Chemistry

The chemistry major and minor are administered by the Department of Chemistry: Professors Browne, Chen (*chair*); Associate Professors Cotter, Gomez (on leave 2009-2010), Hamilton (on leave spring 2010), Nunez; Assistant Professor Dickens; Visiting Assistant Professors Jayathilake, Plata.

Contact Person

Wei Chen, *chair*

Chemistry is the study of the composition, synthesis, physical properties, and transformations of materials, including biological substances, technological materials, and natural products. The goals of the chemistry major are to give students a firm foundation in the fundamental principles of chemistry, its subdisciplines, and their interrelationships; to develop a proficiency in experimental technique, design, and interpretation; and to expose students to contemporary research questions and applications. This is accomplished through hands-on experience with modern instrumentation throughout the curriculum, a broad array of advanced course work, and engagement in active discussion and collaboration with the chemistry faculty.

Requirements for the Major

Recognizing that the physical sciences in general, and chemistry in particular, can be the starting point for a broad variety of career trajectories, the department offers two tracks to the chemistry major, sharing a common disciplinary core. Track A is a specialist track, designed as preparation for doctoral study. Although all of our students receive the bachelor of arts degree, this track is comparable to a traditional bachelor of science. Students who want to focus their undergraduate education on the chemical sciences, but who are considering professions that do not necessarily require a doctorate in the discipline—such as science studies, secondary school science teaching, science writing/journalism—may wish to consider Track B, a generalist track that encourages them to locate their subject-matter expertise in multiple contexts: within the sciences, within the current social matrix, and within the historical scope of human knowledge. Students wishing to teach chemistry in secondary schools within the State of Massachusetts must complete the requirements of Track B in order to qualify for licensure.

These courses of study are not mutually exclusive, and students following either as their principal route to the major are encouraged to consider incorporating some of the spirit of the other track into their educational program.

Track A (Predoctoral)

Credits

- A minimum of 36 credits in chemistry including, seven core courses
- A year of calculus (Mathematics 101 and 202)
- A year of calculus-based physics (Physics 115 and 216)

Courses

- Core courses in chemistry:
  - 101 and 201, General Chemistry I and II
  - 202 and 302, Organic Chemistry I and II
  - 306, Methods of Measurement
  - 308, Chemical Thermodynamics
  - 325, Atomic and Molecular Structure and
- 8 or 12 credits in elective courses, at least four of which must be at the 300 level

Other

- Participation in two semesters of the department comprehensive seminar program
- An individual oral presentation at the annual Senior Symposium

Track B (Generalist/State of Massachusetts Secondary Teaching Licensure)

Credits

- A minimum of 32 credits in chemistry, including six core courses
- A semester of calculus (Mathematics 101)
- A semester of calculus-based physics (Physics 115)

Courses

- Core courses in chemistry:
  - 101 and 201, General Chemistry I and II
  - 202 and 302, Organic Chemistry I and II
  - 306, Methods of Measurement
  - 308, Chemical Thermodynamics
- Elective courses must include at least one from each of the following categories. Permission to use a course other than those listed here must be obtained from the department chair.
  - *Biochemistry:* Chemistry 212, Chemistry of Biomolecules; Chemistry 311, Protein Biochemistry and Cellular Metabolism or Chemistry 314, Nucleic Acids Biochemistry and Molecular Biology; or Chemistry 333, Protein Structure and Function
  - *History and Philosophy of Science:* Chemistry 250, Introduction to the History of Chemistry; Philosophy 206, Introduction to the Philosophy of Science; or Women's Studies 235, Gender, Race, and Science
  - *Earth and Environment:* Environmental Studies 101, Introduction to Environmental Studies; or any geology course
  - *Biology:* 145, Introductory Biology I; or 200, Introductory Biology II: How Organisms Develop

Other

- Participation in two semesters of the department comprehensive seminar program
- An individual oral presentation at the annual Senior Symposium

These two requirements may be waived for a student enrolled in Education 331, Student Teaching, during the second semester of her senior year.

The chemistry major can be pursued at several levels of intensity. To get to the junior and senior years and enjoy the greatest opportunity for advanced courses and independent work, the department recommends the following schedule for students entering the major at 101.

	Fall	*Spring*
Fy	Chemistry 101 or 160 Mathematics 101	Chemistry 201 Mathematics 202
Soph	Chemistry 202 Physics 115	Chemistry 302 Chemistry 306 Physics 216
Jr	Chemistry 308	Chemistry 325
Sr	Additional electives and independent work	

Students entering the major at Chemistry 201 or 202 gain additional flexibility in planning their course work. Students who would like a chemistry major with a biochemical emphasis should consider including some or all of the following courses in their programs: Chemistry 212, 311, and 314 (these students should note the biology prerequisites for Chemistry 311 and 314).

Independent work is encouraged and usually takes the form of work on a problem allied to the research interests of a faculty member, details of which are available from the chemistry department office. A number of Mount Holyoke College students participate in the department's summer research program (eight-ten weeks of paid, full-time research), a valuable addition to their education. Students may pursue independent work at any time in their Mount Holyoke careers. The department is extremely well equipped for research, including two high-field nuclear magnetic resonance spectrometers, two atomic force microscopes (AFM), several gas

(GC) and high performance liquid (HPLC) chromatographs, numerous infrared (IR), ultra-violet/visible (UV-Vis) and fluoresence spectrometers, in addition to specialized equipment for microwave promoted synthesis of peptides and organic molecules, calorimetry, dynamic light scattering, optical microscopy, electrochemistry and computational molecular modeling.

The Department of Chemistry is approved by the American Chemical Society (see below). Students planning graduate study in chemistry should be aware that some programs require additional background in mathematics and physics. Reading knowledge of French, German, or Russian and familiarity with computer languages are also valuable. Given the current emphasis on molecular biology in chemical research, students may find courses in biology particularly valuable.

For information about a biochemistry major, see Biochemistry.

Requirements for the Minor

Credits

- At least 16 credits at the 200 level or above
- At least four of these credits must be at the 300 level.

ACS Certification of an Undergraduate Degree in Chemistry

The process of ACS degree certification works as follows. The Committee on Professional Training of the American Chemical Society sets the criteria for approval of a chemistry program; the chair of the approved program certifies annually those students who have met the curricular guidelines. Recent guidelines state a minimum core requirement of 28 semester credit hours of basic instruction with comparable emphasis on the areas of analytical chemistry, inorganic chemistry, organic chemistry, and calculus-based physical chemistry. Biochemistry must also be part of the undergraduate chemistry curriculum—if not included in the core, then it must be taken as an advanced requirement. Advanced requirements include a minimum of two advanced courses in chemistry or two semesters of independent research.

Choosing a First Chemistry Course

The chemistry department offers three points of entry into the curriculum. Chemistry 101, General Chemistry I, is usually the first course for an entering Mount Holyoke student who has taken fewer than two years of high school chemistry. Chemistry 101 provides such a student with an opportunity to develop her understanding of the foundations of reaction chemistry, thermochemistry, electronic structure, chemical bonding, and acid-base chemistry.

Students interested in studying biochemistry, or interested in satisfying pre-health requirements, may find it helpful to take both introductory biology and introductory chemistry in their first semester. Biology 160/Chemistry 160 integrates topics from biology and chemistry to give an introduction to both disciplines. The eight-credit course has about six hours of lecture/discussion and one 4 hour lab per week. The course prepares students to continue in both second semester chemistry (Chemistry 201) and second semester biology (Biology 200) in the spring semester.

Many students enter Mount Holyoke College with a substantial background in chemical principles. These students should strongly consider one of the chemistry department's 200-level courses. Such students include those who have taken two years of high school chemistry, completed A-level chemistry or the International Baccalaureate, taken the Advanced Placement examination in chemistry with a score of 4 or 5, or taken the Achievement Test in chemistry with a score of 650 or higher. Chemistry 201, General Chemistry II, is usually the appropriate choice. In addition, one year of high school calculus with a grade of B or better is required for the fall version of Chemistry 201. In this course, students extend their understanding of electronic structure, kinetics, equilibrium, spontaneity and electrochemistry. Special topics based on faculty interests

and expertise are also introduced to provide context for discussion.

Course Offerings

101f General Chemistry I
This course provides introduction and development of fundamental concepts including stoichiometry, reactions in aqueous solutions, thermochemistry, atomic structure, chemical bonding, and acid-base reactions. The laboratory emphasizes basic skills, quantitative chemical measurements, and principles discussed in lectures.
Meets Science and Math II-B requirement
A. Dickens, D. Plata
4 credits

150s How Hot? Understanding Global Climate Change
(First-year seminar; Same as Environmental Studies 150) Global climate change ("global warming") is one of the greatest problems facing human society today. Despite overwhelming scientific evidence, the highly charged political and social environment surrounding the issue has seriously obscured this problem. We will examine the science behind climate change, studying the greenhouse effect, the larger climate system, and the changing carbon cycle. We will also discuss the role of uncertainty in science and how misinterpretation has led to both confusion and gross distortion of scientific knowledge. Finally, we will explore proposed solutions to mitigate and/or adapt to climate change.
Does not meet a distribution requirement
A. Dickens
Prereq. fy; 4 credits

201fs General Chemistry II
This course provides background in basic principles of physical, analytical, and inorganic chemistry essential to the study of all chemical phenomena. Topics include elementary principles of molecular electronic structure, quantitative treatment of chemical equilibrium with applications to solubility, acid-base, and electron transfer reactions, and introduction to chemical kinetics and thermodynamics. Laboratory emphasizes on analytical skills and illustrates basic concepts in chemical equilibria, thermodynamics, and kinetics.
Meets Science and Math II-B requirement
W. Chen, M. Nunez, H. Jayathilake, D. Plata
Prereq. for 201f: Chemistry 101 and Mathematics 101, first year only, and permission of instructor (weichen@mtholyoke.edu); 4 credits
Prereq. for 201s: Chemistry 101; 4 credits

202f Organic Chemistry I
Introduces organic chemistry, emphasizing the principles governing broad classes of reactions. Topics include stereochemistry, nucleophilic substitution and elimination reactions, the chemistry of alkanes, alkenes, alkynes, alcohols, and ethers, and an introduction to infrared and nuclear magnetic resonance spectroscopy. Laboratory work includes synthesis, practice in the techniques of distillation, crystallization, chromatography, molecular modeling, and identifying unknown organic compounds by chemical and spectroscopic means.
Meets Science and Math II-B requirement
S. Browne, M. Nunez
Prereq. Chemistry 201 with grade of C or better, or permission of instructor; 4 credits

212s Chemistry of Biomolecules
An examination of the major ideas of biochemistry from the point of view of the chemical sciences rather than the life sciences. Structures of important biomolecules. The role of energetics and reaction dynamics in biochemical processes. Major metabolic pathways are considered, including those of proteins, carbohydrates, lipids, and nucleic acids.
Meets Science and Math II-C requirement
M. Nunez
Prereq. Chemistry 202; This course is not intended for Biochemistry majors, who must complete Biochemistry 311f and 314s. First priority will be given to sophomores and juniors.; 4 credits

***220f Simulating Chemistry, Biochemistry, and Materials Science: An Introduction to Scientific Computing**
From the very early days of computers, they have been used in atomic simulations. Today, there are many algorithms for simulating chemical events. Simulations allow us to gain

insight into possible causes of physical phenomena. This course introduces some of the methods used to simulate chemistry, biochemistry, and materials science. Potential energy surfaces, Monte Carlo methods, and molecular dynamics are introduced and applied to projects in chemistry, biochemistry, and materials science.
Meets Science and Math II-C requirement
M. Gomez
Prereq. Mathematics 202 (or equivalent), or permission of the instructor; 4 credits

232f Global Biogeochemistry
This course will examine the chemistry of the surface of the Earth. Our planet is basically a closed system, and chemical cycles of certain elements are driven by biological and geological processes which, in turn, determine the distribution and nature of life on Earth. We will study the chemistry of the atmosphere, soils, rivers, and oceans and look at how these systems are connected via the global nitrogen, phosphorus, and carbon cycles. We will especially focus on the carbon cycle and examine how humans have altered the distribution of this central element. Lecture sessions will be complemented by reading-based discussions.
Meets Science and Math II-C requirement
A. Dickens
Prereq. Chemistry 101, Chemistry 201 recommended; 2 meetings (75 minutes) plus fourth hour to be arranged; 4 credits

***250s Introduction to the History of Chemistry**
(Writing-intensive course) Traces the growth of chemistry in several ways: as a body of knowledge and beliefs, as a practical means of intervention, and as a community of practitioners linked (or divided) by sociopolitical bonds and common interests, intellectual and otherwise. After an overview of chemical history and an introduction to various scholarly traditions in the field, the balance of the course will be devoted to case studies of narrower topics or episodes, such as the alchemical tradition and Robert Boyle, the eighteenth-century Chemical Revolution, nineteenth-century organic chemistry, Ionism, atomism and elementalism, chemistry and war, the quantum revolution, educational traditions, the role of women.
Meets Science and Math II-C requirement
D. Cotter
Prereq. soph, jr, sr, or permission of instructor; 4 credits

295fs Independent Study
Independent work in chemistry can be conducted with any member of the department.
Does not meet a distribution requirement
The department
Prereq. soph, permission of department required every semester; Note: Students conducting an independent laboratory research project for course credit in a department, program, or laboratory covered by the College's chemical hygiene plan must participate in a safety training session before beginning research. Course credit will not be granted to students who do not receive safety training.; 1-4 credits

302s Organic Chemistry II
A continuation of Chemistry 202 that addresses the chemistry of aromatic compounds, the carbonyl group, and a number of other functional groups. Examples drawn from compounds of biological interest. The laboratory includes organic synthesis and the identification of unknown compounds by chemical and spectroscopic means.
Meets Science and Math II-B requirement
S. Browne
Prereq. Chemistry 202 with grade of C or better; 4 credits

306s Methods of Measurement
We will discuss analytical techniques which are currently applied in chemical, environmental, and medical science. These techniques include: chromatography including GC and LC spectroscopy (UV-Vis, FT-IR, AA, fluoremetry, and NMR), surface science and mass spectrometry. Students will increase their repertoire of laboratory skills while learning to integrate concepts from different subdisciplines of chemistry into a unified experimental approach to problem solving.
Does not meet a distribution requirement
G. Roman
Corequisite: Chemistry 302; 4 credits

308f Chemical Thermodynamics
A consideration of the contribution of thermodynamics to the understanding of the "driving forces" for physical chemical

changes and the nature of the equilibrium state.
Meets Science and Math II-B requirement
H. Jayathilake
Prereq. Chemistry 201, Chemistry 202, Mathematics 101, Physics 103 and 204, or 115 with grade of C or better; 4 credits

311f Protein Biochemistry and Cellular Metabolism
(Same as Biochemistry 311f; Biological Sciences 311f)
Meets Science and Math II-B requirement
L. Hsu
4 credits

314s Nucleic Acids Biochemistry and Molecular Biology
(Same as Biochemistry 314s; Biological Sciences 314s)
Meets Science and Math II-B requirement
L. Hsu
4 credits

***315s Experimental Methods**
Uses extended research-style projects to introduce advanced techniques in physical measurement (e.g., high-resolution spectroscopy, calorimetry, electrochemistry), separation and analysis (e.g., gas- and liquid-phase chromatagraphy, mass spectrometry), and chemical synthesis (e.g., catalytic and enantioselective methods, biomolecules, polymers). Students will increase their repertoire of laboratory skills while learning to integrate concepts from different subdisciplines of chemistry into a unified experimental approach to problem solving.
Does not meet a distribution requirement
A. Dickens
Prereq. Chemistry 302, 2 lectures (75 minutes), 1 discussion (50 minutes), l lab (4 hours); 4 credits

***317s Principles of Polymer Chemistry**
An introduction to the study of molecules of high molecular weights with emphasis on synthetic rather than naturally occurring polymers. Topics include polymerization, structures, molecular weight determination, molecular weight distribution, chain configurations, rubber elasticity, and thermodynamics and statistical mechanics of polymer solutions.
Does not meet a distribution requirement
W. Chen
Prereq. Chemistry 302; offered once every three years; 4 credits

325s Atomic and Molecular Structure
This course is an introduction to experimental and theoretical approaches to the determination of the structure of atoms, molecules, and chemical bonds. Classroom work provides background in the theory of atomic and molecular structure and an introduction to quantum mechanics and spectroscopy.
Meets Science and Math II-B requirement
W. Chen
Prereq. Chemistry 201, Chemistry 202, Mathematics 202, Physics 216 with grade of C or better; 4 credits

334s Advanced Inorganic Chemistry
The implications of molecular symmetry as expressed in the language of group theory are explored in some depth. Group theory provides the context for a discussion of the structural and spectroscopic properties of inorganic compounds, particularly those of the transition metals.
Does not meet a distribution requirement
D. Cotter
Prereq. permission of instructor; corequisite Chemistry 325; offered every other year; 4 credits

***336s Organic Synthesis**
This course emphasizes recent developments in synthetic organic chemistry and deals with general synthetic methods and specific examples of natural product synthesis. It covers such topics as new methods of oxidation and reduction, stereospecific olefin formation, ring-forming reactions, and methods of carbon-carbon bond formation. The application of these reactions to the synthesis of naturally occurring compounds is examined. A general strategy for the synthesis of complex molecules is also presented.
Does not meet a distribution requirement
D. Hamilton
Prereq. Chemistry 302; offered every other year; 4 credits

***337f Physical Organic Chemistry**
An introduction to the concepts and methods of physical organic chemistry. Examination of reaction mechanisms and the experimental results that support these mechanisms. Topics include structure and reactivity, reaction kinetics, mechanism determinations, and Woodward-Hoffman Rules.
Does not meet a distribution requirement
S. Browne
Prereq. Chemistry 302, 308; offered every other year; 4 credits

339f The Organic Chemistry of Biological Pathways
This course explores the underlying organic chemistry of biological pathways and thereby seeks to build a framework for understanding biological transformations from the perspective of mechanistic organic chemistry. Beginning with common biological mechanisms, and drawing parallels with their sophomore organic chemistry counterparts, a broad overview will be constructed of the pathways by which the key classes of biological molecules—lipids, carbohydrates, amino acids, nucleotides—are manufactured, modified, and consumed. Several specific biosyntheses will also be dissected from a mechanistic perspective. These case studies will include antibiotics, an alkaloid, and heme.
Does not meet a distribution requirement
D. Hamilton
Prereq. Chemistry 302; 4 credits

***343s Chemistry of DNA**
(Speaking-intensive course) This advanced-level seminar will focus on the molecular properties of DNA. Using as sources a graduate-level text and readings from the primary literature, the class will discuss a variety of current topics in the research community, including the binding of proteins and small molecules to DNA, the covalent modification of DNA by mutagenic agents, and the dynamic nature of DNA across timescales. Critical analysis of experimental design and conclusions from data will be encouraged. Students will be evaluated based on participation in discussions, oral presentations, and an original research proposal.
Does not meet a distribution requirement
M. Nunez
Prereq. Chemistry 302 and one additional 300-level chemistry course; 4 credits

***345fs Physical Biochemistry**
This course introduces the fields of biophysical chemistry and molecular biophysics, where biological systems are probed and described by physical techniques and models. Topics will include the physical properties of biological molecules (proteins, nucleic acids, carbohydrates, and lipid membranes); applications of spectroscopy to biological systems, both *in vitro* and *in vivo*; the mechanisms of light harvesting and energy conversion; and technological developments inspired by biological systems. Lecture sessions (two per week) will be complemented by a weekly discussion of papers from the contemporary literature.
Does not meet a distribution requirement
The department
Prereq. Chemistry 302 required; Chemistry 212, Biochemistry 311 or Biology 220 recommended, or permission of instructor; 4 credits

395fs Independent Study
Independent work in chemistry can be conducted with any member of the department.
Does not meet a distribution requirement
The department
Prereq. jr, sr, permission of department; Note: See safety training restrictions in description of Chemistry 295; 1-8 credits

399fs Comprehensive Seminar
A seminar series consisting of meetings on alternate weeks to discuss articles from the current chemical literature. The readings will prepare students for attendance at lectures on the chosen topics in the remaining weeks. The lectures are given primarily by visiting speakers, but they may include department faculty. Students will serve as discussion leaders, and each student will write a paper on a presentation of her choice.
Does not meet a distribution requirement
M. Nunez, A. Dickens
Prereq. sr; 1 credit