Chemistry

NATURAL SCIENCES DIVISION

Faculty

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Chemistry is often called the "central science," overlapping significantly with biology, physics, psychology, mathematics, geology, and engineering. All studies of matter at the molecular level (for example, biochemistry, molecular biology, pharmacology, neuroscience, chemical physics, computational chemistry, solid-state physics, geochemistry, the environmental sciences, and material science and engineering) depend on the theories and methodologies of chemistry.

Introductory courses are designed to respond to students' particular backgrounds and interests. Look for the ◆ symbol, which designates those courses particularly appropriate for first-year or upperclass students new to the chemistry curriculum.

The Chemistry Curriculum

The curriculum has a definite vertical structure; that is, you must take courses at one level of sophistication before you may take courses at the next level. For this reason, it is very important to begin your study of chemistry as soon as you can, in your first year if possible, particularly if you are considering a chemistry major or are planning to take courses beyond the introductory level. If you are considering a major in chemistry or another natural science, then either CHEM 111 and CHEM 112 plus CHEM 113 and CHEM 114, or CHEM 115 and CHEM 116 plus CHEM 117 and CHEM 118, are the appropriate introductory courses.

CHEM 111 and CHEM 112 are lecture-and-discussion courses intended for those needing a thorough introduction to the fundamental concepts, theories, and methodologies of chemistry, as well as an introduction to selected topics in organic and inorganic chemistry. CHEM 115 and CHEM 116, also lecture-and-discussion courses, provide a rigorous continuation of the study of matter at the molecular level begun in your secondary-school course(s). CHEM 115 and CHEM 116 are open only to first-year students with good secondary-school preparations in chemistry, as indicated by the chemistry readiness exam.

CHEM 113 and CHEM 114 are the laboratory courses normally taken in conjunction with CHEM 111 and CHEM 112. CHEM 117 and CHEM 118 are the laboratory courses that accompany CHEM 115 and CHEM 116, and are open only to first-year students. Either sequence—CHEM 111 and CHEM 112 plus CHEM 113 and CHEM 114, or CHEM 115 and CHEM 116 plus CHEM 117 and CHEM 118—will enable you to enroll in more advanced chemistry courses or to major in chemistry, biochemistry, molecular biology, or neuroscience.

Either sequence will also satisfy medical-school requirements for a course in general chemistry. Transfer students and those with advanced placement credit or exceptionally strong secondary-school preparation in chemistry will be advised by the department about appropriate courses, after completing the chemistry readiness exam.

The department offers two courses designed to inform you about the chemical aspects of neuroscience and of environmental issues: CHEM 109, Neurochemistry, and CHEM 110, Environmental Chemistry. These courses have no prerequisites, and together fulfill the collegiate distribution requirement of 1 unit of work in a science department. CHEM 109 is a required core course for the Neuroscience Concentration and CHEM 110 is a required core course for the Environmental Studies Concentration. Neither course may serve as a prerequisite for more advanced courses in the department.

Our majors program, accredited by the American Chemical Society, prepares students for professional work or advanced study in chemistry, biochemistry, and related fields; the health sciences such as medicine, dentistry, and nursing; the veterinary sciences; secondary-school teaching; engineering; the environmental sciences; business and the law; and public service. The major stresses the development of independent, critical thinking, as well as problem solving and communication skills.

Numerous opportunities exist for students to participate in the life of the department through (1) participation in research with faculty members, (2) participation in social and academic activities sponsored by the Kenyon Chapter of the Student Affiliates of the American Chemical Society, (3) advising the department in the hiring and evaluation of faculty members and other matters, and (4) employment as stockroom assistants, laboratory proctors, paper graders, and tutors.

Requirements for the Major

The minimum requirement for a chemistry major is 6 or 6 1/2 units of credit in the department, including the following:

- 4 3/4 units of the core curriculum (111 and 112 plus CHEM 113 and CHEM 114) or (115 and 116 plus CHEM 117 and CHEM 118), 231, 232, 233, 234, 335, 336, 341, 475
- 1/2 unit of courses chosen from among 256, 343, 435, 445, 452, 453, 460

and

- either of the following:

  3/4 units from among CHEM 371, 372, 373, 374 **or**

  1/2 unit from among CHEM 371, 372, 373, 374 plus 1/2 unit from CHEM 375 or CHEM 376

In addition, the major must complete PHYS 140 and 135 or PHYS 145 and Calculus B (MATH 112).

The courses in the core curriculum, listed above, are offered every year. Several advanced courses are offered on an alternate-year basis, so care should be taken in planning your chemistry program.

Courses **not** offered in 2003-04 include CHEM 373, 435, 445, 452.

Those students planning to do graduate work in chemistry or related areas should take additional advanced courses in the department as well as in other sciences and mathematics. Those wanting an extended research experience should elect CHEM 375-376 and CHEM 497-498.

The minimum major does not meet American Chemical Society (ACS) certification requirements. For ACS certification, you must complete additional courses, including both CHEM 256 and CHEM 343.

The Senior Exercise in chemistry may consist of each student preparing and presenting a thirty-minute seminar discussion of two papers from the chemical research literature, followed by writing a paper complementing the oral presentation; or a written exam. The seminar presentations take place in February and March.

The chemistry and biology departments offer interdisciplinary majors in biochemistry and molecular biology. Refer to the biochemistry and molecular biology section in this catalogue for descriptions and course requirements. Interested students should consult with the appropriate directors: Rosemary Marusak for biochemistry and Joan Slonczewski for molecular biology.

Year Courses

Seniors Honors Course
CHEM 497Y-498Y (1-1 1/2 units)
Staff

The emphasis is on independent research in collaboration with a faculty mentor, culminating with a thesis that is defended orally to an outside examiner. Credit to be determined at time of registration. Prerequisites: GPA of at least 3.2, enrollment in Section 02 of CHEM 375 or CHEM 376, and permission of department chair.

First-Semester Courses

Neurochemistry
◆ CHEM 109 (1/2 unit)
Lutton

This course offers a description of the nervous system's structure and function in terms of molecular processes. Topics are developed through lectures, discussions, student presentations, class demonstrations, and computer molecular modeling. The course begins with a brief introduction to general and organic chemistry, then continues with the following topics: neurocellular anatomy and the biochemistry of cell neurotransmitters and receptors, and the biochemistry of psychoactive drugs and neurological disorders. This course is a required core course for the Neuroscience Concentration, and with CHEM 110 fulfills the science distribution requirement. No prerequisites. Enrollment limited

Introductory Chemistry I
◆ **QR** CHEM 111 (1/2 unit)
Hemkin

This course provides a thorough introduction to the fundamental concepts, theories, and methodologies of chemistry, and to selected topics in descriptive inorganic and organic chemistry. Topics to be studied include stoichiometry, theories of atomic and molecular structure and bonding, the periodic table, acid-base chemistry, chemical equilibria, selected aspects of chemical thermodynamics, and chemical kinetics. This course provides a basis for the further study of chemistry and the other sciences. The format is lecture and discussion. No prerequisites. Enrollment limited; juniors and seniors with permission of department chair.

Introductory Chemistry Laboratory I
◆ **QR** CHEM 113 (1/4 unit)
Hemkin

This laboratory and lecture course offers an introduction to modern experimental chemistry. Laboratory projects include the synthesis and analysis of a transition metal coordination compound, the synthesis and analysis of a common drug, and the use of infrared and ultraviolet-visible spectrophotometry to elucidate molecular structure. The lecture component treats such topics as laboratory safety, accuracy and precision of measurements, interpretation of data, and the theory of visible and infrared spectrophotometry. Both the laboratory and lecture place special emphasis on developing an understanding of spectrophotometric instrumentation and its proper use for chemical analysis. Emphasis is placed on the use of computers for data analysis and reporting. Communication skills are developed through written laboratory reports and the proper use of a laboratory notebook. One laboratory or lecture session will be held per week. Prerequisite or corequisite: CHEM 111 or its equiva-

lent. Enrollment limited; juniors and seniors with permission of department chair.

Honors Introductory Chemistry I
◆ **QR** CHEM 115 (1/2 unit)
Staff

This lecture-discussion course is designed to build upon your previous study of chemistry. The central theme of the course is that the properties of materials are determined by the structures of their molecules. Over the course of the year, atomic structure, bonding theories, and thermodynamic and kinetic properties of chemical compounds are reviewed. Students are also introduced to advanced topics such as coordination chemistry, molecular orbital theory, biochemistry, and organic chemistry. Due to the accelerated nature of this course, elective topics are included. Prerequisites: at least one year of secondary-school chemistry or its equivalent and permission of department. The department will recommend placement into this course, which is open only to first-year students. Co-requisite: CHEM 117. Enrollment limited.

Honors Introductory Chemistry Laboratory I
◆ **QR** CHEM 117 (1/4 unit)
Keller, Cummings

This laboratory and lecture course is intended to accompany CHEM 115 and CHEM 116 and is open only to first-year students. The laboratory work is organized around individual and team projects involving (1) the synthesis of organic and inorganic molecules, and the use of modern instrumentation to investigate their molecular structures and properties; (2) investigations of the thermodynamics and kinetics; and (3) the use of molecular modeling and computational software to investigate molecular structure and energetics.

Students will utilize such instrumental techniques as nuclear magnetic resonance spectroscopy; ultraviolet, visible, and infrared spectrophotometry; gas and liquid chromatography; and electrochemical potentiometry. The lecture portion presents material necessary to an understanding of the instrumentation and chemistry utilized in the laboratory work. Computerized data acquisition and analysis skills are developed through written laboratory reports. One laboratory or lecture session will be held per week. Prerequisite: permission of the department. Co-requisite: CHEM 115. The department will recommend placement into this course.

Organic Chemistry I
CHEM 231 (1/2 unit)
Hunsen

This lecture course offers a study of the chemical and physical properties of organic compounds. Theoretical principles are developed with particular emphasis on molecular structure and reaction mechanisms. The descriptive aspects of organic chemistry include strategies for synthesis and the study of compounds of biochemical interest. Prerequisites: CHEM 113 and CHEM 114 or CHEM 117 and CHEM 118 or placement, and permission of department chair. Enrollment is limited and requires a grade of C+ or higher in CHEM 111 or CHEM 115.

Organic Chemistry Laboratory I
QR CHEM 233 (1/4 unit)
Getzler, Hunsen

This laboratory course introduces fundamental methods of purification such as extraction, distillation, recrystallization, and column chromatography. Experiments include the isolation of a natural product, oxidation and reduction reactions, a Grignard reaction, an SN2 reaction, and a Diels-Alder reaction. Compounds are identified and assessed for purity by melting point determination, refractometry, gas chromatography, infrared spectroscopy, and proton nuclear magnetic resonance. Co-requisite: CHEM 231.

Chemical Kinetics and Thermodynamics
QR CHEM 335 (1/2 unit)
Cummings

This course presents a study of chemical kinetics and chemical thermodynamics. Specific topics include rate laws and reaction mechanisms, reaction-rate theories, the laws of thermodynamics, thermochemistry, properties of solutions, and equilibrium. Applications will be drawn from organic, inorganic, and biochemistry. Prerequisites: CHEM 111 and CHEM 112 or CHEM 115 and CHEM 116. Prerequisite or co-requisite: MATH 112.

Instrumental Analysis
QR CHEM 341 (1/2 unit)
Keller

This course serves as an introduction to modern instrumental techniques available to the chemist for quantitative and qualitative analysis of organic and inorganic samples. Emphasis will be placed on theory and instrumental design for spectroscopic (UV-Vis, luminescence, IR, NMR, MS), electrochemical (ion-selective electrodes, voltammetry), and chromatographic (GC, HPLC) methods. Prerequisite: CHEM 233 and 234 or permission of instructor.

Inorganic Chemistry
CHEM 343 (1/2 unit)
Staff

The course emphasizes the correlation of structure and bonding, as well as correlations of thermodynamic and kinetic considerations, with the chemical and physical properties of inorganic systems. Special topics include organometallic compounds, and solid state chemistry. Prerequisite or co-requisite: CHEM 335.

Advanced Lab - Biochemistry
CHEM 371 (1/4 unit)
Lutton

Students will be introduced to the theory and application of modern biochemical techniques. Experiments will emphasize amino acid, carbohydrate, and lipid chemistry; protein isolation and characterization; enzyme kinetics and mechanisms; and membrane biochemistry. Prerequisite or co-requisite: CHEM 256. Enrollment limited.

Inorganic Laboratory
CHEM 372 (1/4 unit)
Staff

In this laboratory course, students will engage in a semester-long project that

integrates inorganic synthesis, analytical instrumentation, and physical measurement. This integrated laboratory focuses on four related coordination complexes. Following synthesis of the complexes, the students will use visible spectroscopy, cyclic voltammetry, inert atmosphere electron transfer kinetics, and Marcus Theory to characterize and investigate the complexes' reactivity. The course meets for two three-hour laboratory periods per week. Students are expected either to be concurrently enrolled in, or to have completed, CHEM 335;336 or CHEM 341. Prerequisite: CHEM 233;234 or permission of instructor.

Chemical Research
CHEM 375 (1/4 or 1/2 unit)
Hunsen

Section 01 (1/4 unit). This section is open to first-year and sophomore students **only**. Students engage in independent research under the direction of a faculty mentor. The time requirement is at least three hours in lab per week. Students will learn to search the literature and give professional presentations. This course also provides an introduction to scientific writing. More details can be obtained from the department chair.

Section 02 (1/2 unit). This section is open to all students and is a prerequisite to Chemistry 497-498 (Senior Honors). The time commitment is six to eight hours per week in lab (instructor-dependent). Students will learn to search the literature and give professional scientific presentations as well as to write scientifically. Outside seminar speaker attendance is required. More details can be obtained from the department chair.

Photochemistry and Photophysics
QR CHEM 452 (1/2 unit)
Cummings

Photosynthesis, photography, vision, photolithography, solar energy conversion, light-emitting diodes, atmospheric chemistry, photodynamic cancer treatment, and basic research in environmental, biological, inorganic, physical, and organic chemistry all rely on the principles of photochemistry. This course will explore how the foundations of thermodynamics, kinetics, and quantum chemistry can be applied to the chemistry of excited-state molecules. The processes of absorption, emission, non-radiative relaxation, energy and electron transfer, and photoreactions will be studied. The class has a seminar format and is appropriate for students who have completed at least one year of chemistry. Prerequisite: CHEM 232.

Chemistry Research Seminar
CHEM 475 (1/4 unit)
Staff

This is a required course for all chemistry majors, including those involved in independent research. The course covers topics relating to chemistry research. Weekly meetings will involve (1) searching chemistry literature, (2) analyzing primary research articles, and (3) discussing ethics, trends, funding, and other issues relating to chemistry research. During the semester, students will give written and oral presentations of primary research articles. Prerequisite: junior or senior standing.

Independent Study in Chemistry
CHEM 493 (1/4 or 1/2 unit)
Staff

This course provides the student with an opportunity for independent investigation of a topic not covered in the curriculum or a topic related to a faculty member's research. Prerequisite: permission of department chair.

Second-Semester Courses

Introductory Chemistry II
◆ **QR** CHEM 112 (1/2 unit)
Keller

This course is a continuation of CHEM 111. See first-semester description of CHEM 111. Prerequisite: CHEM 111.

Introductory Chemistry Laboratory II
◆ **QR** CHEM 114 (1/4 unit)
Lutton

This is a continuation of CHEM 113. Laboratory projects may include investigations of the properties of acid-base buffers, the investigation of the kinetics of the hydrolysis of a simple drug, chromatographic separation of amino acids, and the synthesis of several polymers. The lecture component includes the fundamentals of acid-base chemistry, simple chemical kinetics, and thermochemistry. Emphasis is placed on the use of computers for data analysis and reporting. Communication skills are developed through written laboratory reports. One laboratory or lecture session will be held per week. Prerequisite: CHEM 113. Prerequisite or co-requisite: CHEM 112 or its equivalent. Enrollment limited; juniors and seniors with permission of department chair.

Honors Introductory Chemistry II
◆ **QR** CHEM 116 (1/2 unit)
Cummings

This course is a continuation of CHEM 115. See first-semester description of CHEM 115. Prerequisite: CHEM 115. Co-requisite: CHEM 118.

Honors Introductory Chemistry Laboratory II
◆ **QR** CHEM 118 (1/4 unit)
Staff

This course is a continuation of CHEM 117. See first-semester description of CHEM 117. Prerequisite: CHEM 117.

Organic Chemistry II
CHEM 232 (1/2 unit)
Getzler

This course is a continuation of CHEM 231. See first-semester description of CHEM 231. Prerequisite: CHEM 231.

Organic Chemistry Laboratory II
QR CHEM 234 (1/4 unit)
Getzler, Thomas

This laboratory course focuses on the chemistry of dienes, carbonyl compounds, and aromatic compounds, and carbohydrates. New techniques and

instrumentation include thin-layer chromatography, Fourier transform nuclear magnetic resonance spectroscopy, and 13C magnetic resonance. Experiments include a Diels-Alder reaction, an aldol condensation, an ester synthesis, and electrophilic aromatic substitution. Prerequisite: CHEM 233.

Biochemistry
CHEM 256 (1/2 unit)
Lutton

This course is a study of the structure and function of biologically important compounds. Topics include proteins, enzymes, intermediary metabolism, and electron transport with emphasis on thermodynamic and kinetic analysis of biochemical systems. Prerequisite or co-requisite: CHEM 231 and 232. Enrollment limited.

Quantum Chemistry
QR CHEM 336 (1/2 unit)
Hemkin

This course presents a study of quantum mechanics as applied to chemistry. Specific topics include general quantum theory; the time-independent Schrödinger equation applied to electronic, vibrational, and rotational energy states; valence bond and molecular orbital theory; and molecular symmetry. Prerequisites: CHEM 111,112 or 115 and 116. Co-requisite: one year of physics. Two semesters of calculus are recommended.

Spectroscopy Laboratory
CHEM 374 (1/4 unit)
Keller, Cummings

This advanced laboratory course focuses on spectroscopy instrumentation and data analysis. UV-vis, fluorescence, and laser spectroscopies are used to solve research questions involving kinetics, thermodynamics, and molecular structure. Experiments are intended to complement course work in Instrumental Analysis (CHEM 341), Chemical Kinetics and Thermodynamics (CHEM 335), and Quantum Chemistry (CHEM 336), but these courses may be taken in any order. Prerequisite: CHEM 231 and 234.

Chemical Research
CHEM 376 (1/4 or 1/2 unit)
Keller

Section 01 (1/4 unit). See course description of CHEM 375, Section 01. Open to first-year and sophomore students **only**.

Section 02 (1/2 unit). See course description of CHEM 375, Section 02. Open to all students.

Advanced Biochemistry
CHEM 460 (1/2 unit)
Hemkin

This biophysical chemistry seminar will focus on undertaking some of the thermodynamics associated with bio-macromolecules like proteins and DNA (although many of these topics can be generalized to any type of molecule.) We will examine transport processes, the thermodynamics that characterize the intra- and intermolecular interactions in bio-macromolecules, and some of the statistical models that are used to understand these molecules' folding and structural transitions. In this process we will discuss several papers related to these topics. Finally, this course will allow you the opportunity to develop expertise in a biophysical topic of your choice. This expertise will be shared with your classmates and the rest of the world through Web site development, poster presentation, and an in-class talk.

Independent Study in Chemistry
CHEM 494 (1/4 or 1/2 unit)
Staff

This course provides the student with an opportunity for independent investigation of a topic not covered in the curriculum or a topic related to a faculty member's research. Prerequisite: permission of department chair.

The following courses will be offered in 2005-06:

Environmental Chemistry
◆ CHEM 110 (1/2 unit)
Staff

This course offers an introduction to the chemical basis of environmental issues and the environmental consequences of modern technology, with particular emphasis on air and water pollution. Topics include fossil fuels, nuclear power and solar energy, ozone depletion and the greenhouse effect, pollution and toxicology of heavy metals and pesticides, and environmental impact statements. These topics will be developed through lectures, discussions, and class demonstrations. This course is a required core course for the Environmental Studies Concentration, and with CHEM 109 fulfills the science distribution requirement. No prerequisites.

Advanced Organic Chemistry Laboratory
CHEM 373 (1/4 unit)
Staff

In this laboratory course, students will engage in multiweek, multistep projects that integrate both modern organic synthesis and advanced high-field nuclear magnetic resonance techniques. This course meets for two three-hour laboratory periods per week and is designed to illustrate concepts presented in CHEM 453 (Advanced Organic Chemistry). Prerequisite: CHEM 233 and 234.

Special Topics
CHEM 392 (1/2 unit)
Staff

Advanced Organic Chemistry
CHEM 453 (1/2 unit)
Staff

This course covers selected topics in organic chemistry with emphasis on advanced spectral methods of identifying organic compounds (including multiple-pulse and two-dimensional nuclear magnetic resonance spectroscopy) and modern methods of organic synthesis. Prerequisite: CHEM 231 and 232.