CHEMISTRY

Chair, *Associate Professor Kevin Rice*
Associate Chair, *Professor Dasan Thamattoor*
Professors Jeffrey Katz, Whitney King, Julie Millard, and Dasan Thamattoor; Associate Professors Rebecca Conry, Karena McKinney, *and Kevin Rice; Assistant Professors Greg Drozd and Lindsey Madison; 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 from Chemistry 261 or 263, 362 or 367, 411; two laboratory courses from Chemistry 367L, 413, 442, 452 (452 can serve as both required laboratory courses); 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 (or 121 and 122, or 147), 241, 242, 341, 367 (with laboratory), 368 (with laboratory), 493 and 494, and one course from Chemistry 342, 378, 411, 444, 452; Mathematics 121 and 122, or 161 and 162; Physics 141 (or 143) and 145; Biology 163 and 279 (with laboratory). 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 121 and 122, or 147), 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 121 and 122, or 147), 241, 242, 261 (or 263), 341, 493, 494, and one course from Chemistry 263 (or 261), 278, 342, or 411; one laboratory course from Chemistry 413, 442, or 452; Mathematics 121 and 122, or 161 and 162; Physics 141 (or 143) and 145; Economics 133 and 231, or Biology 163 and 164, or Geology 141 (if student did not take CH121 and CH122) and one additional geology class.

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 121 and 122, or 147), 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

[CH121] 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. Students with prior credit for Chemistry 141, 142, or 147 cannot receive credit for this course. *Prerequisite:* Students with prior credit for Chemistry 141, 142, or 147 cannot receive credit for this course. *Four credit hours.* **N, Lb.**

[CH122] 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.**

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 121 or 147 cannot receive credit for this course. Lecture, discussion, and laboratory. *Prerequisite:* Students with prior credit for Chemistry 121 or 147 cannot receive credit for this course. *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 122 or 147 cannot receive credit for this course. Lecture and laboratory. *Prerequisite:* Chemistry 141. Students with prior credit for Chemistry 122 or 147 cannot receive credit for this course. *Four credit hours.* **N, Lb.** MCKINNEY, RICE

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.* KING

[CH144] 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.*

CH147fs 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. *Prerequisite:* Students with prior credit for Chemistry 121, 122, 141 or 142 cannot receive credit for this course. Previously listed as Chemistry 131. *Four credit hours.* **N, Lb.** CONRY, RICE

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 122, 142, 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

CH261s Chemistry of Aqueous Environments Students explore how the Earth's marine and freshwater aqueous environments are shaped by physical, chemical, and biological processes and interactions with the atmosphere, lithosphere, and biosphere. We investigate the fundamental equilibrium and kinetic processes that control a variety of aqueous chemical phenomena relevant for environmental systems at a range of spatial and temporal scales, including acid base chemistry, redox reactions, solid and gas solubility, and reaction rates and mechanisms. Concepts of mass and charge balance are used to calculate chemical speciation in complex systems. Issues such as acid deposition, ocean acidification, eutrophication, water purification, and the fate and toxicity of heavy metals are discussed in the context of natural environmental processes. *Prerequisite:* Chemistry 122, 142, or 147. *Four credit hours.* KING

CH263f Atmospheric Chemistry An investigation of Earth s atmosphere and the chemical and physical principles that shape it. Fundamental processes that determine atmospheric composition and climate, including multistep reaction mechanisms, chemical kinetics, molecular spectroscopy, photolysis, and heterogeneous chemistry, are introduced. Specific topics treated will include atmospheric composition, structure, and motion; element cycling; the transfer of solar and longwave radiation; stratospheric composition and chemistry; tropospheric oxidation processes; air pollution; and the role of human activity in global change. *Prerequisite:* Chemistry 122, 142 or 147. *Four credit hours.* MCKINNEY

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

CH297j Fate and Effects of Organic Pollutants in the Ocean An examination of how the physico-chemical properties of organic pollutants determine their fate in the ocean. We discuss how the environmental behavior and ecotoxicity of legacy and novel chemicals (petroleum, pesticides, microplastics, "forever-chemicals") are influenced by fundamental processes like partitioning, biodegradation, and photodegradation. Lecture, discussions of recent papers, as well as laboratory projects will be involved. *Prerequisite:* Chremistry 241. *Three credit hours.* AEPPLI

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 122, 142, 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 only. *Prerequisite:* Chemistry 341. 342 may be taken before 341 with permission of instructor. *Four credit hours.* MADISON

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

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.* MILLARD

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

CH411f 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 122, 142, or 147 and junior or higher standing. Chemistry 342 is recommended. *Four credit hours.* CONRY

CH413f 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.* CONRY

CH431s 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. *Prerequisite:* Lecture only. Chemistry 242 or equivalent. *Four credit hours.* THAMATTOOR

[CH432] 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.*

CH442s Computational Chemistry Exploring the fundamental physical forces acting on electrons and atoms in molecules to better understand chemical properties and reactivity. Students will build on foundational knowledge of quantum mechanics and thermodynamics to understand how and why computer simulations can offer such chemical insights, deepening their own understanding of reaction mechanisms, condensed phase behavior, and aspects of spectroscopy. After learning the principles of molecular dynamics and electronic structure calculations, students will design and propose a computational experiment to address a research question. Co-requisite: Chemistry 342. *Two credit hours.* MADISON

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 (with laboratory) and 368 (the latter may be taken concurrently), and a W1 course. *Four credit hours.* **W3.** RICE

CH452s Problems in Chemical Analysis An exploration of how physical principles and analytical techniques are used to address research questions by engaging in a semester long, team-based project in which students design, construct, and evaluate a solution to a current chemical analysis problem. In developing a solution, students will draw on fundamental physical chemical concepts, principles, and techniques learned in prior chemistry courses along with independent literature research, and apply advanced quantitative methods, such as potentiometric, spectroscopic, and computational techniques for chemical analysis. Students also gain experience with experimental design, team-based problem solving, and project management, and written and oral communication of scientific results. *Prerequisite:* Chemistry 341. *Four credit hours.* KING, MCKINNEY

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.* CONRY