Chemistry and Chemical Biology (CHEM)

CHEM 1000. Chemistry/Chemical Biology at Northeastern. (1 Hour)
Intended for freshmen in the College of Science. Introduces students to liberal arts; familiarizes them with their major; develops the academic skills necessary to succeed (analytical ability and critical thinking); provides grounding in the culture and values of the University community; and helps to develop interpersonal skills—in short, familiarizes students with all skills needed to become a successful university student.

CHEM 1101. General Chemistry for Health Sciences. (4 Hours)
Provides a one-semester introduction to general chemistry for the health sciences. Covers the fundamentals of elements and atoms; ionic and molecular structure; chemical reactions and their stoichiometry, energetics, rates, and equilibriums; and the properties of matter as gases, liquids, solids, and solutions. Other topics include acids and bases, and nuclear chemistry. Applications to the health sciences are included throughout.

Corequisite(s): CHEM 1102, CHEM 1103
Attribute(s): NUpath Natural/Designed World

CHEM 1102. Lab for CHEM 1101. (1 Hour)
Accompanies CHEM 1101. Covers a range of topics from the course, such as qualitative and quantitative analysis and the characteristics of chemical and physical processes. Includes measurements of heat transfer, rate and equilibrium constants, and the effects of temperature and catalysts. Emphasis is on aqueous acid-base reactions and the properties and uses of buffer systems.

Corequisite(s): CHEM 1101, CHEM 1103

CHEM 1103. Recitation for CHEM 1101. (0 Hours)
Accompanies CHEM 1101. Covers various topics from the course.

Corequisite(s): CHEM 1101, CHEM 1102

CHEM 1117. Chemical Perspectives on Green Energy: Emerging Technologies and Opportunities. (4 Hours)
Introduces the chemical principles behind everyday energy sources in the 21st century, including both classic and emergent sources.Examines critical questions concerning the demand for energy and the environmental impact of fuel consumption. Emphasizes the role that chemistry plays in the search for, and emergence of, renewable energy sources, such as biofuels, wind energy, and advanced battery technology. Offers students an opportunity to develop knowledge concerning evaluation of the efficiency of technologies and their impact on current global climate and to gain an appreciation of the sociopolitical debates surrounding traditional and emergent energy technologies. High school chemistry strongly recommended.

Attribute(s): NUpath Natural/Designed World

CHEM 1151. General Chemistry for Engineers. (4 Hours)
Corresponds to one semester of study in important areas of modern chemistry, such as details of the gaseous, liquid, and solid states of matter; intra- and intermolecular forces; and phase diagrams. Presents the energetics and spontaneity of chemical reactions in the context of chemical thermodynamics, while their extent and speed is discussed through topics in chemical equilibria and kinetics. Aspects of electrochemical energy storage and work are considered in relation to batteries, fuel, and electrolytic cells.

Corequisite(s): CHEM 1153
Attribute(s): NUpath Natural/Designed World

CHEM 1153. Recitation for CHEM 1151. (0 Hours)
Accompanies CHEM 1151. Offers a weekly sixty-five-minute drill/discussion session conducted by chemistry faculty or graduate teaching assistants. Discusses the homework assignments of CHEM 1151 in detail with emphasis on student participation.

Corequisite(s): CHEM 1151

CHEM 1161. General Chemistry for Science Majors. (4 Hours)
Introduces the principles of chemistry, focusing on the particulate nature of matter and its interactions and reactions that form the basis for the underlying molecular dynamics of living systems. Presents basic concepts of chemical bonding and intermolecular interactions for molecules and molecules' behavior in aqueous solutions with examples from biologically relevant molecules. Introduces kinetics and chemical thermodynamics with examples from biological systems. Offers students an opportunity to obtain a framework for understanding the chemical basis for different methods for separating and purifying biological compounds.

Corequisite(s): CHEM 1162, CHEM 1163
Attribute(s): NUpath Natural/Designed World

CHEM 1162. Lab for CHEM 1161. (1 Hour)
Accompanies CHEM 1161. Introduces basic laboratory techniques. Covers a range of topics including qualitative and quantitative analysis and the characteristics of chemical and physical processes.

Corequisite(s): CHEM 1161, CHEM 1163

CHEM 1163. Recitation for CHEM 1161. (0 Hours)
Accompanies CHEM 1161. Covers various topics from the course. Offers students an opportunity to work interactively with instructors and other students to learn and apply the knowledge acquired in lecture.

Corequisite(s): CHEM 1161, CHEM 1162

CHEM 1211. General Chemistry 1. (4 Hours)
Introduces the principles of chemistry, focusing on the states and structure of matter and chemical stoichiometry. Presents basic concepts and definitions, moles, gas laws, atomic structure, periodic properties and chemical bonding, all within a contextual framework.

Corequisite(s): CHEM 1212, CHEM 1213
Attribute(s): NUpath Natural/Designed World

CHEM 1212. Lab for CHEM 1211. (1 Hour)
Accompanies CHEM 1211. Covers a range of topics from the course including qualitative and quantitative analysis and the characteristics of chemical and physical processes.

Corequisite(s): CHEM 1211, CHEM 1213

CHEM 1213. Recitation for CHEM 1211. (0 Hours)
Accompanies CHEM 1211. Covers various topics from the course.

Corequisite(s): CHEM 1211, CHEM 1212

CHEM 1214. General Chemistry 2. (4 Hours)
Continues CHEM 1211. Introduces the principles of chemical equilibrium, the rates and mechanisms of chemical reactions, and energy considerations in chemical transformations. Covers solutions, chemical kinetics, chemical equilibria, chemical thermodynamics, electrochemistry, and chemistry of the representative elements. Such contextual themes as energy resources, smog formation, and acid rain illustrate the principles discussed.

Prerequisite(s): CHEM 1211 with a minimum grade of D
Corequisite(s): CHEM 1215, CHEM 1216
Attribute(s): NUpath Natural/Designed World

CHEM 1215. Lab for CHEM 1214. (1 Hour)
Accompanies CHEM 1214. Covers a range of topics from the course, such as measurements of heat transfer, rate and equilibrium constants, and the effects of temperature and catalysts. Particular attention is paid to aqueous acid-base reactions and to the properties and uses of buffer systems. Quantitative analysis of chemical and physical systems is emphasized throughout.

Corequisite(s): CHEM 1214, CHEM 1216

CHEM 1216. Recitation for CHEM 1214. (0 Hours)
Accompanies CHEM 1214. Covers various topics from the course.

Corequisite(s): CHEM 1214, CHEM 1215

CHEM 1990. Elective. (1-4 Hours)
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CHEM 2117. Chemistry in Culture. (4 Hours)
Offers an examination of the social, cultural, and historical implications associated with the field of chemistry. Builds on a basic understanding of chemistry to explain the important role of the field of chemistry in historical and current events. May be offered as part of a study abroad program with a focus on the culture and history of the host country. May be repeated three times.

Prerequisite(s): CHEM 1151 with a minimum grade of C- or (CHEM 1161 with a minimum grade of C- ; CHEM 1162 with a minimum grade of C-) or (CHEM 1214 with a minimum grade of C- ; CHEM 1215 with a minimum grade of C-)

CHEM 2161. Concepts in Chemistry. (4 Hours)
Explores basic concepts of thermodynamics; electrochemistry; and nuclear, supramolecular, and solid-state chemistry in the context of modern materials. Emphasizes connecting the particulate nature of matter to the properties of substances and patterns of chemical reactivity.

Prerequisite(s): (CHEM 1161 with a minimum grade of C-)
Corequisite(s): CHEM 2162, CHEM 2163
Attribute(s): NUpath Writing Intensive

CHEM 2162. Lab for CHEM 2161. (1 Hour)
Accompanies CHEM 2161. Offers hands-on exploration of the basic concepts of electrochemistry and of nuclear, supramolecular, and solid-state chemistry.

Corequisite(s): CHEM 2161, CHEM 2163

CHEM 2163. Recitation for CHEM 2161. (0 Hours)
Accompanies CHEM 2161. Covers various topics from the course. Offers students an opportunity to work interactively with instructors and other students to learn and apply the knowledge acquired in lecture.

Corequisite(s): CHEM 2161, CHEM 2162

CHEM 2311. Organic Chemistry 1. (4 Hours)
Introduces nomenclature, preparation, properties, stereochemistry, and reactions of common organic compounds. Presents correlations between the structure of organic compounds and their physical and chemical properties, and mechanistic interpretation of organic reactions. Includes chemistry of hydrocarbons and their functional derivatives.

Prerequisite(s): CHEM 1151 with a minimum grade of D or CHEM 1214 with a minimum grade of D or CHEM 1220 with a minimum grade of D or CHEM 1161 with a minimum grade of D
Corequisite(s): CHEM 2312

CHEM 2312. Lab for CHEM 2311. (1 Hour)
Accompanies CHEM 2311. Introduces basic laboratory techniques, such as distillation, crystallization, extraction, chromatography, characterization by physical methods, and measurement of optical rotation. These techniques serve as the foundation for the synthesis, purification, and characterization of products from microscale syntheses integrated with CHEM 2311.

Corequisite(s): CHEM 2311

CHEM 2313. Organic Chemistry 2. (4 Hours)
Continues CHEM 2311. Focuses on additional functional group chemistry including alcohols, ethers, carbonyl compounds, and amines, and also examines chemistry relevant to molecules of nature. Introduces spectroscopic methods for structural identification.

Prerequisite(s): CHEM 2311 with a minimum grade of D or CHEM 2315 with a minimum grade of D
Corequisite(s): CHEM 2314

CHEM 2314. Lab for CHEM 2313. (1 Hour)
Accompanies CHEM 2313. Basic laboratory techniques from CHEM 2312 are applied to chemical reactions of alcohols, ethers, carbonyl compounds, carbohydrates, and amines. Introduces basic laboratory techniques including infrared (IR) spectroscopy and nuclear magnetic resonance (NMR) spectronomy as analytical methods for characterization of organic molecules.

Corequisite(s): CHEM 2313

CHEM 2315. Organic Chemistry 1 for Chemistry Majors. (4 Hours)
Reviews the basics of bonding and thermodynamics of organic compounds as well as conformational and stereochemical considerations. Presents the structure, nomenclature, and reactivity of hydrocarbons and their functional derivatives. Highlights key reaction mechanisms, providing an introduction to the methodology of organic synthesis.

Prerequisite(s): CHEM 1161 with a minimum grade of C- or CHEM 1214 with a minimum grade of C- or CHEM 1220 with a minimum grade of C-
Corequisite(s): CHEM 2316, CHEM 2324

CHEM 2316. Lab for CHEM 2315. (2 Hours)
Accompanies CHEM 2315. Introduces basic laboratory techniques, such as distillation, crystallization, extraction, chromatography, characterization by physical methods, and measurement of optical rotation. These techniques serve as the foundation for the synthesis, purification, and characterization of products from microscale syntheses integrated with CHEM 2315.

Corequisite(s): CHEM 2315, CHEM 2324

CHEM 2317. Organic Chemistry 2 for Chemistry Majors. (4 Hours)
Continues CHEM 2315. Extends the study of functional groups commonly found in organic compounds, further emphasizing conceptual mastery of the relationship between structure and reactivity. Introduces structural identification of organic compounds using contemporary spectroscopic methods such as IR, MS, and NMR. Other topics include structure and reactivity of conjugated and aromatic systems, the chemistry of ethers and epoxides, and the chemistry of carbonyl-containing compounds including aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Offers students an opportunity to develop skills in planning multistep syntheses using the retrosynthesis approach and proposing mechanisms for chemical transformations.

Prerequisite(s): CHEM 2311 with a minimum grade of C- or CHEM 2315 with a minimum grade of C-
Corequisite(s): CHEM 2318, CHEM 2325
Attribute(s): NUpath Creative Express/Innov

CHEM 2318. Lab for CHEM 2317. (2 Hours)
Accompanies CHEM 2317. Introduces basic laboratory techniques including infrared (IR) spectroscopy and nuclear magnetic resonance (NMR) spectronomy as analytical methods for characterization of organic molecules. These methods serve as the basis for characterization of products from microscale syntheses.

Corequisite(s): CHEM 2317, CHEM 2325

CHEM 2321. Analytical Chemistry. (4 Hours)
Introduces the principles and practices in the field of analytical chemistry. Focuses on development of a quantitative understanding of homogeneous and heterogeneous equilibria phenomena as applied to acid-base and complexometric titrations, rudimentary separations, optical spectroscopy, electrochemistry, and statistics.

Prerequisite(s): (CHEM 1151 with a minimum grade of C- or CHEM 1214 with a minimum grade of C- or CHEM 1220 with a minimum grade of C- or CHEM 1161 with a minimum grade of C-); (CHEM 2311 with a minimum grade of C- or CHEM 2315 with a minimum grade of C-)
Corequisite(s): CHEM 2322, CHEM 2323
Attribute(s): NUpath Analyzing/Using Data, NUpath Writing Intensive

CHEM 2322. Lab for CHEM 2321. (1 Hour)
Accompanies CHEM 2321. Lab experiments provide hands-on experience in the analytical methods introduced in CHEM 2321, specifically, silver chloride gravimetry, complexometric titrations, acid-base titrations, UV-vis spectroscopy, cyclic voltammetry, Karl Fischer coulometry, and modern chromatrographic methods.

Corequisite(s): CHEM 2321, CHEM 2323

CHEM 2323. Recitation for CHEM 2321. (0 Hours)
Accompanies CHEM 2321 and CHEM 2322. Covers various topics from the course. Offers students an opportunity to work interactively with instructors and other students to learn and apply the knowledge acquired in lecture and lab.

Corequisite(s): CHEM 2321, CHEM 2322

CHEM 2324. Recitation for CHEM 2315. (0 Hours)
Accompanies CHEM 2315 and CHEM 2316. Offers students an opportunity to work interactively with instructors and other students to learn and apply the knowledge acquired in lab and lecture.

Corequisite(s): CHEM 2315, CHEM 2316

CHEM 2325. Recitation for CHEM 2317. (0 Hours)
Accompanies CHEM 2317 and CHEM 2318. Offers students an opportunity to work interactively with instructors and other students to learn and apply the knowledge acquired in lab and lecture.

Corequisite(s): CHEM 2317, CHEM 2318

CHEM 2326. Introduction to Green Chemistry and Toxicology. (4 Hours)
Focuses on how chemistry can help us address global environmental issues of pollution, sustainable molecular design, and reimagining the chemical enterprise through the lenses of the 12 principles of green chemistry, sustainability, and introductory toxicology. Discussions link foundational principles such as physical and chemical properties of molecules, organic nomenclature, functionality, and polymerization processes. Relates topics to principles of toxicology, bioaccumulation, pollution from industrial practices, and how green chemistry applies to environmental and human health issues and proposed solutions.

Prerequisite(s): (CHEM 1151 with a minimum grade of C- or CHEM 1161 with a minimum grade of C- or CHEM 1214 with a minimum grade of C-); (CHEM 2311 (may be taken concurrently) with a minimum grade of C- or CHEM 2315 (may be taken concurrently) with a minimum grade of C-)

CHEM 2990. Elective. (1-4 Hours)
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CHEM 2991. Research in Chemistry and Chemical Biology. (1-4 Hours)
Offers an opportunity to conduct introductory-level research or creative endeavors under faculty supervision. May be repeated seven times.

CHEM 3100. Cosmetic Chemistry: Design and Innovation. (4 Hours)
Surveys the chemical principles (composition/structure) underlying the design of personal care products. Discusses fundamental knowledge of emulsion chemistry, reaction kinetics/dynamics, formulation design/testing, and stability assessments, as they relate to material selection. Emphasizes first identifying then assembling appropriate ingredient lists that create products (creams, serums, cleansers, hair colorants) to meet the regulatory and quality control standards set by the industry.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-
Corequisite(s): CHEM 3101

CHEM 3101. Lab for CHEM 3100. (1 Hour)
Accompanies CHEM 3100. Focuses on the design of cosmetic products in a project-based lab. Students work in teams randomly assigned at the start of the semester to execute each lab. The design process associated with each lab includes strategy and concept generation, estimation, and prototyping. Emphasizes the development of creative designs that are motivated by content learned through the lecture. Includes a significant communication component as students present ideas in class. Students also write a publication-quality final paper, which they will be encouraged to submit to a conference or journal as part of their final project presentations in the lecture.

Corequisite(s): CHEM 3100

CHEM 3131. Forensic Chemistry. (4 Hours)
Surveys the important chemical principles and techniques used in forensic science and crime scene analysis. Covers the collection and preservation of evidence, serology, hair and fiber, DNA, drugs analysis and identification, toxicology, firearms, and arson/explosives analysis. Uses hands-on experiments to offer students an opportunity to understand techniques used by forensic scientists.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-

CHEM 3331. Bioanalytical Chemistry. (4 Hours)
Offers students an opportunity to obtain a broad familiarity with bioanalytical chemistry at the undergraduate level. After reviewing basic principles of analytical chemistry, the course covers biomolecular analysis by modern methods, including chromatography, electrophoresis, mass spectrometry, and immunohistochemistry. Studies genomics, proteomics, biosensors, bioassays, and protein/DNA sequencing. Exposes students to technical literature and modern applications in biochemistry, molecular biology, and chemistry.

Prerequisite(s): (CHEM 1151 with a minimum grade of C- or CHEM 1161 with a minimum grade of C- or CHEM 1214 with a minimum grade of C- or CHEM 1220 with a minimum grade of C-); (CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); (CHEM 2321 with a minimum grade of C- or BIOL 3611 with a minimum grade of C-); (ENGL 1102 with a minimum grade of C or ENGL 1111 with a minimum grade of C or ENGW 1102 with a minimum grade of C or ENGW 1111 with a minimum grade of C or ENGW 1113 with a minimum grade of C or ENGW 1114 with a minimum grade of C)
Corequisite(s): CHEM 3332
Attribute(s): NUpath Analyzing/Using Data, NUpath Writing Intensive

CHEM 3332. Lab for CHEM 3331. (1 Hour)
Accompanies CHEM 3331. Offers students an opportunity to apply modern analytical instrumentation to a selection of relevant applications as they relate to research and development labs in the biotechnology and pharmaceutical industry.

Corequisite(s): CHEM 3331

CHEM 3401. Chemical Thermodynamics and Kinetics. (4 Hours)
Traces the development of chemical thermodynamics through the three major laws of thermodymamics. These are applied to thermochemistry, chemical reaction and phase equilibria, and the physical behavior of multicomponent systems. Emphasizes quantitative interpretation of physical measurements.

Prerequisite(s): (MATH 1252 with a minimum grade of C- or MATH 1342 with a minimum grade of C-); (CHEM 1214 with a minimum grade of C- or CHEM 1151 with a minimum grade of C- or CHEM 1161 with a minimum grade of C-); (PHYS 1151 with a minimum grade of C- or PHYS 1161 with a minimum grade of C-)
Corequisite(s): CHEM 3402

CHEM 3402. Lab for CHEM 3401. (1 Hour)
Accompanies CHEM 3401. Demonstrates the measurement of selected physical chemical phenomena presented in CHEM 3401, introducing experimental protocol and methods of data analysis. Experiments include investigations of gas nonideality and critical phenomena, electrochemical measurement of equilibrium, construction of phase diagrams, and bomb and differential scanning calorimetry.

Corequisite(s): CHEM 3401

CHEM 3403. Quantum Chemistry and Spectroscopy. (4 Hours)
Studies the theory of quantum chemistry with applications to spectroscopy. Presents some simple quantum mechanical (QM) models, including the particle in a box, rigid rotor, and harmonic oscillator, followed by treatments of electrons in atoms and molecules. Microwave, infrared, Raman, NMR, ESR, atomic absorption, atomic emission, and UV-Vis spectroscopy are discussed in detail.

Prerequisite(s): (CHEM 3401 with a minimum grade of C- or CHEM 3421 with a minimum grade of C- or CHEM 3431 with a minimum grade of C- or CHME 3322 with a minimum grade of C-); MATH 1342 with a minimum grade of C- ; (PHYS 1155 with a minimum grade of C- or PHYS 1165 with a minimum grade of C-)
Corequisite(s): CHEM 3404

CHEM 3404. Lab for CHEM 3403. (1 Hour)
Accompanies CHEM 3403. Explores the principles covered in CHEM 3403 by laboratory experimentation. Experiments include measurement of reaction kinetics, such as excited state dynamics, measurement of gas transport properties, atomic and molecular absorption and emission spectroscopy, infrared spectroscopy of molecular vibrations, and selected applications of fluorimetry.

Corequisite(s): CHEM 3403

CHEM 3410. Environmental Geochemistry. (4 Hours)
Offers students who wish to work in the geosciences or environmental science and engineering fields, including on the land, in freshwater, or the oceans, an opportunity to understand the geochemical principles that shape the natural and managed environment. Seeks to provide a context for understanding the natural elemental cycles and environmental problems through studies in atmospheric, terrestrial, freshwater, and marine geochemistry. Topics include fundamental geochemical principles; environmental mineralogy; organic and isotope geochemistry; the global carbon, nitrogen, and phosphorous cycles; atmospheric pollution; environmental photochemistry; and human-natural climate change feedbacks.

Prerequisite(s): CHEM 1151 with a minimum grade of D- or CHEM 1161 with a minimum grade of D- or CHEM 1214 with a minimum grade of D-
Attribute(s): NUpath Analyzing/Using Data, NUpath Natural/Designed World

CHEM 3431. Physical Chemistry. (4 Hours)
Offers an in-depth survey of physical chemistry. Emphasizes applications in modern research, including examples from biochemistry. Topics include the laws of thermodynamics and their molecular interpretation; equilibrium in chemical and biochemical systems; molecular transport; kinetics, including complex enzyme mechanisms; and an introduction to spectroscopy and the underlying concepts of quantum chemistry.

Prerequisite(s): ((CHEM 1214 with a minimum grade of C- or CHEM 1220 with a minimum grade of C-) or (CHEM 1151 with a minimum grade of C- or CHEM 1161 with a minimum grade of C-)); (MATH 1252 with a minimum grade of C- or MATH 1342 with a minimum grade of C-); (PHYS 1147 with a minimum grade of C- or PHYS 1155 with a minimum grade of C- or PHYS 1165 with a minimum grade of C- or PHYS 1175 with a minimum grade of C-)
Corequisite(s): CHEM 3432

CHEM 3432. Lab for CHEM 3431. (1 Hour)
Accompanies CHEM 3431. Covers practical skills in physical chemistry with an emphasis on current practice in chemistry, biochemistry, and pharmaceutical science. Introduces both ab initio and biological molecular modeling, differential scanning calorimetry, polymer characterization, protein unfolding and protein/ligand binding, electronic absorption spectroscopy, and synthesis of nanoparticles or quantum dots.

Corequisite(s): CHEM 3431

CHEM 3501. Inorganic Chemistry. (4 Hours)
Presents the following topics: basic concepts of molecular topologies, coordination compounds, coordination chemistry, isomerism, electron-transfer reactions, substitution reactions, molecular rearrangements and reactions at ligands, and biochemical applications.

Prerequisite(s): (CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); (CHEM 2321 with a minimum grade of C- or CHEM 2331 with a minimum grade of C- or CHEM 3331 with a minimum grade of C-)
Corequisite(s): CHEM 3502, CHEM 3503
Attribute(s): NUpath Writing Intensive

CHEM 3502. Lab for CHEM 3501. (1 Hour)
Offers a laboratory course in inorganic chemistry with experiments and projects that track with the topics discussed in CHEM 3501. Designed to provide laboratory experience with the synthesis of coordination compounds and with the instrumental methods used to characterize them.

Corequisite(s): CHEM 3501, CHEM 3503

CHEM 3503. Recitation for CHEM 3501. (0 Hours)
Offers students additional opportunities to work interactively with instructors and other students to learn and apply the concepts presented in CHEM 3501.

Corequisite(s): CHEM 3501, CHEM 3502

CHEM 3505. Introduction to Bioinorganic Chemistry. (4 Hours)
Explores basic concepts of molecular topologies, coordination compounds, coordination chemistry, isomerism, electron-transfer reactions, substitution reactions, molecular rearrangements, and reactions at ligands in the context of metal-based drugs, imaging agents, and metalloenzymes.

Prerequisite(s): (CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); (CHEM 2321 with a minimum grade of C- or CHEM 2331 with a minimum grade of C- or CHEM 3331 with a minimum grade of C-)
Corequisite(s): CHEM 3506, CHEM 3507
Attribute(s): NUpath Writing Intensive

CHEM 3506. Lab for CHEM 3505. (1 Hour)
Offers a laboratory course in inorganic chemistry with experiments and projects that track with the topics discussed in CHEM 3505. Designed for students who have mastered basic laboratory techniques in general and organic chemistry. Introduces new synthetic techniques and applies modern analytical characterization tools not previously used in other laboratory courses (such as CHEM 3522 and CHEM 3532).

Corequisite(s): CHEM 3505, CHEM 3507

CHEM 3507. Recitation for CHEM 3505. (0 Hours)
Offers students additional opportunities to work interactively with instructors and other students to learn and apply the concepts presented in CHEM 3505.

Corequisite(s): CHEM 3505, CHEM 3506

CHEM 3990. Elective. (1-4 Hours)
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CHEM 4456. Organic Chemistry 3: Organic Chemistry of Drug Design and Development. (4 Hours)
Studies how to apply principles of organic chemistry, and related areas of chemistry, to the design, preparation, and use of biologically active organic compounds. Explores translational chemical science in the discovery, design, and development of biologically active compounds for medical purposes, using techniques gained in organic reaction mechanisms and synthesis. Evaluates methods to incorporate specific chemical features into organic compounds to meet specific biological and biomedical criteria. Offers students an opportunity to develop problem-solving skills that extend beyond synthetic organic chemistry to a wide range of chemical disciplines.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-

CHEM 4457. Lab for CHEM 4456. (1 Hour)
Accompanies CHEM 4456. Integrates elements of experimental design, organic synthesis, isolation and characterization of organic compounds, and interpretation of experimental observations. Students, working in small groups, evaluate a multistep synthesis of a compound developed for clinical trials as an anticancer agent, conducting the synthetic sequence, completing each reaction, characterizing the products, and interpreting and reporting the results. A final report in the form of an American Chemical Society (ACS) manuscript summarizes each group's efforts.

Corequisite(s): CHEM 4456

CHEM 4628. Introduction to Spectroscopy of Organic Compounds. (4 Hours)
Examines the application of modern spectroscopic techniques to the structural elucidation of small organic molecules. Emphasizes the use of H and C NMR spectroscopy supplemented with information from infrared spectroscopy and mass spectrometry. Explores both the practical and nonmathematical theoretical aspects of 1D and 2D NMR experiments. Topics include the chemical shift, coupling constants, the nuclear Overhauser effect and relaxation, and 2D homonuclear and heteronuclear correlation. Designed for chemists who do not have an extensive math or physics background; no prior knowledge of NMR spectroscopy is assumed.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-
Corequisite(s): CHEM 4629

CHEM 4629. Identification of Organic Compounds. (2 Hours)
Introduces the use of the nuclear magnetic resonance (NMR) spectrometer and basic NMR experiments. Determines the identity of unknown organic compounds by the use of mass spectrometry, infrared spectroscopy, and 1D and 2D nuclear magnetic resonance spectroscopy.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-
Corequisite(s): CHEM 4628

CHEM 4750. Senior Research. (4 Hours)
Conducts original experimental work under the direction of members of the department on a project. Introduces experimental design based on literature and a variety of techniques depending upon the individual project.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-
Attribute(s): NUpath Capstone Experience, NUpath Writing Intensive

CHEM 4901. Undergraduate Research. (4 Hours)
Conducts original research under the direction of members of the department. May be repeated without limit.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C- or CHEM 2321 with a minimum grade of C-
Attribute(s): NUpath Integration Experience

CHEM 4970. Junior/Senior Honors Project 1. (4 Hours)
Focuses on in-depth project in which a student conducts research or produces a product related to the student's major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8 credit honors project. May be repeated without limit.

Attribute(s): NUpath Capstone Experience

CHEM 4971. Junior/Senior Honors Project 2. (4 Hours)
Focuses on second semester of in-depth project in which a student conducts research or produces a product related to the student's major field. May be repeated without limit.

Prerequisite(s): CHEM 4970 with a minimum grade of C
Attribute(s): NUpath Capstone Experience, NUpath Writing Intensive

CHEM 4990. Elective. (1-4 Hours)
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CHEM 4991. Research. (4 Hours)
Offers an opportunity to conduct research under faculty supervision. May be repeated without limit.

Attribute(s): NUpath Integration Experience

CHEM 4992. Directed Study. (1-4 Hours)
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

CHEM 4994. Internship. (4 Hours)
Offers students an opportunity for internship work. May be repeated without limit.

Attribute(s): NUpath Integration Experience

CHEM 5501. Chemical Safety in the Research Laboratory. (1 Hour)
Covers the material needed to complete successfully all the online safety training that is required for our graduate students, best practices for the safe execution of common chemical laboratory procedures, advanced procedures, as well as incidents from the recent literature. Includes discussions of case studies on topics relevant for the safe and effective use of chemicals and other materials in a research laboratory environment. Undergraduates may enroll with permission of the instructor. May be repeated two times.

CHEM 5550. Introduction to Glycobiology and Glycoprotein Analysis. (3 Hours)
Covers the background and methods used for glycoprotein characterization. Offers students an opportunity to obtain the background needed to assess the analytical steps necessary for development of glycoprotein drugs. Analyzes regulatory issues behind glycoprotein drug development. Covers recent developments in analytical and regulatory sciences.

CHEM 5599. Introduction to Research Skills and Ethics in Chemistry. (0 Hours)
Seeks to prepare students for success in CHEM 5600 and in CHEM 7730. May be repeated once. Must be taken in consecutive semesters before registration into CHEM 5600 and CHEM 7730.

CHEM 5600. Research Skills and Ethics in Chemistry. (3 Hours)
Discusses ethics in science. Topics include documentation of work in your laboratory notebook, safety in a chemistry research laboratory, principles of experimental design, online computer searching to access chemical literature, reading and writing technical journal articles, preparation and delivery of an effective oral presentation, and preparation of a competitive research proposal.

Prerequisite(s): CHEM 5599 with a minimum grade of S

CHEM 5610. Polymer Chemistry. (3 Hours)
Discusses the synthesis and analysis of polymer materials. Covers mechanisms and kinetics of condensation/chain-growth polymerization reactions and strategies leading to well-defined polymer architectures and compositions, including living polymerizations (free radical, cationic, anionic), catalytic approaches, and postpolymerization functionalization. Discusses correlation of chemical composition and structure to physical properties and applications.

Prerequisite(s): ((CHEM 2317 with a minimum grade of C- or CHEM 2313 with a minimum grade of C-); (CHEM 3401 (may be taken concurrently) with a minimum grade of C- or CHEM 3421 (may be taken concurrently) with a minimum grade of C- or CHEM 3431 (may be taken concurrently) with a minimum grade of C-)) or graduate program admission

CHEM 5611. Analytical Separations. (3 Hours)
Describes the theory and practice of separating the components of complex mixtures in the gas and liquid phase. Also includes methods to enhance separation efficiency and detection sensitivity. Covers thin-layer, gas, and high-performance liquid chromatography (HPLC) and recently developed techniques based on HPLC including capillary and membrane-based separation, and capillary electrophoresis.

CHEM 5612. Principles of Mass Spectrometry. (3 Hours)
Describes the theory and practice of ion separation in electrostatic and magnetic fields and their subsequent detection. Topics include basic principles of ion trajectories in electrostatic and magnetic fields, design and operation of inlet systems and electron impact ionization, and mass spectra of organic compounds.

CHEM 5614. Electroanalytical Chemistry. (3 Hours)
Describes the theory of electrode processes and modern electroanalytical experiments. Topics include the nature of the electrode-solution interface (double layer models), mass transfer (diffusion, migration, and convection), types of electrodes, reference electrodes, junction potentials, kinetics of electrode reactions, controlled potential methods (cyclic voltammetry, chronoamperometry), chronocoulometry and square wave voltammetry, and controlled current methods (chronopotentiometry).

CHEM 5617. Protein Mass Spectrometry Laboratory. (3 Hours)
Offers students an opportunity to develop an appreciation of the appropriate choice of mass spectrometer for a particular application.

CHEM 5620. Protein Chemistry. (3 Hours)
Describes proteins (what they are, where they come from, and how they work) in the context of analytical analysis and molecular medicine. Discusses the chemical properties of proteins, protein synthesis, and the genetic origins of globular proteins in solution, membrane proteins, and fibrous proteins. Covers the physical intra- and intermolecular interactions that proteins undergo along with descriptions of protein conformation and methods of structural determination. Explores protein folding as well as protein degradation and enzymatic activity. Highlights protein purification and biophysical characterization in relation to protein analysis, drug design, and optimization.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C- or graduate program admission

CHEM 5621. Principles of Chemical Biology. (3 Hours)
Explores the use of natural and unnatural small-molecule chemical tools to probe macromolecules, including affinity labeling and click chemistry. Covers nucleic acid sequencing technologies and solid-phase synthesis of nucleic acids and peptides. Discusses in-vitro selection techniques, aptamers, and quantitative issues in library construction. Uses molecular visualization software tools to investigate structures of macromolecules. Intended for graduate and advanced undergraduate students.

Prerequisite(s): ((CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); (CHEM 2321 with a minimum grade of C- or CHEM 2331 with a minimum grade of C- or CHEM 3331 with a minimum grade of C-); (CHEM 3401 (may be taken concurrently) with a minimum grade of C- or CHEM 3421 (may be taken concurrently) with a minimum grade of C- or CHEM 3431 (may be taken concurrently) with a minimum grade of C-)) or graduate program admission

CHEM 5622. Lab for CHEM 5621. (1 Hour)
Accompanies CHEM 5621. Complements and reinforces the concepts from CHEM 5621 with emphasis on fundamental techniques. Offers an opportunity to complete independent projects in modern chemical biology research.

Prerequisite(s): ((CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); (CHEM 2321 with a minimum grade of C- or CHEM 2331 with a minimum grade of C- or CHEM 3331 with a minimum grade of C-); (CHEM 3401 (may be taken concurrently) with a minimum grade of C- or CHEM 3421 (may be taken concurrently) with a minimum grade of C- or CHEM 3431 (may be taken concurrently) with a minimum grade of C-); (ENGL 1111 with a minimum grade of C or ENGL 1102 with a minimum grade of C or ENGW 1111 with a minimum grade of C or ENGW 1102 with a minimum grade of C or ENGW 1113 with a minimum grade of C or ENGW 1114 with a minimum grade of C)) or graduate program admission
Attribute(s): NUpath Writing Intensive

CHEM 5625. Chemistry and Design of Protein Pharmaceuticals. (3 Hours)
Covers the chemical transformations and protein engineering approaches to protein pharmaceuticals. Describes protein posttranslational modifications, such as oxidation, glycosylation, formation of isoaspartic acid, and disulfide. Then discusses bioconjugate chemistry, including those involved in antibody-drug conjugate and PEGylation. Finally, explores various protein engineering approaches, such as quality by design (QbD), to optimize the stability, immunogenicity, activity, and production of protein pharmaceuticals. Discusses the underlying chemical principles and enzymatic mechanisms as well.

Prerequisite(s): (CHEM 2317 with a minimum grade of C- or CHEM 2313 with a minimum grade of C- or graduate program admission); (CHEM 5620 (may be taken concurrently) with a minimum grade of C- or CHEM 5620 (may be taken concurrently) with a minimum grade of C- or CHEM 5621 (may be taken concurrently) with a minimum grade of C- or CHEM 5621 (may be taken concurrently) with a minimum grade of C-)

CHEM 5626. Organic Synthesis 1. (3 Hours)
Surveys types of organic reactions including stereochemistry, influence of structure and medium, mechanistic aspects, and synthetic applications.

CHEM 5627. Mechanistic and Physical Organic Chemistry. (3 Hours)
Surveys foundational concepts of physical organic chemistry, including thermodynamics, kinetics, and solvent and isotope effects. Treats structure/reactivity relationships in the context of how they can be used in understanding and predicting organic chemistry mechanisms. Topics include conformational analysis, molecular orbital theory, aromaticity, orbital symmetry, and how they are applied to understanding organic and organometallic reactions such as aldol, pericyclic, and other stereoselective reactions. Discusses reaction mechanisms that involve intermediates, including anions, cations, radicals, and carbenes.

CHEM 5628. Principles of Spectroscopy of Organic Compounds. (3 Hours)
Studies how to determine organic structure based on proton and carbon nuclear magnetic resonance spectra, with additional information from mass and infrared spectra and elemental analysis. Presents descriptive theory of nuclear magnetic resonance experiments and applications of advanced techniques to structure determination. Includes relaxation, nuclear Overhauser effect, polarization transfer, and correlation in various one- and two-dimensional experiments. Requires graduate students to have one year of organic chemistry or equivalent.

Prerequisite(s): CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C- or graduate program admission

CHEM 5630. Nucleic Acid Chemistry. (3 Hours)
Offers a broadband introduction to the field of nucleic acid chemistry. Nucleic acids are vital for biology, but their roles have been greatly expanded beyond storage of genetic information. The breadth of utility of nucleic acids stems from a precise understanding of their structures, modern means to synthesize and modify them, and the ability for nucleic acids to engage with varieties of enzymes/proteins and other synthetic/biological systems. Foundational topics include nucleic acid structure, physicochemical properties, syntheses of nucleosides/nucleotides/oligonucleotides, chemical modification of nucleic acids, methods to manipulate and analyze nucleic acids (e.g., PCR, sequencing, and electrophoresis). Advanced topics include nucleic acid therapeutics (e.g., siRNA, antisense technology, CRISPR, and aptamers); DNA damage and repair; and DNA for materials science (e.g., DNA nanotechnology).

CHEM 5631. Lab for CHEM 5628. (1 Hour)
Accompanies CHEM 5628. Offers hands-on experience with instrumentation and data processing necessary for the characterization of organic compounds. Emphasizes nuclear magnetic resonance spectroscopy techniques to differentiate chemical compounds and enable associations between chemical structure and spectroscopic data.

Corequisite(s): CHEM 5628

CHEM 5636. Statistical Thermodynamics. (3 Hours)
Briefly reviews classical thermodynamics before undertaking detailed coverage of statistical thermodynamics, including probability theory, the Boltzmann distribution, partition functions, ensembles, and statistically derived thermodynamic functions. Reconsiders the basic concepts of statistical thermodynamics from the modern viewpoint of information theory. Presents practical applications of the theory to problems of contemporary interest, including polymers and biopolymers, nanoscale systems, molecular modeling, and bioinformatics.

Prerequisite(s): CHEM 3401 with a minimum grade of C- or CHEM 3421 with a minimum grade of C- or CHEM 3431 with a minimum grade of C- or graduate program admission

CHEM 5638. Molecular Modeling. (3 Hours)
Introduces molecular modeling methods that are basic tools in the study of macromolecules. Is structured partly as a practical laboratory using a popular molecular modeling suite, and also aims to elucidate the underlying physical principles upon which molecular mechanics is based. These principles are presented in supplemental lectures or in laboratory workshops.

CHEM 5640. Biopolymeric Materials. (3 Hours)
Examines the structure, properties, and processing of biomaterials, the forms of matter that are produced by or interact with biological systems. One of the pillars of biomedical engineering is to use naturally derived and synthetic biomaterials to treat, augment, or replace human tissues.

CHEM 5641. Computational Chemistry. (3 Hours)
Introduces basic concepts, methods, techniques, and recent advances in computational chemistry and their relevance to experimental characterizations such as spectroscopy. Topics include electronic structure theory (wave function theory and density functional theory), principles of molecular dynamics simulations, multiscale modeling, machine learning, and quantum computing relevant to computational chemistry. Builds a theoretical foundation for students to properly choose computational methods to solve common research problems in chemistry, biochemistry, and materials science. Also introduces the field of research in computational chemistry. Suitable for advanced undergraduate students and graduate students who plan to conduct research in the field of computational chemistry or plan to utilize computational techniques to complement experimental research in the molecular sciences.

CHEM 5642. Photochemistry Fundamentals and Applications. (3 Hours)
Describes fundamental science of light-activated chemistry and photochemistry applications. Topics include organic and inorganic photochemistry and their applications in solar energy, solar fuels, photocatalysis, bioimaging, photochemotherapy, pigments, and photonics.

Prerequisite(s): (CHEM 1151 with a minimum grade of D- or CHEM 1161 with a minimum grade of D-) or graduate program admission

CHEM 5643. Plastics Sustainability and Circular Economy: A Chemical Perspective. (3 Hours)
Explores the measures taken by both academia and industry to address plastic pollution and to integrate these materials into circular economy systems. Examines plastic pollution from a chemical perspective by delving into the properties of polymers and their composites at the molecular level, aiming to understand the root causes of this pervasive problem. Offers students an opportunity to obtain a deeper understanding of the challenges posed by plastic pollution and the innovative solutions being developed to combat it.

CHEM 5648. Chemical Principles and Application of Drug Metabolism and Pharmacokinetics. (3 Hours)
Offers students an opportunity to obtain a comprehensive grounding in the chemistry of drug metabolism and pharmacokinetics (DMPK) and its application to drug design and optimization. Multiple rounds of chemical synthesis and testing are usually required to discover new drugs with the appropriate balance of properties such as potency and selectivity, efficacy in preclinical models of disease, safety, and pharmacokinetics. Introduces students to modern tools and concepts utilized to screen for favorable DMPK properties, as well as methods to predict human PK from in vitro and preclinical data. Examines the linkage between drug levels in the body, pharmacodynamic response (PK/PD), and drug-drug interactions in the context of the iterative process of chemical drug synthesis.

CHEM 5649. Numerical Strategies and Data Analytics for Chemical Sciences. (4 Hours)
Introduces a broad range of numerical methods for solving large-scale, data-driven problems that arise in chemical engineering, chemistry, biochemistry, and other chemical sciences. Offers students an opportunity to obtain a detailed understanding of the derivation, analysis, and use of these numerical methods and learn how these lay the foundations to machine learning techniques. Topics include numerical programming logic, linear and nonlinear algebraic equations, polynomial fitting, numerical calculus, optimization techniques, and large-scale data analysis. Applies to a broad field of chemical and biochemical sciences, where large-scale multivariate data analyses and pattern extraction are key components.

Prerequisite(s): ((MATH 1341 with a minimum grade of D- ; MATH 1342 with a minimum grade of D-) or (MATH 2321 with a minimum grade of D- ; MATH 2341 with a minimum grade of D-)) or graduate program admission

CHEM 5651. Materials Chemistry of Renewable Energy. (3 Hours)
Studies renewable energy in terms of photovoltaics, photoelectrochemistry, fuel cells, batteries, and capacitors. Focuses on the aspects of each component and their relationships to one another.

Prerequisite(s): ((CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); CHEM 3401 with a minimum grade of C- or CHEM 3431 with a minimum grade of C-) or graduate program admission

CHEM 5653. Electrochemistry of Renewable Energy Devices. (1 Hour)
Presents the electrochemistry of renewable energy, an extremely interdisciplinary science encompassing sensors, surface technology, materials science, microsystems technology, nanotechnology, energy storage, and conversion. Offers experience with characterization of energy storage and conversion devices. Emphasizes photovoltaics and batteries.

Corequisite(s): CHEM 5651

CHEM 5655. Molecular Symmetry and Group Theory. (3 Hours)
Covers symmetry operations; point groups and classification of molecules into point groups; as well as matrix representation of symmetry operations, orthogonality theorem, and its use in determining irreducible representation spanned by a basis. Studies decomposition of reducible representation and direct products, characters and character tables, and reviews quantum mechanics. Also covers infrared and Raman spectroscopy, normal modes of vibrations, determining symmetry of vibrations, the role of symmetry in selection rules, LCAO MO theory, Hückel method, electronic spectroscopy, and vibronic spectroscopy and symmetry.

CHEM 5660. Analytical Biochemistry. (3 Hours)
Covers the analysis of biological molecules, which include nucleic acids, proteins, carbohydrates, lipids, and metabolites. Discusses isolation, characterization, and quantification of these molecules.

CHEM 5670. Global Biogeochemistry. (4 Hours)
Examines the biological, chemical, and physical interactions that shape our global environment. These interactions combine in the global biogeochemical cycles. Industrial emission of gases, use of fertilizers and plastics, and the expansion of cities are altering the biogeochemical cycling of the elements carbon, nitrogen, and phosphorus at rates unprecedented in the geological record. Uses lectures and the latest update to Chapter 6, "Carbon and Other Biogeochemical Cycles," of the International Panel on Climate Change report to explore the main interactions between human activity, biogeochemical change, and climate. Discusses primary literature to delve deeper into these interactions.

Attribute(s): NUpath Natural/Designed World

CHEM 5672. Organic Synthesis 2. (3 Hours)
Continues CHEM 5626. Surveys types of organic reactions including stereochemistry, influence of structure and medium, mechanistic aspects, and synthetic applications.

Prerequisite(s): CHEM 5626 with a minimum grade of C- or CHEM 5626 with a minimum grade of D

CHEM 5676. Bioorganic Chemistry. (3 Hours)
Covers host guest complexation by crown ethers, cryptands, podands, spherands, and so forth; molecular recognition including self-replication; peptide and protein structure; coenzymes and metals in bioorganic chemistry; nucleic acid structure; interaction of DNA with proteins and small molecules including DNA-targeted drug design; catalytic RNA; and catalytic antibodies.

Prerequisite(s): (CHEM 5626 with a minimum grade of C- ; CHEM 5627 with a minimum grade of C-) or graduate program admission

CHEM 5688. Principles of Nuclear Magnetic Resonance. (3 Hours)
Presents the physical principles underlying magnetic resonance spectroscopy, including Fourier transform theory, classical and quantum-mechanical treatments of spin angular momentum, the Bloch equations, and spin relaxation. Covers fundamental concepts in time domain magnetic resonance methods, including pulse sequences, selective pulses, phase cycling, coherence pathways, field gradients, and nonuniform sampling. Surveys the NMR methods most commonly applied to chemical structural analysis, including pure shift NMR; 2D correlation (COSY, DQF-COSY, TOCSY, HSQC, HMBC) methods; and cross-relaxation (NOESY, ROESY) methods.

CHEM 5692. Carbon Capture, Utilization, and Storage. (4 Hours)
Discusses diverse technological approaches for carbon capture, utilization, and storage, or CCUS. Lectures cover legislative, economic, and societal considerations of realizing CCUS on a large scale. Offers students an opportunity to gain a comprehensive understanding of climate change and decarbonization problems. Students work on a miniproject on the conceptual design and evaluation of a decarbonization approach (of their choice), which can include, e.g., well-established carbon capture technologies, emerging electrochemical or biological methods, industrial energy efficiency, mineralization, carbon dioxide capture in oceans, or reforestation studies. This course is designed to help develop a solid foundation to embark on a career in a sustainability-related business or research institution.

CHEM 5696. Organometallic Chemistry. (3 Hours)
Presents an advanced graduate-level course in organometallic chemistry featuring both main group and transition metals. Requires an advanced undergraduate or introductory graduate course in organic chemistry and inorganic chemistry. Addresses the structure, bonding, and reactivity patterns of organometallic complexes. Topics include metal-carbon ligands, main group metals and ligands, chemistry of carbon monoxide and analogues, metal π-complexes, and fundamental organometallic reactions and mechanisms. Discusses applications for organometallic chemistry including sustainability, catalysis, and materials.

Prerequisite(s): ((CHEM 2313 with a minimum grade of C- or CHEM 2317 with a minimum grade of C-); (CHEM 3501 (may be taken concurrently) with a minimum grade of C- or CHEM 3505 (may be taken concurrently) with a minimum grade of C-)) or graduate program admission

CHEM 5904. Seminar. (1 Hour)
Focuses on oral reports by master of science and PlusOne participants on current research topics in chemistry and chemical biology. May be repeated up to two times.

CHEM 5976. Directed Study. (1-4 Hours)
Offers independent work under the direction of members of the department on a chosen topic. Course content depends on instructor. May be repeated without limit.

CHEM 5984. Research. (1-6 Hours)
Offers an opportunity to conduct research under faculty supervision. May be repeated up to three times for up to 6 total credits.

CHEM 6962. Elective. (1-4 Hours)
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CHEM 7710. Laboratory Rotations in Chemistry and Chemical Biology. (0 Hours)
Offers an opportunity for students to gain exposure to research laboratories in the department to help them choose a thesis advisor and project.

CHEM 7750. Advanced Problem Solving. (3 Hours)
Designed to provide skills necessary to lead advanced problem-solving case studies. Faculty mentors in one of three thematic areas chosen from organic and medicinal chemistry, physical and materials chemistry, or analytical and biological chemistry assign casework to students for presentation and analysis in group sessions. Students are required to provide rational solutions to complex problems derived from the contemporary literature and engage in dialogue with faculty mentors to justify their analysis. The faculty mentors assign grades to reflect intellectual maturity and ability of the students to display creative, independent thinking. Full-time PhD students who have successfully completed qualifying examinations only.

CHEM 7962. Elective. (1-4 Hours)
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

CHEM 7986. Research. (0 Hours)
Offers students an opportunity to conduct full-time research under faculty supervision.

CHEM 7990. Thesis. (1-4 Hours)
Offers thesis supervision by members of the department. May be repeated without limit.

CHEM 7996. Thesis Continuation - Half-Time. (0 Hours)
Offers continuing thesis supervision by members of the department.

CHEM 8504. Graduate Seminar. (1 Hour)
Focuses on oral reports by the participants on current research topics in chemistry and chemical biology. May be repeated without limit.

CHEM 8960. Exam Preparation—Doctoral. (0 Hours)
Offers the student the opportunity to prepare for and take the PhD qualifying exams (cumulative exams).

CHEM 8984. Research. (1-6 Hours)
Offers the chance to conduct original research, written thesis thereon, or to the establishment of doctoral candidacy. May be repeated without limit.

CHEM 8986. Research. (0 Hours)
Offers the student the opportunity to conduct full-time research for the master's degree. May be repeated without limit.

CHEM 9000. PhD Candidacy Achieved. (0 Hours)
Indicates successful completion of the doctoral comprehensive exam.

CHEM 9984. Research. (1-4 Hours)
Offers an opportunity to conduct research under faculty supervision. May be repeated without limit.

CHEM 9986. Research. (0 Hours)
Offers the student the opportunity to conduct full-time research for the PhD. May be repeated without limit.

CHEM 9990. Dissertation Term 1. (0 Hours)
Offers the student the opportunity to conduct theoretical and experimental research for the PhD degree. Open to chemical biology students.

Prerequisite(s): CHEM 9000 with a minimum grade of S

CHEM 9991. Dissertation Term 2. (0 Hours)
Offers dissertation supervision by members of the department.

Prerequisite(s): CHEM 9990 with a minimum grade of S

CHEM 9996. Dissertation Continuation. (0 Hours)
Offers dissertation supervision by members of the department. Open to chemical biology students.

Prerequisite(s): CHEM 9991 with a minimum grade of S or Dissertation Check with a score of REQ