CHEMISTRY

Chair, Associate Professor Kevin Rice
Associate Chair, Associate Professor Karena McKinney
Professors Jeffrey Katz, Whitney King, Julie Millard, and Dasan Thamattoor; Associate Professors Rebecca Conry, Karena McKinney, and Kevin Rice; Assistant Professors Gregory Drozd and Lindsey Madison; Reuben Hudson, Research Scientist; Senior Laboratory Instructor Lisa Miller; Laboratory Instructor II Edmund Klinkerch; Laboratory Instructor I Victoria Hepburn

Students in the Chemistry Department are provided a firm foundation in the fundamental principles of the discipline. Majors have access to a wide range of instruments for coursework and research projects under supervision of a faculty that includes teaching specialists in analytical, environmental, inorganic, organic, and physical chemistry, and biochemistry. Many students go on to graduate school in chemistry or biochemistry or to careers in medicine, dentistry, health-related fields, or industrial research. Other career choices in recent years have included patent law, chemical engineering, environmental science, computer science, and molecular biology.

The department offers several programs: (1) the chemistry major, (2) the chemistry-biochemistry major, (3) the chemistry major with a concentration in cell and molecular biology/biochemistry, (4) the chemistry-environmental sciences concentration, and (5) the chemistry minor. Additionally, each type of chemistry major can earn accreditation by the American Chemical Society (ACS) with additional courses selected in consultation with the advisor and with approval of the chair. More information about ACS certification can be found on the Chemistry Department website. Chemistry majors who intend to apply for admission to medical, dental, or veterinary schools must take a biology course with laboratory. For maximum flexibility, students are encouraged to take Chemistry 141 and 142 (or Chemistry 147 or Chemistry 121 and 122) in their first year.

Students interested in teaching, private and public, are urged to read the “Education” section of the catalogue and to contact a member of the Education Program.

Requirements for the Major in Chemistry
Chemistry 141 and 142 (or 121 and 122, or 147), 241, 242, 341, 342, 493, 494, and two courses, at least one with laboratory, from Chemistry 331, 362, 367, 411 (413 is the laboratory for 411); Mathematics 121 and 122, or 161 and 162; Physics 141 (or 143) and 145.

Requirements for the Major in Chemistry-Biochemistry
Chemistry 141 and 142 (121 and 122, or 147), 241, 242, 341, 367 (with laboratory), 368 (with laboratory), 493 and 494; Mathematics 121 and 122, or 161 and 162; Physics 141 (or 143) and 145; Biology 163 and 279 (with laboratory); and one course from Chemistry 331, 342, 378, 411, 444. Biology 279 and/or biochemistry courses used to fulfill a biology major cannot count toward the major in chemistry-biochemistry.

Requirements for the Major in Chemistry with a Concentration in Cell and Molecular Biology/Biochemistry
Chemistry 141 and 142 (or 147 or 121 and 122), 241, 242, 341, 367 (with laboratory), 368 (with laboratory), 378, 493, and 494; Biology 163 and 279 (with laboratory); Mathematics 121 and 122, or 161 and 162; Physics 141 (or 143) and 145. Biochemistry 367, 368, 378, and Biology 279 cannot be double counted toward both a biology major and the major in chemistry with a concentration in cell and molecular biology/biochemistry.

Requirements for the Concentration in Chemistry-Environmental Science
Chemistry 141 and 142 (or 147 or 121 and 122), 241, 242, 331, 341, 342, 493, 494, Mathematics 121 and 122, or 161 and 162; Physics 141 (or 143) and 145; Chemistry 217 or 278, and 481 or 482; Economics 133, 231, Biology 163, or Geology 141 and one additional geology class (if student did not take CH121 and CH122).

Additional Requirements for All Majors in the Chemistry Department
Each major must complete a chemistry-related independent study project equivalent to two (or preferably three) credit hours. This requirement may be satisfied through independent study, internship, or summer research, and it forms the basis of the seminar presentations in Chemistry 493 and 494. An off-campus research experience must have prior approval of the chair of the Chemistry Department to satisfy this requirement.

The seminar program (Chemistry 493, 494) is an opportunity for students to interact with chemists from other schools. All senior chemistry majors are required to enroll in Chemistry 493 and 494. Junior chemistry majors are strongly encouraged to attend and may enroll in either Chemistry 493 or 494.

The point scale for retention of the major applies to all required courses and all elected chemistry courses. No requirement for the major may be taken satisfactory/unsatisfactory.
Honors Project in Chemistry

Majors in chemistry are encouraged to elect an honors research project with approval of a faculty sponsor in the department. Honors research normally entails eight to 10 credits across the senior year. Successful completion of the work of the honors research project, and of the major, will enable the student to graduate with “Honors in Chemistry.” Attention is also called to the Senior Scholars Program.

Requirements for the Minor in Chemistry

Chemistry 141 and 142 (or 147 or 121 and 122), 241, and at least 10 additional credit hours in any chemistry courses except Chemistry 112, 115, 143, 144, 197, 481, 482, 491/492 (or other independent study), 493, and 494, with at least one course at the 300- or 400-level. Courses selected to fulfill the minor must include at least four courses in addition to courses taken to satisfy requirements for any major or other minor (e.g., biochemistry courses and Chemistry 217 cannot be double counted toward another major and the chemistry minor). Students are strongly advised to consult with a member of the chemistry faculty to select a logical grouping of courses for the minor.

Course Offerings

**CH115f  The Science of Crime** Over the last century, science has changed how crime has been committed, investigated, and written about. We study crime, including violent crime, while cultivating writing, critical analysis, and research skills. Frequent short essays explore topics surrounding both true and fictional crimes, including characterization of trace evidence, mechanisms of toxicology, DNA profiling, and ethical responsibilities in the forensic laboratory.  *Four credit hours. N, W1. MILLARD*

**CH121f  Earth Systems Chemistry I** The Earth is a dynamic chemical reactor that changes on timescales of seconds to millions of years through natural and anthropogenic forcings. This two-semester sequence explores fundamental chemistry principles, including the structure of the atom, chemical bonding and reactivity, chemical equilibria, and thermodynamics through the lens of Earth's 4.56-billion-year history. By constructing quantitative models of Earth systems, students also learn how Earth processes operate over time and space, how they shape the environments in which we live, and the theoretical and practical limits of resource utilization.  *Four credit hours. N, Lb. KOFFMAN, MCKINNEY*

**CH122s  Earth Systems Chemistry II** The Earth is a dynamic chemical reactor that changes on timescales of seconds to millions of years through natural and anthropogenic forcing. This two-semester sequence explores fundamental chemistry principles, including the structure of the atom, chemical bonding and reactivity, chemical equilibria, and thermodynamics through the lens of Earth's 4.56-billion-year history. By constructing quantitative models of Earth systems, students also learn how Earth processes operate over time and space, how they shape the environments in which we live, and the theoretical and practical limits of resource utilization. *Prerequisite: Chemistry 121.*  *Four credit hours. N, Lb. DROZD, KOFFMAN*

**CH141f  General Chemistry I** Fundamental principles of chemistry including atomic theory, stoichiometry, solution chemistry, gas laws, thermochemistry, chemical bonding, and intermolecular forces. Does not assume prior knowledge in chemistry. Students will become proficient at using pre-calculus-level quantitative skills in a scientific context and will master the interface between narrative and mathematical problem solving. The laboratory will familiarize students with experimental techniques and the accumulation and analysis of experimental data. Students with prior credit for Chemistry 145 may not receive credit for Chemistry 141. Lecture, discussion, and laboratory.  *Four credit hours. N, Lb. KING, MADISON*

**CH142s  General Chemistry II** Explores the fundamental principles of chemistry including chemical equilibria, thermodynamics, kinetics, electrochemistry, and radioactivity. Students will become proficient at using pre-calculus-level quantitative skills in a scientific context and will master the interface between narrative and mathematical problem solving. The laboratory will familiarize students with experimental techniques and the accumulation and analysis of experimental data. Students with prior credit for Chemistry 145 may not receive credit for Chemistry 142. Lecture and laboratory. *Prerequisite: Chemistry 141.*  *Four credit hours. N, Lb. MCKINNEY, MILLARD*

**CH143f  Turbo Chemistry** A recitation section designed to amplify the material covered in General Chemistry lecture with extra challenging homework, practice exams, and required group problem sets. *Prerequisite: Permission of the instructor.*  *One credit hour. MCKINNEY*

**CH144s  Turbo Chemistry** A recitation section designed to amplify the material covered in General Chemistry lecture with extra challenging homework, practice exams, and required group problem sets. *Prerequisite: Permission of the instructor.*  *One credit hour. MCKINNEY*

**CH147s  Comprehensive General Chemistry** Introductory chemistry course with content similar to Chemistry 141 and 142 but in a single semester. Suitable for students with strong high school chemistry preparation. Students will become proficient at using pre-calculus-level quantitative skills in a scientific context and mastering the interface between narrative and mathematical problem solving. The
laboratory will familiarize students with experimental techniques and the accumulation and analysis of experimental data. Structured to fulfill the general chemistry requirement for medical school and counts as both Chemistry 141 and 142 for course prerequisites. Students with prior credit for Chemistry 131, 141, 142, or 145 cannot receive credit for this course. Previously listed as Chemistry 131. Four credit hours. N, Lb.

[CH151] K-8 Chemistry Outreach Activities Development of hands-on activities to fulfill physical science goals required by the Maine Learning Results. Students create age-appropriate science experiments that illustrate the relevance of chemistry to society and implement these activities in area classrooms and on campus. Communication skills are enhanced through the development of teacher kits (written) and interaction with schoolchildren (oral). Lecture only. Prerequisite: Chemistry 112 with laboratory, or 118 with laboratory, or 131, 141, 145, or 147. Three credit hours. N.

[CH176] Exercise Physiology Listed as Biochemistry 176. Three credit hours. N, Lb.

CH217s Environmental Chemistry Develops an understanding of how physical, chemical, and biological processes create and define the natural world. Focus is on the fundamental equilibrium and kinetic processes that control global systems, including the composition of the atmosphere, ocean, and biosphere. Building on the concept of residence time and chemical reactivity, students learn how to evaluate the impact of anthropogenic modifications to the environment over a range of spatial and temporal scales. Current topics such as acid deposition, global warming, atmospheric ozone loss, and the fate and toxicity of heavy metals are discussed in the context of natural environmental processes. Prerequisite: Chemistry 131, 142, 145, or 147. Four credit hours. MCKINNEY

CH241f Organic Chemistry I Exploration of the relationships among structure, reactivity, and synthesis of organic compounds. The lecture portion introduces atoms and molecules, orbitals and bonding, the chemistry of alkanes, alkenes, alkynes, and other functional groups, stereochemistry, ring systems, substitution and elimination reactions, and kinetics and equilibria. The laboratory involves the use of common techniques used by chemists, instrumentation, and molecular modeling. The goals are to help students think critically, solve problems, and write effectively. Prerequisite: Chemistry 131, 142, 145, or 147. Four credit hours. THAMATTOOR

CH242s Organic Chemistry II Theories encountered in Chemistry 141, 142 are used as the basis for a detailed study of the relationships among structure, reactivity, and synthesis of organic compounds. Lecture, discussion, and laboratory. The laboratory explores the use of separation techniques, synthesis, and spectral techniques in organic chemistry. Prerequisite: Chemistry 241. Four credit hours. KATZ

[CH255] Nuclear Magnetic Resonance The theory and practice of one- and two-dimensional NMR, infrared spectroscopy, and mass spectrometry. Examples include complex organic species and biological macromolecules, including proteins. Laboratory exercises include sample preparation and common two-dimensional NMR experiments, including polarization transfer (DEPT), chemical shift correlation (COSY, TOCSY, HMQC, HMBC, Adequate), and nuclear Overhauser effect (NOESY) spectroscopy. Skills developed include the ability to sift through incomplete and sometimes conflicting data to reach a logical conclusion based on available evidence. Offered in alternate January Programs. Lecture and laboratory. Prerequisite: Chemistry 241. Three credit hours.

[CH265] Green Chemistry Intended to provide students with an introduction to green chemistry, not a specific field of its own, but instead a broad philosophy urging the reduction or elimination of the use or generation of hazardous substances in chemical design, manufacturing, and application. Students will examine the principles of green chemistry used on the research and industrial scales, after gaining a general background in toxicology, ecology, and the historical context that led to the search for safer chemicals and methods. Previously offered as Chemistry 297 (2014). Prerequisite: Chemistry 241. Three credit hours.

[CH278] Joules to Dollars Listed as Economics 278. Four credit hours. N.

CH331f Chemical Methods of Analysis A study of the fundamentals of analytical chemistry. Students learn how to use physical measurements to make quantitative chemical measurements reported with defined uncertainties. Concepts of chemical mass and charge balance are used to calculate chemical speciation in complex acid/base and redox systems. Lectures and homework focus on problem-solving skills that provide solutions to new problems based on fundamental chemical principles and constants. The required laboratory introduces advanced volumetric, potentiometric, and spectrophotometric techniques for quantitative chemical analysis. Written lab reports reinforce the technical writing style used in chemical communications. Prerequisite: Chemistry 131, 142, 145, or 147. Four credit hours. KING

CH332s Instrumental Methods of Analysis Instruction in instrumental methods, including modern electroanalytical methods, absorption spectroscopy, fluorescence, Raman spectroscopy, mass spectrometry, and chromatography. Lecture and laboratory. Prerequisite: Chemistry 331. Chemistry 342 is recommended. Four credit hours. KING
CH341f  Physical Chemistry: Thermodynamics and Kinetics  The laws and theories of chemical reactivity and the physical properties of matter. Emphasis is placed on chemical equilibrium, molecular bonding, and the rates of chemical reactions. Major topics: thermodynamics, solutions, and reaction kinetics. Gaining facility with abstraction through building mathematical models, working through the implications of those models, and assessing the validity and inherent errors in the ability of the models to predict and explain physical phenomena are the primary goals. Lecture and laboratory.  Prerequisite: Chemistry 131, 142, 145, or 147; Mathematics 122 or 162; and Physics 145. Chemistry 342 may be taken before 341 with permission of the instructor.  Five credit hours.  DROZD

CH342s  Physical Chemistry: Quantum and Statistical Mechanics  The laws and theories of chemical reactivity and the physical properties of matter. Emphasis is placed on chemical equilibrium, molecular bonding, and the rates of chemical reactions. Major topics: quantum mechanics, spectroscopy, and statistical mechanics. Gaining facility with abstraction through building mathematical models, working through the implications of those models, and assessing the validity and inherent errors in the ability of the models to predict and explain physical phenomena are the primary goals. Lecture and laboratory.  Prerequisite: Chemistry 341. 342 may be taken before 341 with permission of instructor.  Five credit hours.  MADISON

CH362fs  Medical Biochemistry  Listed as Biochemistry 362.  Four credit hours.  MILLARD, MOLONEY

CH367f  Biochemistry of the Cell I  Listed as Biochemistry 367.  Four or five credit hours.  RICE

CH368s  Biochemistry of the Cell II  Listed as Biochemistry 368.  Four or five credit hours.  RICE

CH378s  Molecular Biology  Listed as Biochemistry 378.  Four credit hours.  VAN OERS

[CH411]  Inorganic Chemistry  Current models and concepts in inorganic chemistry are discussed, with an emphasis on general trends and periodic properties of the chemical elements and their compounds. Topics include bonding and structure, acid-base theories, redox properties, molecular symmetry, and coordination compounds. Students will expand their knowledge of fundamental chemical principles as well as their ability to critically think about, communicate, and apply this knowledge in problem solving. Lecture only.  Prerequisite: Chemistry 131, 142, 145, or 147 and junior or higher standing. Chemistry 342 is recommended.  Three credit hours.

[CH413]  Inorganic Laboratory Studies  Synthesis and characterization of inorganic and organometallic compounds of both the representative and transition elements. Discussion and laboratory. Co-requisite: Chemistry 411.  Two credit hours.

[CH431]  Mechanistic Organic Chemistry  Based on original research articles and designed to teach students to think critically about published material. The readings cover topics such as chemical bonding, molecular orbital theory, and aromaticity, the use of isotopes in determining reaction mechanisms, reactions of atomic carbon, matrix isolation spectroscopy, laser flash photolysis, the influence of structure on reactivity, the role of thermodynamics and kinetics in reactions, linear free energy relationships, and unusual molecules. Students are instructed on computational modeling of chemical reactions, structures, and spectroscopic properties and are taught to retrieve information from the chemical literature.  Four credit hours.

CH432s  Advanced Organic Chemistry  The logic and methods of organic synthesis are explored. The elementary organic reactions studied in Chemistry 241, 242 are augmented and used in the synthesis of biologically and chemically important molecules. Lecture only.  Prerequisite: Chemistry 242 or equivalent.  Four credit hours.  KATZ

[CH434]  Symmetry and Spectroscopy  Use of principles of symmetry and group theory as an aid in understanding chemical bonding, interpreting molecular vibrational and electronic spectroscopy, and rationalizing symmetry control of reactions. Lecture only.  Prerequisite: Chemistry 411.  Four credit hours.

CH444s  Advanced Methods in Biochemistry  A detailed look at current trends in experimental research at the interface of chemistry and biology. Critical analyses of recent literature, identification of important problems in the field, and development of proposals to address these problems will be of primary focus. Problem-solving assessments will include both written and oral communication skills. Topics will include proteomics, chemical biology, and advanced enzymology.  Prerequisite: Biochemistry 367 and 368 (the latter may be taken concurrently), and a W1 course.  Four credit hours.  W3.  RICE

[CH481f, 482s]  Special Topics in Environmental Chemistry  Primarily a laboratory course with emphasis on independent studies of environmentally related topics. A paper and oral presentation are required.  Prerequisite: Chemistry 217 and permission of the department.  One to three credit hours.

CH483f, 484s  Honors in Research in Chemistry  Laboratory and library work involving a senior and one or more chemistry faculty
members on a clearly defined project that results in an honors thesis. Prerequisite: Permission of the department and recommendation of the faculty sponsor. One to four credit hours. FACULTY

**CH491f, 492s  Independent Study** Laboratory work of a research nature may be arranged with the instructor. One to four credit hours. FACULTY

**CH493f, 494s  Senior Seminar** Discussion of topics of current interest in all areas of chemistry. Presentations by invited speakers from other colleges, universities, and industry. Seniors give a presentation on their research each semester. Prerequisite: Junior or senior standing as a chemistry major. One credit hour. RICE