CHEM-CHEMISTRY

CHEM 1111. Basic Chemistry
3 Credits (3)
For students whose preparatory science or math training has been deficient. Does not meet the chemistry requirement in any curriculum.
Prerequisite: Enhanced ACT composite score of at least 18 or a grade of C- or better in CCDM 114 N.
Learning Outcomes

1. The goals and objectives for CHEM 1111 are to equip students with the necessary problem solving skills to be successful in CHEM 1215G/1225G

CHEM 1120G. Introduction to Chemistry Lecture and Laboratory (non majors)
4 Credits (3+3P)
This course covers qualitative and quantitative areas of non-organic general chemistry for non-science majors and some health professions. Students will learn and apply principles pertaining, but not limited to, atomic and molecular structure, the periodic table, acids and bases, mass relationships, and solutions. The laboratory component introduces students to techniques for obtaining and analyzing experimental observations pertaining to chemistry using diverse methods and equipment.
Prerequisite: CCDM 114N or A S 103 or MATH 1215 or higher.
Learning Outcomes

1. (Lecture) Use the different systems of measurements and perform conversions within the same system of measurement and between different systems of measurements
2. (Lecture) Identify elements from their name or symbol, use the periodic table to describe reactivity patterns of elements and to predict compound formation.
3. (Lecture) Describe the basic structure of an atom using subatomic particles, and apply these concepts to nuclear reactions.
4. (Lecture) Describe ion formation and the difference between covalent and ionic compounds. Name and write formulas for ionic and simple molecular compounds.
5. (Lecture) Write and balance chemical reactions. Use balanced reactions in stoichiometric calculations.
6. (Lecture) Describe the differences between the solid, liquid and gas phases. Use the gas laws in calculations, and apply these laws to everyday situations.
7. (Lecture) Explain different types of energy, and how energy is released or absorbed in a reaction
8. (Lecture) Describe acid and base behavior.
9. (Lecture) Explain the intermolecular attractive forces that determine physical properties; apply this knowledge to qualitatively evaluate these forces and predict the physical properties that result. 1
10. (Lecture) Explain the intermolecular attractive forces that determine physical properties; apply this knowledge to qualitatively evaluate these forces and predict the physical properties that result 1
11. (Laboratory) Practice concepts associated with laboratory safety, including the possible consequences of not adhering to appropriate safety guidelines. 1
12. (Laboratory) Demonstrate the computational skills needed to perform appropriate laboratory-related calculations to include, but not be limited to determining the number of significant figures in numerical value, solving problems using values represented in exponential notation, solving dimensional analysis problems, and manipulating mathematical formulas as needed to determine the value of a variable. 1
13. (Laboratory) Perform laboratory observations (both qualitative and quantitative) using sensory experience and appropriate measurement instrumentation (both analog and digital). 1
14. (Laboratory) Record quantitatively measured values to the correct number of significant figures and assign the correct units. 1
15. (Laboratory) Master basic laboratory techniques including, but not limited to weighing samples (liquid and solid), determining sample volumes, measuring the temperature of samples, heating and cooling a sample or reaction mixture, decantation, filtration, and titration. 1
16. (Laboratory) Draw appropriate conclusions based on data and analyses. 1
17. Present experimental results in laboratory reports of appropriate length, style and depth, or through other modes as required. 1
18. Determine chemical formulas and classify different types of reactions. 1
19. Relate laboratory experimental observations, operations, calculations, and findings to theoretical concepts presented in the complementary lecture course.

CHEM 1121. General Supplemental Instruction I
1 Credit (1)
Collaborative workshop for students in General Chemistry I. Course does not count toward departmental degree requirements. May be repeated for a maximum of 2 credits.
Corequisite(s): CHEM 1215G.

CHEM 1122. General Supplemental Instruction II
1 Credit (1)
Collaborative workshop for students in General Chemistry II. Course does not count toward departmental degree requirements. May be repeated for a maximum of 2 credits.
Corequisite(s): CHEM 1225G.

CHEM 1123. Principles of Supplemental Instruction III
1 Credit (1)
Collaborative workshop for students in CHEM 1120G, Principles and Applications of Chemistry. Course does not count toward departmental degree requirements. May be repeated for maximum of 2 credits.
Corequisite(s): CHEM 1120G.

CHEM 1215G. General Chemistry I Lecture and Laboratory for STEM Majors
4 Credits (3+3P)
This course covers descriptive and theoretical chemistry.
Prerequisite: (1) grade of C- or better in MATH 1215 or higher, or a Mathematics Placement Exam Score adequate to enroll in mathematics courses beyond MATH 1215.
Learning Outcomes

1. Use dimensional analysis, the SI system of units and appropriate significant figures to solve quantitative calculations in science. Understand the differences between physical and chemical changes to matter. Classify types of matter.
2. Understand the scientific method in the context of scientific discoveries.
3. Explain the structure of atoms, isotopes and ions in terms of subatomic particles.
4. Analyze how periodic properties (e.g. electronegativity, atomic and ionic radii, ionization energy, electron affinity, metallic character) and reactivity of elements results from electron configurations of atoms.

5. Understand the creation of different types of compounds (ionic and molecular), comparing and contrasting their structures, naming schemes and formulas. Apply knowledge of electronic structure to determine molecular spatial arrangement and polarity.
6. Understand bulk pure substances, their properties and their states of matter by understanding and identifying intermolecular forces. Apply kinetic molecular theory to relate atomic level behavior to macroscopic properties. Introduce the mole and apply the mole concept to amounts on a macroscopic and a microscopic level
7. Understand mixtures, solubility by considering intermolecular forces and expressing concentration in molarity.
8. Identify different reaction types. Apply the law of conservation of mass to reactions. Perform stoichiometry on balanced reactions. Laboratory Student Learning Outcomes
9. Demonstrate and apply concepts associated with laboratory safety, including the possible consequences of not adhering to appropriate safety guidelines.
10. Demonstrate the computational skills needed to perform appropriate laboratory related calculations to include, but not be limited to determining the number of significant figures in numerical value with the correct units, solving problems using values represented in exponential notation, solving dimensional analysis problems, and manipulating mathematical formulas as needed to determine the value of a variable.
11. Perform laboratory observations (both qualitative and quantitative) using sensory experience and appropriate measurement instrumentation (both analog and digital).
12. Prepare solutions with an acceptable accuracy to a known concentration using appropriate glassware.
13. Master basic laboratory techniques including, but not limited to weighing samples (liquid and solid), determining sample volumes, measuring the temperature of samples, heating and cooling a sample or reaction mixture, decantation, filtration, and titration.
14. Draw conclusions based on data and analyses from laboratory experiments.
15. Relate laboratory experimental observations, operations, calculations, and findings to theoretical concepts presented in the complementary lecture course.

CHEM 1216. General Chemistry I Lecture and Laboratory for CHEM Majors
4 Credits (3+3P)
As the first of a two-semester sequence, this course teaches fundamental concepts in chemistry, including the electronic structure of atoms, chemical periodicity, nature of chemical bonds, molecular structure, the three phases of matter, etc. Designed for majors in chemical and other physical sciences, including engineering. May be appropriate for the life science major. It is assumed that the students are familiar with college algebra, chemical nomenclature, stoichiometry, and scientific measurements. The laboratory component is designed to complement the theory and concepts presented in lecture, and will introduce students to techniques for obtaining and analyzing experimental observations pertaining to chemistry using diverse methods and equipment.
Prerequisite(s): Eligible to take MATH 1250G and an ACT composite score of 22 or higher.
Learning Outcomes
1. Apply the mole concept to amounts at a microscopic level and use this to perform stoichiometric calculations for reactions in solution, gases and thermochemistry.
2. Calculate solution concentrations in various units.
3. Apply the gas laws and kinetic molecular theory to relate atomic level behavior to macroscopic properties.
4. Explain the electronic structure of atoms, isotopes and ions in terms of its subatomic particles.
5. Analyze how periodic properties (e.g. electronegativity, atomic and ionic radii, ionization energy, electron affinity, metallic character) and reactivity of elements results from electronic configurations of atoms.
6. Understand the nature of chemical bonds (ionic and covalent). Apply knowledge of electronic structure to determine molecular structure and polarity.
7. Understand the formation of different phases of matter and the underlying fundamental intermolecular interactions.
8. Describe physical states and changes, and distinguish these from chemical changes.
9. Describe the energy conversions that occur in chemical reactions and state changes, relating heat of reaction to thermodynamic properties such as enthalpy and internal energy; apply these principles to measure and calculate energy changes in reaction. 1
10. Apply principles of general chemistry to specific real-world problems in environment, engineering and health-related fields.

CHEM 1225G. General Chemistry II Lecture and Laboratory for STEM Majors
4 Credits (3+3P)
This course is intended to serve as a continuation of general chemistry principles for students enrolled in science, engineering, and certain preprofessional programs. The course includes, but is not limited to a theoretical and quantitative coverage of solutions and their properties, kinetics, chemical equilibrium, acids and bases, entropy and free energy, electrochemistry, and nuclear chemistry. Additional topics may include (as time permits) organic, polymer, atmospheric, and biochemistry.
The laboratory component is designed to complement the theory and concepts presented in lecture, and will introduce students to techniques for obtaining and analyzing experimental observations pertaining to chemistry using diverse methods and equipment.
Prerequisite(s): C- or better in CHEM 1215G.
Learning Outcomes
1. Explain the intermolecular attractive forces that determine physical properties and phase transitions, and apply this knowledge to qualitatively evaluate these forces from structure and to predict the physical properties that result.
2. Calculate solution concentrations in various units, explain the effects of temperature, pressure and structure on solubility, and describe the colligative properties of solutions, and determine solution concentrations using colligative property values and vice versa.
3. Describe the dynamic nature of chemical equilibrium, and apply LeChatelier's Principle to predict the effect of concentration, pressure and temperature changes on equilibrium mixtures as well as describe the equilibrium constant and use it to determine whether equilibrium has been established, and calculate equilibrium constants from equilibrium concentrations and vice versa.
4. Describe the different models of acids and base behavior and the molecular basis for acid strength, as well as apply equilibrium principles to aqueous solutions, including acid/base and solubility reactions, and calculate pH and species concentrations in buffered and unbuffered solutions.
5. Explain titration curves as well as calculate concentrations of reactants.

6. Explain and calculate the thermodynamic functions, enthalpy, entropy and Gibbs free energy, for a chemical system, and relate these functions to equilibrium constants Student Learning Outcomes – Laboratory
7. Demonstrate and apply concepts associated with laboratory safety, including the possible consequences of not adhering to appropriate safety guidelines.
8. Demonstrate the computational skills needed to perform appropriate laboratory related calculations to include, but not be limited to determining the number of significant figures in numerical value with the correct units, solving problems using values represented in exponential notation, solving dimensional analysis problems, and manipulating mathematical formulas as needed to determine the value of a variable.
9. Perform laboratory observations (both qualitative and quantitative) using sensory experience and appropriate measurement instrumentation (both analog and digital).
10. Prepare solutions with an acceptable accuracy to a known concentration using appropriate glassware.
11. Perform basic laboratory operations related to, but not limited to, colligative properties of solutions, chemical equilibria, acid/base titrations, electrochemistry.
12. Draw conclusions based on data and analyses from laboratory experiments.
13. Relate laboratory experimental observations, operations, calculations, and findings to theoretical concepts presented in the complementary lecture course.

CHEM 1226. General Chemistry II Lecture and Laboratory for CHEM Majors
4 Credits (3+3P)
As the second of a two-semester sequence, this course teaches fundamental concepts in chemistry, including solutions, equilibria, electrochemistry, thermodynamics and kinetics. Designed for majors in chemical and other physical sciences, including engineering. May be appropriate for the life science major. It is assumed that the students are familiar with college algebra, chemical nomenclature, stoichiometry, and scientific measurements. The laboratory component is designed to complement the theory and concepts presented in lecture, and will introduce students to techniques for obtaining and analyzing experimental observations pertaining to chemistry using diverse methods and equipment.
Prerequisite(s): C- or better in CHEM 1216.
Learning Outcomes
1. Describe the colligative properties of solutions and explain them using intermolecular forces. Determine solution concentrations using colligative property values and vice versa.
2. Explain rates of reactions, rate laws, and half-life; determine the rate, rate law and rate constant of a reaction and calculate concentration as a function of time and vice versa. Understand the principle of catalysis.
3. Explain the collision model of reaction dynamics, including activation energy, catalysts and temperature; Derive a rate law from a reaction mechanism and evaluate the consistency of a mechanism with a given rate law.
4. Describe the dynamic nature of chemical equilibrium and its relation to reaction rates; apply Le Chatelier's Principle to predict the effect of concentration, pressure and temperature changes on equilibrium mixtures.
5. Describe the equilibrium constant and use it to determine whether equilibrium has been established; calculate equilibrium constants from equilibrium concentrations (including pressures) and vice versa.
6. Describe the different models of acids and base behavior, and the molecular basis for acid strength.

CHEM 2111. Explorations in Chemistry
1 Credit (1)
The major intent of this course is to deepen your interest in chemistry and make you aware of research and career opportunities in the field. During this semester we hope to discuss both old and new developments in chemistry that impact our lives. We also want to build our communication skills that are so necessary in our profession. Graded S/U.

CHEM 2115. Survey of Organic Chemistry and Laboratory
4 Credits (3+3P)
This course is a one -semester survey of organic and biological chemicals. Students will be introduced to nomenclature, molecular structure, properties, and reactions of hydrocarbons, alcohols, carbonyls, organic acids and bases, carbohydrates, lipids, and proteins. The handling of organic chemicals, simple organic reactions, tests for functional groups, and synthesis will be learned in the laboratory component of this course.
Prerequisite: C- or better in CHEM 1225G or CHEM 1226.
Learning Outcomes
1. Identify common organic functional groups.
2. Translate between the IUPAC names and structures of simple organic molecules.
3. Predict the products of certain organic chemical reactions from reagents and conditions presented.
4. Predict physical and chemical behavior of organic molecules based on structure.
5. Synthesize several classes of organic compounds in the laboratory that were previously studied in the lecture component of this course.
6. Recognize and name the four basic bioorganic units and certain of their derivatives and macromolecules.
7. Construct 3 dimensional models of organic compounds.
8. Understand and apply safety principles associated with Organic Chemistry laboratory operations and activities.
9. Present experimental results in laboratory reports of appropriate length, style and depth, or through other modes as required. 1
10. Draw/recognize stereochemistry and explain its relevance to bioorganic molecules.

CHEM 2120. Integrated Organic Chemistry and Biochemistry
3 Credits (3)
This course is a one- semester introduction to Organic Chemistry and Biochemistry designed for students in health and environmental occupations. The course surveys organic compounds in terms of structure, physical, and chemical properties, followed by coverage of the chemistry of specific classes of organic compounds in the biological environment. Students will apply course concepts to everyday organic and biological chemistry problems in preparation for careers in health and environmental fields.
Prerequisite: CHEM 1120G or CHEM 1215G.
Learning Outcomes
1. Identify and name basic organic compounds.
2. Construct/draw organic compounds from the names.

3. Predict the products of certain organic chemical reactions from reagents and conditions presented.
4. Recognize and name the four basic bioorganic units and certain of their derivatives and macromolecules.
5. Compare and contrast the function and location of the four bioorganic units and their macromolecules and cofactors.
6. Draw/recognize stereochemistry and explain its relevance to bioorganic molecules.
7. Discuss the pathways and functions of some of the cellular metabolic processes.
8. Recognize and describe metabolic cellular processes and macromolecular structure with respect to health and/or disease state

CHEM 2120L. Integrated Organic Chemistry and Biochemistry Lab
1 Credit (1,3P)
This course provides experiences with the physical properties and laboratory synthesis of organic compounds.
Prerequisite/Corequisite: CHEM 2120.
Learning Outcomes
1. Discuss the chemical, structural, and physical differences among the different functional groups.
2. Prepare, label, and use solutions of appropriate and known concentrations.
3. Recognize chiral organic molecules, and explain their biological significance.
4. Understand and be able to identify the process of organic reactions: nucleophilic and electrophilic, redox reactions, and enzyme catalyzed reactions.
5. Predict the products of substitution, elimination, condensation, and redox reactions.
6. Explain why certain lipids and amino acids are essential while others are not.

CHEM 2130. Organic Chemistry I
3 Credits (3)
This course is the first of a two semester sequence of Organic Chemistry, the chemistry of carbon containing compounds, as required for chemistry, medical science, and engineering majors. The course includes theoretical, qualitative, and quantitative discussion of Organic Chemistry concepts, including but not limited to a review of electronic structure and bonding, acids and bases, stereochemistry, an introduction to organic compounds, isomers, substitution and elimination reactions of alkyl halides, reactions of alkenes, alkynes, alcohols, ethers, epoxides, amines, and thiols, mass and infrared spectrometry, ultraviolet/visible spectroscopy, and nuclear magnetic resonance.
Prerequisite: CHEM 1225G or CHEM 1226.
Learning Outcomes
1. Review properties of elements and molecules discussed in general chemistry (electronegativity, bonding, formal charge, octet rule).
2. Review chemical reactions discussed in general chemistry (products, reactants, balanced equations, byproducts).
3. Classify organic compounds and their properties by functional group, including substitution and elimination reactions of alkyl halides, reactions of alkenes, alkynes, alcohols, ethers, epoxides, amines, and thiols.
4. Use common and IUPAC rules of nomenclature to name organic compounds.
5. Review the structure and stability of compounds.
6. Comprehend the relationship between structure and reactivity.
7. Comprehend configurations of organic compounds (resonance structures, stereochemistry, isomers).
8. Interpret spectral properties and use in structure determination.
9. Correctly describe the four-five step synthesis of a simple organic molecule using reactions learned in the class.

CHEM 2135. Organic Chemistry II
3 Credits (3)
This course is the second of a two semester sequence of Organic Chemistry, the chemistry of carbon containing compounds, as required for chemistry, medical science, and engineering majors. The course will emphasize structure, main physical properties, chemical reactivity, and reaction mechanisms relating to alcohols, arenes and carbonyl compounds, as well as continued integration of mass and infrared spectrometry, ultraviolet/visible spectroscopy, and nuclear magnetic resonance technique and analysis.
Prerequisite: CHEM 2130 or CHEM 313.
Learning Outcomes
1. Identify functional groups and other key features of different organic compounds.
2. Correctly name organic compounds using the proper nomenclature (IUPAC and common names).
3. Analyze relationships among molecular structure, chemical reactivity, physical and spectral properties.
4. Understand chemical reactivity and reaction mechanisms relating, but not limited to dienes, arenes, alcohols, ethers, amines, phenols, and carbonyl compounds, i.e. aldehydes, ketones, carboxylic acids and derivatives.
5. Write out correctly the mechanisms of electrophilic aromatic substitution, formation and hydrolysis of acetals and ketals, formation and hydrolysis of imines and enamines, conjugate addition of nucleophiles to α,β-unsaturated carbonyl compounds, Fischer esterification and hydrolysis of esters under both acidic and basic conditions, transesterification under acidic and basic conditions, amide hydrolysis under acidic and basic conditions, the aldol reaction and condensation, and the Claisen condensation/Dieckmann cyclization for examples that are different than those studied in class.
6. Relate structures to spectral properties, interpreting IR, thirteenC and oneH NMR.
7. Describe the six-seven step synthesis of a simple organic molecule using reactions learned in this class.
8. Convert the Fischer projection of a carbohydrate to its corresponding Haworth projection, or convert the Haworth projection of a carbohydrate to its Fischer projection.
9. Recognize derivatives of carbonic and phosphoric acids, alkaloids, carbohydrates, peptides, steroids, prostaglandins, aglycones, carbohydrate anomers, reducing sugars, waxes, fats, and oils.

CHEM 2991. Introduction to Research
1-3 Credits (3+9P)
Techniques and procedures of chemical research. May be repeated for a maximum of 3 credits.
Prerequisites: 8 credits of chemistry and a 3.0 GPA in chemistry.
Learning Outcomes
1. Varies

CHEM 2996. Special Topics in Chemistry
1-6 Credits (1-6)

Specific subjects in Chemistry. These subjects will be announced in the 'Schedule of Classes'. It may be repeated under different topics for a maximum of 12 credits.

Learning Outcomes

1. Varies

CHEM 303. Organic Supplemental Instruction I
1 Credit (1)
Collaborative workshop for students in Organic Chemistry I. Course does not count toward departmental degree requirements. May be repeated for a maximum of 2 credits.
Corequisite(s): CHEM 313.

CHEM 304. Organic Supplemental Instruction II
1 Credit (1)
Collaborative workshop for students in Organic Chemistry II. Course does not count toward departmental degree requirements. May be repeated for a maximum of 2 credits.
Corequisite(s): CHEM 314.

CHEM 313. Organic Chemistry I
3 Credits (3)
Nomenclature, uses, basic reactions, and preparation methods of the most important classes of aliphatic and aromatic compounds.
Prerequisite(s): C- or better in CHEM 1225G or CHEM 1226.

CHEM 314. Organic Chemistry II
3 Credits (3)
An in-depth focus on reactions and mechanisms as they relate to organometallic compounds, alcohols, ethers, ketones, aldehydes, carboxylic acid derivatives, an amines. May be repeated up to 3 credits.
Prerequisite(s): C- or better in CHEM 313.

Learning Outcomes

1. Identify several new functional groups and other key features of organic compounds
2. Interpret 1H / 13C NMR, IR, UV-Vis, and Mass spectrometry data and have the ability to correlate structural elements with spectral features
3. Understand the chemical reactivity and reaction mechanisms relating, but not limited, to organometallic compounds, alcohols, ethers, ketones, aldehydes, carboxylic acids, and amines. Mechanistic highlights include: etherification, acetal formation / removal, alcohol oxidation, carbonyl addition reactions, enolate (and related) reactions, formation of carboxylic acid derivatives, and nucleophilic acyl substitution processes. Apply these mechanistic and reactivity considerations to these same groups when they appear as substructures in larger biologically-important molecules (e.g. carbohydrates, amino acids, and lipids).
4. Design concise, three to five step syntheses of simple organic molecules using reactions learned in both CHEM 313 and 314
5. Qualitatively assess stability, solubility properties, chemical reactivity, spectral properties, and potential reactions that would lead to preparation, simply via visual inspection of structure.

CHEM 315. Organic Chemistry Laboratory
2 Credits (6P)
Techniques, preparative and analytical methods in organic chemistry. May be repeated up to 2 credits.
Prerequisite(s)/Corequisite(s): CHEM 314. Prerequisite(s): C- or better in CHEM 313 or consent of instructor.

CHEM 351. Special Topics
1-3 Credits
Specific subjects to be announced in the Schedule of Classes. May be repeated for a maximum of 12 credits.
Prerequisite: consent of instructor.

CHEM 357. Synthetic Inorganic Laboratory
2 Credits (6P)
Explores synthesis and analysis of main group and transition metal inorganic compounds. Inorganic laboratory and spectroscopic techniques will be used.
Prerequisites: CHEM 356.

CHEM 371. Analytical Chemistry
4 Credits (2+6P)
The fundamentals of quantitative chemical analysis.
Prerequisite(s): C- or better in CHEM 1225G or CHEM 1226.

CHEM 422. Environmental Chemistry
3 Credits (3)
Chemistry of organic and metal ion pollutants in the environment and principles important to their remediation including bioremediation. Restricted to: Main campus only. Crosslisted with: ENVS 422
Prerequisite(s): CHEM 1225G and either CHEM 2120 or CHEM 313.

Learning Outcomes

1. Describe and explain the solid, liquid, and gas phases of the environment and how they interact.
2. Understand the chemical reactions and processes that occur between various phases of the environment.
3. Learn how the chemical processes can be managed to promote environmental remediation, including the techniques and calculations used.

CHEM 424. Soil Chemistry
3 Credits (3)
Same as SOIL/GEOL 424.

CHEM 430. Physical Chemistry: Thermodynamics, Kinetics, Quantum Chemistry, and Spectroscopy
3 Credits (3)
Lecture course covering the basic four areas of Physical Chemistry at the advanced undergraduate level. Topics include: Statistical Mechanics, Thermodynamics, Kinetics, Quantum Chemistry, Group Theory, and Spectroscopy at the advanced undergraduate level.
Prerequisite: CHEM 1225G or 1226; MATH 1521G or higher; PHYS 1240G, 2140, 2240 or PHYS 1320G.

Learning Outcomes

1. Students will master the theoretical basis and underlying laws governing Physical Chemistry (Thermodynamics, Kinetics, Quantum Chemistry, and Spectroscopy) at the advanced undergraduate level of expertise. In particular, students will develop critical thinking and problem solving skills in the above four areas of Physical Chemistry.

CHEM 431. Physical Chemistry
3 Credits (3)
Principles that govern the physical and chemical behavior of matter. May not be counted toward Bachelor of Science degree in Chemistry.
Prerequisite(s): CHEM 1226 or CHEM 2226; MATH 1521G; PHYS 1240G or PHYS 2240G or PHYS 2140 or PHYS 1320G.

CHEM 431 H. Physical Chemistry Honors
3 Credits (3)
Same as CHEM 431. Additional work to be arranged.
Prerequisite(s): CHEM 1226 or CHEM 2226; MATH 1521G or MATH 1521H; PHYS 1240G or PHYS 2240G or PHYS 2140 or PHYS 1320G.

CHEM 433. Physical Chemistry I
3 Credits (3)

This course will cover topics relevant to the quantum description of the Chemical world at the undergraduate level, with an emphasis on acquiring sufficient background knowledge necessary for subsequent graduate level courses. May be repeated up to 3 credits.
Prerequisite: CHEM 1225 or CHEM 1226; MATH 1521G; PHYS 2140 or PHYS 1320G, or consent of instructor.

Learning Outcomes

1. Students will develop critical thinking and problem-solving skills with direct application to basic Quantum Chemistry and Spectroscopy. Topics the students will master include (but are not limited to): The Schrodinger Equation, One-Electron Atoms, (i.e. the hydrogen atom), Many-Electron Atoms, Molecular Symmetry (Group Theory), Working with and generating Character Tables, Electric Dipole Spectroscopy, Vibrational Spectroscopy, Rotational Spectroscopy.

CHEM 433 H. Physical Chemistry I Honors
3 Credits (3)
Same as CHEM 433. Additional work to be arranged. May be repeated up to 3 credits.
Prerequisite: CHEM 1225 or CHEM 1226; MATH 1521G or MATH 1521H; PHYS 2140 or PHYS 1320G, or consent of instructor.

Learning Outcomes

1. Students will develop critical thinking and problem-solving skills with direct application to basic Quantum Chemistry and Spectroscopy. Topics the students will master include (but are not limited to): The Schrodinger Equation, One-Electron Atoms, (i.e. the hydrogen atom), Many-Electron Atoms, Molecular Symmetry (Group Theory), Working with and generating Character Tables, Electric Dipole Spectroscopy, Vibrational Spectroscopy, Rotational Spectroscopy.

CHEM 434. Physical Chemistry II
3 Credits (3)
Laws and theories underlying chemical phenomena.
Prerequisite: CHME 302 or CHEM 433.

CHEM 435. Physical Chemistry Laboratory
2 Credits (6P)
Prerequisite: concurrent registration in CHEM 434.

CHEM 441. Advanced Research
1-3 Credits (3+9P)
Investigation of chemical problems and the development of special techniques. May be repeated for a maximum of 3 credits.
Prerequisites: consent of instructor, 16 credits of chemistry and 3.0 GPA in chemistry for nonmajors.

CHEM 443. Senior Seminar
1 Credit (1)
Discussions of current chemical research, impact of chemistry on society and/or ethics as applied to chemists. Each student will present a written and an oral report on an approved topic.
Prerequisite: CHEM 431 or CHEM 433.

CHEM 451. Special Topics
1-3 Credits
Specific subjects to be announced in the Schedule of Classes. May be repeated for a maximum of 12 credits.
Prerequisite: consent of instructor.

CHEM 455. Independent Studies
1-3 Credits
Independent studies directed by consulting faculty.
Prerequisite: consent of instructor.

CHEM 456. Inorganic Structure and Bonding
3 Credits (3)
Study of structure and bonding of inorganic elements with a focus on transition metals. An introduction to symmetry, group theory, and spectroscopy will be included. May be repeated up to 3 credits.
Prerequisite: (MATH 1521G or MATH 1521H) and C- or better in CHEM 314.

Learning Outcomes

1. Students will learn about inorganic coordination complexes with a focus on transition metals, and may include the main group and f-elements. Students will learn about inorganic nomenclature and to analyze complexes using Lewis acid-base concepts.
2. Students will learn bonding theories, including group theory and symmetry point groups. Students will learn introductory concepts in organometallic chemistry and electronic spectroscopy.

CHEM 471. Advanced Integrated Inorganic and Physical Chemistry Laboratory
3 Credits (9P)
Laboratory course covering Inorganic and Physical Chemistry techniques at the advanced undergraduate level. Topics may include: Transition metal/Main group synthesis in air and air free environments, Period f-element synthesis, UV-Vis spectroscopy, FT-IR spectroscopy, NMR spectroscopy, Isothermal Titration Calorimetry.
Prerequisite/Corequisite: CHEM 430 and CHEM 315.

Learning Outcomes

1. Students will engage in experiential learning to become proficient in the listed techniques at the advanced undergraduate level of expertise. Students will develop critical thinking and problem solving skills. Students will learn essential laboratory data documentation, record keeping, and communication skills.

CHEM 472. Advanced Integrated Instrumental Analysis and Protein Biochemistry Laboratory
3 Credits (9P)
Laboratory course covering Protein Biochemistry and Instrumental Analysis techniques at the advanced undergraduate level. Topics may include: Affinity-based protein purification, basic protein quantification, protein activity assay, multi-variant analysis, diode array UV/VIS spectroscopy, ICP-MS, absorption and emission spectroscopy, raman spectroscopy, fluorescence, and separation science (HPLC, GCMS). Includes data analysis lab.
Prerequisite: CHEM 371.

Learning Outcomes

1. Students will engage in experiential learning to become proficient in the listed techniques at the advanced undergraduate level of expertise. Students will develop critical thinking and problem solving skills. Students will learn essential laboratory data documentation, record keeping, and communication skills.

CHEM 475. Central Concepts in Chemistry - Safety
1 Credit (1)
Students will obtain university safety training plus departmental-specific safety guidelines for the research laboratory

Learning Outcomes

1. Students completing this course will be knowledgeable of all safety guidelines delineated by the University, College, and Department.
2. When possible accident case-studies will be incorporated within the curriculum.

CHEM 476. Central Concepts in Chemistry - Research Ethics
1 Credit (1)

Students will complete Federal Agency (NSF, NIH, etc.) on-line training modules in responsible conduct in research and discuss relevant case-studies of research misconduct.

Learning Outcomes

1. Completion of this class will yield researchers fully aware of federal and professional guidelines regarding the ethical conduction and dissemination of data and conclusions.

CHEM 477. Central Concepts in Chemistry - ProfessionalDevelopment
1 Credit (1)

Students will receive basic instruction in research dissemination strategies (presentations) and career planning.

CHEM 501. Central Concepts in Chemistry - Energy
3 Credits (3)

This course will provide the students with a detailed examination of several topics in chemical energetics. These topics include: (1) basic thermodynamics concepts, (2) statistical thermodynamics (3) chemical equilibria, and (4) intermolecular interactions.

Learning Outcomes

1. Students completing this course will gain an understanding of chemical thermodynamics and equilibria as they relate to all areas of chemistry.

CHEM 502. Central Concepts in Chemistry - Structure
3 Credits (3)

This course will provide the students with a detailed examination of several topics in chemical reactivity. These topics include: (1) principles of chemical bonding and (2) organic, inorganic and biochemical structure determination.

Learning Outcomes

1. Students completing this course will understand the fundamental components of molecular interactions and their impact on molecular structure and function in all areas of chemistry.
2. In addition, they will learn the theory and practice of physical techniques used to determine molecular structure.

CHEM 503. Central Concepts in Chemistry - Dynamics
3 Credits (3)

This course will provide the students with a detailed examination of several topics in chemical reactivity. These topics include: (1) basic kinetic concepts, (2) fundamental gas phase kinetics (3) organic, inorganic and biochemical reaction mechanisms.

Learning Outcomes

1. Students who successfully complete this course will understand the fundamentals of chemical dynamics: from simple gas or solution phase reaction mechanisms to biomolecular interactions.

CHEM 504. Central Concepts in Chemistry - Measurements
3 Credits (3)

This course will provide the students with a detailed examination of several topics in chemical measurements. These topics include: (1) spectroscopic, electrochemical and chromatographic techniques, (2) statistical methods of measurement and validation relevant to biomolecules, synthetic polymers and mixtures.

Learning Outcomes

1. The collection of quantitative data is central to all subdisciplines of chemistry.
2. Students completing this course will understand the basic principles of chemical measurements and the uncertainties inherently associated with those measurements.
3. They will also gain knowledge of tools available to minimize those uncertainties in data interpretation.

CHEM 507. Chemistry of the Elements
3 Credits (3)

Discussion of the reactions and structures of inorganic compounds.

CHEM 510. Graduate Student Seminar
1 Credit (1)

Research seminar for graduate students in Chemistry. Enrollment required each semester for all graduate students. Masters or Doctoral candidates presenting a research seminar enroll for a letter grade. All other participating students enroll using the S/U grading option.

Learning Outcomes

1. Graduate students will gain experience organizing a research presentation.
2. Graduate students will develop oral presentation skills.

CHEM 514. Organic Structure Determination
1-3 Credits (1-3)

This course is made up of three independent modules of 1 credit each. May be taught in one, two or three modules. Module 1: Infrared Spectroscopy and Other Spectroscopic Methods, Applications of infrared spectroscopy to the structure determination of organic compounds. Module 2: Mass Spectrometry, Application of mass spectrometry to the structure determination of organic compounds. Module 3: NMR spectroscopy, Applications of NMR spectroscopy to the structure determination of organic compounds. May be repeated up to 3 credits.

Learning Outcomes

1. By the end of module one, students will have a general understanding of the physical basis of infrared spectroscopy and molecular vibrations, be able to describe and use the frequency, shape and intensity of diagnostic absorptions in the IR spectra to correlate with common organic functional groups, recognize the utility of the fingerprint region of an IR spectrum to establish identity of small organic compounds, and integrate IR knowledge with other spectroscopic methods for the structure determination of small organic compounds.
2. By the end of module two, students will understand the basis of mass spectrometry as a tool for structure determination, have a general understanding of the different techniques commonly used for sample ionization, describe fragmentation patterns for common classes of organic compounds: alkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, ethers, amines and carbonyl compounds, use molecular ion and fragmentation pattern information to propose structures of small organic molecules, integrate mass spectrometry knowledge with other spectroscopic methods for the structure determination of small organic compounds.
3. By the end of module three, students will understand the physical basis of the nuclear magnetic resonance experiment and the relationship between nuclear and magnetic properties of atoms, describe and use the concepts of chemical and magnetic equivalence, chemical shift, and anisotropic effects in oneH NMR spectra, use information from homonuclear (oneH-oneH) and heteronuclear (oneH-thirteenC) coupling experiments to propose structures of small organic molecules, use information from twoD-NMR experiments (COSY, HMQC, HMBC, NOESY) to propose structures of small organic molecules including stereochemistry, integrate NMR knowledge with other spectroscopic methods for the structure determination of small organic compounds.

CHEM 515. Modern Organic Chemistry
3 Credits (3)
Recent developments in synthesis and theoretical principles of organic chemistry.

CHEM 520. Comprehensive Literature Review Seminar for Graduate Students
1 Credit (1)
Graduate student presents a literature review on an approved topic. The seminar presentation will include cover new developments of primary significance to the topic based on current research papers and culminate in a testable hypothesis. A passing grade allows the student to take the comprehensive exam.

Learning Outcomes

1. Student will prepare an abstract of their presentation understandable to a broad chemistry/biochemistry audience
2. Student will demonstrate a reasonable understanding of every concept introduced
3. Student will present a well-organized topic leading to a logical hypothesis
4. Student will demonstrate the ability to develop a data-supported hypothesis

CHEM 526. Advanced Analytical Chemistry
3 Credits (3)
Equilibria, and the theories of gravimetric, volumetric, and instrumental analysis.

CHEM 527. Separations
3 Credits (3)
Covers the fundamentals of separation methods and relationships to modern analytical techniques such as gas chromatography and liquid chromatography.

CHEM 598. Special Research Programs
1-3 Credits
Individual investigations, either analytical or experimental. Graded S/U.

CHEM 599. Master's Thesis
15 Credits
Thesis preparation.

CHEM 600. Research
1-15 Credits
Course used for assigning credit for research performed prior to successful completion of the doctoral qualifying examination.

CHEM 619. Topics in Organic Chemistry
1-3 Credits
Selected topics of current interest designated by subtitle.

CHEM 629. Advanced Topics in Analytical Chemistry
3 Credits (3)
Discussion of advanced topics in the field of analytical chemistry. May be repeated with different subtitles. Consent of instructor required.

CHEM 639. Topics in Physical Chemistry
1-3 Credits
Selected topics of current interest designated by subtitle.

CHEM 700. Doctoral Dissertation
17 Credits
Dissertation preparation.