



# ILLINOIS VALLEY COMMUNITY COLLEGE

## COURSE OUTLINE

**DIVISION:** Natural Sciences and Business

**COURSE:** CHM 1007 General Chemistry II

Date: Spring 2023

Credit Hours: 5

*Complete all that apply or mark "None" where appropriate:*

Prerequisite(s): CHM 1006

Enrollment by assessment or other measure?  Yes  No

If yes, please describe:

Corequisite(s): None

Pre- or Corequisite(s): None

Consent of Instructor:  Yes  No

Delivery Method:	<input checked="" type="checkbox"/> <b>Lecture</b>	<b>3 Contact Hours</b> (1 contact = 1 credit hour)
	<input checked="" type="checkbox"/> <b>Seminar</b>	<b>1 Contact Hours</b> (1 contact = 1 credit hour)
	<input checked="" type="checkbox"/> <b>Lab</b>	<b>3 Contact Hours</b> (2-3 contact = 1 credit hour)
	<input type="checkbox"/> <b>Clinical</b>	<b>0 Contact Hours</b> (3 contact = 1 credit hour)

Offered:  **Fall**  **Spring**  **Summer**

**CATALOG DESCRIPTION and IAI NUMBER (if applicable):**

This course is a continuation of CHM 1006. Topics include kinetics, equilibrium, acid base theories, buffers, electrochemistry, coordination chemistry, nuclear chemistry and organic chemistry. Laboratory includes gravimetric, volumetric, electroanalytic, and spectrophotometric methods of analysis. **IAI Equivalent: CHM 912**

## ACCREDITATION STATEMENTS AND COURSE NOTES:

None

## COURSE TOPICS AND CONTENT REQUIREMENTS:

### 1. Kinetics

- Factors that Affect Reaction Rates
- Reaction Rates
- Concentration and Rate Laws
- The Change of Concentration with Time
- Temperature and Rate
- Reaction Mechanisms
- Catalysis

### 2. Equilibrium

- The Concept of Equilibrium
- The Equilibrium Constant
- Understanding and Working with Equilibrium Constants
- Heterogeneous Equilibria
- Calculating Equilibrium Constants
- Applications of Equilibrium Constants
- Le Châtelier's Principle

### 3. Acids-Base Equilibrium

- Acids and Bases: A Brief Review
- Bronsted-Lowry Acids and Bases
- The Autoionization of Water
- The pH Scale
- Strong Acids and Bases
- Weak Acids
- Weak Bases
- Relationship Between  $K_a$  and  $K_b$
- Acid-Base Properties of Salt Solutions
- Acid-Base Behavior and Chemical Structure
- Lewis Acids and Bases

### 4. Additional Equilibrium

- The Common-Ion Effect
- Buffered Solutions
- Acid-Base Titrations
- Solubility Equilibria
- Factors that Affect Solubility
- Precipitation and Separation of Ions
- Qualitative Analysis for Metallic Elements

### 5. Thermodynamics

- Spontaneous Processes
- Entropy and the Second Law of Thermodynamics
- Molecular Interpretation of Entropy
- Entropy Changes in Chemical Reactions
- Gibbs Free Energy

- Free Energy and Temperature
- Free Energy and the Equilibrium Constant

## **6. Electrochemistry**

- Oxidation States and Oxidation-Reduction Reactions
- Balancing Redox Equations
- Voltaic Cells
- Cell Potentials Under Standard Conditions
- Free Energy and Redox Reactions
- Cell Potentials Under Nonstandard Conditions
- Batteries and Fuel Cells
- Corrosion
- Electrolysis

## **7. Transition Metals and Coordination Chemistry**

- The Transition Metals
- Transition Metal Complexes
- Common Ligands in Coordination Chemistry
- Nomenclature and Isomerism in Coordination Chemistry
- Color and Magnetism in Coordination Chemistry
- Crystal-Field Theory

## **8. Nuclear Chemistry**

- Radioactivity
- Patterns of Nuclear Stability
- Nuclear Transmutations
- Rates of Radioactive Decay
- Energy Changes in Nuclear Reactions
- Nuclear Power: Fission
- Nuclear Power: Fusion
- Radiation in the Environment and Living System

## **9. Organic Chemistry**

- General Characteristics of Organic Molecules
- Introduction to Hydrocarbons
- Alkenes, Alkynes, and Aromatic Hydrocarbons
- Organic Functional Groups
- Introduction to Biochemistry
- Proteins
- Carbohydrates
- Lipids
- Nucleic Acids

## **INSTRUCTIONAL METHODS:**

Lecture

Lecture demonstrations

YouTube videos (animations of chemical processes, chemical demonstrations)

Laboratory experiments

Laboratory reports

Online Homework and Quizzing system

Examinations  
Peer tutoring

### **EVALUATION OF STUDENT ACHIEVEMENT:**

Regular attendance in lecture, seminar and laboratory  
Reading assignments  
Quizzes  
Online homework assignments  
Exams  
Participation in classroom discussions  
Performance of laboratory experiments

A = 90 -100  
B = 80 – 89  
C = 70 – 79  
D = 60 – 69  
F = 59 and below

### **INSTRUCTIONAL MATERIALS:**

#### **Textbook:**

Chemistry: The Central Science, Brown, Lemay, Bursten Laboratory manual: In house  
Online eBook, homework and quizzing.  
Worksheets

#### **Resources**

Chemistry and Chemical Reactivity, Kotz  
Handbook of Laboratory Safety, Steere  
Handbook of Chemistry and Physics  
Chemistry, Change  
[www.acs.org](http://www.acs.org)  
Journal of Chemical Education  
Chemical and Engineering News

### **LEARNING OUTCOMES AND GOALS:**

#### **Institutional Learning Outcomes**

- 1) Communication – to communicate effectively;
- 2) Inquiry – to apply critical, logical, creative, aesthetic, or quantitative analytical reasoning to formulate a judgement or conclusion;
- 3) Social Consciousness – to understand what it means to be a socially conscious person, locally and globally;
- 4) Responsibility – to recognize how personal choices affect self and society.

## Course Outcomes and Competencies

### Outcome 1 - Students will be able to demonstrate an understanding of chemical kinetics

1. Define reaction rate both in words and in a mathematical statement.
2. Draw an energy vs. reaction coordinate diagram and indicate energy of reactants, activation energy, energy of products, effect of catalyst, whether the reaction is exothermic or endothermic, and discuss those concepts in writing.
3. Draw labeled Maxwell-Boltzman curves for two different temperatures and discuss why high temperature leads to higher reaction rates.
4. Define and give examples of homogeneous and heterogeneous catalysis.
5. Determine the order of a reaction given the equation and the effect of concentration change on the initial rate of reaction.
6. Define and illustrate rate determining step, reaction mechanism, and chain mechanism.
7. Solve problems using the integrated rate law equations including half-life calculations.

### Outcome 2- Students will be able to demonstrate an understanding of basic chemical equilibrium

1. Define equilibrium and give examples of systems at equilibrium, both physical and chemical.
2. Given a chemical reaction, set up the equilibrium expression.
3. State LeChatelier's Principle and apply it to predict the effect of changes in temperature, concentration, pressure, on a system at equilibrium.
4. Predict the effect of changes in temperature, concentration, pressure, and catalyst on the equilibrium constant.
5. Relate the completeness of reaction to a specific equilibrium constant.
6. Solve equilibrium problems such as:
  - a. Calculation of the constant from initial concentration and one equilibrium concentration.
  - b. Calculation of equilibrium concentrations from initial concentrations and the equilibrium constant.
  - c. Calculate the equilibrium constant given the equilibrium concentrations.

### Outcome 3- Students will be able to demonstrate an understanding of solubility equilibrium and $K_{sp}$ calculations.

1. Write the  $K_{sp}$  expression given the formula of the salt and determine its value given the solubility of the salt in g/l or moles/l and vice versa.
2. Predict whether or not a precipitate will form given the  $K_{sp}$  and concentrations of solutions to be mixed.
3. Describe four methods that can be used to dissolve insoluble salts from the standpoint of equilibrium theory.
4. Describe the basis of the group separations in qualitative analysis using equilibrium theory,  $K_{sp}$  values and  $K_a$  or  $K_b$ .
5. Determine by calculations which salt will precipitate first given the conc of the salts and  $K_b$  values.
6. Solve problems involving multiple equilibria.

**Outcome 4- Students will be able to demonstrate an understanding Acid-Base Equilibrium and related calculations.**

1. Define: Lewis acid and base, Arrhenius acid and base, Bronsted-Lowrey acid and base, amphiprotic, leveling effect, conjugate acid and base.
2. Complete equations for the preparation of acids and bases.
3. Given a reaction and using the Bronsted Theory identify the acid, base, conjugates.
4. Given a list of acids and  $K_a$  values, place them in order of acid strength.
5. Describe the properties of an acid or base in view of the Arrhenius theory.
6. Given an equation explain the reaction in light of the Lewis acid-base theory, or given reactants predict the products in light of this theory.
7. Identify weak and strong electrolytes; know the six common strong acids and the common strong bases
8. Write the  $K_i$  expression for a weak acid or weak base.
9. Calculate the  $H^+$  conc. of a solution of a weak acid or base given the initial conc. and the  $K_a$  or  $K_b$ .
10. Describe the salt effect on ionization.
11. Apply the common ion effect and LeChatelier's Principle to situations involving weak acids and bases.
12. Know the ion product value ( $K_w$ ) for water and express it mathematically in an equation.
13. Calculate:
  - $H^+$  conc. given the  $K_a$ , initial conc. of the acid or its salt
  - pH and pOH given the  $H^+$  or  $OH^-$  conc. or vice versa
  - pH of a diprotic acid such as carbonic acid given the  $K$  values and initial conc.
  - ratio of salt to acid to prepare a specific buffer solution
  - pH at various points on a titration curve
  - number of moles or grams of a salt necessary to produce a solution with a given pH, given  $K$
15. Define and illustrate what is meant by a buffer solution.
16. Discuss how an acid-base indicator works and is selected.
17. Define hydrolysis and write equations for such reactions.
18. Identify salts that undergo hydrolysis.
19. Predict whether salt solutions will be acidic, basic or neutral.
20. Derive the  $K_b$  expression from  $K_a$  and  $K_w$  and vice versa.

**Outcome 5- Students will be able to demonstrate an understanding of Thermodynamics**

1. Explain the difference between a spontaneous and nonspontaneous process.
2. Define entropy and the Second Law of Thermodynamics as well as give a molecular interpretation of entropy.
3. Predict net entropy change in chemical reactions.
4. Calculate entropy change in a chemical reaction from standard thermodynamic tables.
5. Calculate Gibbs Free Energy from standard thermodynamic tables.
6. Calculate equilibrium constant given Gibbs Free Energy and vice versa

**Outcome 6- Students will be able to demonstrate an understanding of the chemistry of coordination compounds.**

1. Identify the coordination number, ligands, donor atom, coordination sphere, and chelating group.
2. Memorize the names for common ligands and chelating agents give a list.
3. Given the name write the formula or vice versa for coordination compounds.
4. Predict the type of hybridization and structure given the formula of the compound.
5. Draw diagrams for the isomers that could exist given the formula.
6. Draw crystal field diagrams, determine the CFSE.
7. List several uses of coordination compounds.

**Outcome 7- Students will be able to demonstrate an understanding electrochemistry, corrosion and batteries.**

1. Define and give examples of an electrolytic cell.
2. Diagram and label the parts of an electrolytic cell--anode, cathode, electrolyte, direction of electron flow.
3. State and apply Faraday's Law to calculate the quantity of metal obtained during electrolysis.
4. Define coulombs, (equivalent weight) and Faraday.
5. Define and give an example of a voltaic cell.
6. Diagram and label the parts of a voltaic cell (see 2 above).
7. Describe the migration of ions and current (electron) flow in a voltaic cell given the half reactions.
8. Sketch a standard hydrogen electrode, know the potential under standard conditions and what those conditions are.
9. Define standard cell potential and know the sign convention for prediction of spontaneity.
10. Use a table of reduction potentials and predict spontaneity.
11. Calculate cell potentials using the Nernst Equation.
12. Calculate the change in G and calculate K from the cell potential.
13. Describe one of the following cells in terms of electrodes, electrolyte, half reactions and direction of electron flow:
  - a. dry cell
  - b. lead storage battery
  - c. fuel cell
  - d. corrosion

**Outcome 8- Students will be able to demonstrate an understanding of nuclear chemistry.**

1. Students will be able to discuss the nature of radioactivity.
2. Students will be able to write the symbols for each type of radioactive particle, including appropriate mass numbers and nuclear charge.
3. Students will be able to write, complete and balance nuclear equations.
4. Students will be able to use the half-life of an isotope to determine the age of a sample.
5. Students will be able to predict the amount of a radioactive sample that will remain after a given time period, given the decay constant or half-life of the sample.
6. Students will be able to distinguish nuclear fission from nuclear fusion and predict which nuclides undergo each type of process.
7. Students will be able to distinguish and radiation by their reactions to an electric field, penetrating power, and relative biological effectiveness.

8. Students will be able to describe some applications of radioactive isotopes in chemistry, industry, and medicine.
9. Students will be able to describe the construction and operation of a nuclear reactor.

**Outcome 9- Students will be able to demonstrate an introductory understanding of organic chemistry functional groups.**

1. Given the name of an alkane, alkene, alkyne write the structural formula or vice versa.
2. Recognize an aromatic hydrocarbon from the structural formula.
3. Recognize functional groups such as alcohol, ester, ketone, aldehyde, ether, acid, amine, amide from the structural formula and give a use for a representative compound of each.
4. Draw the isomers for a compound given the formula.