

# CHEMISTRY (CHEM)

## **CHEM 1020 (a) Water Insecurity: Emerging Threats to a Vital Natural Resource**

Brandon Tate.

Non-Standard Rotation. Fall 2024. Enrollment limit: 16.

Explores integrative approaches to address critical threats to the global water supply, drawing on principles of environmental science, sustainable development, and green technology. Through scientific inquiry, policy analysis, and creative problem solving, students develop critical multidisciplinary research and writing skills while investigating a selection of case studies in groundwater depletion, wetland habitat destruction, wastewater remediation, and other emerging sustainability challenges surrounding one of the world's most vital and most threatened natural resources. (Same as: ENV 1028)

## **CHEM 1054 (a, INS) Chemistry in Art and Design**

Non-Standard Rotation. Enrollment limit: 24.

Examines the intersections of chemical science with the visual and performing arts. Fundamental concepts of atomic structure, chemical bonding, and chemical reactions are introduced through discussions of the material composition of artists' tools and media. Selected topics include the molecular origin of color in pigments and dyes, the aging and weathering of architectural structures over time, the science behind the preservation and restoration of works of art, and the development of polymers for 3D printing. Laboratory activities include hands-on applications of the scientific method to answer questions about the chemistry of artistic media as well as the creation of an original work of art inspired by chemistry. Assumes no background in science. Not open to students who have credit for a chemistry course numbered 1000 or higher or who have placements in CHEM 1109, CHEM 2000 level, or CHEM 2000/1109.

Previous terms offered: Fall 2023, Spring 2023.

## **CHEM 1055 (a, INS) Science of Food and Wine**

Non-Standard Rotation. Enrollment limit: 24.

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: Spring 2021.

## **CHEM 1058 (a, INS) Drug Discovery**

Non-Standard Rotation. Enrollment limit: 25.

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: Spring 2021.

## **CHEM 1061 (a, INS) The World at Nanoscale using Computers in Chemistry**

Every Fall. Enrollment limit: 50.

Computers can offer interactive learning experiences, visualization, simulations, and data analysis tools, making the subject more accessible and enjoyable. Students learn about nanoscale forces, using hands-on software exploration to run simple simulations (self-assembly, dissolving salt in water, buffer preparation, free energy estimations, material design for quantum computations) and undertake molecular visualization of their systems. Students learn animation and cinematic representations to explain complex concepts and dynamic processes. All computer codes and other materials will be provided. Assumes no background in science. Two hours lecture and 1-hour hands-on lab. Not open to students who have credit for a chemistry course numbered 1090 or higher.

Previous terms offered: Fall 2023.

## **CHEM 1091 (a, INS) Introductory Chemistry and Quantitative Reasoning I**

Michael Danahy; Abigail Snipe-Bushey; Sahel Mohebbi.

Every Fall. Fall 2024. Enrollment limit: 15.

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 2023, Fall 2022, Fall 2021, Fall 2020.

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

Kana Takematsu; Inoka Pathiraja; Abigail Snipe-Bushey.  
Every Spring. Spring 2025. Enrollment limit: 15.

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.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**CHEM 1093 (a, MCSR) Introduction to Quantitative Reasoning in the Physical Sciences**

Liz McCormack.  
Every Fall. Fall 2024. 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 2023, Fall 2022, Fall 2021, Fall 2020.

**CHEM 1101 (a, INS) Introductory Chemistry I**

Brandon Tate; Abigail Snipe-Bushey; Amnon Ortoll-Bloch; Sahel Mohebbi.  
Every Fall. Fall 2024. Enrollment limit: 45.

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 2023, Fall 2022, Fall 2021, Fall 2020.

**CHEM 1102 (a, INS, MCSR) Introductory Chemistry II**

Elizabeth Stemmler; Inoka Pathiraja; Abigail Snipe-Bushey.  
Every Spring. Spring 2025. Enrollment limit: 40.

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.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**CHEM 1105 (a, INS, MCSR) Perspectives in Environmental Science**

Shana Stewart Deeds; Mary Rogalski; Brandon Tate.  
Every Spring. Spring 2025. 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.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**CHEM 1109 (a, INS, MCSR) General Chemistry**

Inoka Pathiraja; Michael Henderson; Abigail Snipe-Bushey; Denny Tesfa; Thais Scott.  
Every Semester. Fall 2024; Spring 2025. Enrollment limit: 35.

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.

Previous terms offered: Spring 2024, Fall 2023, Spring 2023, Fall 2022, Spring 2022, Fall 2021, Spring 2021, Fall 2020.

**CHEM 2050 (a, INS) Environmental Chemistry**

Every Other Spring. Enrollment limit: 20.

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 1109 or CHEM 2000 - 2969 or Placement in CHEM 2000 level or Placement in CHEM 2000/1109.

Previous terms offered: Spring 2024, Spring 2022.

**CHEM 2100 (a, INS, MCSR) Chemical Analysis**

Elizabeth Stemmler; Kurt Luthy.

Every Fall. Fall 2024. Enrollment limit: 20.

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 2023, Fall 2022, Fall 2021, Fall 2020.

**CHEM 2250 (a) Organic Chemistry I**

Paulette Messier; Danielle Dube; Benjamin Gorske; Michael Danahy; Abigail Snipe-Bushey; Inoka Pathiraja.

Every Fall. Fall 2024. Enrollment limit: 35.

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 2023, Fall 2022, Fall 2021, Fall 2020.

**CHEM 2260 (a) Organic Chemistry II**

Paulette Messier; Michael Danahy; Benjamin Gorske; Martha Black.

Every Spring. Spring 2025. 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.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**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 to 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: Spring 2024.

**CHEM 2320 (a, MCSR) Biochemistry**

Danielle Dube; Kate Farnham.

Every Spring. Spring 2025. 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.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**CHEM 2400 (a, INS, MCSR) Inorganic Chemistry**

Amnon Ortoll-Bloch; Kurt Luthy.

Every Spring. Spring 2025. Enrollment limit: 24.

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.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**CHEM 2510 (a, INS, MCSR) Chemical Thermodynamics and Kinetics**

Martha Black; Kana Takematsu.

Every Fall. Fall 2024. 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 MATH 1700 or higher or Placement in MATH 1800 (M) or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M) and either PHYS 1130 or PHYS 1140.

Previous terms offered: Fall 2023, Fall 2022, Fall 2021, Fall 2020.

**CHEM 2520 (a, INS, MCSR) Quantum Chemistry and Spectroscopy**

Thais Scott; Martha Black.

Every Spring. Spring 2025. Enrollment limit: 12.

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 MATH 1700 or higher or Placement in MATH 1800 (M) or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M) and PHYS 1140.

Previous terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021.

**CHEM 2550 (a, INS, MCSR) Introduction to Computational Chemistry**

Non-Standard Rotation. Enrollment limit: 35.

An introduction to theories, models, and methods in computational chemistry. Computational modeling is used to explain observed chemical phenomena, predict properties of hypothetical chemical systems, and design or propose molecules and/or materials with specific properties. Depending on the nature of the chemical system and the information desired, different approximations and computational approaches are needed and explored in class. Students use existing computational modeling codes running on the Bowdoin high-performance computing grid to apply theories and methods to chemical problems. Three hours of lecture and one hour open lab session per week.

Prerequisites: Three of: either CHEM 2250 or CHEM 2400 or CHEM 2520 or PHYS 3140 and PHYS 1140 and MATH 1700 - 2969 or Placement in MATH 1800 (M) or Placement in MATH 1808 {2108} (M) or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M).

Previous terms offered: Fall 2021, Spring 2021.

**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 2020.

**CHEM 3055 (a) Catalysis in Sustainable Chemical Processes**

Brandon Tate.

Non-Standard Rotation. Spring 2025. Enrollment limit: 16.

Catalysis is a versatile tool in the development of sustainable chemical processes and renewable alternatives to fossil fuels and petrochemicals. The introduction of catalysis to an industrial chemical process provides opportunities for improved energy efficiency, reduced waste, conservation of scarce natural resources, lower costs, and greater selectivity, potentially facilitating chemical transformations that are otherwise inaccessible. This course covers essential concepts in transition state theory and chemical kinetics and the application of catalysis to outstanding problems in global chemical sustainability. Approaches to the design, characterization, and optimization of inorganic, organic, and biological catalysts are discussed in the context of applications including chemical energy storage, carbon capture and utilization, biomass conversion, sustainable plastics and polymers, and environmental remediation. (Same as: ENVS 3904)

Prerequisites: CHEM 2250.

Previous terms offered: Fall 2022.

**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 2024, Spring 2022.

**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) spectroscopies 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 2023, Fall 2021.

**CHEM 3270 (a) Biomimetic and Supramolecular Chemistry**

Benjamin Gorske.

Non-Standard Rotation. Fall 2024. 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 2022, Spring 2022, Spring 2021.

**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 2024, Spring 2023, Fall 2021, Fall 2020.

**CHEM 3320 (a, MCSR) Molecular Biophysics**

Non-Standard Rotation. Enrollment limit: 16.

This course will take a quantitative approach relying on principles from thermodynamics, kinetics and mechanics to explore how the structure, function and assembly of molecular components like lipids, proteins and DNA govern biological systems and their physical-chemical behavior. Topics will include: (1) lipid membrane organization and lipid-protein interactions, (2) transport mechanisms, (3) compartmentalization through liquid-liquid phase separation, and (4) mechanisms of force generation through molecular motors and cytoskeletal polymers. Emphasis throughout the course will be placed on experimental methodologies employed in these topic areas such as optical microscopy, single-molecule approaches, and force spectroscopies. The format will be a combination of lectures, discussions and journal article presentations. (Same as: BIOC 3320)

Prerequisites: Two of: PHYS 1130 and CHEM 2320 (same as BIOC 2320).

Previous terms offered: Fall 2023.

**CHEM 3400 (a) Materials Chemistry**

Amnon Ortoll-Bloch.

Every Other Spring. Fall 2024. Enrollment limit: 12.

Provides an introduction to the field of materials science, emphasizing the relationships between structure, processing, and properties of materials. Topics include imperfections in crystalline solids, crystal nucleation and growth, and solution-phase materials synthesis and crystallization methods. Examples from the current literature will be discussed to familiarize students with the state-of-the-art of the field and to provide opportunities to critically review manuscripts.

Prerequisites: CHEM 2400.

Previous terms offered: Spring 2024, Spring 2023, Spring 2021.

**CHEM 3510 (a) Reactivity and Kinetics**

Kana Takematsu.

Non-Standard Rotation. Spring 2025. 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.