DEPARTMENT OF CHEMISTRY

Chemistry is the study of the world of atoms, molecules, and solids. Chemists are both students and architects of this miniature universe, exploring the changes that occur, discovering the principles that govern these chemical changes, and devising ways to create entirely new classes of compounds and materials. Previous triumphs of chemistry include the synthesis of pharmaceuticals and agricultural products, while current challenges include chemical memory, solar cells, superconductors, clean fuels, batteries, and the solution of numerous important problems relating to health and the environment.

The Department of Chemistry (*http://chemistry.mit.edu*) offers the Bachelor of Science and Doctor of Philosophy degrees. The department's program of teaching and research spans the breadth of chemistry. General areas covered include biological chemistry, inorganic chemistry, organic chemistry, and physical chemistry. Some of the activities of the department, especially those that involve "translational research" (the application of basic science to practical problems) are carried out in association with interdisciplinary laboratories and centers. See the section on Research and Study for more information (*https://catalog.mit.edu/mit/research*).

The Bachelor of Science (p. 3) degree provides rigorous education in the fundamental areas of chemical and biochemical knowledge and experimentation. Undergraduate students are encouraged to participate in the Undergraduate Research Opportunities Program (UROP) (*https://catalog.mit.edu/mit/undergraduate-education/academic-research-options/undergraduate-research-opportunities-program*) and to take graduate-level chemistry classes as well as subjects in other departments at the Institute, Harvard University, or Wellesley College.

The Doctor of Philosophy (p. 4) degree trains students to be world leaders in scientific research and education. In addition to formal coursework, each student undertakes a research problem that forms the core of graduate work. Graduate- and postgraduate-level research is often carried out in collaboration with scientists in other facilities and interdisciplinary laboratories.

Undergraduate Study

Bachelor of Science in Chemistry (Course 5)

Standard Chemistry Option

The Department of Chemistry offers an undergraduate program (*https://catalog.mit.edu/degree-charts/chemistry-course-5*) sufficiently broad as to provide excellent preparation for careers in many different areas of chemistry. Course 5 is designed to provide an education based on science, both for those who intend to go on to graduate study and those who intend to pursue a professional career immediately in either chemistry or an allied field, such as medicine, in which a sound knowledge of chemistry is important. Students receive thorough instruction in the principles of chemistry, supplemented by a strong foundation in mathematics, physics, biology, and the humanities. The Department of Chemistry also teaches courses jointly with the departments of Biology, Chemical Engineering, Biological Engineering, and Materials Science and Engineering. Students at all levels are encouraged to undertake original research under the supervision of a member of the chemistry faculty.

Flexible Chemistry Option

The Flexible Chemistry Option (*https://catalog.mit.edu/degree-charts/chemistry-course-5/#flexibleoptiontext*), “ChemFlex,” is designed to provide an education both for those who intend to pursue chemistry as a career and for those who plan to go into an allied field, such as biotechnology or scientific consulting, in which a sound knowledge of chemistry is important. Students receive thorough instruction in the principles of chemistry, supplemented by a strong foundation in mathematics, physics, biology, and the humanities. This training can be tailored to the student's interests by the judicious choice of elective focus subjects that contribute to the major. The Department of Chemistry also teaches courses jointly with the departments of Biology, Chemical Engineering, Biological Engineering, and Materials Science and Engineering. The student's faculty advisor can offer suggestions for elective subjects that are of value in preparation for specialization in the various broad areas of chemistry. The proper choice of electives is particularly important for students planning to continue their education in a graduate program. Students at all levels are encouraged to undertake original research.

Bachelor of Science in Chemistry and Biology (Course 5-7)

The Departments of Biology and Chemistry jointly offer a Bachelor of Science in Chemistry and Biology (*https://catalog.mit.edu/degree-charts/chemistry-biology-course-5-7*). A detailed description of the requirements for this degree program (*https://catalog.mit.edu/interdisciplinary/undergraduate-programs/degrees/chemistry-biology*) can be found in the section on Interdisciplinary Programs.

Minor in Chemistry

The requirements for a Minor in Chemistry are as follows:

Requirements		
5.12	Organic Chemistry I	12
5.310	Laboratory Chemistry [1]	12
Select 48 units of the following:		48
5.03	Principles of Inorganic Chemistry I	
5.04	Principles of Inorganic Chemistry II	
5.07[J]	Introduction to Biological Chemistry	
5.08[J]	Fundamentals of Chemical Biology	
5.13	Organic Chemistry II	

5.43	Advanced Organic Chemistry	
5.601	Thermodynamics I	
5.602	Thermodynamics II and Kinetics	
5.611	Introduction to Spectroscopy	
5.612	Electronic Structure of Molecules	
5.62	Physical Chemistry	
5.361	Recombinant DNA Technology	
5.362	Cancer Drug Efficacy	
5.363	Organic Structure Determination	
5.371	Continuous Flow Chemistry: Sustainable Conversion of Reclaimed Vegetable Oil into Biodiesel	
5.372	Chemistry of Renewable Energy	
5.373	Synthesis of Boron Heterocycles	
5.381	Quantum Dots	
5.382	Time- and Frequency-resolved Spectroscopy of Photosynthesis	
5.383	Fast-flow Peptide and Protein Synthesis	
Total Units		**72**

[1] *The combination of 5.351 Fundamentals of Spectroscopy, 5.352 Synthesis of Coordination Compounds and Kinetics, and 5.353 Macromolecular Prodrugs is an acceptable alternative.*

Inquiries

Additional information may be obtained from the Chemistry Education Office, Room 6-205, 617-253-7271.

Graduate Study

The Department of Chemistry offers the Doctor of Philosophy degree. The subjects offered aim to develop a sound knowledge of fundamentals and a familiarity with current progress in the most active and important areas of chemistry. In addition to studying formal subjects, each student undertakes a research problem that forms the core of graduate work. Through the experience of conducting an investigation leading to the doctoral thesis, a student learns general methods of approach and acquires training in some of the specialized techniques of research.

The areas of research (*https://chemistry.mit.edu/areas-of-research*) in the department include chemical biology, environmental, inorganic, materials, organic and physical chemistry, broadly defined. Chemical research frequently involves more than one of the traditional subfields. Some research activities of the department are carried out in association with interdisciplinary laboratories and centers (*https://catalog.mit.edu/mit/research*) as described in Research and Study. These interdisciplinary research laboratories provide stimulating interaction among the research programs of several MIT departments and give students opportunities to become familiar with research work in disciplines other than chemistry. The department also participates in the interdisciplinary graduate Program in Polymers and Soft Matter, the Biotechnology Training Program, the Microbiology Program, and the Biophysics Certificate Program.

Admission Requirements for Graduate Study

Students intending to do graduate work in the Chemistry Department should have excellent undergraduate preparation in chemistry. The department is flexible with respect to specific course preparation; the essential requirement is demonstration of ability to progress with advanced study and research in some area of special interest. However, mathematics and physics are important prerequisites for graduate work in physical chemistry or chemical physics, whereas less preparation in these areas is required for work in organic chemistry.

Doctor of Philosophy

The Department of Chemistry offers a program leading to the Doctor of Philosophy or Doctor of Science degree; requirements are the same for both degrees. The subjects offered aim to develop a foundational knowledge of fundamentals and a familiarity with current progress in the most active and important areas of chemistry. In addition to formal coursework, each student undertakes a research project that forms the core of graduate work. Through the experience of conducting an investigation leading to the doctoral thesis, a student learns general methods of scientific approach and acquires training in some of the specialized techniques of research.

The major areas of research in the department include chemical biology, inorganic chemistry, organic chemistry, and physical chemistry. Chemical research frequently involves more than one of the traditional subfields. Some research activities of the department are carried out in association with interdisciplinary laboratories and centers (*https://catalog.mit.edu/mit/research*) as described in Research and Study. These interdisciplinary research laboratories provide stimulating interaction among the research programs of several MIT departments and give students opportunities to become familiar with research work in disciplines other than chemistry. The department also participates in the interdisciplinary graduate Program in Polymers and Soft Matter, the Biotechnology Training Program, the Microbiology Program, and the Biophysics Certificate Program.

The doctoral program in chemistry (*https://catalog.mit.edu/degree-charts/phd-chemistry*) does not have any formal subject requirements. Each student, with the advice of a research supervisor, pursues an individual program of study that is pertinent to the student's long-range research interests. In general, candidates for the PhD degree in chemistry are expected to have completed at least 48 units of subjects approved for this purpose by the department with a grade of B- or better. The MIT English Evaluation Test (EET) is required for international students whose native language is not English. If English language subjects are recommended based on the EET results, students are required to complete the subjects for a letter grade. English language subjects do not count towards the 48 units of general coursework.

All students are required to teach for two terms, usually during the first year. While teaching, students enroll in 18 units of 5.91 Teaching Experience in the Chemical Sciences. During their first two academic semesters, students also enroll in at least 1 unit of 5.90 Problems in Chemistry.

Students typically confirm their research area during their first year in the PhD program. During the first term of residence, all graduate students are encouraged to select research supervisors who serve as their advisors for the duration of their graduate careers. The overall program of graduate subjects is established by each student in consultation with the research supervisor. In planning this program and in establishing the thesis problem, careful consideration is given to the candidate's academic record, interests, and professional experience.

After the first year, students must register for thesis units every term they are in the program as they complete appropriate milestones (forming a thesis committee, passing both the written and oral components of the general exam, writing and successfully defending the thesis, and submitting a final, approved thesis document).

A comprehensive oral examination in the candidate's area of study is held generally in the fourth term of residence. Progress in the student's research is also examined at that time. The written examination occurs in conjunction with the oral examination and involves the preparation and submission of a formal document summarizing the dissertation project and progress to date. A final oral presentation on the subject of the doctoral research is scheduled after the thesis has been submitted and evaluated by a committee of examiners.

All students are expected to register for the appropriate as the 5.9xx series departmental seminars each fall and spring term.

Training and practice in developing original research ideas and expressing them in a formal written proposal is an important part of the PhD degree. Additionally, the development of good oral communication skills is an integral part of becoming an effective scientist. To this end, several exercises have been established to ensure that every student interested in obtaining training and experience in presenting written research proposals and seminars to the department on their thesis research will have an opportunity to do so. These exercises generally occur in the third or fourth year. A brief summary of requirements for each research area follows:

- **Chemical Biology:** Students prepare and present an independent research proposal in the third year, and present a public seminar as part of their thesis defense.
- **Inorganic Chemistry:** Students prepare and present an independent research proposal in the third year, and present a public seminar in their fourth or fifth year as part of the regular Inorganic Seminar Series.
- **Organic Chemistry:** Students prepare an independent research proposal in the fourth year, and present a public seminar as part of their thesis defense.
- **Physical Chemistry:** Students present a public seminar as part of their thesis defense.

Upon satisfactory complete of the program requirements and successful defense of their thesis, the student is awarded the Doctor of Philosophy of Chemistry or Doctor of Science in Chemistry degree.

Interdisciplinary Programs

Polymers and Soft Matter

The Program in Polymers and Soft Matter (PPSM) (*http://polymerscience.mit.edu*) offers students from participating departments an interdisciplinary core curriculum in polymer science and engineering, exposure to the broader polymer community through seminars, contact with visitors from industry and academia, and interdepartmental collaboration while working towards a PhD or ScD degree.

Research opportunities include functional polymers, controlled drug delivery, nanostructured polymers, polymers at interfaces, biomaterials, molecular modeling, polymer synthesis, biomimetic materials, polymer mechanics and rheology, self-assembly, and polymers in energy. The program is described in more detail (*https://catalog.mit.edu/interdisciplinary/graduate-programs/polymers-soft-matter*) under Interdisciplinary Graduate Programs.

Financial Support

First-year graduate students are usually supported by a combination of departmental fellowships and research assistantships while they complete the academic teaching requirement. Most students receive appointments to research assistantships after their first year, and departmental fellowships are also available. Financial support after the first academic year is subject to the availability of funds and provided for students who maintain a satisfactory record.

Inquiries

Correspondence about the graduate program or appointments should be addressed to the Chemistry Education Office, Room 6-205, 617-253-1851.

Faculty and Teaching Staff

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Jeremiah A. Johnson, PhD
Thomas Guertin Professor
Professor of Chemistry
Associate Head, Department of Chemistry

Elizabeth M. Nolan, PhD
Ivan R. Cottrell Professor of Immunology
Professor of Chemistry
Associate Head, Department of Chemistry

Professors

Moungi G. Bawendi, PhD
Lester Wolfe Professor
Professor of Chemistry
(On leave, fall)

Stephen Leffler Buchwald, PhD
Camille Dreyfus Professor
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Jianshu Cao, PhD
Professor of Chemistry

Sylvia Ceyer, PhD
John C. Sheehan Professor
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Professor of Chemistry
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Professor Post-Tenure of Chemistry

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(On leave, fall)

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Alex K. Shalek, PhD
J. W. Kieckhefer Professor
Professor of Chemistry
Director, Institute for Medical Engineering and Science

Yang Shao-Horn, PhD
JR East Professor of Engineering
Professor of Mechanical Engineering
Professor of Materials Science and Engineering
Professor of Chemistry

Matthew D. Shoulders, PhD
Professor of Chemistry
(On leave, fall)

Susan Solomon, PhD
Lee and Geraldine Martin Professor in Environmental Studies
Professor of Atmospheric Chemistry and Climate Science
Professor of Chemistry

Yogesh Surendranath, PhD
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Professor of Chemical Engineering

Timothy M. Swager, PhD
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Associate Professors

Robert J. Gilliard, PhD
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Brett McGuire, PhD
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(On leave, fall)

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Thomas D. and Virginia W. Cabot Professor
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Alison Wendlandt, PhD
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(On leave, spring)

Bin Zhang, PhD
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(On leave, spring)

Assistant Professors

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Assistant Professor of Chemistry

Oleta Johnson, PhD
William R (1964) and Daniel L. (1995) Young Career Development Professor
Assistant Professor of Chemistry

Chunte Sam Peng, PhD
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Pushpa Venkatesan, PhD
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Research Staff

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Principal Research Scientist of Chemistry

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Bridget Becker, PhD
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Gang Liu, PhD
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Richard Royce Schrock, PhD
Frederick George Keyes Professor Emeritus
Professor Emeritus of Chemistry

Jeffrey I. Steinfeld, PhD
Professor Emeritus of Chemistry

JoAnne Stubbe, PhD
Novartis Professor Emerita
Professor Emerita of Chemistry
Professor Emerita of Biology

Steven R. Tannenbaum, PhD
Underwood-Prescott Professor Emeritus
Professor Emeritus of Toxicology and Biological Engineering
Professor Emeritus of Chemistry

5.000[J] Dimensions of Geoengineering
Same subject as 1.850[J], 10.600[J], 11.388[J], 12.884[J], 15.036[J], 16.645[J]
Prereq: None
G (Fall; first half of term)
Not offered regularly; consult department
2-0-4 units

Familiarizes students with the potential contributions and risks of using geoengineering technologies to control climate damage from global warming caused by greenhouse gas emissions. Discusses geoengineering in relation to other climate change responses: reducing emissions, removing CO2 from the atmosphere, and adapting to the impacts of climate change. Limited to 100.
J. Deutch, M. Zuber

5.002[J] Viruses, Pandemics, and Immunity
Same subject as 10.380[J], HST.438[J]
Prereq: None
U (Spring)
Not offered regularly; consult department
2-0-1 units

See description under subject HST.438[J]. Preference to first-year students; all others should take HST.439[J].
A. Chakraborty

5.003[J] Viruses, Pandemics, and Immunity
Same subject as 8.245[J], 10.382[J], HST.439[J]
Prereq: None
U (Spring)
Not offered regularly; consult department
2-0-1 units

See description under subject HST.439[J]. HST.438[J] intended for first-year students; all others should take HST.439[J].
A. Chakraborty

5.008[J] Models of Molecular Systems: from Newtonian Mechanics to Machine Learning
Same subject as 10.09[J]
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Spring)
2-0-7 units

See description under subject 10.09[J].
B. L. Trout

5.009[J] Ocean Chemistry Change Laboratory
Same subject as 12.314[J]
Prereq: Chemistry (GIR)
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Fall; first half of term)
1-3-2 units. Partial Lab

See description under subject 12.314[J].
A. Babbin

5.03 Principles of Inorganic Chemistry I
Prereq: 5.12
U (Spring)
5-0-7 units. REST

Presents principles of chemical bonding and molecular structure, and their application to the chemistry of representative elements of the periodic system.
D. Suess, R. Gilliard

5.04 Principles of Inorganic Chemistry II
Prereq: 5.03
U (Fall)
4-0-8 units

Systematic presentation of the chemical applications of group theory. Emphasis on the formal development of the subject and its applications to the physical methods of inorganic chemical compounds. Against the backdrop of electronic structure, the electronic, vibrational, and magnetic properties of transition metal complexes are presented and their investigation by the appropriate spectroscopy described.
Y. Surendranath, D. Freedman

5.05 Principles of Inorganic Chemistry III
Prereq: 5.03; *Coreq: 5.04*
G (Fall; second half of term)
2-0-4 units

Principles of main group (s and p block) element chemistry with an emphasis on synthesis, structure, bonding, and reaction mechanisms.
C. C. Cummins

5.061 Principles of Organometallic Chemistry
Prereq: 5.03
G (Spring; first half of term)
2-0-4 units

A comprehensive treatment of organometallic compounds of the transition metals with emphasis on structure, bonding, synthesis, and mechanism.
C. Cummins

5.062 Principles of Bioinorganic Chemistry
Prereq: 5.03
G (Fall; first half of term)
2-0-4 units

Delineates principles that form the basis for understanding how metal ions function in biology. Examples chosen from recent literature on a range of topics, including the global biogeochemical cycles of the elements; choice, uptake and assembly of metal-containing units; structure, function and biosynthesis of complex metallocofactors; electron-transfer and redox chemistry; atom and group transfer chemistry; protein tuning of metal properties; metalloprotein engineering and design; and applications to diagnosis and treatment of disease.
D. Suess

5.064 Solid-state Materials Chemistry
Prereq: 5.03
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; second half of term)
3-0-3 units

Fundamentals of materials chemistry with a focus on solid-state materials. Builds upon ideas of band structure from a chemical perspective and progresses to physical properties, including magnetism and conductivity.
D. Freedman

5.065 Electrochemistry
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; first half of term)
3-0-3 units

Fundamentals of electrochemistry with an emphasis on physical principles, experimental techniques, and select applications. Builds from molecular-level theories of charge transfer reactions and double layer structure and progress to the use of electrochemistry as a method for characterizing redox properties, synthesizing materials, and interconverting electrical and chemical energy. Background in organic chemistry required.
Y. Surendranath

5.067 Crystal Structure Refinement
Prereq: 5.069 or permission of instructor
G (Fall)
2-3-1 units

Practical aspects of crystal structure determination from data collection strategies to data reduction and basic and advanced refinement problems of organic and inorganic molecules.
P. Mueller

5.068 Physical Inorganic Chemistry
Prereq: 5.03 and 5.04
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; second half of term)
3-0-3 units

Discusses the physical methods used to probe the electronic and geometric structures of inorganic compounds, with additional techniques employed in the characterization of inorganic solids and surfaces. Includes vibrational spectroscopy, solid state and solution magnetochemical methods, Mossbauer spectroscopy, electron paramagnetic resonance spectroscopy, electrochemical methods, and a brief survey of surface techniques. Applications to current research problems in inorganic and solid-state chemistry.
D. Freedman

5.069 Crystal Structure Analysis
Prereq: 5.03 and 5.04
G (Spring; first half of term)
2-0-4 units

Introduction to X-ray crystallography: symmetry in real and reciprocal space, space and Laue groups, geometry of diffraction, structure factors, phase problem, direct and Patterson methods, electron density maps, structure refinement, crystal growth, powder methods, limits of diffraction methods, structure data bases.
P. Mueller

5.07[J] Introduction to Biological Chemistry
Same subject as 20.507[J]
Prereq: 5.12
U (Fall)
5-0-7 units. REST
Credit cannot also be received for 7.05

Chemical and physical properties of the cell and its building blocks. Structures of proteins and principles of catalysis. The chemistry of organic/inorganic cofactors required for chemical transformations within the cell. Basic principles of metabolism and regulation in pathways, including glycolysis, gluconeogenesis, fatty acid synthesis/degradation, pentose phosphate pathway, Krebs cycle and oxidative phosphorylation, DNA replication, and transcription and translation.
R. Raines, O. Johnson

5.08[J] Fundamentals of Chemical Biology
Same subject as 7.08[J]
Subject meets with 7.80
Prereq: (Biology (GIR), 5.13, and (5.07[J] or 7.05)) or permission of instructor
U (Spring)
4-0-8 units

Spanning the fields of biology, chemistry, and engineering, this class introduces students to the principles of chemical biology and the application of chemical and physical methods and reagents to the study and manipulation of biological systems. Topics include nucleic acid structure, recognition, and manipulation; protein folding and stability, and proteostasis; bioorthogonal reactions and activity-based protein profiling; chemical genetics and small-molecule inhibitor screening; fluorescent probes for biological analysis and imaging; and unnatural amino acid mutagenesis. The class will also discuss the logic of dynamic post-translational modification reactions with an emphasis on chemical biology approaches for studying complex processes including glycosylation, phosphorylation, and lipidation. Students taking the graduate version are expected to explore the subject in greater depth.
B. Imperiali, M. Shoulders

5.111 Principles of Chemical Science
Prereq: None
U (Fall, Spring)
5-0-7 units. CHEMISTRY
Credit cannot also be received for 3.091, 5.112, CC.5111, ES.5111, ES.5112

Introduction to chemistry, with emphasis on basic principles of atomic and molecular electronic structure, thermodynamics, acid-base and redox equilibria, chemical kinetics, and catalysis. Introduction to the chemistry of biological, inorganic, and organic molecules.
A. Willard, B. Pentelute, M. Hong, B. McGuire

5.112 Principles of Chemical Science
Prereq: None
U (Fall)
5-0-7 units. CHEMISTRY
Credit cannot also be received for 3.091, 5.111, CC.5111, ES.5111, ES.5112

Introduction to chemistry for students who have taken two or more years of high school chemistry or who have earned a score of at least 4 on the ETS Advanced Placement Exam. Emphasis on basic principles of atomic and molecular electronic structure, thermodynamics, acid-base and redox equilibria, chemical kinetics, and catalysis. Applications of basic principles to problems in metal coordination chemistry, organic chemistry, and biological chemistry.
S. Ceyer, C. Cummins

5.12 Organic Chemistry I
Prereq: Chemistry (GIR)
U (Fall, Spring)
5-0-7 units. REST
Credit cannot also be received for CC.512

Introduction to organic chemistry. Development of basic principles to understand the structure and reactivity of organic molecules. Emphasis on substitution and elimination reactions and chemistry of the carbonyl group. Introduction to the chemistry of aromatic compounds.
J. Johnson, A. Wendlandt, R. Danheiser

5.13 Organic Chemistry II
Prereq: 5.12
U (Fall)
5-0-7 units

Focuses on synthesis, structure determination, mechanism, and the relationships between structure and reactivity. Selected topics illustrate the role of organic chemistry in biological systems and in the chemical industry.
<p class="p1">M. Elkin, S. Buchwald

5.24[J] Archaeological Science
Same subject as 3.985[J], 12.011[J]
Prereq: Chemistry (GIR) or Physics I (GIR)
U (Spring)
3-1-5 units. HASS-S

See description under subject 3.985[J].
J. Meanwell

5.301 Chemistry Laboratory Techniques
Prereq: Chemistry (GIR) and permission of instructor
U (IAP)
1-4-1 units

Practical training in basic chemistry laboratory techniques. Intended to provide students with the skills necessary to undertake original research projects in chemistry. Limited to first-year students in IAP (application required); open to all students in spring (enrollment by lottery).
P. Venkatesan

5.302 Introduction to Experimental Chemistry
Prereq: None
U (IAP; partial term)
Not offered regularly; consult department
0-3-0 units

Illustrates fundamental principles of chemical science through practical experience with chemical phenomena. Students explore the theoretical concepts of chemistry through the experiments which informed their discovery, and make chemistry happen with activities that are intellectually stimulating and fun. Preference to first-year students.
M. Shoulders

5.310 Laboratory Chemistry
Prereq: None. *Coreq: 5.12*
U (Fall, Spring)
2-7-3 units. Institute LAB

Introduces experimental chemistry for students who are not majoring in Course 5. Principles and applications of chemical laboratory techniques, including preparation and analysis of chemical materials, measurement of pH, gas and liquid chromatography, visible-ultraviolet spectrophotometry, infrared spectroscopy, kinetics, data analysis, and elementary synthesis, are described, in addition to experimental design principles. Includes instruction and practice in written and oral communication to multiple audiences. Enrollment limited.
P. Venkatesan

5.351 Fundamentals of Spectroscopy
Prereq: Chemistry (GIR)
U (Fall, Spring; partial term)
1-2-1 units. Partial Lab

Students carry out an experiment that introduces fundamental principles of the most common types of spectroscopy, including UV-visible absorption and fluorescence, infrared, and nuclear magnetic resonance. Emphasizes principles of how light interacts with matter, a fundamental and hands-on understanding of how spectrometers work, and what can be learned through spectroscopy about prototype molecules and materials. Students record and analyze spectra of small organic molecules, native and denatured proteins, semiconductor quantum dots, and laser crystals. Satisfies 4 units of Institute Laboratory credit.
K. Nelson

5.352 Synthesis of Coordination Compounds and Kinetics
Prereq: None. *Coreq: 5.351*
U (Fall, Spring; partial term)
1-2-2 units. Partial Lab

Students carry out an experiment that provides an introduction to the synthesis of simple coordination compounds and chemical kinetics. Illustrates cobalt coordination chemistry and its transformations as detected by visible spectroscopy. Students observe isosbestic points in visible spectra, determine the rate and rate law, measure the rate constant at several temperatures, and derive the activation energy for the aquation reaction. Satisfies 5 units of Institute Laboratory credit.
Y. Surendranath

5.353 Macromolecular Prodrugs
Prereq: None. *Coreq: 5.12 and 5.352*
U (Fall, Spring; partial term)
1-2-1 units. Partial Lab

Students carry out an experiment that builds skills in how to rationally design macromolecules for drug delivery based on fundamental principles of physical organic chemistry. Begins with conjugation of a drug molecule to a polymerizable group through a cleavable linker to generate a prodrug monomer. Continues with polymerization of monomer to produce macromolecular (i.e., polymer) prodrug; monomer and polymer prodrugs are fully characterized. Rate of drug release is measured and correlated to the size of the macromolecule as well as the structure of the cleavable linker. Satisfies 4 units of Institute Laboratory credit.
J. Johnson

5.361 Recombinant DNA Technology
Prereq: (5.07[J] or 7.05) and (5.310 or 5.352)
U (Spring; partial term)
1-2-1 units

Students explore the biochemical basis for the efficacy of a blockbuster drug: Gleevec, which is used to treat chronic myelogenous leukemia. Its target, Abl kinase, is produced in E. coli by recombinant DNA technology, purified using affinity chromatography, and analyzed with polyacrylamide gel electrophoresis, UV-vis spectroscopy, and a colorimetric assay. Natural mutations found in Gleevec-resistant cancer patients are introduced into the ABL1 proto-oncogene with PCR-based mutagenesis and analyzed by agarose gel electrophoresis.
E. Nolan

5.362 Cancer Drug Efficacy
Prereq: (5.07[J] or 7.05) and (5.310 or 5.352); *Coreq: 5.361*
U (Spring; partial term)
1-2-2 units

Students probe the structural basis for the development of resistance to Gleevec by cancer patients. LC-MS is used to quantify the effect of Gleevec on catalysis by wild-type Abl kinase and a Gleevec-resistant variant (Module 4). Other potential drugs are tested as inhibitors of the Abl variant. Molecular graphics software is used to understand catalysis by Abl kinase, its inhibition by Gleevec, and the basis for drug resistance.
E. Nolan

5.363 Organic Structure Determination
Prereq: 5.12; *Coreq: 5.13*
U (Fall; partial term)
1-2-1 units. Partial Lab

Introduces modern methods for the elucidation of the structure of organic compounds. Students carry out transition metal-catalyzed coupling reactions, based on chemistry developed in the Buchwald laboratory, using reactants of unknown structure. Students also perform full spectroscopic characterization - by proton and carbon NMR, IR, and mass spectrometry of the reactants - and carry out coupling products in order to identify the structures of each compound. Other techniques include transfer and manipulation of organic and organometallic reagents and compounds, separation by extraction, and purification by column chromatography. Satisfies 4 units of Institute Laboratory credit.
S. Buchwald

5.371 Continuous Flow Chemistry: Sustainable Conversion of Reclaimed Vegetable Oil into Biodiesel
Prereq: 5.13 and 5.363
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Spring; partial term)
1-2-1 units

Presents the theoretical and practical fundamentals of continuous flow synthesis, wherein pumps, tubes, and connectors are used to conduct chemical reactions instead of flasks, beakers, etc. Focuses on a catalytic reaction that converts natural vegetable oil into biodiesel that can be used in a variety of combustion engines. Provides instruction in several important organic chemistry experimental techniques, including purification by extraction, rotary evaporation, acid-base titration, gas chromatography (GC), and ¹H NMR.
Staff

5.372 Chemistry of Renewable Energy
Prereq: 5.03 and 5.352
U (Fall; partial term)
1-2-1 units

Introduces the electrochemical processes that underlie renewable energy storage and recovery. Students investigate charge transfer reactions at electrode surfaces that are critical to the operation of advanced batteries, fuel cells, and electrolyzers. Develops basic theory behind inner- and outer-sphere charge transfer reactions at interfaces and applies this theory to construct mechanistic models for important energy conversion reactions including the reduction of O_2 to water and the reduction of protons to H_2. Students will also synthesize new catalytic materials for these reactions and investigate their relative performance.
Y. Surendranath

5.373 Synthesis of Boron Heterocycles
Prereq: 5.03 and 5.363
U (Fall; partial term)
1-2-1 units

Experimental module focused on the synthesis and characterization of boron heterocycles, which are used as chemical synthons for metal complexes, small-molecule activation (e.g., carbon dioxide), catalysis mediators, components of optoelectronic materials, monomers for polymeric systems, and molecular building blocks for photochemistry. Covers techniques such as glovebox and Schlenk line methods for synthesis in the absence of oxygen and water; ligand effects, filtration, reaction mixture concentration, and recrystallization under an inert atmosphere. Characterization methods include proton and boron NMR spectroscopy, UV-Vis spectroscopy, and fluorescence measurements.
R. Gilliard

5.381 Quantum Dots
Prereq: 5.353 and 5.611
U (Spring; partial term)
1-2-1 units

Covers synthesis of a discrete size series of quantum dots, followed by synthesis of a single size of core/shell quantum dots utilizing air-free Schlenk manipulation of precursors. Uses characterization by absorption and fluorescence spectroscopies to rationalize the compositional/size dependence of the shell on the electronic structure of the quantum dots. Students acquire time traces of the fluorescence of single core and core/shell quantum dots using single molecule spectroscopic tools. The fluorescence on/off blinking distribution observed will be fit to a standard model. Students use Matlab for computational modeling of the electron and hole wavefunction in core and core/shell quantum dots. Analyzes several commercial applications of quantum dot technologies.
M. Bawendi

5.382 Time- and Frequency-resolved Spectroscopy of Photosynthesis
Prereq: 5.611 and (5.07[J] or 7.05); *Coreq: 5.361*
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Spring; partial term)
1-2-2 units

Uses time- and frequency-resolved fluorescence measurements to investigate photosynthetic light harvesting and energy transfer.
G. Schlau-Cohen

5.383 Fast-flow Peptide and Protein Synthesis
Prereq: 5.363 and (5.07[J] or 7.05)
U (Spring; partial term)
1-2-1 units

Develops understanding of both the theory and practice of fundamental techniques in biological chemistry, including chemical reactivity (amide-bond formation, solid phase synthesis, disulfide bond formation, and protecting group chemistry); separation science for purification and analysis, such as preparative HPLC and MALDI-TOF MS; and protein structure-function relationships (protein folding and binding). Periodically, guest lecturers from the local biotech research community will describe practical applications in industry.
B. Pentelute

5.39 Research and Communication in Chemistry
Prereq: An approved research experience and permission of instructor
U (Spring)
2-12-6 units

Independent research under the direction of a member of the Chemistry Department faculty. Allows students with a strong interest in independent research to fulfill part of the laboratory requirement for the Chemistry Department Program in the context of a research laboratory at MIT. The research must be conducted on the MIT campus and be a continuation of a previous 12-unit UROP project or full-time work over the summer. Instruction and practice in written and oral communication is provided, culminating in a poster presentation of the work at the annual departmental UROP symposium and a research publication-style writeup of the results. Permission of the faculty research advisor and the Chemistry Education Office must be obtained in advance. Preference to juniors. Students in other years should consult with their faculty research advisor.
A. Radosevich

5.43 Advanced Organic Chemistry
Prereq: 5.13
U (Spring)
4-0-8 units

Reaction mechanisms in organic chemistry: methods of investigation, relation of structure to reactivity, and reactive intermediates. Photochemistry and organometallic chemistry, with an emphasis on fundamental reactivity, mechanistic studies, and applications in organic chemistry.
T. Swager

5.44 Organometallic Chemistry
Prereq: 5.061, 5.43, 5.47, or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall; second half of term)
2-0-4 units

Examination of the most important transformations of organotransition-metal species. Emphasizes basic mechanisms of their reactions, structure-reactivity relationships, and applications in synthesis.
A. Wendlandt

5.45 Heterocyclic Chemistry
Prereq: 5.511 and 5.53
G (Spring; first half of term)
2-0-4 units

Provides an introduction to the chemistry of heterocyclic compounds. Surveys synthesis and reactivity of the major classes of heterocyclic organic compounds. Discusses the importance of these molecules in the pharmaceutical and other industries.
S. Buchwald

5.46 NMR Spectroscopy and Organic Structure Determination
Prereq: 5.13 or permission of instructor
G (Spring; first half of term)
2-0-4 units

Develops the nuclear magnetic resonance (NMR) spectroscopy skills necessary to solve the structures of organic molecules. Covers basic NMR experiments and demonstrates how to apply them. Discusses the chemical shift assignment strategies for known compounds, approaches to solving unknown structures, and best practice for chemistry publications and patents. Examples in organic and inorganic chemistry, polymer science, and biochemistry presented.
W. Massefski

5.47 Tutorial in Organic Chemistry
Prereq: 5.43 and permission of instructor
G (Fall; partial term)
2-0-4 units

Systematic review of fundamental concepts concerned with the structure and transformations of organic molecules. Problem-solving workshop format. The program is intended primarily for first-year graduate students with a strong interest in organic chemistry. Meets during the month of September.
Staff

5.48[J] Protein Folding in Health and Disease
Same subject as 7.88[J]
Prereq: (5.07[J] or 7.05) and permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; first half of term)
3-0-3 units

Focuses on understanding the chemical and biological mechanisms of protein folding, misfolding, aggregation, and quality control. Topics covered include: molecular mechanisms of protein folding; experimental and computational strategies to study protein folding; how cells fold and quality control proteins; protein misfolding and aggregation; proteostasis and human disease; strategies to address protein folding failures in disease; and protein folding in biotechnology development. Provides state-of-the-art understanding of the field, fosters ability to critically assess and use the literature, and empowers students to study and address protein folding issues in their research and beyond.
M. Shoulders

5.49 Chemical Microbiology
Prereq: (5.07[J] or 7.05) and permission of instructor
G (Spring; first half of term)
3-0-3 units

Focuses on molecular understanding of fundamental processes central to microbial physiology and infectious disease. Topics covered vary and may include (i) secondary metabolite biosynthesis and function, (ii) small molecule mediators of microbe-microbe and microbe-host interactions, (iii) membrane assembly, (iv) metal homeostasis and regulation, (v) antibiotics and antibiotic resistance, (vi) chemistry of the microbiome, and (vii) molecular basis of host-pathogen interactions. Integrates experimental approaches and primary literature.
E. Nolan

5.511 Synthetic Organic Chemistry I
Prereq: 5.43 and permission of instructor
G (Fall; second half of term)
2-0-4 units

Presents and discusses important topics in modern synthetic organic chemistry, with the objective of developing problem-solving skills for the design of synthetic routes to complex molecules.
M. Movassaghi

5.512 Synthetic Organic Chemistry II
Prereq: 5.511
G (Spring; second half of term)
2-0-4 units

General methods and strategies for the synthesis of complex organic compounds.
M. Movassaghi

5.52 Tutorial in Chemical Biology
Prereq: Permission of instructor
G (Fall)
2-2-8 units

Provides an overview of the core principles of chemistry that underlie biological systems. Students explore research topics and methods in chemical biology by participating in laboratory rotations, then present on experiments performed during each rotation. Intended for first-year graduate students with a strong interest in chemical biology.
R. Raines

5.53 Molecular Structure and Reactivity
Prereq: 5.43, 5.601, and 5.602
G (Fall)
3-0-9 units

Reaction mechanisms in organic chemistry: methods of investigation, relation of structure to reactivity, and reactive intermediates.
A. Radosevich, M. Elkin

5.54[J] Advances in Chemical Biology
Same subject as 7.540[J], 20.554[J]
Prereq: 5.07[J], 5.13, 7.06, and permission of instructor
G (Fall)
3-0-9 units

Introduction to current research at the interface of chemistry, biology, and bioengineering. Topics include imaging of biological processes, metabolic pathway engineering, protein engineering, mechanisms of DNA damage, RNA structure and function, macromolecular machines, protein misfolding and disease, metabolomics, and methods for analyzing signaling network dynamics. Lectures are interspersed with class discussions and student presentations based on current literature.
L. Kiessling, O. Johnson

5.55 NMR Spectroscopy and Biochemical Structure Determination
Prereq: 5.07[J], 5.08[J], or permission of instructor
G (Spring; second half of term)
2-0-4 units

An exploration in nuclear magnetic resonance (NMR) spectroscopy applied to problems in biochemistry and chemical biology. Covers the application of NMR to questions of structure and dynamics in proteins, nucleic acids, and carbohydrates. NMR applications to ligand binding, including STD and DOSY methods, highlighted. An understanding of the material from 5.46 is preferred, but not required.
W. Massefski

5.56 Molecular Structure and Reactivity II
Prereq: 5.53 or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; second half of term)
2-0-4 units

Application of physical principles and methods to contemporary problems of interest in organic and polymer chemistry.
J. Johnson

5.561 Chemistry in Industry
Prereq: 5.03, 5.13, and (5.07[J] or 7.05)
G (Spring)
Not offered regularly; consult department
2-0-4 units

Examination of recent advances in organic, biological, and inorganic and physical chemical research in industry. Taught in seminar format with participation by scientists from industrial research laboratories.
R. L. Danheiser

5.601 Thermodynamics I
Prereq: Calculus II (GIR) and Chemistry (GIR)
U (Fall, Spring; first half of term)
2-0-4 units

Basic thermodynamics: state of a system, state variables. Work, heat, first law of thermodynamics, thermochemistry. Second and third law of thermodynamics: entropy and free energy, including the molecular basis for these thermodynamic functions. Equilibrium properties of macroscopic systems. Special attention to thermodynamics related to global energy issues and biological systems. Combination of 5.601 and 5.602 counts as a REST subject.
G. Schlau-Cohen, T. Van Voorhis

5.602 Thermodynamics II and Kinetics
Prereq: 5.601
U (Fall, Spring; second half of term)
2-0-4 units

Free energy and chemical potential. Phase equilibrium and properties of solutions. Chemical equilibrium of reactions. Rates of chemical reactions. Special attention to thermodynamics related to global energy issues and biological systems. Combination of 5.601 and 5.602 counts as a REST subject.
S. Peng

5.611 Introduction to Spectroscopy
Prereq: Calculus II (GIR), Chemistry (GIR), and Physics II (GIR)
U (Fall; first half of term)
2-0-4 units

Introductory quantum chemistry; particles and waves; wave mechanics; harmonic oscillator; applications to IR, Microwave and NMR spectroscopy. Combination of 5.611 and 5.612 counts as a REST subject.
M. Hong

5.612 Electronic Structure of Molecules
Prereq: 5.611
U (Fall; second half of term)
2-0-4 units

Introductory electronic structure; atomic structure and the Periodic Table; valence and molecular orbital theory; molecular structure, and photochemistry. Combination of 5.611 and 5.612 counts as a REST subject.
R. Griffin

5.613 Exploring Quantum Chemistry Using Python (New)
Prereq: 5.612
U (Spring)
2-0-4 units

Introduces the Python coding language through interactive lectures in order to develop computational thinking and build upon the concepts covered in 5.611 and 5.612 with the end goal of performing quantum chemical calculations. Quantum mechanical topics covered include tunneling, rotational spectroscopy, vibrational spectroscopy, and Hartree-Fock methods of quantum chemistry. Computational topics covered include concepts of modeling, coding, and evaluating results, data visualization, and fundamental concepts of computation such as Fourier analysis, linear algebra, fitting, and optimization. No prior coding knowledge is required.
D. Grimes

5.62 Physical Chemistry
Prereq: 5.601, 5.602, 5.611, and 5.612
U (Spring)
4-0-8 units

Elementary statistical mechanics; transport properties; kinetic theory; solid state; reaction rate theory; and chemical reaction dynamics.
S. Ceyer, A. Willard

5.64[J] Advances in Interdisciplinary Science in Human Health and Disease
Same subject as HST.539[J]
Prereq: 5.13, 5.601, 5.602, and (5.07[J] or 7.05)
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
3-0-9 units

Introduces major principles, concepts, and clinical applications of biophysics, biophysical chemistry, and systems biology. Emphasizes biological macromolecular interactions, biochemical reaction dynamics, and genomics. Discusses current technological frontiers and areas of active research at the interface of basic and clinical science. Provides integrated, interdisciplinary training and core experimental and computational methods in molecular biochemistry and genomics.
A. Shalek, X. Wang

5.65 Artificial Intelligence and Machine Learning in Chemical Biology
Prereq: Permission of instructor
G (Spring; second half of term)
3-0-3 units

Introduces core concepts in artificial intelligence and machine learning through the lens of chemical biology. Designed for graduate students with strong backgrounds in chemical biology and no programming experience. Topics include protein structure prediction, drug discovery, and high-throughput data analysis. Students will gain an intuitive understanding of AI/ML models and explore case studies where these tools have transformed research in molecular science. Intended for graduate students in chemical biology or a chemical biology-related program. No prior experience in AI, machine learning, or programming is required.
B. Pentelute

5.68[J] Kinetics of Chemical Reactions
Same subject as 10.652[J]
Prereq: 5.62, 10.37, or 10.65
Acad Year 2025-2026: G (Fall)
Acad Year 2026-2027: Not offered
3-0-6 units

Experimental and theoretical aspects of chemical reaction kinetics, including transition-state theories, molecular beam scattering, classical techniques, quantum and statistical mechanical estimation of rate constants, pressure-dependence and chemical activation, modeling complex reacting mixtures, and uncertainty/ sensitivity analyses. Reactions in the gas phase, liquid phase, and on surfaces are discussed with examples drawn from atmospheric, combustion, industrial, catalytic, and biological chemistry.
W. H. Green

5.697[J] Computational Chemistry
Same subject as 10.437[J]
Subject meets with 5.698[J], 10.637[J]
Prereq: Permission of instructor
U (Fall)
3-0-9 units

See description under subject 10.437[J]. Limited to 35; no listeners.
H. J. Kulik

5.698[J] Computational Chemistry
Same subject as 10.637[J]
Subject meets with 5.697[J], 10.437[J]
Prereq: Permission of instructor
G (Fall)
3-0-9 units

See description under subject 10.637[J]. Limited to 35; no listeners.
H. J. Kulik

5.70[J] Statistical Thermodynamics
Same subject as 10.546[J]
Prereq: 5.601 or permission of instructor
G (Fall)
3-0-9 units

Develops classical equilibrium statistical mechanical concepts for application to chemical physics problems. Basic concepts of ensemble theory formulated on the basis of thermodynamic fluctuations. Examples of applications include Ising models, lattice models of binding, ionic and non-ionic solutions, liquid theory, polymer and protein conformations, phase transition, and pattern formation. Introduces computational techniques with examples of liquid and polymer simulations.
J. Cao, B. Zhang

5.72 Statistical Mechanics
Prereq: 5.70[J] or permission of instructor
Acad Year 2025-2026: G (Spring; second half of term)
Acad Year 2026-2027: Not offered
2-0-4 units

Principles and methods of statistical mechanics. Classical and quantum statistics, grand ensembles, fluctuations, molecular distribution functions, and other topics in equilibrium statistical mechanics. Topics in thermodynamics and statistical mechanics of irreversible processes.
J. Cao. B. Zhang

5.73 Introductory Quantum Mechanics I
Prereq: 5.611, 5.612, 8.03, and 18.03
G (Fall)
3-0-9 units

Presents the fundamental concepts of quantum mechanics: wave properties, uncertainty principles, Schrodinger equation, and operator and matrix methods. Includes applications to one-dimensional potentials (harmonic oscillator), three-dimensional centrosymetric potentials (hydrogen atom), and angular momentum and spin. Approximation methods include WKB, variational principle, and perturbation theory.
M. Bawendi

5.74 Introductory Quantum Mechanics II
Prereq: 5.73
G (Spring)
3-0-9 units

Time-dependent quantum mechanics and spectroscopy. Topics include perturbation theory, two-level systems, light-matter interactions, relaxation in quantum systems, correlation functions and linear response theory, and nonlinear spectroscopy.
K. Nelson, G. Schlau-Cohen

5.78 Biophysical Chemistry Techniques
Subject meets with 7.71
Prereq: 5.07[J] or 7.05
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
2-0-4 units

Presents principles of macromolecular crystallography that are essential for structure determinations. Topics include crystallization, diffraction theory, symmetry and space groups, data collection, phase determination methods, model building, and refinement. Discussion of crystallography theory complemented with exercises such as crystallization, data processing, and model building. Meets with 7.71 when offered concurrently. Enrollment limited.
C. Drennan

5.80 Advanced Topics of Current Special Interest
Prereq: None
G (Fall, Spring)
Units arranged

Advanced topics of current special interest.
Staff

5.81[J] United States Energy Policy: Lessons Learned for the Future
Same subject as 15.029[J]
Subject meets with 5.811[J], 15.0291J
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall; second half of term)
2-0-4 units

Compares the US policy responses, from the Nixon administration to the current administration, on issues ranging from oil import dependence to nuclear nonproliferation. Examines what lessons were learned from these issues and how they have shaped the country's current climate change policy. Prepares students to be informed and effective participants in policy deliberations that require difficult decisions and trade-offs. Addresses both domestic and international policy aspects. Students taking graduate version complete additional assignments.
J. Deutch

5.811[J] United States Energy Policy: Lessons Learned for the Future
Same subject as 15.0291J
Subject meets with 5.81[J], 15.029[J]
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Fall; second half of term)
2-0-4 units

Compares the US policy responses, from the Nixon administration to the current administration, on issues ranging from oil import dependence to nuclear nonproliferation. Examines what lessons were learned from these issues and how they have shaped the country's current climate change policy. Prepares students to be informed and effective participants in policy deliberations that require difficult decisions and trade-offs. Addresses both domestic and international policy aspects. Students taking graduate version complete additional assignments.
J. Deutch

5.812[J] Principles of Innovation
Same subject as 10.258[J]
Subject meets with 5.82[J], 10.582[J]
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: U (Spring; second half of term)
2-0-4 units

Presents the key elements required for new technical ideas and business practices to be successfully deployed in an open economy, subject to international trade and external environmental costs. Examines the challenges of climate change and increased international competitiveness as they relate to innovation. Offers recommendations for major policy changes to how innovation is encouraged in the United States and the global economy. Students taking graduate version complete additional assignments.
J. Deutch

5.82[J] Principles of Innovation
Same subject as 10.582[J]
Subject meets with 5.812[J], 10.258[J]
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; second half of term)
2-0-4 units

Presents the key elements required for new technical ideas and business practices to be successfully deployed in an open economy, subject to international trade and external environmental costs. Examines the challenges of climate change and increased international competitiveness as they relate to innovation. Offers recommendations for major policy changes to how innovation is encouraged in the United States and the global economy. Students taking graduate version complete additional assignments.
J. Deutch

5.83 Advanced NMR Spectroscopy
Prereq: 5.73 or permission of instructor
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; first half of term)
2-0-4 units

Offers a classical and quantum mechanical description of nuclear magnetic resonance (NMR) spectroscopy. The former includes key concepts such as nuclear spin magnetic moment, Larmor precession, Bloch equations, the rotating frame, radio-frequency pulses, vector model of pulsed NMR, Fourier transformation in 1D and nD NMR, orientation dependence of nuclear spin frequencies, and NMR relaxation. The latter covers nuclear spin Hamiltonians, density operator and its time evolution, the interaction representation, Average Hamiltonian Theory for multi-pulse experiments, and analysis of some common pulse sequences in solution and solid-state NMR.
R. Griffin

5.891 Independent Study in Chemistry for Undergraduates
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of independent study under direction of Chemistry faculty member. May not substitute for required courses for the Chemistry major or minor.
Staff

5.892 Independent Study in Chemistry for Undergraduates
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Program of independent study under direction of Chemistry faculty member. May not substitute for required courses for the Chemistry major or minor.
Staff

5.893 Practical Internship Experience in Chemistry
Prereq: None
U (Summer)
0-1-0 units
Can be repeated for credit.

For Course 5 and 5-7 students participating in curriculum-related off-campus internship experiences in chemistry. Before enrolling, students must consult the Chemistry Education Office for details on procedures and restrictions, and have approval from their faculty advisor. Subject to department approval. Upon completion, the student must submit a write-up of the experience, approved by their faculty advisor.
J. Weisman

5.90 Problems in Chemistry
Prereq: Permission of instructor
G (Fall, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Directed research and study of special chemical problems. For Chemistry graduate students only.
J. Weisman

5.91 Teaching Experience in the Chemical Sciences
Prereq: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

For students in the chemistry graduate program while teaching. Classroom or laboratory teaching under the supervision of a faculty member and classroom-based instruction on timely topics related to education and modern teaching practices. Limited to chemistry graduate students who are teaching the same term.
E. Nolan

5.913 Seminar in Organic Chemistry
Prereq: Permission of instructor
G (Fall, Spring)
1-0-0 units
Can be repeated for credit.

Discusses current journal publications in organic chemistry.
Staff

5.921 Seminar in Chemical Biology
Prereq: Permission of instructor
G (Fall, Spring)
1-0-0 units
Can be repeated for credit.

Discusses topics of current interest in chemical biology.
Staff

5.931 Seminar in Physical Chemistry
Prereq: 5.60
G (Fall, Spring)
1-0-0 units
Can be repeated for credit.

Discusses topics of current interest in physical chemistry.
Staff

5.941 Seminar in Inorganic Chemistry
Prereq: 5.03
G (Fall, Spring)
1-0-0 units
Can be repeated for credit.

Discusses current research in inorganic chemistry.
Staff

5.95[J] Teaching College-Level Science and Engineering
Same subject as 1.95[J], 7.59[J], 8.395[J], 18.094[J]
Subject meets with 2.978
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Fall)
2-0-2 units

Participatory seminar focuses on the knowledge and skills necessary for teaching science and engineering in higher education. Topics include theories of adult learning; course development; promoting active learning, problemsolving, and critical thinking in students; communicating with a diverse student body; using educational technology to further learning; lecturing; creating effective tests and assignments; and assessment and evaluation. Students research and present a relevant topic of particular interest. Appropriate for both novices and those with teaching experience.
J. Rankin

5.961[J] Leadership and Professional Strategies & Skills Training (LEAPS), Part I: Advancing Your Professional Strategies and Skills
Same subject as 8.396[J], 9.980[J], 12.396[J], 18.896[J]
Prereq: None
G (Spring; second half of term)
2-0-1 units

See description under subject 8.396[J]. Limited to 80.
A. Frebel

5.962[J] Leadership and Professional Strategies & Skills Training (LEAPS), Part II: Developing Your Leadership Competencies
Same subject as 8.397[J], 9.981[J], 12.397[J], 18.897[J]
Prereq: None
G (Spring; first half of term)
2-0-1 units

See description under subject 8.397[J]. Limited to 80.
D. Rigos

5.S00 Special Subject in Chemistry
Prereq: None
G (Fall; second half of term)
Not offered regularly; consult department
Units arranged

Organized lecture, subject consisting of material in the broadly-defined field of chemistry not offered in regularly scheduled subjects.
J. Deutch

5.S64 Special Subject in Chemistry
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring; first half of term)
2-0-4 units

Organized lecture consisting of material in the broadly-defined field of chemistry not offered in regularly scheduled subjects.
X. Wang

5.S72 Special Subject in Chemistry
Prereq: None
Acad Year 2025-2026: Not offered
Acad Year 2026-2027: G (Spring)
3-0-9 units

Organized lecture consisting of material in the broadly defined field of chemistry not offered in regularly scheduled subjects.
J. Cao, B. Zhang

5.S75 Special Subject in Chemistry
Prereq: None
Acad Year 2025-2026: G (Spring; first half of term)
Acad Year 2026-2027: Not offered
2-0-4 units

Organized lecture consisting of material in the broadly-defined field of chemistry not offered in regularly scheduled subjects.
K. Nelson

5.THG Graduate Thesis
Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of a PhD thesis; to be arranged by the student and an appropriate MIT faculty member.
J. Weisman

5.THU Undergraduate Thesis
Prereq: Permission of instructor
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of original research under supervision of a chemistry faculty member, culminating with the preparation of a thesis. Ordinarily requires equivalent of two terms of research with chemistry department faculty member.
Staff

5.UAR[J] Climate and Sustainability Undergraduate Advanced Research
Same subject as 1.UAR[J], 3.UAR[J], 11.UAR[J], 12.UAR[J], 15.UAR[J], 22.UAR[J]
Prereq: Permission of instructor
U (Fall, Spring)
Not offered regularly; consult department
2-0-4 units
Can be repeated for credit.

See description under subject 1.UAR[J]. Application required; consult MCSC website for more information.
D. Plata, E. Olivetti

5.UR Undergraduate Research
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged [P/D/F]
Can be repeated for credit.

Program of research to be arranged by the student and a departmental faculty member. Research can be applied toward undergraduate thesis.
A. Radosevich

5.URG Undergraduate Research
Prereq: None
U (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research to be arranged by the student and a departmental faculty member. May be taken for up to 12 units per term, not to exceed a cumulative total of 48 units. A 10-page paper summarizing research is required.
A. Radosevich