# CHEM-1310: GENERAL CHEMISTRY II

## Cuyahoga Community College

### Viewing: CHEM-1310 : General Chemistry II

**Board of Trustees:**
January 2022

**Academic Term:**
Fall 2022

**Subject Code**
CHEM - Chemistry

**Course Number:**
1310

**Title:**
General Chemistry II

**Catalog Description:**
Emphasis on kinetics, equilibrium concepts, electrochemistry, thermodynamics, liquids and solids and phase transitions, solutions, and descriptive chemistry, including periodic patterns of chemical properties and reactivities. To fulfill laboratory science requirement, students should enroll in related laboratory course.

**Credit Hour(s):**
4

**Lecture Hour(s):**
4

**Lab Hour(s):**
0

**Other Hour(s):**
0

## Requisites

**Prerequisite and Corequisite**
CHEM-1300 General Chemistry I, or CHEM-130H Honors General Chemistry I; or departmental approval: equivalent knowledge or skills.

## Outcomes

**Course Outcome(s):**
Apply the principles of chemistry to advanced scientific studies and/or applications of chemistry in society.

**Essential Learning Outcome Mapping:**
Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**
1. Identify and explain the kinetics of a reaction.
2. Predict the sign of the entropy change for a reaction.
3. Write the expression that relates the equilibrium constant to the Gibbs free energy.
4. Relate the decay constant, half-life and activity to a nuclear reaction.
5. Discuss the differences between the various main groups of elements in the periodic table.
6. Determine whether geometric or optical isomers are possible in transition metal complexes.
7. Explain the theories of coordination chemistry.
8. Name and draw structures for coordination compounds.
9. Define a catalyst.
10. Describe the rate of reactant disappearance and product appearance for a chemical reaction.
11. Describe collision theory.

12. Describe the enthalpy of vaporization and the enthalpy of fusion.
13. Describe colligative properties.
14. Describe a galvanic and electrolytic cell.
15. Define a reducing agent and oxidizing agent.
16. Describe a buffer.
17. Define an acid and a base using both the Lewis theory and Bronsted-Lowry theory.
18. Define Ka, Kb, pKa, and pKb.
19. Determine acid strength using the acid ionization constants.
20. Determine the conjugate acid and base species in an acid-base reaction.
21. Describe a titration.
22. Describe equilibrium and the equilibrium constant.
23. Describe LeChatelier's Principle.
24. Write equilibrium expressions.

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**Course Outcome(s):**

Develop interpretative skills to apply mathematical methods to solve problems in other scientific studies and/or real world applications.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.
Quantitative Reasoning: Analyze problems, including real-world scenarios, through the application of mathematical and numerical concepts and skills, including the interpretation of data, tables, charts, or graphs.

**Objective(s):**

1. Calculate the Ksp from the solubility and vice versa.
2. Calculate the change in entropy for a reaction.
3. Calculate the Gibbs free-energy change for a reaction.
4. Calculate the emf from the electrode potentials, Gibbs free-energy or standard potentials.
5. Determine the orders and rate constant for a reaction.
6. Determine the fraction of a nuclei remaining after a specified period of time.
7. Solve equilibrium problems for homogeneous and heterogeneous equilibria.
8. Use the Clausius-Clapeyron equation to calculate the enthalpy of vaporization.
9. Determine the formula for a compound from the cubic unit cell.
10. Determine the concentration of a solution using percent by mass and density.
11. Determine the individual oxidation numbers of elements in a reaction.
12. Determine the strength of an oxidizing or reducing agent based on the standard cell potentials.
13. Determine the effect of concentration on cell potential.
14. Calculate the net cell potential using half-cell potentials.
15. Use half-life to calculate the concentration of a radioactive material.
16. Describe and apply the Henderson-Hasselbach equation.
17. Determine the pH of a salt solution.
18. Calculate equilibrium constants.
19. Understand the relationship between Kc and Kp.
20. Calculate the pH, pOH, and the H+ and OH- concentrations in a solution.
21. Calculate the pH of a buffer solution, given the concentrations of its components.
22. Calculate the concentration of all species at any point in an acid-base titration.

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**Course Outcome(s):**

Utilize the fundamental knowledge of chemistry to analyze chemical reactions and associated properties and develop critical thinking skills to predict and determine the causes of physical and/or chemical change.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Predict the change in solubility of a salt based on the presence of common ions, hydrolysis, and complexation.
2. Determine the completeness of precipitation.
3. Predict the spontaneity of a reaction based on the value of the Gibbs free-energy, cell potential, or equilibrium constant.
4. Relate the amount of charge and product in an electrolysis.
5. Describe the periodic trends in the transition elements.
6. Predict the wavelength of absorption of complex ions.
7. Determine whether a reaction mechanism is plausible based on the rate law.
8. Use the reaction quotient.

9. Use a potential energy diagram to describe the kinetics and thermodynamics of a chemical reaction.
10. Use a reaction mechanism to determine reaction order and rate law.
11. Explain the impact of concentration changes and catalysts on potential energy of a reaction.
12. Use the Arrhenius equation to relate changes in temperature, rate constant, rate, and activation energy.
13. Use Le Chatelier's principle and other theories to explain equilibria.
14. Interpret the thermodynamics of a heating or cooling curve.
15. Understand the relationship between the molar mass of a molecular substance and physical properties such as boiling point and vapor pressure.
16. Use a phase diagram to describe phase changes of a substance.
17. Explain the effect of pressure and volume on vapor pressure.
18. Explain the type and strength of intermolecular forces present in a substance.
19. Describe the relationship between type and strength of intermolecular forces and macroscopic physical properties of particles.
20. Describe the relationship of temperature and pressure on gas solubility in a liquid.
21. Determine the impact of polarity on solubility.
22. Use colligative properties to calculate the boiling point, melting point, vapor pressure, or osmotic pressure of a solution.
23. Write a formula of a compound using the elements and periodic trends.
24. Interpret an acid-base titration curve to determine pK and molar concentration.
25. Describe the species present in a solution using ionizations constants.
26. Understand the relationship of equilibrium constants and reaction quotients on reaction progress.
27. Predict entropy based on formula.
28. Explain the impact of free energy on reaction progress.
29. Explain the impact of the equilibrium constant on the free energy of the reaction.

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**Course Outcome(s):**

Apply the scientific method to solve a problem and explain the design of scientific studies.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

**Objective(s):**

1. Recall the scientific method including the basic steps of the process.
2. Apply the steps of the scientific method to solve a problem.
3. Apply the scientific method to explain scientific studies.

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**Course Outcome(s):**

Evaluate and differentiate between credible and non-credible sources of scientific arguments, use the gathered scientific information effectively, and appropriately cite the source of the information.

**Essential Learning Outcome Mapping:**

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.
Information Literacy: Acquire, evaluate, and use information from credible sources in order to meet information needs for a specific research purpose.

**Objective(s):**

1. Locate and review credible, scientific information relevant to a specific purpose.
2. Use credible, scientific information to advance the purpose of a research project or to solve a problem.
3. Use information ethically including citing sources using the appropriate format.
4. Differentiate between scholarly, scientific information and popular, non-scientific information.
5. Understand the importance of utilizing scholarly, scientific information in advanced scientific studies and the application of chemistry in society.

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**Methods of Evaluation:**

1. Written examinations
2. Quizzes
3. In-class group work/assignments
4. Out-of-class assignments
5. American Chemical Society - General Chemistry Exam

6. Research Papers
7. Case Studies

**Course Content Outline:**

1. States of matter
    a. Intermolecular forces
        i. Type and strength
            1. Dispersion
            2. Dipole-dipole
            3. Hydrogen bonding
            4. Ion-dipole
        ii. Relationship to physical properties
            1. Boiling point and melting point
            2. Vapor pressure
            3. Solubility
    b. Liquid state
        i. Physical properties
        ii. Phase transitions
        iii. Clausius-Claperyon equation
    c. Solid state of crystalline substances
        i. Types of crystalline solids
        ii. Lattice structures
        iii. Physical properties
        iv. Phase transitions
    d. Phase changes
        i. Thermodynamics
        ii. Heating and cooling curves
        iii. Phase diagrams
2. Solutions
    a. Electrolytes and nonelectrolytes
    b. Solubility
    c. Concentration units
        i. Molarity
        ii. Molality
        iii. Mole fraction
    d. Colligative properties
        i. Vapor pressure lowering
        ii. Boiling point elevation
        iii. Melting point depression
        iv. Osmotic pressure
3. Kinetics
    a. Chemical reaction rates
    b. Factors affecting reaction rates
    c. Rate laws
        i. Orders of the reaction
        ii. Rate constant
        iii. Arrhenius equation
        iv. Catalysts
    d. Integrated rate laws
    e. Experimental determination of the rate law
        i. Initial rate method
        ii. Graphical method
    f. Kinetics of nuclear decay
        i. First order rate law
        ii. Rate constant
        iii. Half-life
        iv. Integrated rate law
    g. Collision theory
    h. Reaction mechanisms

4. Chemical equilibria
    a. Relationship to rate constant
    b. Equilibrium constants
        i. Kc
        ii. Kp
        iii. Relationship of Kc and Kp
    c. Equilibrium calculations
    d. Reaction Quotient
    e. Le Chatelier"s principle
5. Acid-base equilibria
    a. Acid-base definition
        i. Arrhenius
        ii. Bronsted-Lowry
        iii. Lewis
    b. Autoionization of water, Kw and pKw
        i. $[H^+]$ and pH
        ii. $[OH^-]$ and pOH
    c. Acid ionization equilibria
        i. Strong verses weak acids
        ii. Acid ionization constant, Ka
        iii. Relative acidity based on structure
        iv. Monoprotic and polyprotic acids
    d. Base ionization equilibria
        i. Strong verses weak bases
        ii. Base ionization constant, Kb
    e. Hydrolysis of salt solutions
        i. Hydrolysis reactions
        ii. Prediction of solution pH
    f. Buffers
        i. Composition and function
        ii. pH determination
    g. Titrations
        i. Titration curves
        ii. pH determination
        iii. Acid-base indicators
    h. Solubility equilibria
        i. Solubility product constants
        ii. Common ion effect
        iii. Hydrolysis and pH effect
        iv. Complexation effect
        v. Precipitation
    i. Complex ion equilibria
6. Thermodynamics
    a. Spontaneity
    b. Entropy
        i. Second law of thermodynamics
        ii. Third law of thermodynamics
        iii. Standard entropy change from $S^o$
    c. Free energy
        i. Spontaneous conditions
        ii. Standard free energy change from $\Delta G^o_f$
        iii. Standard free energy change from $\Delta H^o$ and $\Delta S^o$
        iv. Free energy and equilibrium
7. Representative metals, metalloids, and nonmetals
    a. Periodicity
    b. Properties
8. Transition metals
    a. Properties
    b. Metallurgy

c. Coordination chemistry
    i. Nomenclature
    ii. Isomerism
    iii. Valence bond theory
    iv. Crystal field theory

9. Electrochemistry
    a. Oxidation-reduction reactions
        i. Balancing
        ii. Oxidizing agents
        iii. Reducing agents
    b. Standard potentials
        i. Standard reduction potential table
        ii. Spontaneous conditions
    c. Galvanic or voltaic cells
        i. Standard cell potentials
        ii. Free energy and the Nernst equation
        iii. Applications of voltaic cells
    d. Electrolytic cells
        i. Standard cell potentials
        ii. Faraday law
        iii. Applications of electrolytic cells
10. Critical Evaluation of Information
    - Sources of information
        - Scholarly
        - Popular
        - Fact
        - Opinion
    - Determining bias in information
    - Citing information
        - Formats used in scientific research
        - Critical citation components
    - Evaluating information for credibility and scientific accuracy
        - Peer-reviewed sources
        - Non-peer reviewed sources
        - Websites
            1. Government
            2. Commercial
            3. Educational
            4. Organizations, including non-profit
        - Bias
        - Social media

## Resources

Chang, Raymond, and Kenneth Goldsby. *Chemistry*. 13th ed. New York: McGraw-Hill Companies Inc., 2019.

Silberberg, Martin; Amateis, Patricia. . *Chemistry: The Molecular Nature of Matter*. 9th ed. New York: McGraw-Hill Companies Inc., 2021.

Burdge, Julia. *Chemistry*. 5th ed. New York: McGraw-Hill Companies, Inc, 2019.

Burdge, Julia and Overby, Jason. *Chemistry: Atoms First*. 4th ed. New York: McGraw-Hill Companies, Inc, 2020.

OpenStax. *Chemistry*. 2nd ed. Houston: OpenStax, 2019.

Sapling Learning. *General Chemistry II Access.* New York: Macmillian Higher Ed., 2009.

**Resources Other**

Eubanks, Lucy and Dwaine Eubanks. *Preparing for your ACS Examination in General Chemistry*. Milwaukee: American Chemical Society, Division of Chemical Education Examinations Institute, 2008.

## Instructional Services

**OAN Number:**

Ohio Transfer 36 TMNS and Transfer Assurance Guide OSC009 (Course 1 of 2, both must be taken), and OSC023 (Course 3 of 4, all must be taken)

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