

## DEPARTMENT OF CHEMISTRY

<http://www.uvm.edu/cas/chemistry> (<http://www.uvm.edu/cas/chemistry/>)

Chemistry is the center of science. Chemists seek understanding of all aspects of the physical and biological worlds at the molecular level, developing methodologies to probe the structure of molecules and chemical reactions. These techniques are critical to solving biological and biomedical problems and also provide tools to address important problems in materials science, geology, and in the environmental sciences.

Chemistry students gain the intellectual skills needed to confront and solve difficult problems and develop a rigorous lifelong commitment to learning. In conjunction with the Chemistry Department's active Ph.D. program, undergraduate Chemistry majors work with faculty members and graduate students engaged in cutting-edge research. This participation brings state-of-the-art perspectives to undergraduate learning that can only be obtained at a modern research university.

Chemistry students learn to be creative thinkers, scientists, and clear communicators, under the guidance of internationally recognized faculty who are deeply committed to teaching, advising, and research. Faculty regularly garner funding from the National Science Foundation, National Institutes of Health, and the U.S. Department of Energy, among others, for research in areas that include biomedical applications and drug development, environmental science, and materials science.

## MAJORS

### CHEMISTRY MAJORS

Chemistry B.A. (<http://catalogue.uvm.edu/undergraduate/artsandsciences/chemistry/chemistry-ba/>)

Chemistry B.S. (<http://catalogue.uvm.edu/undergraduate/artsandsciences/chemistry/chemistry-bs/>)

## MINORS

### CHEMISTRY MINOR

Chemistry (<http://catalogue.uvm.edu/undergraduate/artsandsciences/chemistry/chemistry-minor/>)

## GRADUATE

Chemistry AMP

Chemistry M.S.

Chemistry Ph.D.

See the online Graduate Catalogue (<http://catalogue.uvm.edu/graduate/>) for more information.

## Courses

### **CHEM 023. Outline of General Chemistry. 0 or 4 Credits.**

One-semester survey of principles and concepts of general chemistry, topics covered include bonding, mole ratios, equilibrium, and nuclear chemistry. May not be taken for credit concurrently with, or following receipt of, credit for CHEM 025, CHEM 031, or CHEM 035.

### **CHEM 025. Outline of General Chemistry. 3 Credits.**

One-semester survey of principles and concepts of general chemistry, topics covered include bonding, mole ratios, equilibrium, and nuclear chemistry. NO LABORATORY. May not be taken for credit concurrently with, or following receipt of, credit for CHEM 023, CHEM 031 or CHEM 035.

### **CHEM 026. Outline of Organic & Biochem. 0 or 4 Credits.**

Broad overview of most important facts and principles of organic and biochemistry and interrelationships between these branches of chemistry. May not be taken for credit concurrently with, or following receipt of, credit for CHEM 028, CHEM 042 or CHEM 044. Prerequisite: CHEM 023 or CHEM 031.

### **CHEM 028. Outline of Organic & Biochem. 3 Credits.**

Broad overview of most important facts and principles of organic and biochemistry and of interrelationships between these branches of chemistry. NO LABORATORY. May not be taken for credit concurrently with, or following receipt of, credit for CHEM 026, CHEM 042 or CHEM 044. Prerequisite: CHEM 023, CHEM 025, or CHEM 031.

### **CHEM 031. General Chemistry 1. 0 or 4 Credits.**

First semester of a two-semester sequence. Topics include matter, stoichiometry, gas laws, thermochemistry, quantum theory, atomic structure, electronic configurations, bonding, and intermolecular forces. May not be taken for credit concurrently with, or following receipt of, credit for, CHEM 023, CHEM 025 or CHEM 035.

### **CHEM 032. General Chemistry 2. 0 or 4 Credits.**

Second semester of a two-semester sequence. Topics include solutions, kinetics, equilibrium, acid-base chemistry, aqueous ionic equilibria, thermodynamics, electrochemistry, and nuclear chemistry. May not be taken for credit concurrently with, or following receipt of, credit for CHEM 036. Prerequisite: CHEM 031 or CHEM 035.

### **CHEM 042. Intro Organic Chemistry. 0 or 4 Credits.**

Properties and reactivity of basic organic compounds of technological and biological significance. Not recommended for pre-medical students. No concurrent credit with, or credit following, credit for CHEM 026, CHEM 028, CHEM 044, CHEM 047, CHEM 141, or CHEM 143. Prerequisite: CHEM 023 or CHEM 032.

### **CHEM 044. Intro Organic Chemistry. 3 Credits.**

Properties and reactivity of organic molecules of technological and biological significance. NO LABORATORY. Not recommended for pre-medical students. No concurrent credit with, or credit following, credit for CHEM 026, CHEM 028, CHEM 042, CHEM 047, CHEM 141, or CHEM 143. Prerequisite: CHEM 023 or CHEM 025 or CHEM 032.

**CHEM 047. Organic Chemistry for Majors 1. 0 or 4 Credits.**

An exploration of the basic principles of Organic Chemistry including structure, bonding, conformational analysis, stereochemistry and reactivity. Designed for Chemistry and Biochemistry majors who have a strong high school chemistry background.

**CHEM 048. Organic Chemistry for Majors 2. 0 or 4 Credits.**

A survey of the reactivity of organic functional groups from a mechanistic standpoint. Organic synthesis will be emphasized. Prerequisite: CHEM 047 or instructor permission.

**CHEM 051. Exploring Chemistry 1. 1 Credit.**

Discovery-based laboratory addressing foundational chemical principles and experimental methods. For first-year Chemistry and Biochemistry majors also enrolled in CHEM 047. Co-requisite: CHEM 047.

**CHEM 052. Exploring Chemistry 2. 1 Credit.**

Second semester of a discovery-based laboratory laboratory addressing foundational chemical principles and experimental methods. For first-year Chemistry and Biochemistry majors also enrolled in CHEM 048. Prerequisites: CHEM 047 and CHEM 051. Co-requisite: CHEM 048.

**CHEM 071. Contemporary Chemical Topics. 3 Credits.**

Subjects vary by semester. Background in science is helpful, but generally not required. Representative topics: Environmental Risk; Chemistry of Honeybees. May be repeated for credit with different content. Topics vary by offering; periodic offering at intervals that may exceed four years.

**CHEM 090. Internship. 1-3 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**CHEM 092. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**CHEM 095. Intro Special Topics. 0-18 Credits.**

See Schedule of Courses for specific titles.

**CHEM 096. Intro Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CHEM 098. Chemistry Scholars Workshop. 1 Credit.**

For qualified first-year Chemistry majors. Students discuss how to design a hypothesis, learn how research is performed in various chemistry subfields, and listen to faculty research talks. By the end of the semester, students select research advisors and plan future research projects. Prerequisite: Instructor permission.

**CHEM 114. Advanced Synthesis Techniques. 3 Credits.**

Laboratory for Chemistry majors that covers advanced inorganic and organic techniques in synthesis, purification, and spectroscopic characterization. Prerequisite: CHEM 048 or CHEM 142.

**CHEM 121. Quantitative Analysis. 0 or 4 Credits.**

Theory and practice of volumetric and gravimetric analysis. Theoretical discussion of indicators, buffers, pH, etc. Introduction to data analysis, spectrophotometry, and chromatography. Prerequisite: CHEM 032 or CHEM 036 or CHEM 052.

**CHEM 131. Inorganic Chemistry. 3 Credits.**

Symmetry, group theory, molecular structure; electronic structure of atoms; bonding models including MO, crystal field, and ligand field; solid state, acid-base, and simple organometallic systems. Prerequisite: CHEM 047 or CHEM 141 or CHEM 143.

**CHEM 141. Organic Chemistry 1. 0 or 4 Credits.**

Properties and reactivity of organic compounds with consideration of bonding, stereochemistry, and reaction mechanisms. For premedical and biological sciences students. No credit if taken concurrently with, or following receipt of, credit for CHEM 042, CHEM 044, CHEM 047, CHEM 143. Prerequisite: CHEM 032 or CHEM 036.

**CHEM 142. Organic Chemistry 2. 0 or 4 Credits.**

Reactivity of organic compounds and applications to synthesis. Spectroscopy is discussed in relation to compound characterization. For premedical and biological sciences students. May not be taken concurrently with, or following receipt of, credit for CHEM 048 or CHEM 144. Prerequisite: CHEM 047 or CHEM 141 or CHEM 143.

**CHEM 165. Intro Physical Chemistry. 3 Credits.**

An introduction to physical chemistry concepts in quantum chemistry, thermodynamics, and kinetics, suitable for students from most science disciplines. Background in calculus and physics is required. Prerequisites: CHEM 032 or CHEM 036 or CHEM 052; MATH 020 or MATH 022 or MATH 023; PHYS 011 or PHYS 031 or PHYS 051.

**CHEM 166. Physical Chemistry Lab. 1 Credit.**

Laboratory course accompanying CHEM 165. Topics include quantum chemistry and thermodynamics. Prerequisites: CHEM 048 or CHEM 142; CHEM 165.

**CHEM 167. Physical Chemistry Preparation. 1 Credit.**

Review of relevant mathematical and physical concepts as applied to physical chemistry. Prerequisites: CHEM 032 or CHEM 036 or CHEM 052; MATH 022.

**CHEM 181. 2nd Year Seminar: Writing. 1 Credit.**

Development of chemical information literacy skills through critical analysis and written reporting on areas of current chemical interest. Emphasizes scientific writing. Prerequisite: CHEM 032 or CHEM 052.

**CHEM 182. 2nd Year Seminar: Presentation. 1 Credit.**

Presentation on a subject of current chemical interest, building on chemical information literacy skills. Emphasizes oral presentation techniques. Prerequisite: CHEM 181.

**CHEM 190. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

**CHEM 191. Teaching Assistantship. 1-3 Credits.**

Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

**CHEM 192. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**CHEM 195. Intermediate Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CHEM 196. Intermediate Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CHEM 198. Undergraduate Research. 1-18 Credits.**

Undergraduate students work on research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**CHEM 199. Professional Development. 1 Credit.**

Skills necessary for senior Chemistry majors to transition to postgraduate careers, including resume and proposal writing, presentations, and other techniques. Prerequisite: CHEM 182.

**CHEM 205. Biochemistry I. 3 Credits.**

Introduction to chemistry and structure of biological macromolecules; examination of mechanisms of chemical processes in biological systems including enzyme catalysis, biosynthesis, regulation, and information transfer. Prerequisite: CHEM 048 or CHEM 142 or CHEM 144. Cross-listed with: BIOC 205 and MMG 205.

**CHEM 206. Biochemistry II. 3 Credits.**

Continuation of Biochemistry I. Biochemistry of nucleic acids; nucleic acid based processes, such as replication and transcription; cellular information transfer, genomics, and proteomics. Prerequisite: BIOC 205, CHEM 205, or MMG 205. Cross-listed with: BIOC 206 and MMG 206.

**CHEM 207. Biochemistry Lab. 3 Credits.**

Introduction to biochemical tools, including spectrometry, chromatography, and electrophoresis; natural and recombinant enzyme isolation; assays of DNA-modifying enzymes; computer-based structure/function exercises. Prerequisite: BIOC 205, CHEM 205, or MMG 205. Cross-listed with: BIOC 207 and MMG 207.

**CHEM 214. Polymer Chemistry. 3 Credits.**

Polymer synthesis and characterization. Kinetic models for polymerization and copolymerization. Physical properties, characterization of polymers in the solid state and in solution. Prerequisite: CHEM 048 or CHEM 142 or CHEM 144, and CHEM 165.

**CHEM 219. Instrumental Analysis Lab. 1 Credit.**

Laboratory component to CHEM 221, for undergraduates. Application of chemical and physical principles to qualitative and quantitative chemical problems. Study of the interplay of data, hypotheses, and hypothesis-driven experimentation through application of the scientific method. Prerequisites: CHEM 221.

**CHEM 221. Instrumental Analysis. 3 Credits.**

Systematic survey of modern methods of chemical analysis. Fundamental principles and applications of spectroscopy, electrochemistry, and separation techniques. Prerequisite: CHEM 121. Credit for or concurrent enrollment in CHEM 165 strongly recommended.

**CHEM 226. Analytical Spectroscopy. 3 Credits.**

Principles of optical spectroscopic methods of analysis. Emphasis on theory and practice of atomic spectroscopy and new molecular spectroscopic methods. Prerequisite: CHEM 221. Alternate years.

**CHEM 231. Advanced Inorganic Chemistry. 3 Credits.**

Molecular symmetry and group theory with an emphasis on applications (vibrational and electronic spectra, bonding and reactivity); introduction to transition metal processes; bioinorganic chemistry. Prerequisite: CHEM 165; CHEM 047, CHEM 141, or CHEM 143.

**CHEM 234. Organometallic Chemistry. 3 Credits.**

Synthesis, structure, bonding, properties, reactions, and applications of organometallic systems; mechanisms of organometallic reactions including oxidative addition and insertion reactions with applications in catalysis. Prerequisite: CHEM 131 or CHEM 231.

**CHEM 236. Physical Inorganic Chemistry. 3 Credits.**

Determination of molecular and electronic structure of inorganic complexes using spectroscopic techniques. Introduction to magnetism. Interpretation of spectroscopic data within the frameworks of group theory and electronic structure calculations. Prerequisites: CHEM 131 and CHEM 165; or CHEM 231.

**CHEM 241. Advanced Organic Chemistry 1. 3 Credits.**

Stereochemistry, conformational analysis, stereoelectronic effects, transition state theory, molecular orbital theory, and reactivity criteria are discussed in regards to reaction mechanisms and functional group manipulations. Prerequisite: CHEM 142 or CHEM 144.

**CHEM 242. Advanced Organic Chemistry 2. 3 Credits.**

Modern synthetic organic methods and approaches to multi-step synthesis are discussed. Selected total syntheses are reviewed to highlight important concepts including diastereoselective and enantioselective processes. Prerequisite: CHEM 241.

**CHEM 260. Advanced Physical Chemistry. 3 Credits.**

Builds on the concepts from Introductory Physical Chemistry (CHEM 165). The three major areas of quantum chemistry, thermodynamics, and kinetics are extended in greater depth, and at a higher level of mathematical rigor. Prerequisite: CHEM 165. Co-requisites: CHEM 167 or MATH 121.

**CHEM 267. Topics in Physical Chemistry. 1-3 Credits.**

Selected topics of current interest in physical chemistry. See Schedule of Courses for specific titles. May be repeated for credit with different content. Topics vary by offering; periodic offering at intervals that may exceed four years. Prerequisite: CHEM 260.

**CHEM 274. Solid State Chemistry. 3 Credits.**

Explores the rich field of solid-state chemistry. Solid-state materials represent some of the most promising advanced materials in development, with applications ranging from pharmaceuticals to flexible electronics. Introduces the chemical physics surrounding solids. Topics include (but are not limited to) crystals and their properties, nanomaterials, semiconductors, and characterization methods. Prerequisite: CHEM 165.

**CHEM 275. Computational Chemistry. 3 Credits.**

Explores the techniques and applications of computational chemistry to model organic, inorganic, and biological molecules. Introduces basic level of classical and quantum modeling, cheminformatics and big chemical data, as well as computer-aided design of new materials and medicines. Prerequisite: CHEM 260.

**CHEM 285. Special Topics. 1-3 Credits.**

Selected topics of current interest that do not fall into one of the traditional areas of chemistry.

**CHEM 286. Special Topics. 1-3 Credits.**

Selected topics of current interest that do not fall into one of the traditional areas of chemistry.

**CHEM 290. Internship. 1-18 Credits.**

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is Offered at department discretion.

**CHEM 291. Undergraduate Research. 1-18 Credits.**

Undergraduate students work on research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion. Prerequisite: Departmental permission.

**CHEM 292. Independent Study. 1-18 Credits.**

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

**CHEM 293. Teaching Assistantship. 1-3 Credits.**

Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

**CHEM 295. Advanced Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**CHEM 296. Advanced Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.