CHEMISTRY (CHEM)

CHEM 105 Chemistry and Society (4 Credits)
Fundamentals of chemistry are studied with the aim of gaining an understanding of the importance of chemistry for humanity and society. Topics of historical interest and current relevance are explored. Laboratory emphasis is on the principles of scientific inquiry, including the collection, analysis and interpretation of data. Intended primarily for non-science majors. Fall and spring.
Prerequisites: None

CHEM 121 Skills in Chemistry (2 Credits)
This course will help students develop the visualization, problem solving, and critical thinking skills necessary for success in CHEM 125. Students will work in small groups in a student-centered learning environment that will provide support as they address some of the challenging concepts in chemical structure and properties. The course content will be coordinated closely with the first half of CHEM 125 and will be scheduled to run parallel to it. The course is intended for students who have been identified as likely benefiting from this experience. Prereq MATH proficiency. Must also register for CHEM 125. Course offered for S/U grading only.
Prerequisites: None
Corequisites: CHEM 125

CHEM 125 Introduction to Chemical Structure and Properties (4 Credits)
An introductory chemistry course in which students study how the structure of atoms, ions, and molecules determine their physical and chemical properties. Starting with atoms and their electron configurations, students build a progressive and linked understand of bonding, ionic and molecular geometry, and physical and chemical properties that emerge from structure. Intended as a first course for students majoring in the natural sciences. Students usually co-enroll in CHEM 125 and 201.
Prerequisites: None
Equivalent courses: CHEM 123, CHEM 123Z, CHEM 125A, CHEM 125B, CHEM 125C, HONR 210E
Attributes: Thematic Encounter1/2 - Truth

CHEM 125A Introduction to Chemical Structure and Properties-FoCuS (4 Credits)
An introductory chemistry course in which students study how the structure of atoms, ions, and molecules determine their physical and chemical properties. Starting with atoms and their electron configurations, students build a progressive and linked understand of bonding, ionic and molecular geometry, and physical and chemical properties that emerge from structure. Intended as a first course for students majoring in the natural sciences.
Prerequisites: None
Equivalent courses: CHEM 125

CHEM 201 Purification and Separation Lab I (1 Credit)
An introductory laboratory course in basic purification techniques and analysis in chemistry. Emphasis is on mastery of technique and analysis of experimental data Students usually co-enroll in CHEM 125 and 201.
Prerequisites: CHEM 125 or HONR 210E
Equivalent courses: CHEM 201A
Attributes: Natural World (NW)

CHEM 201A Purification and Separation Lab I-FoCuS (1 Credit)
An introductory laboratory course in basic purification techniques and analysis in chemistry. Emphasis is on mastery of technique and analysis of experimental data Students usually co-enroll in CHEM 125 and 201. However, students may withdraw from either one during the semester and take that course in a subsequent semester. Students who take CHEM 121 and CHEM 125 in the same semester should take CHEM 201 lab in the following semester. Course offered for A-F grading only. Students must complete both CHEM 125 and CHEM 201 in order to earn the NS designation. If a student only completes CHEM 125 they will not earn the NS designation for the Common Curriculum. If a student only completes CHEM 201 they will not earn the NS designation for the Common Curriculum.
Prerequisites: None
Equivalent courses: CHEM 201

CHEM 202 Purification and Chromatography Lab II (1 Credit)
A laboratory course in the use of chromatography as a tool to purify and analyze chemistry mixtures. Emphasis is on mastery of techniques and analysis of experimental data.
Prerequisites: CHEM 201
Equivalent courses: CHEM 202A

CHEM 202A Purification and Chromatography Lab II-FoCuS (1 Credit)
A laboratory course in the use of chromatography as a tool to purify and analyze chemistry mixtures. Emphasis is on mastery of techniques and analysis of experimental data. Prerequisite: CHEM 201A. Course offered for A-F grading only.
Prerequisites: CHEM 201A
Equivalent courses: CHEM 202

CHEM 203 Synthesis Lab (1 Credit)
A laboratory course in synthetic techniques. Students will learn a variety of techniques for synthesis including air sensitive, biochemical and organic reactions. Students will continue to develop independence, literature searching, project design, data interpretation and writing skills. Prerequisites: CHEM 202 and 250 or department permission. A-F grading only.
Prerequisites: (CHEM 202 or CHEM 202A) and (CHEM 250 or CHEM 250A)
Equivalent courses: CHEM 203A
Attributes: Thematic Encounter1/2-Movement

CHEM 203A Synthesis Lab-FoCuS (1 Credit)
A laboratory course in synthetic techniques. Students will learn a variety of techniques for synthesis including air sensitive, biochemical and organic reactions. Students will continue to develop independence, literature searching, project design, data interpretation and writing skills. Prerequisites: CHEM 202A and 250A or department permission. A-F grading only
Prerequisites: CHEM 202A
Equivalent courses: CHEM 203

CHEM 205 Chemical Measurement Lab (1 Credit)
A laboratory introduction to the science of chemical measurement. Using classical techniques (quantitative analysis, spectroscopic techniques) students will learn to measure important physical and chemical properties, quantitate and minimize measurement errors, and obtain accurate calibrations. Laboratory experiments will focus on student development of precision and accuracy, data analysis and reporting as well as scientific writing. Prerequisite: CHEM 201. A-F grading only.
Prerequisites: (CHEM 201 or CHEM 201A)
Attributes: Writing Requirement (WR)

CHEM 215 Problem Solving Seminar I (1 Credit)
This course is to expose sophomore students to a sampling of fundamental and applied research problems, develop problem solving and communications skills (written and oral) skills, and prepare them for advanced laboratory research projects. Resources and methods for searching the chemical literature, proper referencing, protocols, and technology enhanced presentation skills will be emphasized. The assigned problems will engage students in hands-on activities and provide a supportive environment to develop their confidence in understanding, operating, and manipulating instruments, and computational methods. At the end of the semester, students will present their results through written reports and oral presentations. Prerequisite: CHEM 125 (or HONR 210E), CHEM 250, CHEM 201, CHEM 202 or departmental permission.
Prerequisites: (CHEM 125 or CHEM 125A or HONR 210E) and (CHEM 250 or CHEM 250A) and (CHEM 201 or CHEM 201A) and (CHEM 202 or CHEM 202A)

CHEM 215A Problem Solving Seminar I-FoCuS (1 Credit)
This is the first course in a year-long sequence and is required for all students participating in the NSF sponsored FoCuS program in their sophomore year. This course is to expose the students to a sampling of fundamental and applied research problems, develop problem solving and communications skills (written and oral) skills, and prepare them for advanced laboratory research projects. Resources and methods for searching the chemical literature, proper referencing, protocols, and technology enhanced presentation skills will be emphasized. The assigned problems will engage students in hands-on activities and provide a supportive environment to develop their confidence in understanding, operating, and manipulating instruments, and computational methods. At the end of the semester, students will present their results through written reports and oral presentations. Prerequisite: CHEM 125A, CHEM 250A, CHEM 201A, CHEM 202A
Prerequisites: CHEM 125A and CHEM 250A and CHEM 201A and CHEM 202A

CHEM 216 Problem Solving Seminar II (1 Credit)
This is the second course in a year-long sequence and is open to other students with instructor approval only. The course description parallels that of CHEM 215. Prerequisite: CHEM 125, CHEM 250, CHEM 201, CHEM 202, CHEM 215
Prerequisites: (CHEM 125 or CHEM 125A or HONR 210E) and (CHEM 250 or CHEM 250A) and (CHEM 201 or CHEM 201A) and (CHEM 202 or CHEM 202A) and (CHEM 215 or CHEM 215A)

CHEM 216A Problem Solving Seminar II-FoCuS (1 Credit)
This is the second course in a year-long sequence and is required for all students participating in the NSF sponsored FoCuS program in their sophomore year. This course is open to other students with instructor approval only. The course description parallels that of CHEM 215. Prerequisite: CHEM 125A, CHEM 250A, CHEM 201A, CHEM 202A, CHEM 215
Prerequisites: CHEM 125A and CHEM 250A and CHEM 201A and CHEM 202A and (CHEM 215 or CHEM 215A)

CHEM 250 Reactions of Nucleophiles and Electrophiles (Reactivity 1) (4 Credits)
An understanding of chemical reactivity is developed based on principles of Lewis acidity and basicity. The formation, stability and reactivity of coordination complexes serves as an introduction to electrophilicity, nucleophilicity, and steric and electronic effects. Investigations of carbonyl reactivity (addition and substitution) using analogous principles are used to develop pattern recognition skills in understanding chemical processes. Some emphasis is placed on energetics as a basis of understanding reactivity. Together, these topics lead to an understanding of simple biochemical pathways. Applications of the material are drawn from organic, biological and inorganic chemistry.
Prerequisites: CHEM 125 or CHEM 125A or HONR 210E
Equivalent courses: CHEM 235, CHEM 236, CHEM 250A, CHEM 341

CHEM 250A Reactions of Nucleophiles and Electrophiles (Reactivity 1)-FoCuS (4 Credits)
An understanding of chemical reactivity is developed based on principles of Lewis acidity and basicity. The formation, stability and reactivity of coordination complexes serves as an introduction to electrophilicity, nucleophilicity, and steric and electronic effects. Investigations of carbonyl reactivity (addition and substitution) using analogous principles are used to develop pattern recognition skills in understanding chemical processes. Some emphasis is placed on energetics as a basis of understanding reactivity. Together, these topics lead to an understanding of simple biochemical pathways. Applications of the material are drawn from organic, biological and inorganic chemistry. Prerequisite: CHEM 125A
Prerequisites: CHEM 125A
Equivalent courses: CHEM 250

CHEM 251 Intermediate Reactions of Nucleophiles and Electrophiles (Reactivity 2) (4 Credits)
An understanding of chemical reactivity, initiated in Reactivity I, is further developed based on principles of Lewis acidity and basicity. Alternative mechanisms of ligand substitution in coordination complexes are considered in terms of steric and electronic effects. An understanding of kinetic evidence is developed in order to determine which mechanism has occurred in a particular case. Organic nucleophilic substitution pathways are studied using analogous principles. Electrophilic addition and substitution in pi systems (alkenes and aromatics) are used to extend these principles to new systems and complete an overview of polar reactions. Applications of the material are drawn from organic, biological and inorganic chemistry. 0
Prerequisites: CHEM 250 or CHEM 250A
Equivalent courses: CHEM 236, CHEM 251A

CHEM 251A Intermediate Reactions of Nucleophiles and Electrophiles (Reactivity 2)-FoCuS (4 Credits)
An understanding of chemical reactivity, initiated in Reactivity I, is further developed based on principles of Lewis acidity and basicity. Alternative mechanisms of ligand substitution in coordination complexes are considered in terms of steric and electronic effects. An understanding of kinetic evidence is developed in order to determine which mechanism has occurred in a particular case. Organic nucleophilic substitution pathways are studied using analogous principles. Electrophilic addition and substitution in pi systems (alkenes and aromatics) are used to extend these principles to new systems and complete an overview of polar reactions. Applications of the material are drawn from organic, biological and inorganic chemistry. Prerequisite: CHEM 250A
Prerequisites: CHEM 250A
Equivalent courses: CHEM 251

CHEM 255 Macroscopic Chemical Analysis (4 Credits)
Fundamentals of Macroscopic Chemic Analysis explores thermodynamic approaches to chemical equilibrium. Emphasis on free energy as the driving force for chemical reactions will be explored through the quantitative analysis of chemical equilibria in simple as well as complex systems. Statistical methods will be developed for the assessment of data. Chemical systems in equilibrium as well as in dynamic situations will be studied.
Prerequisites: CHEM 125 or CHEM 125A or HONR 210E
Attributes: Quantitative Reasoning (QR), Writing Requirement (WR)

CHEM 271 Individual Learning Project (1-4 Credits)
Supervised reading or research at the lower-division level. Permission of department chair required. Consult department for applicability towards major requirements. Not available to first-year students.
Prerequisites: None

CHEM 304 Analytical Method Development and Validation Laboratory (1 Credit)
Analytical Method Development and Validation is an an advanced laboratory that builds on the techniques, skills, and concepts developed in the foundation level laboratory courses. Students will complete projects that that involve experimental design and optimization of GC and LC instrumental techniques. Students will develop methods for separating mixtures of compounds, quantify amounts of a specific compound in a mixture, and analytically validate a method. Additional topics will include topics such as sample preparation and instrumental response. Students will further their understanding of how to communicate laboratory results in industrial settings.
Prerequisites: (CHEM 202 or CHEM 202A) and CHEM 205 and CHEM 255

CHEM 305 Integrated Laboratory (4 Credits)
Integrated Laboratory builds on the Foundation technique-based laboratories with the goal of allowing students to develop an understanding that chemistry is not five separate disciplines, but is an integrated approach to chemical problems. The laboratory will have one recitation and two laboratory session each cycle. The laboratory experiments are project-based where the projects will include synthesis, method development for analysis, data reduction and computational components. Students will develop the skills needed to conduct an individual laboratory research project. Offered Fall and Spring. Prerequisites: Four Foundation Labs (201, 202, 203, 205), CHEM 251. Co-requisites: Chem 315 or 255.
Prerequisites: (CHEM 201 or CHEM 201A) and (CHEM 202 or CHEM 202A) and (CHEM 203 or CHEM 203A) and CHEM 205 and (CHEM 251 or CHEM 251A) and (CHEM 315 (may be taken concurrently) or CHEM 255 (may be taken concurrently))

CHEM 306 Advanced Laboratory Topics (1 Credit)
Advanced Laboratory Topics courses will extend techniques, skills and concepts developed in the foundation level laboratories (CHEM 201, 202, 203, 205). Each laboratory course will consist of projects for students to develop mastery of chemical laboratory skills in a specific discipline. Students will further their understanding of how to communicate laboratory results.
Prerequisites: None

CHEM 306A Advanced Electronics & Instrumentation Lab (1 Credit)
Prerequisite CHEM 205 & 255
Prerequisites: CHEM 205 and CHEM 255

CHEM 306B Advanced Biochemical Techniques Lab (1 Credit)
Prerequisite CHEM 205 & 255
Prerequisites: CHEM 205 and CHEM 255

CHEM 306C Advanced Lab Topic: Synthesis (1 Credit)
Prerequisite: CHEM 205 & 255
Prerequisites: CHEM 205 and CHEM 255

CHEM 306D Advanced Lab Topic: Materials (1 Credit)
Prerequisite CHEM 205 & 255
Prerequisites: CHEM 205 and CHEM 255

CHEM 306E Advanced Lab Topic: Protein Engineering (1 Credit)
In this research-based biochemistry lab experience, students will work towards redesigning malate dehydrogenase (MDH) to be able to detect conformational changes upon its binding to other proteins in the citric acid cycle. The semester long experiment will begin with analyzing the published crystal structure of MDH to make a hypothesis about where mutations can be made that will incorporate a fluorophore, while not negatively impacting the activity of the enzyme. Students will then design primers for their mutations, perform the mutagenesis, transform the resultant mutant plasmid, and over-express the mutant MDH protein. After protein purification and quantitation, the specific activity, Michaelis-Menten kinetic parameters, and fluorescent properties of both wild-type and the mutated MDH will be spectroscopically determined and compared. Analyzing class data will allow us to reach some conclusions, refine our initial hypotheses, and determine next steps. Data will be shared with other undergraduate labs across the country studying different aspects of MDH.
Prerequisites: CHEM 202 and CHEM 250

CHEM 315 Advanced Reactions (Reactivity 3) (4 Credits)
An understanding of chemical reactivity, developed in Reactivity 1 and 2, is extended through the study of redox, radical, photochemical and pericyclic reactions. Molecular orbital theory is exploited to explain a number of reactions. With a firm understanding of an array of reactions in hand, a number of applications, including biochemical pathways such as oxidative phosphorylation and photosynthesis, are examined in detail. The roles of enzyme catalysis, enzyme cofactors and regulatory pathways are also explored.
Prerequisites: (CHEM 251 or CHEM 251A)
Equivalent courses: CHEM 341
Attributes: Natural World (NW), Thematic Encounter3 - Movement

CHEM 316 Catalysts & Initiators (1 Credit)
This course will engage students in service leadership in chemistry. Students will design and implement a service or leadership project in the context of the chemistry department and/or the broader community. This course is typically taken in the third year. Course offered for S/U grading only.
Prerequisites: CHEM 250 or CHEM 250A

CHEM 318 Microscopic Chemical Analysis (4 Credits)
Exploration of chemical systems from a quantum mechanical perspective. Spectroscopy will be emphasized as one of the techniques that link theory with data. Statistical methods will be developed for the assessment of instrumentation as well as a fundamental understanding of spectroscopic and chromatographic techniques used in the analysis and exploration of chemical properties. Prerequisite: CHEM 255; Prerequisite or Corequisite: MATH 120; PHYS 106 or 200.
Prerequisites: CHEM 255 and (MATH 120 or MATH 120Z and (PHYS 106 or PHYS 106Z or PHYS 200 or PHYS 200Z
Attributes: Abstract Structures (AS), Quantitative Reasoning (QR)

CHEM 321 Topics in Computational Chemistry (1-4 Credits)
The Chemistry Department offers a series of topics courses, 321-326. These courses, offered for variable credit, cover the major areas in chemistry and are used to extend or supplement topics introduced in previous chemistry courses.
Prerequisites: None

CHEM 322A Topics in Analytical Chemistry - Forensics (2 Credits)
Forensic chemistry is the application of chemistry and toxicology in a legal setting. This course covers various criminalistic detection and analysis techniques involving DNA, fiber, hair, body fluids, pigments, fingerprints, footprints, toxic substances and illegal drugs. The proper handling of evidence, careful observation, and logical interpretation of crime scene evidence will also be stressed. Prerequisite: 250, Corequisite or Prerequisite 255 & 205.
Prerequisites: CHEM 255 and (CHEM 205 and (CHEM 255

CHEM 322B Topic: Food Analysis (2 Credits)
Prerequisites: None

CHEM 323A Food Toxicology (2 Credits)
Have you ever wondered why cherry pits made the list of the most dangerous foods in the world, what the latest lettuce recall is all about, what the causative agent of bovine spongiform encephalopathy (BSE or mad cow disease) is, why peanut allergies are so severe for many people, or whether it's a good idea to eat the deviled eggs Grandpa made for the family picnic that have been sitting out in the sun all day? We will explore these topics and more as we focus on understanding naturally occurring toxins in food, synthetic toxins in food, toxins introduced into food in its preparation, processing, and preservation as well as how the body reacts to and rids itself of these toxins. In the first part of the course, we will immerse ourselves in basic principles of toxicology to be able to understand primary literature in the latter part of the course. Students will also design and complete a project based on their interest related to food toxicity. Prerequisites: CHEM 250.
Prerequisites: CHEM 250

CHEM 323B Topics in Biochemistry: Fermentation (4 Credits)
This course will cover the use of fermentation processes in the production of foods, beverages, and chemical products. We will build on topics involving structure and reactivity of important biomolecules. The course will then cover a variety of biochemical pathways and investigate the types of organisms typically used in fermentation. This material will then be applied to the processes involved in making fermented foods (such as cheese, yogurt, bread and pickles) and beverages (beer, wine, spirits and kombucha). Topics may also include the use of fermentation in pharmaceutical and chemical industries including tours of MN companies. A study abroad component after the semester will include tours of several industries, reflections on the different cultural contexts for brewing and industry. Prerequisite: CHEM 125 & 250. Offered for A-F grading only.
Prerequisites: CHEM 125 and CHEM 250

CHEM 323C The Biochemistry of SARS-CoV-2 (COVID-19) (2 Credits)
In the winter of 2020, COVID-19 took the world by surprise. This course will focus on the biochemical aspects of what we now know about the virus and what we have still yet to learn. We will begin by immersing ourselves in background material on viruses and SARS-CoV-2 in particular, and use the primary literature to explore the vaccines that have been approved and those that look promising as well as the drug targets that have been identified and those that have been used to design therapeutics. Students will also design and complete a project based on their interest in COVID-19.
Prerequisites: CHEM 250

CHEM 323D Biochemical Pharmacology (2 Credits)
This course will focus on the molecular level, biochemical details of drug action. The course will begin with background topics in pharmacodynamics and pharmacokinetics, including how drugs interact with protein targets and how they are absorbed, distributed, metabolized, and excreted by the human body. The main part of the course will use that background knowledge to read and understand primary literature-based case studies on the mechanism of action of drugs that have been recently FDA approved, including those for SARS-CoV2, Hutchinson-Gilford Progeria Syndrome (an orphan disease), and neurodegenerative diseases. Each student will be invited to bring their interests, experiences, and backgrounds into the course in a culminating final project.
Prerequisites: CHEM 250 or CHEM 250A

CHEM 324A Electrochemistry, Batteries and Sensors (2 Credits)
Reactions in which electrons are transferred provide unique opportunities for chemists to analyze redox-active species and store energy.
This course will explore electroanalytical techniques such as cyclic voltammetry, which can be used to study electron transfer kinetics, detect species of only transient stability or probe the mechanism of a chemical reaction. In addition, we will explore batteries and fuel cells in current use as well those that may be part of our energy future. Finally, we will see how electrochemistry allows the development of qualitative and quantitative sensors, such the glucose sensor in insulin pumps, ion-selective electrodes and oxygen sensors in cars. Learning goals: after completion of the course, successful students. 1. Will gain an understanding of electrochemical techniques in which current or voltage are applied to gain qualitative or quantitative information about a sample. 2. Will understand situations in which a current or voltage is generated, such as batteries and fuel cells. 3. Will be able to understand applications in which electrochemically active species are detected and quantified, such as sensors. Prerequisite: CHEM 315 (Reactivity 3) or departmental permission. This course will count for the Environmental and Industrial/ Materials concentrations.
Prerequisites: CHEM 315

CHEM 330 Chemistry Lab Research (2 Credits)
Independent laboratory research will be completed under the supervision of a faculty advisor. In this course, students will apply foundation level laboratory skills in the research setting, learn trouble-shooting, data analysis and other research skills, discuss the results of research activities with a faculty mentor and use primary literature to develop new approaches to answering a research question.
Prerequisites: CHEM 203 or CHEM 203A or CHEM 205

CHEM 343 Climate & Habitat Change (2 Credits)
Along with the positive advances that result from chemistry, copious amounts of toxic and corrosive chemicals have also been produced and dispersed into the environment. The course will address selections from different areas of environmental study that impact our climate and habitat. Specific topics could include; global warming, ozone depletion, pollution, energy production and usage, and toxic waste disposal. Approaches for remediation will be discussed. Prerequisites: CHEM 250 and 255 or departmental permission.
Prerequisites: CHEM 255 or CHEM 255A

CHEM 344A Environmental Chemistry: Atmosphere (2 Credits)
The behavior of chemicals in earth's natural systems is critical to the study of environmental chemistry. Recently, copious amounts of toxic and corrosive chemicals have been produced and dispersed into the environment. This course will address the source and fate of compounds found both in natural and polluted air. The reactivity of compounds and their effect on the natural cycle in the atmosphere will also be explored. Specific topics could include CFCs, dioxins, pesticides, polycyclic aromatic hydrocarbons (PAHs), ozone, and particulate matter. Prerequisite or Corequisite: CHEM 343 or departmental permission.
Prerequisites: CHEM 343

CHEM 344B Environmental Chemistry: Lithosphere and Hydrosphere (2 Credits)
The behavior of chemicals in earth's natural systems is critical to the study of environmental chemistry. Recently, copious amounts of toxic and corrosive chemicals have been produced and dispersed into the environment. This course will address the source and fate of compounds found both in natural and polluted soil and water. The reactivity of compounds and their effect on the natural cycle in the lithosphere and hydrosphere will also be explored. Specific topics could include water treatment processes, pharmaceuticals and personal care products, dioxins, pesticides, polybrominated biphenyl ethers (PBDEs), and DOM. Prerequisite: CHEM 250 & 255 or departmental permission
Prerequisites: CHEM 250 and CHEM 255

CHEM 345 Industrial Engineering Processes (2 Credits)
This course is intended to teach students the underlying principles in the operation and process development of a product for industrial scale mass production. Topics for this course will include; testing/trials, production design, and resource management. Prerequisite: CHEM 255 or departmental permission.
Prerequisites: CHEM 255

CHEM 346 Nanomaterials (2 Credits)
This course will focus on the fundamental principles in nanomaterials. Topics may include; structural materials, conductors, semiconductors, sensors, or polymers. The students will be presented with current synthetic techniques for the production of bulk and nanostructured materials along with analytical methodologies to physically characterize materials. NOTE: The in-depth courses do not require a completion of all the foundation courses indicated by the specified prerequisite course(s).
Prerequisites: CHEM 255

CHEM 347 Chemical Biology (2 Credits)
Chemical biology will cover topics of current interest in chemical biology and will survey the way in which small molecules are used to investigate and manipulate biological systems wither for a biological or chemical purpose. Specific topics may include; protein design, development of unnatural biological molecules, peptide-carbohydrate interactions, combinatorial synthesis/libraries, molecular recognition, chemical genetics, biosynthesis, and methods of drug discovery. Prerequisite: CHEM 251 or departmental permission. Recommended: BIOL 121 and CHEM 315
Prerequisites: CHEM 251 or CHEM 251A

CHEM 348A Molecular Design-Organic (2 Credits)
Molecular design and catalysts are important applications of chemical reactivity concepts. In this course, students will learn about some current methods useful in synthesis and see these methods applied in the synthesis of complex molecules. Topics may include; organo-transition metal reactions, catalytic methods of enantioselective synthesis and retrosynthetic analysis. Students will demonstrate basic proficiency in these areas and also carry out detailed analyses of total syntheses from the current literature. Pre- OR co-requisite CHEM 315 or departmental permission.
Prerequisites: CHEM 315 (may be taken concurrently)

CHEM 348B Molecular Design-Inorganic (2 Credits)
The design and synthesis of compounds containing transition metals is an important area of modern chemistry. In this course, students will learn the general principles of inorganic syntheses. Case studies from the chemical literature will then be examined in areas such as the synthesis of homogenous and heterogeneous catalysts, models for active sites in metalloenzymes, and solid state compounds. Pre- OR Co-requisite: CHEM 315 or departmental permission.
Prerequisites: CHEM 315 (may be taken concurrently)

CHEM 349 Chemistry in Experience and Practice (1 Credit)
Students will participate in and write reflections about structured activities designed to explore jobs, graduate education, research, ethical issues, and general career planning in chemistry. Students should enroll in their sophomore or junior year. Required for Chemistry majors. Offered for A-F grading only.
Prerequisites: None

CHEM 352 Signal Transduction (2 Credits)
Living cells and organisms must respond to their environment, which allows them to adapt to a variety of external conditions. We will use the language of chemistry (thermodynamics, kinetics, analysis, reactivity, and modeling) as well as the languages of biology and mathematics, to explore systems of regulation within and between cells, and how signaling and regulation within complex biological systems leads to biological function, behavior, homeostasis, adaptation, and emergence of new traits. Special attention will be given to the development of learning and memory. Prerequisites: CHEM 251, 315, BIOL 121 or departmental permission.
Prerequisites: (CHEM 251 or CHEM 251A) and CHEM 315 and (BIOL 121 or BIOL 121Z or BIOL 101 or BIOL 101Z)

CHEM 353 Xenobiotic Metabolism (2 Credits)
This course will explore biological mechanisms of activation and detoxification of xenobiotics. Topics will include; oxidation/reduction mechanisms (e.g. Cytochrome P450, Flavin Mono-Oxygenase), transferase reactions (e.g. Glutathione S-Transferase, Glycosyltransferases, Acetyltransferases), adduct formation, and repair mechanisms. Prerequisite: CHEM 315 or departmental permission. Recommended: BIOL 121
Prerequisites: CHEM 315

CHEM 354 Sustainable Energy (2 Credits)
The world's energy demands are increasing and drawbacks associated with fossil fuels have spurred the search for energy alternatives. This course will examine alternative options such as solar energy, nuclear energy, hydrogen economy and fuel cells, ethanol production from switchgrass or algae versus corn, other biofuels, and batteries. In addition, methods for making fossil fuels more sustainable will be discussed. Emphasis will be on the chemistry and thermodynamics of these processes with a focus not only the final energy production but the actual energy costs and environmental impacts of a given technology. Prerequisites: CHEM 250 and 255 or departmental permission.
Prerequisites: (CHEM 250 or CHEM 250A) and (CHEM 255 or CHEM 255A)

CHEM 355 Analysis of Biomaterials (2 Credits)
This course provides an overview of principles of bioanalytic methods and the application of modern instrumental techniques to biological systems. Particular focus will be placed on fundamental principles and analytical measurements of biomolecules, immunoassays, separations, biological mass spectrometry, microscopy, and imaging. Emerging technologies such as nanotechnology-enabled biosensors, microfluidic devices, and lab-on-chip may also be addressed. Error analysis, statistical treatment of data, and validation of bioanalytical methods and devices are included. Prerequisite: CHEM 205 and 255 or departmental permission. Recommended: BIOL 121
Prerequisites: CHEM 255 and CHEM 205

CHEM 356 Instrumental Design and Technology (2 Credits)
This course will study the modern techniques of instrumental analysis focusing on electronics, optics, physical design and limitations of instrumentation in analytical chemistry. Upon completion of this course students will understand the theory of instrumentation for optical spectroscopy, chromatography, and mass spectroscopy. Additionally, students will be able to select an instrument based on experimental goals and sample types. The course will also examine the development of new technologies for instrumentation used in security devices, in the human body for medical devices, as well as in space and underwater exploration. Prerequisite: CHEM 205, 255 or departmental permission.
Prerequisites: CHEM 205 and CHEM 255

CHEM 357 Separation Science (2 Credits)
This course provides a systematic study of the modern techniques for analytical separations in terms of underlying principles, instrumentation, data interpretation, and practical applications. Emphasis will be placed on gas and liquid chromatography, electrophoresis, two dimensional separations, and hyphenated techniques. Topics will be explored through a combination of scientific readings, case studies, and independent projects. Prerequisites: CHEM 205, 255 or departmental permission.
Prerequisites: CHEM 205 and CHEM 255

CHEM 358 Biomacromolecules (2 Credits)
Students will explore how the unique 3D structures of proteins, RNA, nucleic acids, and glycans arise and confer on those molecules, their role in catalysis, regulation, recognition, and informational storage. Students will develop an enhanced structural, thermodynamic, and dynamic understandings of biomacromolecules and their biological functions, and how in vivo and in vitro alternations in structure confers on them new biological properties. Prerequisites: CHEM 251, 255 Recommended: BIOL 121 or departmental permission.
Prerequisites: CHEM 251 and CHEM 255

CHEM 359 Symmetry & Spectroscopy (2 Credits)
Symmetry, group theory, and molecular orbital theory will be used to explore and explain the behavior of chemical systems on the molecular and atomic scale. The emphasis will be to develop orbital theory in order to gain an understanding of observed spectroscopic behavior such as Raman, IR, and UV. Additionally, symmetry and orbital theory will be used to explain chemical reactivity using models such as Woodward-Hoffman rules and photochemical selection rules. Prerequisite: CHEM 359 or departmental permission.
Prerequisites: CHEM 318

CHEM 360 Junior/Senior Capstone Research (2 Credits)
CHEM 360 (2) is a writing intensive capstone course required for all chemistry majors in their senior year. In this course students will complete a literature review, prepare a final paper, and make an oral presentation in a public setting on a chemistry topic. Note: COLG 398 (All College Thesis) fulfills this capstone requirement.
Prerequisites: None
Restrictions: Enrollment limited to students with a class of Junior or Senior. Enrollment is limited to students with a major in Chemistry.
Equivalent courses: CHEM 350, CHEM 351

CHEM 361 Mechanistic Determination (2 Credits)
This course will study how chemists determine organic, inorganic, and biochemical reactions. Emphasis will be on methods for monitoring reaction rates and using experimental data to propose reaction mechanisms. Techniques discussed could include kinetics, isotopic labeling studies, isolation of reaction intermediates, site-directed mutagenesis, computational models, and/or synthesis of compounds for model studies. Co or prerequisite: CHEM 315 or departmental permission
Prerequisites: CHEM 315

CHEM 362 Polymers (2 Credits)
This course explores various aspects of the chemistry of macromolecules. Topics may include synthetic approaches; chemical composition, molar mass and structure relationships to properties/property relationships; applications of soft materials, thermodynamic and kinetic considerations in property control, and physical characterization of pure polymers, solutions, and blends. Prerequisites: CHEM 255 and 315 or departmental permission.
Prerequisites: CHEM 255 and CHEM 315

CHEM 363 Structural Elucidation (2 Credits)
The major emphasis of this course will be on molecular structure determination. This skill is essential for chemists in many areas, such as medicinal chemistry, process chemistry, natural products chemistry, polymer chemistry, forensic chemistry, and many other sub-specialties of analytical chemistry. This course will prepare students with an up-to-date presentation of the tools used for the advanced analysis and structure elucidation of organic molecules using a variety of spectroscopic data including mass spectrometry, IR spectroscopy, fluorimetry, x-ray spectroscopy, etc. The specific techniques may vary depending on instructor choice. However, as NMR has proven to be one of the most powerful tools available, this course will provide students with an understanding of the basic principles of NMR and the students will explore the use of different techniques such as decoupling, relaxation time measurements, nOe, and interpretation of 1D and 2D NMR spectra. Prerequisite: CHEM 203 or 203A.
Prerequisites: CHEM 203 or CHEM 203A

CHEM 364 Medicinal Chemistry (2 Credits)
This course will explore the fundamental aspects and current methodologies involved in the drug discovery process. The fundamental aspects include the physical, chemical, and pharmaceutical properties of drugs. The methodologies include lead discovery strategies, structure activity relationships, structure-based and mechanism-based design methods, computational drug design methods, combinatorial chemistry techniques, and drug delivery considerations. Application to current topics such as chemotherapy of cancer, or viral or microbial diseases will be examined. Prerequisite: CHEM 315 or departmental permission; Recommended BIOL 121
Prerequisites: CHEM 251

CHEM 371 Individual Learning Project (1-4 Credits)
Supervised reading or research at the upper-division level. Permission of department chair and completion and/or concurrent registration of 12 credits within the department required. Consult department for applicability towards major requirements. Not available to first-year students.
Prerequisites: None

CHEM 390 Science Ethics: How Science and Policy Shape How We Live in the World (4 Credits)
This course will explore the idea of an ethical scientific process and its effect on our society. Topics may include: air pollution, persistent pollutants, disposal of waste, vaccines, energy production, work hazards, factory farms (antibiotic resistance), pesticides, GMOs, geoengineering, climate change (water, land, and food access; infectious diseases; impact of extreme weather), and pharmaceutical industry practices. Students will apply current ethical philosophies to examine their own place in the scientific world through readings, discussion, and case studies.
Prerequisites: None
Restrictions: Enrollment limited to students with a class of Junior, Sophomore or Senior.
Attributes: Benedictine Raven (BN), CSD: Systems (CS)

CHEM 397 Internship (4-16 Credits)
Completed Application for Internship Form REQUIRED. See Internship Office Web Page.
Prerequisites: None
Attributes: Experiential Engagement (EX)