CHEMISTRY

REQUIREMENTS

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.

NEW 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 CHEMISTRY 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 about the Senior Exercise.

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 about honors in chemistry.

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. Offered every two years.

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. No prerequisite. Offered annually.

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. No prerequisite. Offered every two years.

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. Offered every fall semester.

CHEM 122 CHEMICAL PRINCIPLES

Credit: 0.5 QR

This course covers a full year of chemistry in one semester and is designed for students with previous study of chemistry. We will explore and review key principles and methods from both CHEM 121 and 124. Prerequisite: AP score of 4 or 5 or placement exam. Corequisite: CHEM 123. Offered every fall semester.

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 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. Offered every fall semester.

CHEM 124 INTRODUCTORY CHEMISTRY II

Credit: 0.5 QR

This lecture-discussion course continues the introductory chemistry sequence started in CHEM 121. We will explore the chemical principles of molecular structure, bonding, reactivity, electrochemistry, kinetics and intermolecular forces. Prerequisite: CHEM 121 or 122. Offered every spring semester.

Biophysical and Medicinal Chemistry section
Chemical principles are explored in the context of biomolecules and molecular approaches to medicine.

Current Topics in Chemistry section
Chemistry principles are explored in the context of current issues in the study or application of chemistry. Topics include sustainability, molecular neuroscience, environmental chemistry, biomedical technology and renewable energy.

CHEM 126 INTRODUCTORY CHEMISTRY LAB II

Credit: 0.25 QR

This lab is an experimental course to accompany CHEM 124 or 243. One three-hour laboratory session will be held per week. Juniors and seniors may enroll with permission of department chair. Prerequisite: CHEM 123. Offered every spring semester.

Biophysical and Medicinal Chemistry Lab sections
Laboratory experiments involve the application of chemical principles and techniques to systems of biological and medicinal importance. Possible experiments include synthesis of aspirin, enzyme kinetics and chromatographic analysis.

Nanoscience Lab section
Laboratory experiments involve the synthesis of functional materials, the analysis of their properties and the assembly of materials into working devices. Possible experiments include making solar cells, synthesis of nanocrystalline materials, quantum dots and an independent project.

Spectroscopic Analysis sections
Laboratory experiments involve quantitative analysis of materials using molecular spectroscopy, such as NMR, IR, and UV/Vis spectroscopy. Possible experiments include identification of pharmaceutical or fragrance mixtures, polymer characterization, determination of equilibrium constants, and testing of food or drug products.

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. Requires a grade of C+ or higher in CHEM 121 or 122. Prerequisite: CHEM 122 and 123 or CHEM 126 or permission of department chair. Offered every spring semester.

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 231. Offered every fall semester.

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. Offered every spring semester.

CHEM 234 ORGANIC CHEMISTRY LAB II

Credit: 0.25 QR

This laboratory course focuses on the chemistry of dienes, carbonyl compounds and aromatic compounds. Techniques and instrumentation include thin-layer chromatography, infrared spectroscopy and nuclear magnetic resonance spectroscopy. The focus of the semester is a seven-step convergent synthesis to be conducted in a research-like manner. Prerequisite: CHEM 233. Corequisite: CHEM 232. Offered every fall semester.

CHEM 243 INORGANIC CHEMISTRY

Credit: 0.5

This course provides a foundation in the principles of structure, bonding, and reactivity in inorganic compounds and materials. We will emphasize the physical properties that make these materials useful in functional devices and biological systems. Possible applications may include semiconductor devices, solar-energy conversion, battery technology, photonic devices and sensors. Throughout our explorations, we will build models, both metaphorical and mathematical, that guide chemists in the design, use and analysis of materials. Prerequisite: CHEM 122, 124, or 231 or permission of instructor. Offered every fall semester.

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 232. Offered every spring semester.

CHEM 293 INDIVIDUAL STUDY

Credit: 0.5

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. MATH 112 is highly recommended. Prerequisite: CHEM 122 or 124. Offered every fall semester.

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 Schrödinger 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. MATH 112 is highly recommended. Prerequisite: CHEM 122, 124 or 126. Offered every two years for the spring semester.

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: four semesters of CHEM lab or permission of instructor. Offered every spring semester.

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 or corequisite: CHEM 335 or permission of instructor. Offered every three years.

Instructor: Hemkin

CHEM 371 ADVANCED LAB: BIOCHEMISTRY

Credit: 0.25

This course is an introduction to fundamental laboratory techniques in biochemistry. The focus of the course is the isolation, purification, characterization and detailed kinetic analysis of alkaline phosphatase from E. coli. This course meets for one three-hour laboratory period per week. Prerequisite or corequisite: CHEM 256. Offered every spring semester.

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. Offered every two years.

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. Offered every two years.

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 CHEM 341, 335 and 336, but these courses may be taken in any order. This course meets for one three-hour laboratory period per week. Prerequisite: CHEM 122 and 123 or 126. Offered every year.

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 literature and give professional presentations. This course also provides an introduction to scientific writing. More details can be obtained from the department chair. Permission of instructor required. Offered every semester.

Section 02 (.5 unit): This section is a prerequisite to CHEM 497 and 498. The time commitment is six to eight hours per week in lab. Students will learn to search literature and give professional presentations as well as to write scientifically. More details can be obtained from the department chair. Permission of instructor required. Offered every semester.

CHEM 401 CHEMISTRY AND BIOCHEMISTRY SEMINAR

Credit: 0.5

Selected topics in advanced chemistry and biochemistry are explored with an emphasis on reading and discussing current scientific research and literature. Prerequisite: CHEM 234 or permission of instructor unless otherwise indicated. Offered every semester, sections will change.

Biophysical Chemistry Seminar
Section 01: This seminar focuses on understanding some of the thermodynamics associated with bio-macromolecules like proteins and DNA. We may examine transport processes, the thermodynamics that characterize the intra- and intermolecular interactions, and some of the statistical models that are used to understand folding and structural transitions. For Fall 2017 (Instructor: Hemkin), this course will contain a community-engaged learning component.

Advanced Organic Chemistry Seminar
Section 02: Selected topics in organic chemistry are covered with an emphasis on advanced spectral methods of identifying organic compounds and modern methods of organic synthesis. Copy and paste the following URL to access the application for permission of instructor.
https://docs.google.com/a/kenyon.edu/forms/d/15omFVZFGtTkDJyVYCOZT-g8JN16LVU5W5aKDwI_fxqs/viewform

Art and Chemistry Seminar
Section 03: This seminar focuses on understanding some of the relationships between art and chemistry, for example, the chemical basis of pigmentation and the use of chemical techniques to identify works from unknown origins.

Chemical Biology Seminar
Section 04: Chemical biology is a scientific discipline at the interface of chemistry and biology. This seminar explores the applications of chemical techniques to manipulate and investigate biological systems. Using resources including current literature, this course covers the chemical techniques used to understand and treat diseases such as cancer and viral, microbial, and neurodegenerative diseases.

Hydrogen Energy Systems Seminar
Section 05: In the search for abundant, renewable, and carbon-free energy sources, scientists are on a quest to develop inexpensive and renewable methods to produce, store and use hydrogen fuel. This seminar explores various aspects of hydrogen energy systems, including the development of a "hydrogen economy" infrastructure; hydrogen production from fossil fuel reforming and from water splitting; solid-state storage materials; hydrogen fuel cell operation and design; and advanced research directions in hydrogen energy.

Enzyme Mechanism Seminar
Section 06: Over the past two decades, our collective knowledge base in chemical biology has exploded. One powerful approach to organizing this enormous body of information is to recognize that nature is bound by the same principles that govern chemistry. Students will explore the mechanistic logic behind biological pathways and examine the technical aspects of how reasonable enzyme mechanisms are determined.

Emerging Techniques in Biological Chemistry
Section 07: Recent advances in biotechnology have had a huge impact on the ability to detect and analyze micro- and nano-size biomolecules with greater accuracy. This literature-based course will look at several emerging techniques and instrumentation that are being used to advance research in topics such as protein dynamics, single molecule detection and metabolic engineering in areas that range from neuroscience to biofuels.

Advanced Biochemistry
Section 08: We will explore the molecular details of key metabolic pathways, biological signaling and molecular transport machinery. The topics discussed will be valuable to students on a trajectory toward careers in life science research and medicine. Students will engage the primary literature to explore current research related to the topics discussed. This course will

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. Offered every fall semester.

CHEM 493 INDIVIDUAL STUDY

Credit: 0.25-0.5

Individual study in chemistry is intended to supplement, not take the place of, coursework. For that reason, such study cannot be used to fulfill requirements for the major or minor. To enroll in an individual study, a student must identify a member of the Chemistry Department willing to direct the project and obtain the approval of the department chair. At a minimum, the department expects a student to meet regularly with his or her instructor for at least one hour per week. Because students must enroll for individual studies by the end of the seventh class day of each semester, they should begin discussion of the proposed individual study preferably the semester before, so that there is time to devise the proposal and seek departmental approval before the registrar's deadline.

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. See department chair or website for full description. Prerequisite: GPA of at least 3.2, enrollment in Section 02 of CHEM 375 or CHEM 376, and permission of department chair.

CHEM 498 SENIOR HONORS

Credit: 0.5

See course description for CHEM 497.