 CHEMISTRY

Overview & Learning Goals

Learning Goals

Mission Statement

Our mission is to help our students develop an understanding of and appreciation for chemistry and to inspire and enable them to learn the practical and critical thinking skills necessary to both excel in their careers and to contribute to society as scientifically literate citizens. We believe that this mission is best accomplished using a two-pronged strategy:

1. by applying proven and innovative approaches to teaching and learning in the classroom and the laboratory
2. by coupling our classroom pedagogy to high-quality research at the frontiers of chemistry.

Download the Mapping Learning Goals to the Chemistry Curriculum Chart (https://www.bowdoin.edu/chemistry/pdf/chemistry-learning-goals-mapping.pdf)

Learning Outcomes for the Chemistry Major

Our students will understand, integrate, apply, and communicate fundamental and emerging chemical principles, moving from guided to self-designed investigations through courses or independent research. Our students will achieve these outcomes by meeting knowledge and skill-based competencies

Chemistry Knowledge Competencies

1. Structure and properties
2. Synthesis, reactivity, and transformation
3. Energy, equilibrium, and kinetics
4. Models and measurements

Skill-Based Competencies

1. Apply problem-solving strategies to quantitative and conceptual problems
2. Perform routine laboratory activities safely and responsibly
3. Document laboratory activities and manage data responsibly and ethically
4. Use chemical instruments with an understanding of their principles, capabilities, and outputs
5. Interpret complex data sets and propose evidence-based conclusions
6. Apply theoretical, conceptual, and empirical models
7. Search, engage, and evaluate scientific literature and databases
8. Communicate chemistry effectively in written, visual, and oral formats
9. Work collaboratively
10. Independently propose, design, and implement experiments and approaches to address questions in chemistry

Requirements

Chemistry Major

The chemistry major consists of a core curriculum and additional electives within a single area of concentration.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Courses</td>
<td>Select one of the following: a</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 1092</td>
<td>Introductory Chemistry and Quantitative Reasoning II</td>
<td></td>
</tr>
<tr>
<td>CHEM 1102</td>
<td>Introductory Chemistry II</td>
<td></td>
</tr>
<tr>
<td>CHEM 1109</td>
<td>General Chemistry</td>
<td></td>
</tr>
<tr>
<td>CHEM 2100</td>
<td>Chemical Analysis</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2250</td>
<td>Organic Chemistry I</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2400</td>
<td>Inorganic Chemistry</td>
<td>1</td>
</tr>
<tr>
<td>Select one of the following: b</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MATH 1700</td>
<td>Integral Calculus</td>
<td></td>
</tr>
<tr>
<td>MATH 1750</td>
<td>Integral Calculus, Advanced Section</td>
<td></td>
</tr>
<tr>
<td>placement above MATH 1750</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>PHYS 1130</td>
<td>Introductory Physics I</td>
<td>2</td>
</tr>
<tr>
<td>PHYS 1140</td>
<td>and Introductory Physics II</td>
<td></td>
</tr>
</tbody>
</table>

Select a concentration:

1. Chemical Concentration (p. 2) 5
2. Educational Concentration (p. 2) 7
3. Environmental Concentration (p. ) 5
4. Geochemical Concentration (p. 2) 5
5. Neurochemical Concentration (p. 2) 7

a Note that CHEM 1091 Introductory Chemistry and Quantitative Reasoning is a prerequisite for CHEM 1092 Introductory Chemistry and Quantitative Reasoning II; CHEM 1101 Introductory Chemistry is a prerequisite for CHEM 1102 Introductory Chemistry II. Placement above CHEM 1109 General Chemistry serves to meet this requirement and students do not have to replace the credit as part of the major requirements.

b Placement above MATH 1700 Integral Calculus/MATH 1750 Integral Calculus, Advanced Section satisfies the math requirement for the major and students do not have to replace the credit as part of the major requirements. Students intending to pursue graduate studies are encouraged to take a math course.
Only one physics course is required for students placed into PHYS 1140 Introductory Physics II. Students placed above PHYS 1140 Introductory Physics II are not required to take a physics course to satisfy the requirements of the major nor do they have to replace the credit in order to complete the requirements for the major. Note that PHYS 1130 Introductory Physics I is a prerequisite for PHYS 1140 Introductory Physics II.

Students are advised to begin their core curriculum as soon as possible. Depending on preparation and placement results, some students may begin with advanced courses.

**Chemical Concentration**

The Chemical Concentration consists of five credits.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2260</td>
<td>Organic Chemistry II</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 2261</td>
<td>Organic Chemistry II with Research Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2510</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2520</td>
<td>Quantum Chemistry and Spectroscopy</td>
<td>1</td>
</tr>
<tr>
<td>Select two electives from the following:</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CHEM 2320</td>
<td>Biochemistry</td>
<td></td>
</tr>
<tr>
<td>CHEM 3000 or higher</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

d Only one course numbered 4000 or higher can serve as one of the two electives.

**Educational Concentration**

The Educational Concentration consists of seven credits.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2510</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 2520</td>
<td>Quantum Chemistry and Spectroscopy</td>
<td></td>
</tr>
<tr>
<td>EDUC 1101</td>
<td>Contemporary American Education</td>
<td>1</td>
</tr>
<tr>
<td>EDUC 2203</td>
<td>Educating All Students</td>
<td>1</td>
</tr>
<tr>
<td>EDUC 3301</td>
<td>Teaching and Learning</td>
<td>1</td>
</tr>
<tr>
<td>EDUC 3302</td>
<td>Curriculum Development</td>
<td>1</td>
</tr>
<tr>
<td>Select two additional chemistry electives selected in consultation with the advisor</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

e These four courses also count toward an education minor or education coordinate major. This is the only exception to chemistry's double-counting rule that allows only two courses to count double between two majors or a major and a minor.

Students interested in pursuing a minor or coordinate major in education, or the Bowdoin Teacher Scholars certification program, should consult with their major advisor as well as with a faculty member in the education department to discuss course selection and content area prerequisites.

**Environmental Concentration**

The Environmental Concentration consists of five credits.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2510</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>1</td>
</tr>
<tr>
<td>Select two molecular perspective courses:</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CHEM 2050</td>
<td>Environmental Chemistry</td>
<td></td>
</tr>
<tr>
<td>CHEM 3050</td>
<td>Environmental Fate of Organic Chemicals</td>
<td></td>
</tr>
</tbody>
</table>

**Geochemical Concentration**

The Geochemical Concentration consists of five credits.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 2050</td>
<td>Environmental Chemistry</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2510</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 3100</td>
<td>Instrumental Analysis</td>
<td>1</td>
</tr>
<tr>
<td>Select two electives from the following:</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>EOS 2005</td>
<td>Biogeochmstry: An Analysis of Global Change</td>
<td></td>
</tr>
<tr>
<td>EOS 2165</td>
<td>Mountains to Trenches: Petrology and Process</td>
<td></td>
</tr>
<tr>
<td>EOS 2585</td>
<td>Ocean and Climate</td>
<td></td>
</tr>
<tr>
<td>EOS 3020</td>
<td>Earth Climate History</td>
<td></td>
</tr>
<tr>
<td>EOS 3115</td>
<td>Research in Mineral Science</td>
<td></td>
</tr>
</tbody>
</table>

f At least one elective must be at the advanced level (3000-3999)

**Neurochemical Concentration**

The Neurochemical Concentration consists of seven credits.

Chemistry majors completing the neurochemical concentration cannot also major in neuroscience.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1102</td>
<td>Biological Principles II</td>
<td>1</td>
</tr>
<tr>
<td>or BIOL 1109</td>
<td>Scientific Reasoning in Biology</td>
<td></td>
</tr>
<tr>
<td>CHEM 2260</td>
<td>Organic Chemistry II</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 2261</td>
<td>Organic Chemistry II with Research Laboratory</td>
<td></td>
</tr>
<tr>
<td>CHEM 2320</td>
<td>Biochemistry</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 2510</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 2520</td>
<td>Quantum Chemistry and Spectroscopy</td>
<td></td>
</tr>
<tr>
<td>Select two electives from the following:</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>BIOL 2135</td>
<td>Neurobiology</td>
<td></td>
</tr>
<tr>
<td>BIOL 2553</td>
<td>Neurophysiology</td>
<td></td>
</tr>
</tbody>
</table>
Chemistry Minor
The minor consists of four chemistry courses at or above the intermediate level (2000–2969). One intermediate or advanced independent study can count toward the minor.

Interdisciplinary Majors
The chemistry department participates in the biochemistry and environmental studies programs, as well as the interdisciplinary chemical physics major. See the Interdisciplinary Majors (https://catalogue.bowdoin.edu/departments-programs/interdisciplinary-majors) for more information.

Additional Information

Advanced Placement/International Baccalaureate (AP/IB)
Students who received a minimum score of four on the Chemistry AP exam or a minimum score of five on the Chemistry IB exam are eligible to receive a credit and can count it toward the major or minor after completion of CHEM 2050 Environmental Chemistry, CHEM 2100 Chemical Analysis, CHEM 2250 Organic Chemistry I, CHEM 2400 Inorganic Chemistry, CHEM 2510 Chemical Thermodynamics and Kinetics, or CHEM 2520 Quantum Chemistry and Spectroscopy with a minimum grade of C; however, credit is not given if the student places into or elects to take CHEM 1091 Introductory Chemistry and Quantitative Reasoning I, CHEM 1092 Introductory Chemistry and Quantitative Reasoning II, CHEM 1101 Introductory Chemistry I, CHEM 1102 Introductory Chemistry II or CHEM 1109 General Chemistry. Regardless of AP/IB score, all students must take the placement exam. In order to receive credit for advanced placement work, students must have their scores officially reported to the Office of the Registrar by the end of their sophomore year at Bowdoin.

The chemistry major can serve as preparation for many career paths after college, including the profession of chemistry, graduate studies in the sciences, medicine, secondary school teaching, and many fields in the business world. The department offers programs based on the interests and goals of the student; therefore, a prospective major should discuss their plans with the department as soon as possible. Regardless of career goals, students are encouraged to develop their critical thinking and problem-solving skills by participating in a collaborative student-faculty research project (Chemistry 2970–2999, 4000–4051, or summer research).

The department also offers an American Chemical Society-certified major in chemistry. The requirements for certification are met by taking additional courses in chemistry and other disciplines. Students interested in this certification program should consult their advisor and refer to guidelines found at acs.org/cpt (http://acs.org/cpt).

Independent Study/Honors Projects
Students may engage in independent study at the intermediate (2970–2999) or advanced (4000–4051) level. Majors pursuing honors in chemistry are required to register for CHEM 4050 during the fall and CHEM 4051 during the spring semester of their senior year and attend weekly seminars/workshops on Fridays, 2:30–4:00 p.m., during both semesters.

Courses

CHEM 1055 (a, INS) Science of Food and Wine
Non-Standard Rotation. Enrollment limit: 36.
Methods of food and wine preparation and production emerged from essentially controlled scientific experiments, even if the techniques of cooking are often carried out without thought of the underlying physical processes at play. Considers the science behind food and wine using bread baking, cooking techniques, the role of microbes in our diet, and wine making and appreciation to explore the chemistry and biology that underlie our gastronomy. Molecular structures and complex interactions central to cooking and wine are examined in integrated laboratory exercises. Assumes no background in science. Not open to students who have credit for a chemistry course numbered 1090 or higher.

Previous terms offered: Fall 2016.

CHEM 1056 (a, INS, MCSR) Investigations: The Chemistry of Forensics Science
A study of scientific principles that underlie chemical, instrumental, and some biological techniques used in criminal investigations by forensic scientists. Focuses on understanding materials at an atomic or molecular level to learn how forensic chemistry is used to make qualitative and quantitative measurements key to forensic investigations. Makes use of case studies and the study of specific chemical, physical, and spectroscopic techniques used in forensic investigations. Assumes no background in science. Students take part in three to four laboratory experiences. Not open to students who have credit for a chemistry course numbered 1090 or higher or to students who have credit for Mathematics 1300, Psychology 2520, or Economics 2557.

Previous terms offered: Spring 2017.
CHEM 1058 (a, INS) Drug Discovery
Danielle Dube.

The process of drug discovery of medicinal compounds has evolved over millennia, from the shaman’s use of medicinal herbs to the highly evolved techniques of rational design and high-throughput screening used by today’s pharmaceutical industry. Examines past and present approaches to drug discovery, with an emphasis on the natural world as a source of drugs, historical examples of drug discovery, and the experiments undertaken to validate a drug. Encourages students to take initial steps to identify novel therapeutics and to directly compare conventional versus herbal remedies in integrated laboratory exercises. Assumes no background in science. Not open to students who have credit for a chemistry course numbered 1090 or higher.

Previous terms offered: Fall 2017.

CHEM 1059 (a, INS) Chemistry of Consumer Goods
Non-Standard Rotation. Enrollment limit: 50.

Natural and synthetic “chemicals” make up virtually everything we purchase and consume from breakfast cereals to soaps, shampoo bottles, and over-the-counter medications. Examines the chemical components of food, drugs, soaps, plastics, and other consumer goods we encounter daily. Explores scientific resources that can be used to obtain information on product components, safety, and regulations. Also considers topics related to some of the current safety concerns raised by chemicals found in common household items through case studies and research projects. Assumes no background in science. Not open to students who have credit for a chemistry course numbered 1090 or higher.

Previous terms offered: Spring 2019.

CHEM 1060 (a, INS) Chemistry and the Quest for Discovery
Non-Standard Rotation. Enrollment limit: 25.

An exploration of the nature and evolution of the scientific discovery process as viewed through the lens of important historical and contemporary innovations in the field of chemistry. Examines relationships between cultural context and the motivation, practice, and impact of scientific research. Assumes no background in science. Students participate in weekly laboratory discovery experiences. Not open to students who have credit for a chemistry course numbered 1090 or higher.

Previous terms offered: Spring 2018, Spring 2016.

CHEM 1091 (a, INS) Introductory Chemistry and Quantitative Reasoning I
Michael Danahy.

The first course in a two-semester introductory college chemistry sequence covering the same content as Chemistry 1101/1102 with additional instruction focused on developing quantitative reasoning and problem-solving skills in the context of learning chemistry. Topics include the properties of matter, atomic and molecular structure, quantum and periodic trends, chemical bonding, intermolecular forces, stoichiometry, and aqueous solutions. Three hours of lecture, mandatory one-hour problem-solving session, and three hours of laboratory work per week. To ensure proper placement, students must take the chemistry placement examination prior to registration and must be recommended for placement in Chemistry 1091. Not open to students who have taken Chemistry 1101, 1102, or 1109. Students continuing in chemistry take Chemistry 1092 as their next chemistry course.

Prerequisites: Placement in CHEM 1091.

Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.

CHEM 1092 (a, INS, MCSR) Introductory Chemistry and Quantitative Reasoning II

The second course in a two-semester introductory college chemistry sequence that follows Chemistry 1091. Incorporates additional instruction focused on developing quantitative reasoning and problem-solving skills in the context of learning chemistry. Topics include gases, properties of solutions, thermodynamics and thermochemistry, kinetics, equilibrium, electrochemistry, and acid-base chemistry. Three hours of lecture, mandatory one-hour problem-solving session, and four hours of laboratory work per week.

Prerequisites: CHEM 1091.


CHEM 1093 (a, MCSR) Introduction to Quantitative Reasoning in the Physical Sciences
Every Fall. Enrollment limit: 20.

Climate science. Quantum Physics. Bioengineering. Rocket science. Who can understand it? Anyone with high school mathematics (geometry and algebra) can start. Getting started in physics requires an ability to mathematically describe real world objects and experiences. Prepares students for additional work in physical science and engineering by focused practice in quantitative description, interpretation, and calculation. Includes hands-on measurements, some introductory computer programming, and many questions about the physics all around us. Registration for this course is by placement only. To ensure proper placement, students must have taken the physics placement examination prior to registering for Physics 1093. (Same as: PHYS 1093)

Prerequisites: Placement in PHYS 1093.

Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.
CHEM 1101 (a, INS)  Introductory Chemistry I
Jeffrey Nagle.
Every Fall. Fall 2019. Enrollment limit: 30.

The first course in a two-semester introductory college chemistry sequence. Introduction to the states of matter and their properties, stoichiometry and the mole unit, properties of gases, thermochemistry, atomic structure, and periodic properties of the elements. Lectures, review sessions, and four hours of laboratory work per week. To ensure proper placement, students must take the chemistry placement examination and must be recommended for placement in Chemistry 1101. Students continuing in chemistry take Chemistry 1102, not Chemistry 1109, as their next chemistry course.

Prerequisites: Placement in CHEM 1101 or Placement in CHEM 1109/1101.

Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.

CHEM 1102 (a, INS, MCSR)  Introductory Chemistry II
Every Spring. Enrollment limit: 35.

The second course in a two-semester introductory college chemistry sequence. Introduction to chemical bonding and intermolecular forces, characterization of chemical systems at equilibrium and spontaneous processes, the rates of chemical reactions, and special topics. Lectures, review sessions, and four hours of laboratory work per week. Students who have taken Chemistry 1109 may not take Chemistry 1102 for credit.

Prerequisites: CHEM 1101.


CHEM 1105 (a, INS, MCSR)  Perspectives in Environmental Science
Every Spring. Enrollment limit: 35.

Understanding environmental challenges requires scientific knowledge about the different spheres of the Earth — land, water, air, and life — and how they interact. Presents integrated perspectives across the fields of biology, chemistry, and earth and oceanographic science to examine the scientific basis for environmental change from the molecular to the global level. Foundational principles are developed to address major course themes, including climate change, energy, soil/air/water pollution, chemical exposure and risk, land use change, and biodiversity loss. Laboratory sessions consist of local field trips, laboratory experiments, group research, case study exercises, and discussions of current and classic scientific literature. (Same as: ENVS 2201, BIOL 1158)

Prerequisites: BIOL 1101 or BIOL 1109 or CHEM 1091 - 2260 or PHYS 1130 or PHYS 1140 or EOS 1105 or EOS 1305 (same as ENVS 1104) or EOS 1505 (same as ENVS 1102) or EOS 2005 (same as ENVS 2221) or EOS 2115 or EOS 2335 or EOS 2345 (same as ENVS 2270) or EOS 2365 or EOS 2525 (same as ENVS 2251) or EOS 2535 or EOS 2585 (same as ENVS 2282) or ENVS 1101.


CHEM 1109 (a, INS, MCSR)  General Chemistry
Allison Dzubak.

A one-semester introductory chemistry course. Introduction to models of atomic structure, chemical bonding, and intermolecular forces; characterization of chemical systems at equilibrium and spontaneous processes; the rates of chemical reactions; and special topics. Lectures, review sessions, and four hours of laboratory work per week. Students who have taken Chemistry 1102 may not take Chemistry 1109 for credit. To ensure proper placement, students must take the chemistry placement examination and must be recommended for placement in Chemistry 1109.

Prerequisites: Placement in CHEM 1109/1101 or Placement in CHEM 1109 or Placement in CHEM 2000/1109 or Placement in CHEM 2000 level.

Previous terms offered: Spring 2019, Fall 2018, Spring 2018, Fall 2017, Spring 2017, Fall 2016, Fall 2015.

CHEM 2050 (a, INS)  Environmental Chemistry
Every Other Spring. Enrollment limit: 35.

Focuses on two key processes that influence human and wildlife exposure to potentially harmful substances, chemical speciation and transformation. Equilibrium principles as applied to acid-base, complexation, precipitation, and dissolution reactions are used to explore organic and inorganic compound speciation in natural and polluted waters; quantitative approaches are emphasized. Weekly laboratory sections are concerned with the detection and quantification of organic and inorganic compounds in air, water, and soils/sediments. (Same as: ENVS 2255, EOS 2325)

Prerequisites: CHEM 1092 or CHEM 1102 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109.

Previous terms offered: Spring 2018, Spring 2016.

CHEM 2100 (a, INS, MCSR)  Chemical Analysis
Elizabeth Stemmler.
Every Fall. Fall 2019. Enrollment limit: 35.

Methods of separating and quantifying inorganic and organic compounds using volumetric, spectrophotometric, electrometric, and chromatographic techniques are covered. Chemical equilibria and the statistical analysis of data are addressed. Lectures and four hours of laboratory work per week.

Prerequisites: CHEM 1092 or CHEM 1102 or CHEM 1109 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109.

Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.
CHEM 2250 (a) Organic Chemistry I
Richard Broene; Michael Danahy.
Every Fall. Fall 2019. Enrollment limit: 42.
Introduction to the chemistry of the compounds of carbon. Describes bonding, conformations, and stereochemistry of small organic molecules. Reactions of hydrocarbons, alkyl halides, and alcohols are discussed. Kinetic and thermodynamic data are used to formulate reaction mechanisms. Lectures, review sessions, and four hours of laboratory work per week.
Prerequisites: CHEM 1092 or CHEM 1102 or CHEM 1109 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109.
Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.

CHEM 2260 (a) Organic Chemistry II
Every Spring. Enrollment limit: 30.
Continuation of the study of the compounds of carbon. Highlights the reactions of aromatic, carbonyl-containing, and amine functional groups. Mechanistic reasoning provides a basis for understanding these reactions. Skills for designing logical synthetic approaches to complex organic molecules are developed. Lectures, review sessions, and four hours of laboratory work per week.
Prerequisites: CHEM 2250.

CHEM 2261 (a) Organic Chemistry II with Research Laboratory
Non-Standard Rotation. Enrollment limit: 08.
This laboratory section will differ from the others associated with this course by focusing on the conduct of actual research, in which students will design, construct, and test new enzyme mimics intended to facilitate the discovery of new medicines. As in the other laboratory sections, students will learn to generate experimental plans based on those found in the literature, execute experiments efficiently and safely, analyze and explain their data, and generate appropriate reports of their activities. The assessment and time expectations both in and outside of the laboratory are designed to be identical to those of the other laboratory sections, while giving the participants a perspective on modern chemistry research techniques and allowing them to contribute to advancing an important scientific field.
Prerequisites: CHEM 2250.
Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.

CHEM 2320 (a, MCSR) Biochemistry
Every Spring. Enrollment limit: 36.
Focuses on the chemistry of living organisms. Topics include structure, conformation, and properties of the major classes of biomolecules (proteins, nucleic acids, carbohydrates, and lipids); enzyme mechanisms, kinetics, and regulation; metabolic transformations; energetics and metabolic control. Lectures and four hours of laboratory work per week. This course satisfies a requirement for the biochemistry major. (Same as: BIOC 2320)
Prerequisites: CHEM 2260 or CHEM 2261.

CHEM 2400 (a, INS, MCSR) Inorganic Chemistry
Every Spring. Enrollment limit: 30.
An introduction to the chemistry of the elements with a focus on chemical bonding, periodic properties, and coordination compounds. Topics in solid state, bioinorganic, and environmental inorganic chemistry are also included. Provides a foundation for further work in chemistry and biochemistry. Lectures and four hours of laboratory work per week.
Prerequisites: CHEM 1092 or CHEM 1102 or CHEM 1109 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109.

CHEM 2510 (a, INS, MCSR) Chemical Thermodynamics and Kinetics
Kana Takematsu.
Every Fall. Fall 2019. Enrollment limit: 36.
Thermodynamics and its application to chemical changes and equilibria that occur in the gaseous, solid, and liquid states. The behavior of systems at equilibrium and chemical kinetics are related to molecular properties by means of statistical mechanics and the laws of thermodynamics. Lectures and four hours of laboratory work per week. Mathematics 1800 is recommended.
Prerequisites: Three of: either CHEM 1092 or CHEM 1102 or CHEM 1109 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109 and either PHYS 1130 or PHYS 1140 and MATH 1700 or higher or Placement in MATH 1800 (M) or Placement in 2000, 2020, 2206 (M).
Previous terms offered: Fall 2018, Fall 2017, Fall 2016, Fall 2015.

CHEM 2520 (a, INS, MCSR) Quantum Chemistry and Spectroscopy
Every Spring. Enrollment limit: 35.
Development and principles of quantum chemistry with applications to atomic structure, chemical bonding, chemical reactivity, and molecular spectroscopy. Lectures and four hours of laboratory work per week. Mathematics 1800 is recommended. Note: Chemistry 2510 is not a prerequisite for Chemistry 2520.
Prerequisites: Three of: either CHEM 1092 or CHEM 1102 or CHEM 1109 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109 and either PHYS 1130 or PHYS 1140.
CHEM 3050 (a, INS) Environmental Fate of Organic Chemicals
Non-Standard Rotation. Enrollment limit: 16.

More than 100,000 synthetic chemicals are currently in daily use. In order to determine the risk posed to humans and ecosystems, the extent and routes of chemical exposure must be understood and anticipated. Addresses the fate of organic chemicals following their intentional or unintentional release into the environment. Why do these chemicals either persist or break down, and how are they distributed between surface water, ground water, soil, sediments, biota, and air? Analysis of chemical structure used to gain insight into molecular interactions that determine the various chemical transfer and transformation processes, while emphasizing the quantitative description of these processes. (Same as: ENVS 3905)

Prerequisites: CHEM 2250.

Previous terms offered: Fall 2015.

CHEM 3100 (a) Instrumental Analysis
Every Other Spring. Enrollment limit: 15.

Theoretical and practical aspects of instrumental techniques, including nuclear magnetic resonance spectroscopy, infrared spectroscopy, Raman spectroscopy, and mass spectrometry are covered, in conjunction with advanced chromatographic methods. Applications of instrumental techniques to the analysis of biological and environmental samples are covered. Lectures and two hours of laboratory work per week.

Prerequisites: CHEM 2100.

Previous terms offered: Spring 2018, Spring 2016.

CHEM 3200 (a) Advanced Organic Chemistry: Organometallic Chemistry
Richard Broene.

In-depth study of compounds containing metal-carbon bonds and their reactions, with emphasis on synthesis and spectroscopy. A mechanistic approach is used to discover how these species act as catalysts or intermediates in synthetic organic reactions. Special techniques for handling these often sensitive molecules are introduced.

Prerequisites: Two of: either CHEM 2260 or CHEM 2261 and CHEM 2400.

Previous terms offered: Fall 2015.

CHEM 3250 (a) Structure Determination in Organic Chemistry
Non-Standard Rotation. Enrollment limit: 12.

The theory and application of spectroscopic techniques useful for the determination of the molecular structures of organic molecules are discussed. Mass spectrometry and infrared, ultraviolet-visible, and nuclear magnetic resonance (NMR) spectrosopies are applied to structure elucidation. Heavy emphasis is placed on applications of multiple-pulse, Fourier transform NMR spectroscopic techniques. Lectures and at least two hours of laboratory work per week.

Prerequisites: CHEM 2260 or CHEM 2261.

Previous terms offered: Fall 2017.

CHEM 3270 (a) Biomimetic and Supramolecular Chemistry
Non-Standard Rotation. Enrollment limit: 15.

A guided exploration of the primary scientific literature concerning weak covalent and noncovalent interactions that collectively determine the three-dimensional structures of biomimetic and foldameric molecules and that govern the aggregation of molecules into discrete multi-molecular assemblies. Surveys practical applications in biochemical investigation, catalysis, and medicine, as well as in the young but rapidly expanding sciences of molecular and nanostructural engineering. NOTE: There is NO LABORATORY WORK associated with this course. The required designated lab is a required discussion session.

Prerequisites: CHEM 2260 or CHEM 2261.

Previous terms offered: Fall 2018, Fall 2016.

CHEM 3310 (a) Chemical Biology
Every Other Fall. Enrollment limit: 16.

The power of organic synthesis has had a tremendous impact on understanding of biological systems. Examines case studies in which synthetically derived small molecules have been used as tools to tease out answers to questions of biological significance. Topics include synthetic strategies that have been used to make derivatives of the major classes of biomolecules (nucleic acids, proteins, carbohydrates, and lipids) and the experimental breakthroughs these molecules have enabled (e.g., polymerase-chain reaction, DNA sequencing, microarray technology). Emphasis on current literature, experimental design, and critical review of manuscripts.

Prerequisites: CHEM 2320.

Previous terms offered: Spring 2019, Fall 2017, Spring 2016.

CHEM 3400 (a) Advanced Inorganic Chemistry
Every Other Spring. Enrollment limit: 12.

Inorganic chemistry is incredibly diverse and wide-ranging in scope. Symmetry, spectroscopy, and quantum-based theories and computational methods are employed to gain insight into the molecular and electronic structures and reaction mechanisms of inorganic compounds. Examples from the current literature emphasized, including topics in inorganic photochemistry and biochemistry. Chemistry 2520 is recommended.

Prerequisites: CHEM 2400.

Previous terms offered: Spring 2019, Spring 2017.

CHEM 3510 (a) Reactivity and Kinetics
Non-Standard Rotation. Enrollment limit: 15.

Explores reactivity and kinetics from a physical chemistry perspective. We will survey theories and applications to model observed synthetic, gas phase, surface, and biological reactions. In particular, we will utilize a molecular picture to rationalize current and past discoveries in chemistry. Planned topics include aspects of the isotope effect and tunneling in catalysis, potential energy surfaces and molecular dynamic models, photochemistry and conical intersections, reaction dynamics and molecular beam experiments, enzymology, surface catalysis, polymer-binding, and charge-transfer models. Emphasis will be placed on reading and discussing scientific literature.

Prerequisites: CHEM 2510.

CHEM 3520 (a) Methods in Computational Chemistry
Non-Standard Rotation. Enrollment limit: 12.

Modern computational tools have deepened understanding of nearly all aspects of chemistry. Introduces a wide array of computational methods to solve problems ranging from atomic and molecular structure to experimental data analysis. Students work with commercial and open-source tools such as Matlab, R, GAMESS, Gaussian, and LabView.

Prerequisites: CHEM 1092 or CHEM 1109 or CHEM 1102.

Previous terms offered: Fall 2016.