CHEM-2000: ANALYTICAL CHEMISTRY

Cuyahoga Community College

Viewing: CHEM-2000 : Analytical Chemistry

Board of Trustees:
2018-06-28

Academic Term:
2018-08-27

Subject Code
CHEM - Chemistry

Course Number:
2000

Title:
Analytical Chemistry

Catalog Description:
An introduction to the theoretical principles of quantitative and instrumental analysis. Emphasis on experimental methods, sampling techniques, statistics, error theory, chemical equilibrium, stoichiometry, and volumetric and gravimetric procedures as applied to quantitative determinations. Provides an introduction to spectroscopic, electroanalytical, and chromatographic methods of analyses. Provides hands-on experience to students by completion of laboratory experiments related to these principles. Emphasis on development of laboratory techniques.

Credit Hour(s):
5

Lecture Hour(s):
3

Lab Hour(s):
6

Requisites

Prerequisite and Corequisite
CHEM-1310 General Chemistry II and CHEM-131L General Chemistry Laboratory II; or CHEM-131H Honors General Chemistry II.

Outcomes

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

Essential Learning Outcome Mapping:
Information Literacy: Acquire, evaluate, and use information from credible sources in order to meet information needs for a specific research purpose.

Objective(s):
1. Use LeChatelier's Principle and stoichiometry to explain chemical equilibria and solve equilibrium problems for homogeneous and heterogeneous reactions.
2. Describe the differences between activity and molar concentration.
3. Describe how to choose an appropriate indicator for an acid-base titration.
4. Describe the difference between the isoelectric and isoionic point of a polyprotic species.
5. Explain Beer's Law.
6. Describe the major components of a spectrometer and explain the purpose of each component.
7. Describe the similarities and differences between selected electroanalytical techniques.
8. Describe how a chromatograph separates a mixture.

Course Outcome(s):

Develop strong analytical and 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.

Objective(s):

1. Calculate the composition of a solution by applying the systematic treatment of equilibria.
2. Calculate moles of analyte in a gravimetric analysis.
3. Calculate the pH, pOH, and concentration of all species in an acid-base system.
4. Use stoichiometry and chemical equilibrium to calculate the moles of analyte in a precipitation, acid-base, complexometric, or redox titration.
5. Solve the concentration of analyte in an aqueous solution using potentiometry.
6. Solve the moles of analyte by coulometric titration.
7. Solve the moles of analyte by electrogravimetric analysis.
8. Calculate the concentration of analyte from a Beer's Law Plot.
9. Calculate the ionic strength, activity coefficient, and activity of an aqueous solution.

Course Outcome(s):

Develop analytical and preparative skills to safely and effectively collect, analyze, and report data in scientific studies and/or real world applications.

Essential Learning Outcome Mapping:

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. Construct a Gran plot to determine the endpoint and equilibrium constant for a weak acid or base.
2. Perform experiments related to the topical outline for hands-on experience.
3. Develop appropriate laboratory techniques for wet lab and instrumental analysis.
4. Formulate experimental methods to collect, represent, and interpret laboratory data.
5. Use Excel for statistical and graphical analysis .
6. Apply elementary statistics to determine error and uncertainty in measurements.
7. Evaluate laboratory results for accuracy and precision by completing a statistical review and error analysis.

Methods of Evaluation:

1. Written Examinations
2. American Chemical Society Standardized Examination for Quantitative Analysis & Instrumental Analysis
3. Quizzes
4. In Class Assignments
5. Out of Class Assignments
6. Laboratory Reports

Course Content Outline:

1. Error Analysis.
    a. Significant Figures.
    b. Types of Error.
    c. Propagation of Uncertainty from Random and Systematic Error.
2. Statistics.
    a. Gaussian Distributions.
    b. Confidence Intervals.
    c. Comparison of Means with Student"s t Test.
    d. Comparison of Standard Deviation with F Test.
    e. Method of Least Squares.
    f. Calibration Curves.
    g. Excel Spreadsheets for Student"s t and Least Squares.
3. Activity.

   a. Ionic Strength.
   b. Activity Coefficients.
   c. Systematic Treatment of Equilibrium.
4. Gravimetric Analysis.
   a. Types of Precipitations.
   b. Examples of Gravimetric Calculations.
   c. Combustion Analysis.
   d. Precipitation Titration Curves.
   e. End-Point Detection.
5. Monoprotic Acid-Base Equilibria.
   a. Strong and Weak Acids and Bases.
   b. Weak-Acid Equilibria.
   c. Weak-Base Equilibria.
   d. Buffers.
6. Polyprotic Acid-Base Equilibria.
   a. Diprotic Acids and Bases.
   b. Diprotic Buffers.
   c. Polyprotic Acids and Bases.
   d. Fractional Composition Equations.
   e. Isoelectric and Isoionic pH.
7. Acid-Base Titrations.
   a. Monoprotic Acid-Base Titrations.
   b. Diprotic Acid-Base Titrations.
   c. End-Point Detection with Indicators.
   d. End-Point Detection with a pH Electrode.
   e. Calculating Titration Curves with Excel Spreadsheets.
8. Complexation Equilibria.
   a. Metal-Chelate Complexes.
   b. EDTA Titration Curves and Titration Techniques.
   c. Auxiliary Complexing Agents.
   d. Metal Ion Indicators.
9. Electrochemistry.
   a. Galvanic Cells.
   b. Standard Potentials.
   c. The Nerst Equation.
   d. Calculation of an Equilibrium Constant from E^{o}.
10. Potentiometry.
    a. Reference and Indicator Electrodes.
    b. Liquid-Junction Potential.
    c. Types of Ion-Selective Electrodes.
11. Redox Titrations.
    a. Redox Titration Curves.
    b. End-Point Detection for a Redox Titration.
12. Electroanalytical Techniques.
    a. Electrolysis.
    b. Electrogravimetric Analysis.
    c. Coulometry.
    d. Amperometry.
    e. Voltammetry.
13. Fundamentals of Spectroscopy.
    a. Absorption of Light and Measuring Absorbance.
    b. Beer"s Law.
    c. Spectrophotometric Titrations.
    d. Applications of Spectrophotometry.
14. Atomic Spectroscopy.
    a. Overview of Atomization: Flames, Furnaces, and Plasmas.
    b. Instrumentation.
    c. Interferences.
15. Chromatographic Methods.

a. Overview of the Separation Process.
b. Gas Chromatography.
c. High-Performance Liquid Chromatography.

16. Laboratory Experiments.
    a. Statistical Analysis of Pennies.
    b. Standardization Methods.
    c. Determination of Mass Percent of Various Unknowns Using Wet Lab Techniques.
    d. Potentiometric Titration of Unknown Monoprotic and Polyprotic Acids.
    e. Potentiometric Determination of Fluoride Ion.
    f. Spectrophotometric Determination of Unknowns.
    g. Atomic Absorption Determinationof Calcium.

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Resources

Daniel C. Harris. *Exploring Chemical Analysis.* 5th ed. New York: W.H. Freeman, 2013.

Daniel C. Harris. *Quantitative Chemical Analysis.* 9th ed. New York: W.H.Freeman, 2016.

David S. Hage and James R. Carr. *Analytical Chemistry and Quantitative Analysis.* 1st ed. Englecliffs: Prentice-Hall, 2011.

Hobart Willard, Lynne Merritt, John Dean, and Frank Settle. *Instrumental Methods of Analysis.* 7th ed. New Jersey: John Wiley Sons Inc., 2010.

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

J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas. *Vogel'sTextbook of Quantitative Chemical Analysis.* 6th ed. Englecliffs: Prentice-Hall, 2000.

Daniel C. Harris. *Solutions Manual for Quantitative Chemical Analysis.* 9th ed. New York: W.H.Freeman, 2016.

Resources Other

1. Maryadele J. O''Neil ed. *The Merck* Index. 15th ed., New York: John Wiley & Sons, Inc., 2013.
2. James G. Speight ed. *Lange"s Handbook of Chemistry*. 17th ed., New York: McGraw-Hill, 2016.
3. William M. Haynes ed. *CRC Handbook of Chemistry and Physics*. 97th ed., New York: CRC Press, 2016.

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