

Chemistry

Natural Sciences Division

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, nanoscience, computational chemistry, solid-state physics, geochemistry, the environmental sciences, and material science and engineering) depend on the theories and methods of chemistry.

FOR FIRST-YEAR STUDENTS

The first semester of introductory chemistry is offered at two levels.

CHEM 121 is a lecture-and-discussion course intended to give students a thorough introduction to the fundamental concepts, theories and methods of chemistry; enrollment priority is given to first- and second-year students. CHEM 122 is an accelerated lecture course covering a full year of general chemistry in one semester and is designed for students with previous study of chemistry. (The prerequisite for CHEM 122 is a score of 4 or 5 on the AP chemistry test.) These two courses meet at the same time. CHEM 123 is the accompanying lab course. It is highly recommended for students in CHEM 121 and is required for students in CHEM 122.

Students who have successfully completed CHEM 121 advance to CHEM 124 which continues the investigation of chemical principles as they apply to issues in modern chemistry, such as sustainability, neurochemistry, biochemistry and molecular medicine. CHEM 126 is the accompanying lab course and is highly recommended for students in CHEM 124. Students who complete CHEM 122 may enroll directly into CHEM 231 Organic Chemistry I in the spring and get an early start on the upper-level curriculum.

Completion of one of the introductory lecture and lab sequences either CHEM 121, 123, 124 and 126 or CHEM 122 and 123, is a prerequisite for enrolling in organic chemistry or any other advanced chemistry courses.

Students planning to complete medical school requirements should, in their first year, plan to take either the traditional introductory chemistry sequence CHEM 121, 123, 124 and 126 or the accelerated sequence CHEM 122, 123, 231 and 233. Please consult with your likely applicant medical schools regarding exact chemistry requirements for each institution. The following combinations should satisfy the medical-school requirements for courses in general chemistry: CHEM 121, 123, 124 and 126; CHEM 122, 123, 124 and 126; or CHEM 122 and 123 but confirm with your likely applicant schools. The organic requirements should be satisfied by CHEM 231, 232, 233 and 234.

The department also offers several courses designed for students who are not planning to continue beyond one or two semesters of study. These "non-majors" courses, which are numbered below 120 and have no prerequisite, serve various purposes. CHEM 109 is a required core course for the concentration in neuroscience, and CHEM 108 or CHEM 110 is a required core course for the concentration in environmental studies. Students wanting to complete the College requirements for one unit (1) in the natural sciences can take any two of these, and CHEM 108 satisfies the College quantitative reasoning (QR) requirement. Non-majors courses do not serve as a prerequisite for any higher-numbered courses in the department.

THE CHEMISTRY CURRICULUM

The chemistry curriculum begins with a series of courses covering introductory chemistry and organic chemistry in the first two years, then branches out to advanced topics in physical, inorganic, analytical and biochemistry. Because of this vertical structure, we advise students to begin their study of chemistry as soon as possible. This also helps capitalize on secondary-school preparation in math and science, the roots of college chemistry.

Students who are considering a chemistry, biochemistry or molecular biology major should plan to take CHEM 121 and 123 or CHEM 122 and 123 in their first semester and continue on with the appropriate chemistry courses in the second semester, either CHEM 124 and 126 or CHEM 231 and 233. The chemistry major is rounded out with an offering of courses and labs on the major sub-disciplines of the field, along with seminar-style special topics courses. Opportunities to work on independent research projects are available at all levels of the curriculum.

A capstone Chemistry research seminar for seniors in the fall semester guides students through a self-study of an individual research topic, and the Senior Exercise in the spring semester involves preparing and presenting a 30-minute talk on two research papers on the senior research topic.

Chemistry majors are well prepared for professional employment or graduate 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 law; and public service. The major emphasizes the development of independent, critical thinking as well as problem-solving and communication skills. Our department is accredited by the American Chemical Society (ACS) and students may elect to receive a degree certified by the ACS (see below).

Numerous opportunities exist for students to participate in the life of the department through (1) undertaking research with faculty members, (2) participating in social and outreach activities, (3) advising the department in the hiring and evaluation of faculty members and other matters and (4) working as stockroom assistants, laboratory proctors, paper graders and tutors.

REQUIREMENTS FOR THE MAJOR

The minimum requirement for a chemistry major is six (6) units of credit in the department, including the following:

1. One year of introductory chemistry lecture with lab:

CHEM 121, 123, 124 and 126

or

CHEM 122 (prerequisite: AP score of 4 or 5) and CHEM 123

2. One semester of organic chemistry with lab (.75 unit):

CHEM 231 and CHEM 233 (prerequisite: CHEM 124 and 126 or CHEM 122 and 123)

3. Required advanced lecture courses (1.75 units):

CHEM 243 (prerequisite: CHEM 122 or 124)

CHEM 335 (prerequisite: CHEM 122 or 124 and MATH 112 strongly recommended)

CHEM 341 (prerequisite: four semesters of CHEM lab or permission of instructor)

CHEM 475 (prerequisite: senior standing)

4. Two elective advanced courses from list below (1 unit):

CHEM 232 (prerequisite: CHEM 231)

CHEM 336 (prerequisite: CHEM 122, 124 or 126; co-requisite: Introductory physics) and MATH 112 is recommended)

CHEM 401 (prerequisite: check specific section for more information)

Of special note: MATH 112 is highly recommended before enrolling in CHEM 335 or 336 and introductory physics is a co-requisite of CHEM 336.

5. Four advanced labs from list below (1 unit):

CHEM 234

CHEM 370, 371, 372, 373 or 374

.50 unit of CHEM 375 may replace one advanced lab (.25 unit)

6. Senior Exercise

Students planning to do graduate work in chemistry or related areas should take additional advanced courses in chemistry and the natural sciences division and partake in research opportunities during the school year and summer. We encourage students to take upper-level courses in departments affiliated with chemistry (biology, math, neuroscience, physics or psychology). With department approval, one of the required advanced labs can be replaced with one unit of selected 200- or 300-level coursework in another department.

For a degree to be certified by the American Chemical Society, a student must complete one-and-a-half (1.5) units of introductory physics, the minimum chemistry major plus CHEM 256 and one unit (1) of research in CHEM 375.

The chemistry and biology departments offer interdisciplinary majors in biochemistry and molecular biology. Refer to the biochemistry and molecular biology section in the course catalog for more information.

REQUIREMENTS FOR THE MINOR

The minor in chemistry requires a minimum of two-and-one-half units (2.5) of credit earned in the chemistry curriculum; these include completion of CHEM 122 and 123 or CHEM 124 and 126, an advanced seminar CHEM 401, and two upper-level lectures from CHEM 231, 232, 243, 256, 335, 336 or 341 or additional sections of 401.

RESEARCH

Students can gain research experience by participating in independent research CHEM 375 under the supervision of a faculty advisor. Although independent research is not required for the major, conducting research is a valuable educational experience, particularly for students planning to pursue graduate or medical training.

SENIOR EXERCISE

The Senior Exercise in chemistry has two components, one written and one oral. At the end of the fall semester, students submit a review paper on an assigned topic. During the spring semester, senior chemistry majors must prepare and present a 30-minute talk on two research papers relating to their senior research topic. See the chair and the [department website](#) for more information.

HONORS

Departmental honors in chemistry involve demonstrating excellence in both depth and breadth of the discipline, through accomplishments on a specific research project and achievement in studying the principal areas of chemistry knowledge. Students wishing to pursue senior honors research in chemistry should apply to the chemistry department chair no later than April 15 of their junior year. See the chair and [department website](#) for more information.

TRANSFER CREDIT

Any transfer credit to be counted for the chemistry major or minor must be approved in advance by the department chair.

Courses

CHEM 108 SOLAR ENERGY

Credit: 0.5 QR

The exigencies of peak oil, global warming, and unsustainable growth in energy consumption have sparked a quest for clean, abundant, renewable energy to replace fossil fuels. This course explores the chemistry of fossil fuels and potential solar-energy alternatives, ranging from biofuels to solar panels to hydrogen. Chemical principles such as reaction stoichiometry, molecular structure, thermochemistry, catalysis, energy quantization, and electrochemistry will be learned in the context of investigating solar radiation, greenhouse gases, photovoltaics, artificial photosynthesis, fuel cells, and the production and storage of hydrogen. This course is a required core course for the Environmental Studies Concentration. This course plus CHEM 109 or CHEM 110 fulfills the 1 unit natural science distribution requirement.

Instructor: Cummings

CHEM 109 NEUROCHEMISTRY

Credit: 0.5

This course offers a description of the nervous system's structure and function in terms of molecular processes. Topics are developed through lectures, discussions and student presentations. 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 108 or CHEM 110 fulfills the natural science distribution requirement. No prerequisites.

Instructor: Hemkin

CHEM 110 ENVIRONMENTAL CHEMISTRY

Credit: 0.5 QR

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 108 or CHEM 109 fulfills the natural science distribution requirement. No prerequisites.

Instructor: Staff

CHEM 121 INTRODUCTORY CHEMISTRY

Credit: 0.5 QR

This course provides a thorough introduction to the fundamental concepts, theories, and methodologies of chemistry. Topics may include stoichiometry, theories of molecular structure

and bonding, the periodic table, acid-base chemistry, chemical equilibria, and thermodynamics. This course provides a basis for the further study of chemistry. The format is lecture and discussion. Prerequisites: for first-year students, chemistry readiness test and survey; none for other students.

Instructor: Staff

CHEM 122 CHEMICAL PRINCIPLES

Credit: 0.5 QR

This lecture-discussion course is designed to build upon your previous study of chemistry. Chemical stoichiometry, atomic theory, and principles of molecular structure and bonding are reviewed, and acid-base chemistry, chemical equilibria, and thermodynamics are covered in more depth. Additional advanced topics and applications are included. Prerequisites: chemistry readiness test and survey. The department will recommend placement into this course, which is open only to first-year students. (All other students begin with CHEM 121.) Corequisite: CHEM 123.

Instructor: Staff

CHEM 123 INTRODUCTORY CHEMISTRY LAB I

Credit: 0.25 QR

This laboratory course accompanies CHEM 121 and 122 with an introduction to modern experimental chemistry. Laboratory experiments explore inorganic synthesis, molecular structure and properties, and spectroscopy, with an emphasis on laboratory safety, computerized data acquisition and analysis, and the theory of analytical instrumentation. The laboratory work is organized around individual and team projects. Communication skills are developed through written laboratory reports and the proper use of a laboratory notebook. One three-hour laboratory is held per week. Corequisite: CHEM 121 or 122. Juniors and seniors may enroll with permission of department chair.

CHEM 124 INTRODUCTORY CHEMISTRY II

Credit: 0.5 QR

This lecture-discussion course is one of two paths to continue the introductory chemistry sequence started in CHEM 121 or 122. Chemical principles of molecular structure and bonding, reactivity, electrochemistry, kinetics, and intermolecular forces will be explored in the context of biomolecules and molecular approaches to medicine. Prerequisite: CHEM 121 or 122.

Instructor: Staff

CHEM 126 INTRODUCTORY CHEMISTRY LAB II

Credit: 0.25 QR

Biophysical and Medicinal Chemistry Lab sections 01, 02, 03

This lab is an experimental course to accompany CHEM 124. One three-hour laboratory session will be held per week. Juniors and seniors may enroll with permission of department chair.

Prerequisite: CHEM 123. Corequisite: CHEM 124 or 125.

Nanoscience Lab section 04

This lab is an experimental course to accompany CHEM 125. One three-hour laboratory session will be held per week. Laboratory experiments involve the synthesis of functional materials, the analysis of their properties, and the assembly of materials into useful working devices. Specific activities may include: solar cells, nanocrystalline materials, quantum data, and excited state kinetics. Juniors and seniors may enroll with permission of department chair. Prerequisite: CHEM 123. Corequisite: CHEM 124 or 125.

CHEM 231 ORGANIC CHEMISTRY I

Credit: 0.5

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 126, or permission of department chair. Enrollment is limited and requires a grade of C+ or higher in CHEM 121 or CHEM 122.

CHEM 232 ORGANIC CHEMISTRY II

Credit: 0.5

This course is a continuation of CHEM 231. 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. Prerequisite: CHEM 232.

CHEM 233 ORGANIC CHEMISTRY LAB I

Credit: 0.25 QR

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, and an examination of E1 and E2 reactions. Compounds are identified and assessed for purity by melting point determination, refractometry, gas chromatography, infrared spectroscopy, and proton nuclear magnetic resonance. Corequisite: CHEM 231.

CHEM 234 ORGANIC CHEMISTRY LAB II

Credit: 0.25 QR

This laboratory course focuses on the chemistry of dienes, carbonyl compounds, and aromatic compounds. New techniques and instrumentation include thin-layer chromatography, Fourier transform nuclear magnetic resonance spectroscopy, and ^{13}C magnetic resonance. The focus of the semester is a seven-step convergent synthesis to be conducted in a research-like manner. Corequisite: CHEM 232.

CHEM 243 INORGANIC CHEMISTRY

Credit: 0.5

Instructor: Staff

CHEM 256 BIOCHEMISTRY

Credit: 0.5

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 corequisite: CHEM 231 and 232.

Instructor: Staff

CHEM 335 CHEMICAL KINETICS AND THERMODYNAMICS

Credit: 0.5 QR

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, and inorganic chemistry, as well as biochemistry. Prerequisites: CHEM 126. MATH 112 is highly recommended.

Instructor: Staff

CHEM 336 QUANTUM CHEMISTRY

Credit: 0.5 QR

This course presents a study of quantum mechanics as applied to chemistry. Specific topics include general quantum theory; the time-independent Schrodinger equation applied to electronic, vibrational, and rotational energy states; valence bond and molecular orbital theory; and molecular symmetry. This course is offered every other year. Prerequisites: CHEM 126. Corequisite: one year of physics. MATH 112 is highly recommended.

Instructor: Keller

CHEM 341 INSTRUMENTAL ANALYSIS

Credit: 0.5 QR

Is your water safe? How do you know what compounds are in your water, food, body, and local environment? How do you measure and quantify these compounds? How do you convince yourself that your measurements are valid or invalid? CHEM 341 is a hybrid lecture/laboratory course on the theory and practice of quantitative chemical analysis. Students will apply fundamental principles of measurement, instrument design, and data analysis to instrumental methods. After applying these principles to a sequence of laboratory experiments, students will then develop and evaluate their own instrumental methods. Topics include spectroscopic, electrochemical, and chromatographic methods. According to student interest, additional topics may include environmental analysis, biochemical assays, food quality, and consumer safety.

Prerequisite: CHEM 234 or permission of the instructor.

Instructor: Staff

CHEM 370 ADVANCED LAB: COMPUTATIONAL CHEMISTRY

Credit: 0.25

This advanced laboratory course focuses on using computational methods to understand chemistry and biochemistry. Part of the course will concentrate on using these methods to understand and visualize molecular structure, and part of the course will concentrate on using numerical methods to understand the kinetics and mechanisms associated with reaction systems. Computational work will involve both short experiments done individually and a larger research project that will be conducted in conjunction with classmates. This course meets for one three-hour laboratory period per week. Prerequisite: CHEM 234 or permission of the instructor. Instructor: Hemkin

CHEM 371 ADVANCED LAB: BIOCHEMISTRY

Credit: 0.25

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. The course meets for one three-hour laboratory period per week. Prerequisite or corequisite: CHEM 256. Instructor: Staff

CHEM 372 ADVANCED LAB: INORGANIC

Credit: 0.25

In this laboratory course, students will engage in projects that integrate inorganic synthesis, analytical instrumentation, and physical measurement, focusing on coordination complexes. The course meets for one three-hour laboratory period per week. Prerequisite: CHEM 234 or permission of instructor. Instructor: Cummings

CHEM 373 ADVANCED LAB: ORGANIC

Credit: 0.25

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 one three-hour laboratory period per week. Prerequisite: CHEM 234. Instructor: Getzler

CHEM 374 ADVANCED LAB: SPECTROSCOPY

Credit: 0.25

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. This course meets for one three-hour laboratory period per week. Prerequisite: CHEM 234.

Instructor: Keller

CHEM 375 CHEMICAL RESEARCH

Credit: 0.25-0.5

Section 01 (.25 unit) 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 (.5 unit). This section is a prerequisite to Chemistry 497-498 (Senior Honors). The time commitment is six to eight hours per week in lab. Students will learn to search the literature and give professional scientific presentations as well as to write scientifically. More details can be obtained from the department chair. Prerequisite: permission of instructor.

CHEM 401 CHEMISTRY AND BIOCHEMISTRY SEMINAR

Credit: 0.5

This seminar course covers selected topics in advanced chemistry and biochemistry, with an emphasis on reading and discussing current scientific research and literature. Topics vary by semester, but may include structural biochemistry, computational chemistry, photochemistry, biophysical chemistry, spectroscopy, or organometallic chemistry. Prerequisite: permission of instructor.

CHEM 475 CHEMISTRY RESEARCH SEMINAR

Credit: 0.25

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: senior standing.

Instructor: Staff

CHEM 493 INDIVIDUAL STUDY

Credit: 0.25-0.5

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.

CHEM 497 SENIOR HONORS

Credit: 0.5

The emphasis is on independent research in collaboration with a faculty mentor, culminating with a thesis that is defended orally to an outside examiner. Prerequisites: GPA of at least 3.2,

enrollment in Section 02 of CHEM 375 or CHEM 376, and permission of department chair. See department chair or Web site for full description.

CHEM 498 SENIOR HONORS

Credit: 0.5

The emphasis is on independent research in collaboration with a faculty mentor, culminating with a thesis that is defended orally to an outside examiner. Prerequisites: GPA of at least 3.2, enrollment in Section 02 of CHEM 375 or CHEM 376, and permission of department chair. See department chair or Web site for full description.