

# DEPARTMENT OF CHEMISTRY

## Introduction

Chemistry is the scientific study of the composition and properties of matter and the investigation of the laws that govern them. Classically, chemistry is divided into several subdisciplines. Organic chemistry deals primarily with carbon compounds; inorganic chemistry, with compounds of the other elements. Physical chemistry seeks to describe relationships between the chemical and physical properties of all substances.

Analytical chemistry studies the analysis of the chemical composition of all substances. Biological chemistry pursues the chemistry of living organisms. At the borders of these subdisciplines are many hybrid areas of study: physical organic, organometallic, bioinorganic, and others. At the interface of chemistry with other sciences, several active fields are fueled by insights gained from two ways of thinking about things: for example, chemical physics, chemical biology, organic geochemistry, and the extensive chemical problems in biotechnology, nanotechnology, material sciences, and molecular medicine. In all of these areas the chemist's approach may be theoretical, experimental, or both.

All chemists have a common core of knowledge, learned through a highly structured sequence of undergraduate courses in which the content is divided into the classical subdisciplines. Toward the end of students' progress through their four years of undergraduate study, they may choose to concentrate in one or more areas of chemistry through the courses selected to fulfill the chemistry elective requirements and through undergraduate research.

## Advising

Faculty advisors are available in the Department of Chemistry for both walk-in meetings and scheduled advising appointments. The departmental advisors assist students with a variety of areas: course planning for the chemistry major, career/graduate school planning, study abroad opportunities, undergraduate research opportunities, and how to deal with academic difficulties. Chemistry majors are required to meet with a departmental advisor by appointment prior to registering for any semester beyond the fourth term in residence. The faculty advisors also schedule many events for the majors.

## Graduate School and Career Opportunities

An undergraduate degree tailored according to the student's interests can open doors to graduate programs in many academic disciplines: chemistry, environmental science, materials science, polymer science, chemical engineering, geochemistry, chemical physics, and several disciplines at the interface between biology and chemistry. A technically oriented administrator in the chemical industry might choose to obtain a master's degree in business administration. More than 100 schools in the United States offer graduate programs in chemistry and related areas, and the usual practice is to complete a graduate degree at an institution different from the undergraduate institution. It is necessary to specialize in graduate study, either within one of the branches previously mentioned or at the interface between two of them. A student admitted to a graduate program in chemistry in the United States is usually offered a teaching assistantship or fellowship.

Chemists have a wide choice of academic, governmental, or industrial positions. By far the greatest percentage accept industrial positions, mostly in chemical manufacturing or the petroleum, food, and pharmaceutical industries, where they may be developing new products to benefit humanity or assessing the level of risk in the processes for

some proposed production methods, for example. Most government chemists are employed in agriculture, health, energy, environmental, and defense-related areas. In the academic field, with such a broad spectrum of colleges and universities in this country, chemists can set career goals with varying levels of emphasis on training students in research and teaching in the classroom and instructional laboratory.

### Majors

- Chemistry Major, B.A. (<https://catalog.unc.edu/undergraduate/programs-study/chemistry-major-ba/>)
- Chemistry Major, B.S. (<https://catalog.unc.edu/undergraduate/programs-study/chemistry-major-bs/>)
- Chemistry Major, B.S.–Biochemistry Track (<https://catalog.unc.edu/undergraduate/programs-study/chemistry-major-bs-biochemistry-track/>)
- Chemistry Major, B.S.–Polymer Track (<https://catalog.unc.edu/undergraduate/programs-study/chemistry-major-bs-polymer-track/>)

### Minor

- Chemistry Minor (<https://catalog.unc.edu/undergraduate/programs-study/chemistry-minor/>)

### Graduate Programs

- M.A. in Chemistry (<https://catalog.unc.edu/graduate/schools-departments/chemistry/>)
- M.S. in Chemistry (<https://catalog.unc.edu/graduate/schools-departments/chemistry/>)
- Ph.D. in Chemistry (<https://catalog.unc.edu/graduate/schools-departments/chemistry/>)

## Professors

Erik J. Alexanian, Jeffrey Aubé, James F. Cahoon, Jillian L. Dempsey, Andrey V. Dobrynin, Dorothy A. Erie, Michel R. Gagné, Gary L. Glish, Jeffrey S. Johnson, Yosuke Kanai, David S. Lawrence, Gerald J. Meyer, Alexander J.M. Miller, Andrew M. Moran, David A. Nicewicz, Gary J. Pielak, J. Michael Ramsey, Matthew R. Redinbo, Mark H. Schoenfish, Sergey S. Sheiko, Jason D. Surratt, Joseph L. Templeton, Marcey L. Waters, Kevin M. Weeks, Wei You.

## Associate Professors

Erin Baker, Leslie M. Hicks, Frank A. Leibfarth, Bo Li, Matthew R. Lockett, Simon J. Meek, Scott C. Warren.

## Assistant Professors

Joanna M. Atkin, Elizabeth C. Brunk, Megan Jackson, Abigail Knight, Huong Kratochvil, Zhiyue Lu, Sidney M. Wilkerson-Hill, Aleksandr V. Zhukhovitskiy.

## Teaching Professors

Todd L. Austell, Brian P. Hogan, Domenic J. Tiani.

## Teaching Associate Professors

Nita Eskew, Thomas C. Freeman.

## Teaching Assistant Professors

Joshua E. Beaver, Carribeth L. Bliem, Anna C. Curtis, Jade Fostvedt, Danielle Zurcher.

## Course Sequencing

Careful attention should be given to prerequisites and course timing when planning a long-term schedule. A C- or better grade in CHEM 101 is required to continue into CHEM 102/CHEM 102L. CHEM 102 is a prerequisite for CHEM 241/CHEM 241L, CHEM 251, and CHEM 261. A C- or better grade in CHEM 102 is required to continue into ANY higher-level chemistry course. A C- or better grade in CHEM 261 is a prerequisite for CHEM 262, and CHEM 241L is a prerequisite for CHEM 262L. Students intending to take pregraduate or preprofessional exams (such as the GRE or MCAT) should plan accordingly.

## CHEM—Chemistry Undergraduate-level Courses

### CHEM 70. First-Year Seminar: You Don't Have to Be a Rocket Scientist. 3 Credits.

The goal of this seminar is to develop tools for extracting information from or finding flaws in news reports and popular science writing. Group work on such issues as biomass fuels, the hydrogen economy, and other alternative energy sources will develop an understanding of their economic and environmental impact.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FY-SEMINAR.

**Making Connections Gen Ed:** PL.

**Grading Status:** Letter grade.

### CHEM 73. First-Year Seminar: From Atomic Bombs to Cancer Treatments: The Broad Scope of Nuclear Chemistry. 3 Credits.

A course engaging the topic of nuclear chemistry on the introductory chemistry course level (e.g., CHEM 101/102). Atomic structure, nuclear fission, and nuclear fusion processes will be introduced to provide the background necessary to understand applications of the processes. Applications discussed will include power generation, medical treatments, weapons, and more. Honors version available.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FY-SEMINAR.

**Making Connections Gen Ed:** PL.

**Grading Status:** Letter grade.

### CHEM 74. First-Year Seminar: Polymers: How Plastic Changed our World. 3 Credits.

From milk bottles and grocery bags to contact lenses and diapers, polymers influence nearly every aspect of our daily lives. Through hands-on activities, readings, and interactive lessons, we will examine the role polymers have played, both positive and negative, on our society and world.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FY-SEMINAR.

**Grading Status:** Letter grade.

### CHEM 75. First-Year Seminar: Bread from Air? The Chemistry of Fertilizers. 3 Credits.

Fear of a global famine inspired chemist Fritz Haber's research into the production of ammonia from nitrogen in the air. Following a breakthrough laboratory discovery, engineer Carl Bosch led the development of a large-scale industrial process to produce ammonia...and together they changed the world. This First-Year Seminar introduces concepts of scientific inquiry and interdisciplinary collaboration in the context of the humankind's utilization of fertilizers.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FY-SEMINAR, FC-NATSCI.

**Grading Status:** Letter grade.

### CHEM 89. First-Year Seminar: Special Topics. 3 Credits.

Special topics course. Content will vary each semester.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FY-SEMINAR.

**Grading Status:** Letter grade.

### CHEM 100. Foundations of Chemistry. 3 Credits.

This course is an introduction to fundamental threshold concepts in chemistry as preparation for the two-course sequence of General Descriptive Chemistry (CHEM 101 and 102). This course emphasizes developing contextualized algebra skills for solving chemistry problems including physical unit conversions, molar mass, and reaction stoichiometry. Permission of instructor required.

#### Rules & Requirements

**Requisites:** Prerequisite, MATH 110.

**Grading Status:** Letter grade.

### CHEM 101. General Descriptive Chemistry I. 3 Credits.

The first course in a two-semester sequence. See also CHEM 102. Atomic and molecular structure, intermolecular forces, stoichiometry and conservation of mass, and properties of gases. Honors version available. Honors version available.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FY-LAUNCH (only designated sections), FC-NATSCI.

**Making Connections Gen Ed:** PX.

**Requisites:** Prerequisite, MATH 110.

**Grading Status:** Letter grade.

### CHEM 101L. Quantitative Chemistry Laboratory I. 1 Credits.

Computerized data collection, scientific measurement, basic laboratory skills, spectroscopy, molecular structure and bonding, and intermolecular forces. Laptop computer required. One three-hour laboratory a week.

#### Rules & Requirements

 IDEAs in Action Gen Ed: FC-LAB.

**Requisites:** Pre- or corequisite, CHEM 101.

**Grading Status:** Letter grade.

**CHEM 102. General Descriptive Chemistry II. 3 Credits.**

The course is the second in a two-semester sequence. See also CHEM 101. Solutions, thermochemical changes including conservation of energy, thermodynamics, reaction rates, chemical equilibria including acid-base chemistry, and electrochemistry. Honors version available. Honors version available.

**Rules & Requirements**

**IDEAs in Action Gen Ed:** FY-LAUNCH (only designated sections), FC-NATSCI.

**Making Connections Gen Ed:** PX.

**Requisites:** Prerequisites, CHEM 101 and 101L; C- or better required in CHEM 101.

**Grading Status:** Letter grade.

**CHEM 102L. Quantitative Chemistry Laboratory II. 1 Credits.**

Computerized data collection, basic laboratory skills, thermochemistry, colligative properties, chemical kinetics, and acid-base titrations. Laptop computer required. One three-hour laboratory a week.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 101L; Pre- or corequisite, CHEM 102 or 102H.

**Grading Status:** Letter grade.

**CHEM 190. Special Topics in Chemistry. 3 Credits.**

An undergraduate seminar course that is designated to be a participatory intellectual adventure on an advanced, emergent, and stimulating topic within a selected discipline in chemistry. This course does not count as credit towards the chemistry major.

**Rules & Requirements**

**Grading Status:** Letter grade.

**CHEM 200. Extraordinary Chemistry of Ordinary Things. 3 Credits.**

Coregistration in CHEM 200 and 101L fulfills the physical and life science with a laboratory requirement (PX). This course helps students understand the chemistry behind important societal issues and the consequences of actions aimed at addressing the issues. Students who have taken CHEM 200 cannot take CHEM 101 for credit.

**Rules & Requirements**

**Making Connections Gen Ed:** PX.

**Requisites:** Prerequisite, MATH 110.

**Grading Status:** Letter grade.

**CHEM 210. Service Learning in Chemistry. 1 Credits.**

This is an APPLES service-learning course that collaborates with a community partner. Students will develop research questions and test their hypotheses using chemistry lab techniques and instrumentation. Students will keep a reflection journal on their service work and a lab notebook for recording all experimentation. At the end of the semester, students will write a paper and present research posters. Findings will be shared with the community partner. Students must send applications to the instructor.

**Rules & Requirements**

**IDEAs in Action Gen Ed:** RESEARCH.

**Making Connections Gen Ed:** EE- Service Learning, EE- Mentored Research.

**Grading Status:** Letter grade.

**CHEM 241. Modern Analytical Methods for Separation and Characterization. 3 Credits.**

Analytical separations, chromatographic methods, spectrophotometry, acid-base equilibria and titrations, fundamentals of electrochemistry. Honors version available.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 102 or 102H; C- or better required.

**Grading Status:** Letter grade.

**CHEM 241L. Laboratory in Separations and Analytical Characterization of Organic and Biological Compounds. 1 Credits.**

Applications of separation and spectrophotometric techniques to organic compounds, including some of biological interest. One three-hour laboratory a week. Students may not receive credit for both CHEM 241L and CHEM 245L.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 102L; pre- or corequisite, CHEM 241 or 241H.

**Grading Status:** Letter grade.

**CHEM 245L. Honors Laboratory in Separations and Analytical Characterization of Organic and Biological Compound. 1 Credits.**

Applications of separation and spectrophotometric techniques to samples from the real world, including some of biological interest. Final portion of course consists of group research projects presented to the Department of Chemistry in poster session format. Honors equivalent of CHEM 241L. Students may not receive credit for both CHEM 241L and CHEM 245L. One three-hour laboratory each week.

**Rules & Requirements**

**Making Connections Gen Ed:** EE- Mentored Research.

**Requisites:** Prerequisite, CHEM 102L; pre- or corequisite, CHEM 241H.

**Grading Status:** Letter grade.

**CHEM 251. Introduction to Inorganic Chemistry. 3 Credits.**

Chemical periodicity, introductory atomic theory and molecular orbital theory, structure and bonding in solids, descriptive nonmetal chemistry, structures and reactions of transition metal complexes, applications of inorganic complexes and materials.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 102 or 102H; C- or better required.

**Grading Status:** Letter grade.

**CHEM 261. Introduction to Organic Chemistry I. 3 Credits.**

Molecular structure and its determination by modern physical methods, correlation between structure and reactivity and the theoretical basis for these relationships, classification of reaction types exhibited by organic molecules using as examples molecules of biological importance. Honors version available.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 102 or 102H; C- or better required.

**Grading Status:** Letter grade.

**CHEM 262. Introduction to Organic Chemistry II. 3 Credits.**

Continuation of CHEM 261, with particular emphasis on the chemical properties of organic molecules of biological importance. Honors version available.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 261 or 261H; C- or better required.

**Grading Status:** Letter grade.

**CHEM 262L. Laboratory in Organic Chemistry. 1 Credits.**

Continuation of CHEM 241L or 245L with particular emphasis on organic chemistry synthesis protocols, separation techniques, and compound characterization using modern spectroscopic instrumentation. This course serves as an organic chemistry laboratory for premedical and predoctoral students. Students may not receive credit for both CHEM 262L and CHEM 263L. One three-hour laboratory each week.

**Rules & Requirements**

**IDEAs in Action Gen Ed:** RESEARCH.

**Making Connections Gen Ed:** EE- Mentored Research.

**Requisites:** Prerequisites, CHEM 102L, and CHEM 241L or 245L; pre- or corequisite, CHEM 262 or 262H.

**Grading Status:** Letter grade.

**CHEM 290. Special Topics in Chemistry. 1-3 Credits.**

Elective topics in the field of chemistry. This course has variable content and may be taken multiple times for credit.

**Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.

**Grading Status:** Letter grade.

**CHEM 291. Seminar on Academic Mentoring. 1-3 Credits.**

Experience includes academic mentoring for small groups, preparing review sessions, and facilitating lecture hall activity. Students will apply concepts in pedagogy, leadership, communication, and group dynamics. Does not fulfill chemistry major requirements. GPA above 3.0 required.

**Rules & Requirements**

**IDEAs in Action Gen Ed:** HI-SERVICE.

**Requisites:** Prerequisites, CHEM 102 or 102H, and MATH 231; permission of the instructor for students lacking the prerequisites; Pre- or corequisite, EDUC 150.

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 6 total completions.

**Grading Status:** Pass/Fail.

**CHEM 293. Undergraduate Internship in Chemistry. 3 Credits.**

The sponsored, off-campus work must involve at least 135 hours. Does not fulfill any requirement in the chemistry major or minor. Chemistry majors only. Permission of instructor/department

**Rules & Requirements**

**IDEAs in Action Gen Ed:** HI-INTERN.

**Making Connections Gen Ed:** EE- Academic Internship, EE- Service Learning, EE- Field Work.

**Grading Status:** Pass/Fail.

**CHEM 295. Educational and Social Research in Chemistry. 1-3 Credits.**

This class is designed for students interested in pursuing educational or social research related to the field of chemistry under the mentorship of a faculty member in the UNC Department of Chemistry or another department on campus. This course does not count as a chemistry elective in the chemistry major or minor.

**Rules & Requirements**

**IDEAs in Action Gen Ed:** RESEARCH.

**Requisites:** Prerequisite, CHEM 101.

**Grading Status:** Letter grade.

**CHEM 395. Research in Chemistry for Undergraduates. 3 Credits.**

Required preparation, one CHEM course 420 or higher, or permission of the instructor. For advanced chemistry and applied sciences majors conducting on-campus research. Students prepare a report for their faculty supervisor and present their work at a poster session. May count only once as a chemistry elective. Honors version available.

**Rules & Requirements**

**IDEAs in Action Gen Ed:** RESEARCH.

**Making Connections Gen Ed:** EE- Mentored Research.

**Repeat Rules:** May be repeated for credit. 9 total credits. 3 total completions.

**Grading Status:** Letter grade.

**CHEM 396. Special Problems in Chemistry. 1-3 Credits.**

Permission of the director of undergraduate studies. Literature or laboratory work equivalent of one to three hours each week. Honors version available.

**Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 3 total completions.

**Grading Status:** Letter grade.

**CHEM 397H. Honors Colloquium in Chemistry. 1 Credits.**

Weekly meetings complement research carried out under CHEM 395H. Expands students' exposure to specialized areas of research through guided readings and seminars with invited speakers. Aids students in preparing their research for evaluation. CHEM 395H and 397H together can contribute no more than nine total hours toward graduation.

**Rules & Requirements**

**Making Connections Gen Ed:** EE- Mentored Research.

**Requisites:** Corequisite, CHEM 395H.

**Repeat Rules:** May be repeated for credit. 2 total credits. 2 total completions.

**Grading Status:** Letter grade.

**Advanced Undergraduate and Graduate-level Courses****CHEM 410. Instructional Methods in the Chemistry Classroom. 4 Credits.**

Permission of the instructor. This course explores secondary school chemical education through current chemical education theory and classroom teaching. Students will develop a comprehensive approach to teaching chemistry content through student-centered activities.

**Rules & Requirements**

**Making Connections Gen Ed:** EE- Field Work.

**Requisites:** Prerequisites, CHEM 241, 251, 262, and 262L.

**Grading Status:** Letter grade.

**CHEM 420. Introduction to Polymers. 3 Credits.**

Chemical structure and nomenclature of macromolecules, synthesis of polymers, characteristic polymer properties.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 261 or 261H; pre- or corequisites, CHEM 262 or 262H, and 262L or 263L.

**Grading Status:** Letter grade.

**Same as:** APPL 420.

**CHEM 421. Synthesis of Polymers. 3 Credits.**

Synthesis and reactions of polymers; various polymerization techniques.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 251 and 262 or 262H.

**Grading Status:** Letter grade.

**Same as:** APPL 421.

**CHEM 422. Physical Chemistry of Polymers. 3 Credits.**

Polymerization and characterization of macromolecules in solution.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 420 and 481.

**Grading Status:** Letter grade.

**Same as:** APPL 422.

**CHEM 423. Intermediate Polymer Chemistry. 3 Credits.**

Polymer dynamics, networks and gels.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 422.

**Grading Status:** Letter grade.

**Same as:** APPL 423.

**CHEM 425. Polymer Materials. 3 Credits.**

Solid-state properties of polymers; polymer melts, glasses and crystals.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 421 or 422.

**Grading Status:** Letter grade.

**CHEM 430. Introduction to Biological Chemistry. 3 Credits.**

The study of cellular processes including catalysts, metabolism, bioenergetics, and biochemical genetics. The structure and function of biological macromolecules involved in these processes is emphasized. Honors version available.

**Rules & Requirements**

**Requisites:** Prerequisites, BIOL 101, and CHEM 262 or 262H.

**Grading Status:** Letter grade.

**Same as:** BIOL 430.

**CHEM 431. Macromolecular Structure and Metabolism. 3 Credits.**

Structure of DNA and methods in biotechnology; DNA replication and repair; RNA structure, synthesis, localization and transcriptional regulation; protein structure/function, biosynthesis, modification, localization, and degradation.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 430 and BIOL 103 or BIOL 202.

**Grading Status:** Letter grade.

**CHEM 432. Metabolic Chemistry and Cellular Regulatory Networks. 3 Credits.**

Biological membranes, membrane protein structure, transport phenomena; metabolic pathways, reaction themes, regulatory networks; metabolic transformations with carbohydrates, lipids, amino acids, and nucleotides; regulatory networks, signal transduction.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 430.

**Grading Status:** Letter grade.

**CHEM 441. Intermediate Analytical Chemistry. 3 Credits.**

Spectroscopy, electroanalytical chemistry, chromatography, thermal methods of analysis, signal processing.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 241, 241L, 262, and 480 or 481.

**Grading Status:** Letter grade.

**CHEM 441L. Intermediate Analytical Chemistry Laboratory. 2 Credits.**

Experiments in spectroscopy, electroanalytical chemistry, chromatography, thermal methods of analysis, and signal processing. One four-hour laboratory a week and one one-hour lecture.

**Rules & Requirements**

**Requisites:** Corequisite, CHEM 441.

**Grading Status:** Letter grade.

**CHEM 443. Surface Analysis. 3 Credits.**

This class will focus on analytical techniques capable of probing the physical and chemical properties of surfaces and interfaces. These analyses are extremely challenging, as the sample sizes are small (e.g., 1E14 molecules/cm<sup>2</sup> of a material). The course will focus on complementary techniques to assess surface structure and topography, atomic and molecular composition, organization or disorder, and reactivity.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 441 or CHEM 481; permission of the instructor for students lacking the prerequisite.

**Grading Status:** Letter grade.

**CHEM 444. Separations. 3 Credits.**

Theory and applications of equilibrium and nonequilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electrophoresis, ultracentrifugation, and other separation methods.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 441 and CHEM 480 or 481.

**Grading Status:** Letter grade.

**CHEM 445. Electroanalytical Chemistry. 3 Credits.**

Basic principles of electrochemical reactions, electroanalytical voltammetry as applied to analysis, the chemistry of heterogeneous electron transfers, and electrochemical instrumentation.

**Rules & Requirements**

**Making Connections Gen Ed:** EE- Mentored Research.

**Requisites:** Prerequisites, CHEM 480 or 481, and CHEM 441.

**Grading Status:** Letter grade.

**CHEM 446. Analytical Spectroscopy. 3 Credits.**

Optical spectroscopic techniques for chemical analysis including conventional and laser-based methods. Absorption, fluorescence, scattering and nonlinear spectroscopies, instrumentation and signal processing.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 441 and 482.

**Grading Status:** Letter grade.

**CHEM 447. Bioanalytical Chemistry. 3 Credits.**

Principles and applications of biospecific binding as a tool for performing selective chemical analysis.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 441.

**Grading Status:** Letter grade.

**CHEM 448. Mass Spectrometry. 3 Credits.**

Fundamental theory of gaseous ion chemistry, instrumentation, combination with separation techniques, spectral interpretation for organic compounds, applications to biological and environmental chemistry.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 480 or 481, and CHEM 441.

**Grading Status:** Letter grade.

**CHEM 449. Microfabricated Chemical Measurement Systems. 3 Credits.**

Introduction to micro and nanofabrication techniques, fluid and molecular transport at the micrometer to nanometer length scales, applications of microtechnology to chemical and biochemical measurements.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 441.

**Grading Status:** Letter grade.

**CHEM 450. Intermediate Inorganic Chemistry. 3 Credits.**

Introduction to symmetry and group theory; bonding, electronic spectra, and reaction mechanisms of coordination complexes; organometallic complexes, reactions, and catalysis; bioinorganic chemistry. Honors version available.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 251.

**Grading Status:** Letter grade.

**CHEM 451. Theoretical Inorganic Chemistry. 3 Credits.**

Chemical applications of symmetry and group theory, crystal field theory, molecular orbital theory. The first third of the course, corresponding to one credit hour, covers point symmetry, group theoretical foundations and character tables.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 262 or 262H and 450.

**Grading Status:** Letter grade.

**CHEM 452. Electronic Structure of Transition Metal Complexes. 3 Credits.**

A detailed discussion of ligand field theory and the techniques that rely on the theoretical development of ligand field theory, including electronic spectroscopy, electron paramagnetic resonance spectroscopy, and magnetism.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 451.

**Grading Status:** Letter grade.

**CHEM 453. Organotransition Metal Chemistry. 2 Credits.**

Exploring the synthesis, bonding, and reactivity of organotransition metal complexes. Topics typically include organometallic ligand classification, the elementary steps of organometallic reactions, and applications in catalysis.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 465.

**Grading Status:** Letter grade.

**CHEM 460. Intermediate Organic Chemistry. 3 Credits.**

Modern topics in organic chemistry. Honors version available.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 262 or 262H.

**Grading Status:** Letter grade.

**CHEM 463. Bioorganic Chemistry. 3 Credits.**

Bioorganic chemistry integrates topics from synthetic chemistry, biochemistry, and biophysics to study biomacromolecules and develop tools and materials that utilize them.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 262 and CHEM 430.

**Grading Status:** Letter grade.

**CHEM 465. Mechanisms of Organic and Inorganic Reactions. 4 Credits.**

Kinetics and thermodynamics, free energy relationships, isotope effects, acidity and basicity, kinetics and mechanisms of substitution reactions, one- and two-electron transfer processes, principles and applications of photochemistry, organometallic reaction mechanisms.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 450.

**Grading Status:** Letter grade.

**CHEM 466. Advanced Organic Chemistry I. 3 Credits.**

A survey of fundamental organic reactions including substitutions, additions, elimination, and rearrangements; static and dynamic stereochemistry; conformational analysis; molecular orbital concepts and orbital symmetry.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 460.

**Grading Status:** Letter grade.

**CHEM 467. Advanced Organic Chemistry II. 2 Credits.**

Spectroscopic methods of analysis with emphasis on elucidation of the structure of organic molecules:  $^1\text{H}$  and  $^{13}\text{C}$  NMR, infrared, ultraviolet, ORD-CD, mass, and photoelectron spectroscopy.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 466.

**Grading Status:** Letter grade.

**CHEM 468. Synthetic Aspects of Organic Chemistry. 3 Credits.**

Modern synthetic methods and their application to the synthesis of complicated molecules.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 466.

**Grading Status:** Letter grade.

**CHEM 469. Organometallics and Catalysis. 3 Credits.**

Structure and reactivity of organometallic complexes and their role in modern catalytic reactions

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 450 and 466.

**Grading Status:** Letter grade.

**CHEM 470. Fundamentals of Materials Science. 3 Credits.**

Crystal geometry, diffusion in solids, mechanical properties of solids, electrical conduction in solids, thermal properties of materials, phase equilibria.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 482 or PHYS 128; Pre- or corequisite, PHYS 441.

**Grading Status:** Letter grade.

**Same as:** APPL 470.

**CHEM 472. Chemistry and Physics of Electronic Materials Processing. 3 Credits.**

Permission of the instructor. A survey of materials processing and characterization used in fabricating microelectronic devices. Crystal growth, thin film deposition and etching, and microlithography.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 482 or PHYS 117 or 119.

**Grading Status:** Letter grade.

**Same as:** PHYS 472, APPL 472.

**CHEM 473. Chemistry and Physics of Surfaces. 3 Credits.**

The structural and energetic nature of surface states and sites, experimental surface measurements, reactions on surfaces including bonding to surfaces and adsorption, interfaces.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 470.

**Grading Status:** Letter grade.

**Same as:** APPL 473.

**CHEM 480. Introduction to Biophysical Chemistry. 3 Credits.**

Does not carry credit toward graduate work in chemistry or credit toward any track of the B.S. degree with a major in chemistry. Application of thermodynamics to biochemical processes, enzyme kinetics, properties of biopolymers in solution.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 261 or 261H; and MATH 232; and PHYS 105, or 115, or 117, or 119.

**Grading Status:** Letter grade.

**CHEM 481. Physical Chemistry I. 3 Credits.**

Thermodynamics, kinetic theory, chemical kinetics.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 102 or 102H, PHYS 118 or 116; pre- or corequisites, MATH 383 and PHYS 119 or 117; C- or better required in chemistry course prerequisites.

**Grading Status:** Letter grade.

**CHEM 481L. Physical Chemistry Laboratory I. 2 Credits.**

Experiments in physical chemistry. One four-hour laboratory each week.

**Rules & Requirements**

**Requisites:** Pre- or corequisite, CHEM 482.

**Grading Status:** Letter grade.

**CHEM 482. Physical Chemistry II. 3 Credits.**

Introduction to quantum mechanics, atomic and molecular structure, spectroscopy, statistical mechanics.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 481.

**Grading Status:** Letter grade.

**CHEM 482L. Physical Chemistry Laboratory II. 2 Credits.**

Experiments in physical chemistry. Solving thermodynamic and quantum mechanical problems using computer simulations. One three-hour laboratory and a single one-hour lecture each week.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 482.

**Grading Status:** Letter grade.

**CHEM 484. Thermodynamics and Introduction to Statistical Thermodynamics. 3 Credits.**

Thermodynamics, followed by an introduction to the classical statistical mechanics and non-equilibrium thermodynamics.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 482.

**Grading Status:** Letter grade.

**CHEM 485. Chemical Dynamics. 3 Credits.**

Experimental and theoretical aspects of atomic and molecular reaction dynamics.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 481 and 482.

**Grading Status:** Letter grade.

**CHEM 486. Introduction to Quantum Chemistry. 3 Credits.**

Introduction to the principles of quantum mechanics. Approximation methods, angular momentum, simple atoms and molecules.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 481 and 482.

**Grading Status:** Letter grade.

**CHEM 487. Introduction to Molecular Spectroscopy. 3 Credits.**

Interaction of radiation with matter; selection rules; rotational, vibrational, and electronic spectra of molecules; laser based spectroscopy and nonlinear optical effects.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 486.

**Grading Status:** Letter grade.

**CHEM 488. Quantum Chemistry. 3 Credits.**

Applications of quantum mechanics to chemistry. Molecular structure, time-dependent perturbation theory, interaction of radiation with matter.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 486.

**Grading Status:** Letter grade.

**CHEM 489. Statistical Mechanics. 3 Credits.**

Applications of statistical mechanics to chemistry. Ensemble formalism, condensed phases, nonequilibrium processes.

**Rules & Requirements**

**Requisites:** Prerequisite, CHEM 484.

**Grading Status:** Letter grade.

**CHEM 492. Molecular Modeling in Chemistry. 2 Credits.**

This course is offered to first-year graduate and upper-class undergraduate students in different chemistry disciplines who are interested in gaining skills in molecular modeling using modern methodologies from computational chemistry. No prior experience is required. An overview of quantum mechanics (QM) and molecular dynamics (MD) methodologies will be provided. It will also provide extensive experiences to perform different types of computations with abundant hands-on exercises using Gaussian package for QM and LAMMPS for MD simulations.

**Rules & Requirements**

**Grading Status:** Letter grade.

 **CHEM 520L. Polymer Chemistry Laboratory. 2 Credits.**

Various polymerization techniques and characterization methods. One four-hour laboratory each week.

**Rules & Requirements**

 **IDEAs in Action Gen Ed:** RESEARCH.

**Making Connections Gen Ed:** EE- Mentored Research.

**Requisites:** Pre- or corequisite, CHEM 420 or 421 or 425.

**Grading Status:** Letter grade.

**Same as:** APPL 520L.

 **CHEM 530L. Laboratory Techniques for Biochemistry. 3 Credits.**

An introduction to chemical techniques and research procedures of use in the fields of protein and nucleic acid chemistry. Two four-hour laboratories and one one-hour lecture a week.

**Rules & Requirements**

 **IDEAs in Action Gen Ed:** RESEARCH.

**Making Connections Gen Ed:** EE- Mentored Research.

**Requisites:** Prerequisites, BIOL 202; pre- or co-requisite, CHEM 430.

**Grading Status:** Letter grade.

 **CHEM 541L. Advanced Instrumentation and Analytical Measurement Laboratory. 2 Credits.**

A laboratory devoted to modern instrumental methods and analytical techniques. One four-hour laboratory and one one-hour lecture each week.

**Rules & Requirements**

 **IDEAs in Action Gen Ed:** RESEARCH.

**Requisites:** Pre- or corequisite, CHEM 441.

**Grading Status:** Letter grade.

 **CHEM 550L. Synthetic Chemistry Laboratory I. 2 Credits.**

A laboratory devoted to synthesis and characterization of inorganic complexes and materials. A four-hour synthesis laboratory, a characterization laboratory outside of the regular laboratory period, and a one-hour recitation each week.

**Rules & Requirements**

 **IDEAs in Action Gen Ed:** RESEARCH.

**Making Connections Gen Ed:** CI.

**Requisites:** Prerequisites, CHEM 241L or 245L, 251, and 262L or 263L.

**Grading Status:** Letter grade.

**CHEM 551L. Honors Synthetic Chemistry Lab. 2 Credits.**

This is an honors laboratory course designed to lead you from challenging introductory experiments to five weeks of laboratory work on an independent research project. In addition to exposing you to advanced synthetic techniques, this course will allow you to use multiple modern techniques to characterize the inorganic and organometallic complexes you prepare. Students may not receive credit in both CHEM 551L and CHEM 550L.

**Rules & Requirements**

**Requisites:** Prerequisites, CHEM 262L and 251.

**Grading Status:** Letter grade.

**CHEM 692H. Senior Honors Thesis. 3 Credits.**

CHEM 395 must have been in the same laboratory as 692H. Senior majors only. Required of all candidates for honors or highest honors.

**Rules & Requirements**

**Requisites:** Prerequisite, six credit hours of CHEM 395.

**Grading Status:** Letter grade.

## Contact Information

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