CHEMISTRY AND BIOCHEMISTRY

Undergraduate Program Information

A degree in chemistry or biochemistry enables a student to pursue a wide variety of careers in: research, production, sales, management and teaching. These degrees are also an excellent preparation for professional studies in medicine, dentistry, forensics, veterinary science, optometry, pharmacology, pharmacy and law.

The NMSU **Bachelor of Science Chemistry major** is certified by the American Chemical Society (ACS). Graduates who complete the program are also eligible for immediate election to membership in the ACS.

The NMSU **Bachelor of Science Biochemistry major** is accredited by the American Society of Biochemistry and Molecular Biology (ASBMB). BS Biochemistry majors are eligible to obtain degree certification through examination.

The department offers **concentrations in Secondary Education** for the Bachelor of Arts in Chemistry major and the Bachelor of Science in Chemistry major. These concentrations follow the same Chemistry degree plans but also provide the Education courses that lead to a certification as a secondary education teacher in science.

The department also offers a **Pre-Med concentration** for the Bachelor of Arts in Chemistry major. The concentration in Pre-Medical Studies provides foundational knowledge to students who are preparing to take the MCAT exam. Graduates will successfully complete medical school pre-requisite coursework and obtain an interdisciplinary understanding of healthcare that includes scientific, humanistic, and social science perspectives.

All departmental and nondepartmental requirements may not be taken S/U, unless the course only offers S/U grading option, and must earn a C- or better final grade.

This department does not have a foreign language requirement for any of its degrees.

Graduate Program Information

The Department of Chemistry and Biochemistry offers programs leading to the **MS and Ph.D. degrees in Chemistry** in the areas of physical, organic, inorganic, and analytical chemistry, and we offer a **concentration in Biochemistry**. Admission to these programs without deficiency is based on an undergraduate program essentially equivalent to that pursued by a chemistry or biochemistry major at this university. All applying students must submit undergraduate transcripts, a personal statement and CV, and arrange for 3 letters of recommendation. All foreign students from undergraduate programs taught in a language other than English must additionally submit TOEFL or IELTS scores and demonstrate adequate English speaking and writing skills. GRE scores are not required to apply.

The core course work required of students entering the Chemistry MS or PhD programs with no previous graduate study in chemistry or biochemistry consists of courses exploring the concepts of Energy, Structure, Dynamics, and Measurements as applied to all disciplines of chemistry. Students enrolled in the Biochemistry concentration take core course work in Biochemistry. All graduate students also take short courses in Safety, Research Ethics, and Professional Development. Successful completion of a Qualifying Exam taken after the first year of coursework will determine whether a student is qualified to pursue continued study at the M.S. or Ph.D. level. Ph.D. candidates must take at least 6 additional credits of specialized coursework chosen in consultation with the thesis committee while M.S. candidates must take at least 3 additional credits. Ph.D. candidates must successfully complete a Comprehensive Exam in order to be eligible to write and defend a Ph.D. thesis. All students are expected to participate in discussion groups and department colloquia.

Students enrolled in the Biochemistry concentration take core course work in Biochemistry

Since research is central in both the M.S. and Ph.D. programs, the early selection of a research advisor is encouraged. Students may choose to rotate through up to 3 research labs during their first semester before selecting a research advisor. Financial support is provided to all graduate students during their first year through teaching assistantships. Continued support may be provided through a research or teaching assistantship, depending upon individual laboratory funding. All support is contingent upon satisfactory academic and research performance. In addition, numerous traineeships and fellowships are available to qualified students. Inquiries regarding these opportunities should be directed to the graduate program coordinator.

Degrees for the Department

Bachelor Degree(s)

- Biochemistry - Bachelor of Science (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/biochemistry-bachelor-science/)
- Chemistry (Pre-Med) - Bachelor of Arts (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/chemistry-pre-med-bachelor-arts/)
- Chemistry (Secondary Education) - Bachelor of Arts (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/chemistry-secondary-education-bachelor-arts/)
- Chemistry (Secondary Education) - Bachelor of Science (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/chemistry-secondary-education-bachelor-science/)
- Chemistry - Bachelor of Arts (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/chemistry-bachelor-arts/)
- Chemistry - Bachelor of Science (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/chemistry-bachelor-science/)

Master Degree(s)

- Chemistry (Biochemistry) - Master of Science (https://catalogs.nmsu.edu/nmsu/graduate-school/chemistry-biochemistry-master-science/)
- Chemistry - Master of Science (https://catalogs.nmsu.edu/nmsu/graduate-school/chemistry-master-science/)

Doctoral Degree(s)

- Chemistry (Biochemistry) - Doctor of Philosophy (https://catalogs.nmsu.edu/nmsu/graduate-school/chemistry-biochemistry-doctor-philosophy/)
- Chemistry - Doctor of Philosophy (https://catalogs.nmsu.edu/nmsu/graduate-school/chemistry-doctor-philosophy/)

Minors for the Department

- Biochemistry - Undergraduate Minor (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/biochemistry-undergraduate-minor/)
- Chemistry - Undergraduate Minor (https://catalogs.nmsu.edu/nmsu/arts-sciences/chemistry-biochemistry/chemistry-undergraduate-minor/)

Shelley Lusetti, Department Head

Professors Houston, Lusetti, Maio, Yukl; ***Associate Professors*** Ashley, Baker, Talipov, Tello-Aburto; ***Assistant Professors*** Folkman, Frank, Gold, Guberman-Pfeffer, Vincent-Ruz, Windorff; ***College Professor*** Dunlavy; ***College Associate Professor*** Chinnasamy; ***College Assistant Professors*** Beltran, Marcheschi; ***Emeritus Professors*** Arterburn, Eiceman, Gopalan, Herndon, Johnson, Kuehn, Lara, Lyons, Quintana, Rayson, Smirnov

S. Lusetti, Department Head, Ph.D. (Wisconsin–Madison)– biochemistry; enzymology of DNA repair; *A. K. Ashley, Ph.D. (Colorado State)– biochemistry and toxicology; DNA replication and repair, cancer; C. A. Baker, Ph.D. (Florida State)– analytical chemistry; separation science, micro- and nanotechnologies for neuroscience and astrobiology; S. J. Folkman, Ph.D. (Colorado State University)- electrochemistry, materials; inorganic, green chemistry, for sustainability; C. E. Frank, Ph.D. (Rutgers- New Brunswick)- solid state inorganic chemistry; crystal growth, magnetic, topological, and multifunctional materials; B. Gold, Ph.D. (Florida State)– organic chemistry; synthetic methods for chemical biology; bioorganic and medicinal chemistry; M. J. Guberman-Pfeffer, Ph.D. (University of Connecticut)– physical chemistry; energy and electron transfer in biosystems; science accessibility; K. D. Houston, Ph.D. (Texas- MD Anderson)– biochemistry; molecular mechanisms of hormone action in tumorigenesis; W. A. Maio, Ph.D. (Johns Hopkins)– organic chemistry; total synthesis of marine natural products and explorations of new chemical methods; M. R. Talipov, Ph.D. (Bashkir State)– theoretical physical chemistry; electronic structure calculations, ab initio calculations, density functional theory calculations; R. Tello-Aburto, Ph.D. (Iowa) - medicinal and natural products chemistry, asymmetric organic synthesis; P. Vincent-Ruz, Ph.D. (Pittsburgh) - chemistry education research, equity and justice, quantitative methods; C. J. Windorff, Ph.D. (UC-Irvine)- inorganic chemistry; organometallic f-element and transition metal chemistry, redox chemistry; E. T. Yukl, Ph.D. (Oregon Health and Science)– biochemistry; x-ray crystallography and spectroscopy of bacterial metalloproteins*

Biochemistry Courses

BCHE 140. Explorations in Chemistry and Biochemistry
1 Credit (1)
In introduction to the experience of chemistry and biochemistry degrees. In this course, students will prepare a degree plan and personal statement. Career opportunities in chemistry and biochemistry will be presented and discussed. Graded S/U.
Learning Outcomes

1. Demonstrate knowledge and understanding of the sub-disciplines of Chemistry and Biochemistry.
2. Demonstrate knowledge and understanding of the requirements for the Chemistry and Biochemistry majors and career opportunities available to these majors.
3. Adopt strategies to prepare for future success in a job search or graduate school application.
4. Learn about undergraduate research opportunities in chemistry and biochemistry.

BCHE 241. Introduction to Research in Biochemistry
1-3 Credits
Techniques and procedures of biochemical research. May be repeated for a maximum of 3 credits.
Prerequisites: 8 credits of chemistry and 3.0 GPA in chemistry.

BCHE 395. Biochemistry I
3 Credits (3)
Principles governing chemistry and physics of life processes with emphasis on the relationships between molecular structure and cell function. Basic principles of biochemical processes, enzymology, and the structure/function of the major classes of biomolecules with introductions to metabolism. Introduction to catabolic metabolism. May be repeated up to 3 credits.
Prerequisite: C- or better in CHEM 314.
Learning Outcomes

1. Understand the structure, reactivity, and metabolic function of the presented biological molecules and apply that knowledge to biomolecules encountered in future experiences. Examples include the 20 common amino acids, carbohydrate molecules of glycolysis, carboxylic acids of the citric acid cycle, lipid components of biological membranes, and many catalytic enzymes.
2. Understand the theory and application of many of the experimental techniques of Biochemistry.
3. Understand biochemical regulation and the interconnectedness of metabolic processes. A large fraction of contemporary biochemical research is devoted to delineating biochemical regulation. Details of biochemical regulation will be interwoven with material presented throughout the semester, stressing the principles of regulation that are common in many organisms.
4. Understand enzyme kinetics and enzyme mechanism.

BCHE 395H. Biochemistry I Honors
3 Credits (3)
Principles governing chemistry and physics of life processes with emphasis on the relationships between molecular structure and cell function. Basic principles of biochemical processes, enzymology, and the structure/function of the major classes of biomolecules with introductions to metabolism. Introduction to catabolic metabolism. Taught with BCHE 395 with additional experiential-focused work required.
Prerequisite: C- or better in CHEM 314.
Learning Outcomes

1. Understand the structure, reactivity, and metabolic function of the presented biological molecules and apply that knowledge to biomolecules encountered in future experiences: Examples include the 20 common amino acids, carbohydrate molecules of glycolysis, carboxylic acids of the citric acid cycle, lipid components of biological membranes, and many catalytic enzymes.
2. Understand the theory and application of many of the experimental techniques of Biochemistry.
3. Understand biochemical regulation and the interconnectedness of metabolic processes. A large fraction of contemporary biochemical research is devoted to delineating biochemical regulation. Details of biochemical regulation will be interwoven with material presented throughout the semester, stressing the principles of regulation that are common in many organisms.
4. Understand enzyme kinetics and enzyme mechanism.

5. Demonstrate proficiency in problem-based learning and scientific communication.

BCHE 396. Biochemistry II, Lecture and Laboratory
4 Credits (2.5+3P)
Introduction to anabolic metabolism and hormonal regulation. Biochemical principles of the mechanism and regulation of replication, transcription, recombination and translation in prokaryotes and eukaryotes. Introduction to DNA-based information technology. Taught with BCHE 396 H. May be repeated up to 4 credits.
Prerequisite: C- or better in BCHE 395.
Learning Outcomes

1. Recognize the essential biochemical reactions and enzymatic mechanisms required for nucleic acid, amino acid, and fatty acid synthesis.
2. Learn the biochemical reaction mechanisms associated with key elements of the central dogma of molecular biology.
3. Identify the reactions and enzymes required for DNA maintenance and replication, transcription and RNA polymerization, and the translation of mRNA to primary amino acid sequence and protein synthesis.
4. Conduct experiments safely.
5. Select and manipulate plasmids to achieve desired recombinant DNA for experimentation.
6. Obtain relevant DNA sequence information from public databases.
7. Transform and isolate plasmid DNA to be used for cloning procedures.
8. Design DNA specific primers for PCR reactions.
9. Perform restriction digest and ligation reactions. 1
10. Analyze DNA sequence to validate the outcome of recombinant DNA experimentation. 1
11. Demonstrate scientific dissemination skills by attending scientific seminars or review primary literature and provide summary via written or oral presentation.

BCHE 396 H. Biochemistry II Honors, Lecture and Laboratory
4 Credits (2.5+3P)
Introduction to anabolic metabolism and hormonal regulation. Biochemical principles of the mechanism and regulation of replication, transcription, recombination and translation in prokaryotes and eukaryotes. Introduction to DNA-based information technology. Taught with BCHE 396 with additional work required. May be repeated up to 3 credits.
Prerequisite: C- or better in BCHE 395.
Learning Outcomes

1. Recognize the essential biochemical reactions and enzymatic mechanisms required for nucleic acid, amino acid, and fatty acid synthesis.
2. Learn the biochemical reaction mechanisms associated with key elements of the central dogma of molecular biology.
3. Identify the reactions and enzymes required for DNA maintenance and replication, transcription and RNA polymerization, and the translation of mRNA to primary amino acid sequence and protein synthesis.
4. Conduct experiments safely.
5. Select and manipulate plasmids to achieve desired recombinant DNA for experimentation.
6. Obtain relevant DNA sequence information from public databases.
7. Transform and isolate plasmid DNA to be used for cloning procedures.
8. Design DNA specific primers for PCR reactions.
9. Perform restriction digest and ligation reactions. 1
10. Analyze DNA sequence to validate the outcome of recombinant DNA experimentation. 1
11. Demonstrate scientific dissemination skills by attending scientific seminars or review primary literature and provide summary via written or oral presentation.

BCHE 432. Physical Biochemistry
3 Credits (3)
This course focuses on the theoretical principles of biophysical techniques and how they are applied to biological problems. Primary literature is used heavily to explain concepts and applications along with periodic demonstrations of biophysical techniques using department instruments. Students taking this course will be expected to present primary literature highlighting the applications of various techniques.
Prerequisite: CHEM 430 or CHEM 433.
Learning Outcomes

1. Understand the theoretical principles of spectroscopic and biophysical techniques.
2. Understand the appropriate applications for various instruments.
3. Be able to interpret spectroscopic and biophysical data.
4. Understand and describe biophysical literature.
5. Be able to describe biophysical studies to a diverse audience of scientists and non-scientists.

BCHE 440. Biochemistry Seminar
1 Credit (1)
Introduction to current literature in biochemistry and molecular biology. Selected topics in the field will be presented by the faculty. Students will present written and oral reports from literature searches. Restricted to: BCHE majors.
Prerequisite: BCHE 396.
Learning Outcomes

1. Students are proficient in reading scientific literature.
2. Students are proficient in the oral communication of scientific literature.

BCHE 441. Advanced Research in Biochemistry
1-3 Credits
Investigation of biochemical 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.

BCHE 451. Special Topics
1-3 Credits
Selected topics of current interest designated by title and credit. May be repeated up to 12 credits.
Learning Outcomes

1. Increase depth of knowledge in a specific area of biochemistry.
2. Learn how to read and critically review primary research papers in a specific area of biochemistry.
3. Gain experience in presenting primary research papers in a specific area of biochemistry.

BCHE 452. Chemical Carcinogenesis
3 Credits (3)

Chemical-dependent DNA mutagenesis, cancer development, and progression, with an emphasis on current research.
Prerequisite: CHEM 314 or CHEM 2120.
Learning Outcomes

1. Students can describe the fundamental principles of multistage carcinogenesis, including initiation, promotion, and progression.
2. Students can explain the role of DNA mutagenesis and repair mechanisms in the development and prevention of cancer.
3. Students can summarize the basic principles of toxicokinetics and explain how carcinogens are metabolized and interact with biological systems.
4. Analyze and critically evaluate primary scientific literature related to chemical carcinogenesis.
5. Assess the significance and implications of recent advancements in carcinogenesis research.

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

BCHE 542. Biochemistry I
3 Credits (3)
Principles governing chemistry and physics of life processes with emphasis on the relationships between molecular structure and cell function. In depth principles of biochemical processes, enzymology, and the structure/function of the major classes of biomolecules. Enzyme reaction and regulatory mechanisms in central metabolism and principles of bioenergetics are covered.
Prerequisite: CHEM 314 and CHEM 430 or CHEM 433; or BCHE 395 or equivalent.
Learning Outcomes

1. Understand the structure, reactivity, and metabolic function of the presented biological molecules and apply that knowledge to biomolecules encountered in future experiences: examples include the 20 common amino acids, carbohydrate molecules of glycolysis, carboxylic acids of the citric acid cycle, lipid components of biological membranes, and many catalytic enzymes.
2. Understand the theory and application of many of the experimental techniques of Biochemistry.
3. Understand biochemical regulation and the interconnectedness of metabolic processes: a large fraction of contemporary biochemical research is devoted to delineating biochemical regulation.
4. Apply the principles of enzyme kinetics as a technique to determine enzyme mechanism and regulation.
5. Propose novel enzyme reaction mechanisms based on the understanding of various classes of enzyme mechanisms and the known function of cofactors.
6. Details of biochemical regulation will be interwoven with material presented throughout the semester, stressing the principles of regulation that are common in many organisms.

BCHE 545. Molecular and Biochemical Genetics
3 Credits (3)
An accelerated treatment of the molecular basis of gene expression. Discussion of chemical, enzymological, and genetic techniques of molecular biology.
Prerequisite/Corequisite: BCHE 542.
Learning Outcomes

1. Understand and explain fundamental concepts in biochemical genetics: describe the molecular structure and function of DNA, RNA, and proteins.
2. Analyze genetic mechanisms and their applications: Evaluate the processes of DNA repair, recombination, and site-specific recombination.
3. Develop and apply scientific inquiry and problem-solving skills: Formulate and articulate relevant research questions based on course material by demonstrate the ability to apply biochemical and genetic concepts to experimental design and interpretation and engaging in critical thinking through weekly question submissions and article discussions and communicating scientific concepts effectively and construct clear, well-reasoned written and verbal explanations of biochemical genetics concepts.
4. Demonstrate the ability to communicate complex genetic mechanisms to peers: Properly cite and reference academic sources, including AI-generated content when applicable: Understand and adhere to ethical guidelines regarding plagiarism, academic integrity, and responsible scientific conduct by completing a plagiarism tutorial and apply best practices in scientific writing and Engaging in respectful, collaborative discussions and maintain a professional attitude in all course interactions.
5. Apply knowledge to broader scientific and biomedical contexts: Relate biochemical genetic principles to real-world applications, including genetic engineering, biotechnology, and medical research.
6. Compare and contrast the mechanisms of DNA replication, transcription, and translation in prokaryotic and eukaryotic systems.
7. Explain the biochemical principles underlying gene expression and its regulation.
8. Recognize the importance of biochemical genetics in understanding diseases and developing therapeutic strategies.
9. Appreciate the evolutionary and functional implications of genetic mechanisms across biological systems. 1
10. Discuss epigenetic modifications and chromatin remodeling in gene regulation. 1
11. Analyze the role of non-coding RNAs and other regulatory elements in gene expression. 1
12. Interpret and critically assess primary scientific literature related to biochemical genetics and Synthesize experimental evidence to support or refute scientific hypotheses. 1
13. Identify key methodologies used in genetic and biochemical research.

BCHE 546. Biochemistry II: Central and Intermediary Metabolism
3 Credits (3)
Intermediary metabolism: catabolic and anabolic pathways of carbohydrates, lipids, amino acids, and nucleic acids, including their regulation.
Prerequisite: BCHE 542, or BCHE 395 with consent of instructor.
Learning Outcomes

1. Apply knowledge of the structure, reactivity, and metabolic function of scores of biological molecules: examples include the 20 amino acids, carbohydrate molecules of glycolysis, carboxylic acids of the citric acid cycle, lipid components of biological membranes, and many catalytic enzymes.
2. Apply the function of enzymes, enzymatic cofactors to the design and regulation of both catabolic and anabolic pathways.
3. Master an understanding of biochemical regulation and the interconnectedness of metabolic processes and a large fraction

of contemporary biochemical research is devoted to delineating biochemical regulation.
4. Identify resources and communicate the connection between metabolism and disease or mutational analysis for basic research.
5. Develop an appreciation of the unity of life processes at the molecular level, the field of Biochemistry offers a unique perspective on human existence, you will begin to understand that we are not as different, nor as separate, from the animals, plants, and microbes of this world as is commonly assumed.

BCHE 598. Special Research Programs
1-3 Credits
May be repeated for a maximum of 6 credits. Same as CHEM 598. Graded S/U.

BCHE 599. Master's Thesis
15 Credits
May be repeated for a maximum of 6 credits. Same as CHEM 599.

BCHE 600. Research
1-15 Credits
May be repeated for a maximum of 20 credits. PR/U grading. Same as CHEM 600.

BCHE 647. Physical Biochemistry
3 Credits (3)
Fundamental applications of physical chemistry to the investigation of biological metabolites and biological macromolecules, including proteins, oligo-nucleotides, and molecular arrays with an emphasis on understanding biological functions based on chemical structures. Taught with BCHE 432. May be repeated up to 3 credits.
Prerequisite: C- or better in CHEM 430 or CHEM 433 or BCHE 542.
Learning Outcomes
1. Understand the theoretical principles of spectroscopic and biophysical techniques.
2. Understand the appropriate applications for various instruments.
3. Be able to interpret spectroscopic and biophysical data.
4. Understand and describe biophysical literature.
5. Be able to describe biophysical studies to a diverse audience of scientists and non-scientists.

BCHE 649. Topics in Biochemistry
1-3 Credits
Selected topics of current interest designated by title and credit. May be repeated for a maximum of 3 credits.

BCHE 652. Chemical Carcinogenesis
3 Credits (3)
Chemical-dependent DNA mutagenesis, cancer development, and progression, with an emphasis on current research.
Learning Outcomes
1. Students can describe the fundamental principles of multistage carcinogenesis, including initiation, promotion, and progression.
2. Students can explain the role of DNA mutagenesis and repair mechanisms in the development and prevention of cancer.
3. Students can summarize the basic principles of toxicokinetics and explain how carcinogens are metabolized and interact with biological systems.
4. Analyze and critically evaluate primary scientific literature related to chemical carcinogenesis.
5. Assess the significance and implications of recent advancements in carcinogenesis research.

BCHE 700. Doctoral Dissertation
20 Credits
May be repeated for a maximum of 20 credits. Graded PR/U. Same as CHEM 700.

Chemistry Courses

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 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, or grade of C- or better in CHEM 1111.

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 and C- or better in MATH 1215 or higher.

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 and Biochemistry
1 Credit (1)
In introduction to the experience of chemistry and biochemistry degrees. In this course, students will prepare a degree plan and personal statement. Career opportunities in chemistry and biochemistry will be presented and discussed.
Learning Outcomes
1. Demonstrate knowledge and understanding of the subdisciplines of Chemistry and Biochemistry.
2. Demonstrate knowledge and understanding of the requirements for the Chemistry and Biochemistry majors and career opportunities available to these majors.
3. Adopt strategies to prepare for future success in a job search or graduate school application.
4. Learn about undergraduate research opportunities in chemistry and biochemistry.

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. May be repeated up to 3 credits.

Prerequisite: CHEM 1120G or CHEM 1215G.
Corequisite: CHEM 2120L.
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.
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 313. Organic Chemistry I
3 Credits (3)
An introduction to the structure, properties, nomenclature, and reactivity of organic molecules. Topics include functional groups, stereochemistry, reaction mechanisms, and multi-step synthesis. Emphasis is placed on substitution and elimination reactions, reactions of alkenes, alkynes, alcohols, phenols, and radicals. Builds on general chemistry concepts such as bonding, acid-base reactions, and molecular stability to develop a foundational understanding of organic reactivity.
Prerequisite: C- or better in CHEM 1225G or CHEM 1226.

Learning Outcomes

1. Demonstrate knowledge of the properties of elements and molecules discussed in general chemistry (electronegativity, bonding, formal charge, octet rule).
2. Demonstrate knowledge of the chemical reactions discussed in general chemistry, specifically Acid / Base Reactions (products, reactants, balanced equations).
3. Classify organic compounds and their properties by functional group, including substitution and elimination reactions of alkyl halides, reactions of alkenes, alkynes, radicals, alcohols, and phenols.
4. Use common and IUPAC rules of nomenclature to name organic compounds.
5. Demonstrate knowledge of the structure and stability of organic compounds.
6. Demonstrate comprehension of the relationship between organic structure and reactivity.
7. Demonstrate comprehension of the configurations of organic compounds (resonance structures, stereochemistry, isomers).
8. Correctly describe the four-five step synthesis of a simple organic molecule using various reactions.
9. Critically interpret molecular structures, predict chemical behavior based on structure, and articulate the relationship between form and function in organic compounds.

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.
Prerequisite: C- or better in CHEM 313 or consent of instructor.
Prerequisite/Corequisite: CHEM 314.

Learning Outcomes

1. Students engage in safe laboratory practices and understand the importance of personal protective equipment (PPE) for the handling of laboratory glassware, chemical reagents, and the operation of analytical instrumentation.
2. Students demonstrate the ability to record scientific observations and critically evaluate data to determine the identity, purity, and yield of products.
3. Through laboratory reports, students summarize and discuss their findings in a clear and concise manner.
4. Students identify and characterize organic molecules by utilizing physical / spectroscopic means, including melting / boiling point determination, Infra-red (IR) Nuclear Magnetic Resonance (NMR) spectroscopies.
5. Students demonstrate proficiency in performing common laboratory techniques, including reflux, distillation, recrystallization, vacuum filtration, aqueous extraction, and thin layer chromatography.
6. Related to pre- / co-requisite coursework in CHEM 313 / 314, students demonstrate an ability to determine the outcome of simple organic reactions, utilizing a basic understanding of mechanisms and the relative reactivity of functional groups.

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 371. Analytical Chemistry
4 Credits (2+6P)
The fundamental principles of quantitative chemical measurements including concepts in statistics, chemical equilibrium, and physical properties and phenomena that underlie modern analytical instrumentation.
Prerequisite: C- or better in CHEM 1225G or CHEM 1226.

Learning Outcomes

1. Evaluate and interpret the sources and effects of error and uncertainty in measurements.
2. Apply statistical tools to evaluate and interpret data from chemical analyses.
3. Apply knowledge of acid/base equilibria for the preparation of buffers and the execution of titration-based analyses.
4. Understand the design and application of standards and calibration in chemical analysis.
5. Quantify chemical concentrations via spectroscopy.

6. Understand the fundamental equilibria governing chemical separations.

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 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 1225G 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 1225G 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 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.
Prerequisite: CHEM 430.
Learning Outcomes
1. Students are proficient in reading and analyzing scientific literature.
2. Students are proficient in the oral communication of scientific literature.

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.
Prerequisite/Corequisite: BCHE 395.
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 474. Radiochemistry
3 Credits (1+6P)
The course contains a lecture and a laboratory component. The lecture component will introduce students to the fundamentals of radiation, radiation detection, and radiation safety. The applications of radiation in industry, medicine, and energy production will also be discussed. A primary focus will include actinide chemistry. The laboratory section will introduce students to practical concepts covered in the lecture portion of class, the handling of radioactive material and the spectroscopic identification of radioactive materials.
Prerequisite: C- or better in CHEM 1225G and C- or better in MATH 1511G.
Learning Outcomes

1. From the lecture portion of the course students will gain familiarity with identifying different types of radiation, be able to describe radioactivity, radiation detection, how radiation interacts with matter, explain historic and modern uses of radiation.
2. In the laboratory section of the course students will be able to follow and perform radiation safety protocols, understand and apply basic radiochemical spectroscopic and counting techniques, and the safe handling of radioactive materials.

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.
Learning Outcomes

1. Completion of this class will yield researchers fully aware of research dissemination strategies, be able to set career goals, and create a plan to attain those goals.

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 and inorganic 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 and inorganic 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
1-3 Credits (1-3)
Discussion of the reactions and structures of inorganic compounds. This course is made up of three independent modules of 1 credit each. It may be taught in one, two or three modules. Module 1: Synthesis and preparation of inorganic or organometallic compounds. Module 2: Analysis of inorganic or organometallic compounds. Module 3: Applications of inorganic or organometallic compounds. May be repeated up to 3 credits.

Learning Outcomes

1. By the end of module one, students will have a general understanding of synthetic techniques or strategies used for the preparation of inorganic or organometallic molecular or extended structure systems.
2. Model One may include a focus on solution, hydrothermal, pyrochemical, solid-state or other synthetic techniques.
3. By the end of module two, students will understand the basics of different analysis methods used for inorganic or organometallic molecular or extended structure systems.
4. Model Two, the analysis methods may cover solution, solid, or gas phase methods.
5. Model Two, the module will cover aspects of spectroscopic methods such as paramagnetic NMR, EPR, UV-vis-NIR, IR, and analysis methods covered may include single or powder X-ray diffraction, magnetometry, and more.
6. By the end of module three, students will understand the industrial applications relevant to inorganic or organometallic molecular or extended structure systems: some of these may include the generation of energy, industrial catalysis, materials science, and more.

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
1-3 Credits (1-3)
Recent developments in synthesis and theoretical principles of organic chemistry. This course is made up of three independent modules of 1 credit each. May be taught in one, two, or three modules. Module 1: Structure and Reactivity. Module 2: Reactions. Module 3: Synthesis. May be repeated up to 3 credits.

Learning Outcomes

1. By the end of module one, students will have a general understanding of the fundamental basis of structure and reactivity of organic compounds.
2. Module one, topics can include but are not limited to: structure and bonding, reactivity and stability, aromaticity, stereochemistry, conformational, steric and stereoelectronic effects.
3. By the end of module two, students will have a general understanding of current synthetically useful reactions for organic compounds.
4. Module two, topics can include but are not limited to: additions and eliminations, substitutions, pericyclic, radical and photochemical reactions, functional group interconversions, oxidations and reductions, protecting groups.
5. By the end of module three, students will have a general understanding of the basis for organic synthesis.
6. Module three, topics can cover but are not limited to retrosynthesis and planning, comparative analysis, strategies and tactics for the synthesis of medium to complex targets.
7. Module three, emphasis is placed in showcasing the utility of catalytic, asymmetric, chemo-, regio- and stereo-selective transformations.

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.

Phone: (575) 646-2505

Email: chembche@nmsu.edu

Website: https://chemistry.nmsu.edu