CHEM-131H: HONORS GENERAL CHEMISTRY II

Cuyahoga Community College

Viewing: CHEM-131H : Honors General Chemistry II

Board of Trustees:
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Academic Term:
Fall 2022

Subject Code
CHEM - Chemistry

Course Number:
131H

Title:
Honors General Chemistry II

Catalog Description:
Study of the fundamental principles of chemistry emphasizing chemical and nuclear kinetics, thermodynamics, and equilibrium. Introduction and study into the specific branches of chemistry: electrochemistry, coordination, organic, nuclear, and environmental chemistry. Perform laboratory experiments designed to demonstrate chemical principles and support theoretical phenomena. Honors General Chemistry II combines lecture and laboratory into one course.

Credit Hour(s):
5

Lecture Hour(s):
4

Lab Hour(s):
3

Requisites

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

Outcomes

Course Outcome(s):
Apply the principles of general 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.

Course Outcome(s):

Develop strong interpretative skills to effectively apply mathematical and statistical 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.

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.

Course Outcome(s):

Develop preparative skills to safely and effectively use various experimental techniques to collect laboratory data required to support chemical concepts and principles. To use these skills in advanced 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.

Objective(s):

1. Demonstrate knowledge of rules of safety in the laboratory.
2. Measure and calculate using the metric system.
3. Demonstrate an understanding of chemical nomenclature.
4. Record data to the correct number of significant figures.
5. Acquire knowledge of basic statistics.
6. Perform basic laboratory techniques.
7. Use various types of laboratory equipment and computer software to acquire data.
8. Perform experiments related to the topical outline for hands-on experience.

Course Outcome(s):

Develop analytical skills required to interpret, evaluate, and report experimental results.

Essential Learning Outcome Mapping:

Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

Objective(s):

1. Calculate using rules of significant figures.
2. Calculate average, average deviation, and standard deviation of a data pool.
3. Evaluate laboratory results for accuracy and precision by completing a statistical review and error analysis.
4. Demonstrate graphing techniques.
5. Observe chemical reactions, identify the products, and summarize the change by a chemical equation.
6. Develop an appreciation for the laboratory as a means of supporting theoretical phenomena.
7. Formulate experimental methods to collect, represent, and interpret data.

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 scientific studies.
3. Apply the steps of the scientific method to solve a problem.

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.
6. Calculate using rules of significant figures.
7. Calculate average, average deviation, and standard deviation of a data pool.
8. Determine the accuracy and precision of a set of measurements.
9. Demonstrate graphing techniques.
10. Observe chemical reactions, identify the products, and summarize the change by a chemical equation.
11. Describe the purpose of the laboratory as a means of supporting theoretical phenomena.
12. Collect, organize, and interpret data.

Course Outcome(s):

Apply preparative skills and experimental techniques safely and effectively to acquire laboratory data to support chemical concepts and principles.

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. Demonstrate knowledge of rules of safety in the laboratory.
2. Measure and calculate using the metric system.
3. Demonstrate an understanding of chemical nomenclature.
4. Record data with the correct number of significant figures.
5. Acquire knowledge of basic statistics.
6. Perform basic laboratory techniques.
7. Use various types of laboratory equipment and computer software to acquire data.
8. Perform experiments relating to the topical outline.

Course Outcome(s):

Apply laboratory skills and techniques in advanced 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.

Objective(s):

1. Demonstrate knowledge of rules of safety in the laboratory.
2. Use the metric system when performing experiments.
3. Apply chemical nomenclature to experiments.

4. Use various types of laboratory equipment and computer software to acquire data.
5. Perform experiments relating to the topical outline.
6. Use laboratory techniques to complete experiments or scientific studies.
7. Apply statistical analysis to experiments results to determine the validity of data.
8. Apply statistical analysis to examine the reproducibility of experimental data.
9. Use significant figures appropriately during data collection and data analysis.

Course Outcome(s):

Evaluate experimental results and communicate the analysis and conclusions effectively using appropriate scientific language.

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.
Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

Objective(s):

1. Calculate using rules of significant figures.
2. Calculate average, average deviation, and standard deviation of a data pool.
3. Determine the accuracy and precision of a set of measurements.
4. Demonstrate graphing techniques.
5. Observe chemical reactions, identify the products, and summarize the change by a chemical equation.
6. Describe the purpose of the laboratory as a means of supporting theoretical phenomena.
7. Collect, organize, and interpret data.

Methods of Evaluation:

1. Written examinations
2. Quizzes
3. In-class group work
4. Out-of-class assignments
5. American Chemical Society - General Chemistry Exam
6. Oral presentations
7. Laboratory
    a. Assignments
    b. Reports
    c. Notebook
8. Research Papers
9. 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 ΔG^o_f
      iii. Standard free energy change from ΔH^o and ΔS^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

11. Laboratory
    a. Laboratory safety
       i. Safety procedures
       ii. Safety equipment
       iii. Correct handling of chemicals
       iv. Waste disposal
    b. Metric system
       i. Measurements
       ii. Conversions
    c. Significant figures
       i. Raw data
       ii. Calculations
    d. Physical Measurements
       i. Accuracy
       ii. Precision
       iii. Uncertainty
    e. Statistics
       i. Average
       ii. Average deviation
       iii. Standard deviation
       iv. Error analysis
    f. Graphical analysis
       i. Preparation of a graph
       ii. Data abstraction
    g. Chemical nomenclature
       i. Inorganic
       ii. Organic
       iii. Coordination compounds
    h. Basic Equipment Use
    i. i. Analytical balance
       ii. Bunsen burner
       iii. Volumetric glassware
       iv. Class A pipettes
       v. Variable micropipettes
       vi. Centrifuge
       vii. Buret
       viii. pH meter
    j. Experiments (Based on lab facilities.)
       i. Synthesis of alum
       ii. Determination of an equilibrium constant

iii. LeChatelier's principle
iv. Acids and bases
v. Acid-Base titration: pH meter
vi. Determination of Ksp of calcium hydroxide
vii. Colligative property: freezing point depression
viii. Electrochemistry
ix. Potentiometric determination of iodide ion
x. Kinetics: initial rate method – determination of rate, rate law, and activation energy
xi. Kinetics: graphical method – determination of rate law
xii. Synthesis and structural analysis of a coordination compound
xiii. Qualitative cation analysis

k. Scientific Method
   i. Observations
   ii. Hypothesis
   iii. Controlled Experiment
      1. Variables
         a. Independent Variable
         b. Dependent Variable
         c. Controlling Variables
      2. Control Group
      3. Experimental Group
   iv. Model

Resources

Billo, Joseph. *Excel for Chemists.* 3rd ed. New York: John Wiley Sons, Inc., 2011.

American Chemical Society. *Chemistry in Context.* 7th ed. New York: McGraw-Hill Companies Inc., 2011.

Hansen-Polcar, Lois. *Inquiry-Based Cooperative General Chemistry Laboratory II*. 3rd ed. Parma: CCC West, 2017.

Speight, James. *Lange's Handbook of Chemistry*. 17th ed. New York: McGraw-Hill Companies Inc., 2017.

Haynes, William ed. *CRC Handbook of Chemistry and Physics*. 102nd ed. Boca Raton: CRC Press, 2021.

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

Murov, Steven. *Experiments in General Chemistry*. 6th ed. Boston: Cengage Learning, 2015.

Ebbing, Darrell. *Experiments in General Chemistry*. 10th ed. Belmont: Brooks/Cole Publishing, 2013.

Randall, Jack. *Advanced Chemistry with Vernier*. Beaverton: Vernier Software and Technology, 2016.

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: MacMillan Higher Ed, 2009.

Allota, Paula; DiFrancesco, Dale.; Distler, Anne; Emmer, Elizabeth. *Laboratory Experiments for General Chemistry*. Open Source, 2021.

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 and OSC023 (2 of 2 courses, both must be taken)

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