chemistry, biochemistry, and nuclear chemistry.

**Course Competencies:**

The learning outcomes and competencies detailed in this syllabus meet or exceed the learning outcomes and competencies specified by the Kansas Core Outcomes Groups for this course as approved by the Kansas Board of Regents. (Kansas Regents Shared Number Course and Title: **KRSN Course CHM 1020/CHM 1021/CHM 1022 Chemistry II & Lab/Lecture/Lab.**)

Upon completion of this course, students will be able to:

**Lecture Portion**

1. Colligative Properties
  - a. Describe the origins and relative magnitudes of intermolecular forces.
  - b. Relate phase behavior to nature of intermolecular forces.
  - c. Define saturated solution, unsaturated solution, supersaturated solution, solubility, solute, and solvent.
  - d. Understand and perform calculations using Henry's Law.
  - e. Calculate concentration in molality, molarity, mole fraction, and percent composition, and interconvert between these units.
  - f. Explain and calculate vapor pressure using Raoult's Law.
  - g. Explain other colligative properties, including freezing point depression, boiling, point elevation, and osmotic pressure.
  - h. Perform calculations using colligative properties, including molecular weight, freezing point depression, boiling point elevation and osmotic pressure.
  - i. Differentiate between the behaviors of non-ionizing and ionizing compounds in solution.
2. Kinetics
  - a. Discuss the meaning of the rate of a reaction.
  - b. Explain the factors that affect reaction rates.
  - c. Use the initial rate method to determine reaction order from experimental data.
  - d. Determine orders of reaction for reactants from data expressing changes in concentration as a function of longer times.
  - e. Use the rate law to determine the overall order of a reaction.
  - f. Determine a reaction rate law from initial rate data.

- g. Describe the relationship between order of reaction and molecularity.
  - h. Use experimental data to determine the rate law for a reaction.
  - i. Use an integrated form of the rate expression to perform calculations relating reactant or product concentration with reaction time.
  - j. Compare zero, first and second order rate reactions.
  - k. Discuss the collision theory of a reaction rate.
  - l. Use the Arrhenius equation to illustrate the relationship between energy of activation and rate law constant.
  - m. Describe the relationships among the mechanism, the overall reaction and elementary steps.
  - n. Identify reaction intermediates and catalysts in reaction mechanisms.
  - o. Draw and interpret energy diagrams and illustrate the effect of a catalyst on the energy diagram.
3. Equilibrium Principles
- a. Explain the relationship between the terms reversible reaction and dynamic equilibrium.
  - b. Write the general equilibrium constant expression and explain its significance.
  - c. Calculate  $K_{eq}$  given equilibrium concentrations of reactants and products.
  - d. Calculate equilibrium concentrations of reactants and products given the equilibrium concentration of other reactants and products.
  - e. Calculate new equilibrium concentrations of reactants and products after an increase or decrease in the concentration of one of the reactants or products.
  - f. Explain why the concentrations of pure liquids and solids are never used in equilibrium constant expressions.
  - g. Show how the numerical value of the equilibrium constant changes when the stoichiometric coefficients are changed, or the reaction is reversed.
  - h. Explain the differences between the terms  $K_c$  and  $K_p$  and the relation of either to  $Q_c$ .
  - i. Explain the difference between an equilibrium position and an equilibrium constant.
  - j. Given  $K_{eq}$  and initial concentration of reactants and/or products, calculate the final concentrations of reactants and/or products.
  - k. List and explain the external factors that can affect equilibria.
  - l. Using Le Chatelier's Principle, explain how changes in temperature, pressure, volume, or concentration affect the equilibrium position for a chemical reaction.
4. Equilibrium of Aqueous Solutions
- a. Use the definition of acids and bases to distinguish between strong and weak acids and bases, equilibrium relationships among them, and the aqueous properties of their salts.
  - b. Use the concepts of pH, pOH,  $K_a$ , and  $K_b$  to calculate the pH of aqueous solutions of acids, bases, and their salts.
  - c. Determine the specific species present in an aqueous solution and the concentrations of those species.
  - d. Describe the shape of acid-base titration curves for strong acid-strong base, weak acid-strong base, strong acid-weak base and weak acid-weak base titrations.
  - e. Describe the effect of common ions and calculate concentrations of all species present in solutions of weak acids and bases.
  - f. Describe the ionization of poly-protic acid in aqueous solution.
  - g. Explain the buffer effect, predict the influence of added acids and bases on buffers, and calculate the concentrations of species in solution (using acid or base dissociation constant expressions, or Henderson-Hasselbach equation).
  - h. Calculate the pH of a buffer solution outside of the buffer region.
  - i. Identify titration curves for strong, weak, and poly functional acids and bases.

- j. Understand the use of volumetric methods to determine the concentrations of species in solution.
  - k. Understand application of indicators in titration.
  - l. Write an equation to express the relationship between a solid solute and its constituent ions in a saturated solution.
  - m. Calculate the  $K_{sp}$  from molar solubility and molar solubility from  $K_{sp}$ .
  - n. Calculate the effect of a common ion on the molar solubility of a salt.
  - o. Predict whether precipitation will occur when salt solutions are mixed and determine the concentration of ions remaining in solution after precipitation.
5. Thermodynamics
- a. Explain the similarities and differences between such terms as enthalpy, entropy, and free energy.
  - b. Explain how the First, Second, and Third Laws of Thermodynamics apply chemical and physical processes.
  - c. Predict whether the entropy change in a given process is positive, negative, or near zero.
  - d. Use data tables to determine enthalpy, entropy, and free energy changes.
  - e. Explain how  $\Delta H^\circ$ ,  $\Delta S^\circ$ , and  $\Delta G^\circ$  are related to reaction spontaneity.
  - f. Explain how knowledge of  $\Delta H^\circ$ ,  $\Delta S^\circ$ , and  $\Delta G^\circ$  allows one to predict the conditions under which a reaction will occur.
  - g. Describe and calculate the relationship between the standard free energy of reaction and the equilibrium constant.
  - h. Calculate  $\Delta G$  for a chemical reaction that occurs under nonstandard conditions.
6. Electrochemistry
- a. Describe galvanic and electrolytic cells and their operation, including the identification of half reactions at the anode and cathode.
  - b. Write half reactions given a balanced redox reaction, and generate a balanced redox reaction given redox half reactions.
  - c. Calculate cell potentials and determine spontaneity of oxidation/ reduction reactions.
  - d. Understand and use Faraday's Law.
  - e. Understand and apply the relationship of thermodynamics to electrochemistry.
  - f. Understand and use the Nernst Equation.
  - g. Understand the relationship between the cell potential  $E$  and  $\Delta G$ , and use this relationship in problem solving.
  - h. Give examples of natural and/or commercial applications of electrochemical processes.

### Laboratory Portion

1. Work in the laboratory in accordance with good laboratory practices
  - a. Dress in an appropriate manner as to promote safety in the laboratory, wearing appropriate laboratory attire and goggles when anyone is working with chemicals in the laboratory
  - b. Follow written directions accurately
  - c. Work safely and effectively, using equipment and chemical carefully and correctly
  - d. Demonstrate use of required techniques
  - e. Dispose of waste products in a proper manner
  - f. Know how to find and understand MSDS's for the chemicals used in a laboratory
2. Gather and record qualitative and quantitative data accurately
  - a. Acquire data using balances and volumetric glassware
  - b. Make and record visual observations
  - c. Use computers, when appropriate, as data acquisition tools

- d. List or describe experimental assumptions made and any deviations from the written experimental procedures
3. Handle and evaluate data in logical, productive, and meaningful ways
  - a. Create notebooks and laboratory reports that are clear, understandable, and accurately represent the data collected
  - b. Display computer data in a spreadsheet or graphically, as appropriate
  - c. Correlate observations with chemical or physical processes
  - d. Carry out suitable calculations with quantitative data, recognizing when data and calculations are within a reasonable range
  - e. Use observations of experimental data to present relevant conclusions pertaining to the experimental procedure
4. Correlate laboratory work with principal topics in College Chemistry II lecture

### Course Content:

- A. The chemistry of solids
- B. Organic chemistry: fuels and materials
- C. Thermodynamics: spontaneous processes, entropy, and free energy
- D. Chemical kinetics
- E. Chemical equilibrium
- F. Equilibrium in the aqueous phase
- G. Chemistry of transition metals
- H. Electrochemistry and electric vehicles
- I. Biochemistry: the compounds of life
- J. Nuclear chemistry

### Learning Assessments:

Course competencies will be assessed by exams, quizzes, homework assignments, lab work and reports, and final exam.

### Instructional Materials:

Textbook: Davies, G., Foster, N., Gilbert, T. R., & Kirss, R. V. (2015). *Chemistry: The Science in Context* (4th ed.). New York, NY: W.W. Norton. ISBN: 978-0-393-91937-0

Laboratory manual: *PS 112 College Chemistry II HCC Custom Lab Manual*. New Jersey: Pearson. ISBN: 978-1323864562

#### **Guidelines for Requesting Accommodations Based on Documented Disability or Medical Condition**

It is the intention of Highland Community College to work toward full compliance with the Americans with Disabilities Act, to make instructional programs accessible to all people, and to provide reasonable accommodations according to the law.

Students should understand that it is their responsibility to self-identify their need(s) for accommodation and that they must provide current, comprehensive diagnosis of a specific disability or medical condition from a qualified professional in order to receive services. Documentation must include specific recommendations for accommodation(s). Documentation should be provided in a timely manner prior to or early in the semester so that the requested accommodation can be considered and, if warranted, arranged.

In order to begin the process all students **must** complete the "Disabilities Self-Identification Form" on our [Disability Services website](#).

This form can also be accessed at the Highland Community College homepage under Students Services/Student Resources/Disability Service or by contacting the Disabilities Coordinator.

### **A Note on Harassment, Discrimination and Sexual Misconduct**

Highland Community College seeks to assure all community members learn and work in a welcoming and inclusive environment. Title VII, Title IX, and College policy prohibit harassment, discrimination and sexual misconduct. Highland Community College encourages anyone experiencing harassment, discrimination or sexual misconduct to talk to report to the Vice President for Student Services, the Human Resources Director or complete an [online report](#) about what happened so that they can get the support they need and Highland Community College can respond appropriately.

There are both confidential and non-confidential resources and reporting options available to you. Highland Community College is legally obligated to respond to reports of sexual misconduct, and therefore we cannot guarantee the confidentiality of a report, unless made to a confidential resource. Responses may vary from support services to formal investigations. As a faculty member, I am required to report incidents of sexual misconduct and thus cannot guarantee confidentiality. I must provide our Title IX coordinator with relevant details such as the names of those involved in the incident. For more information about policies and resources or reporting options, please review our [Equity Grievance Policy](#).