Department of
Chemistry

Courses of Study:
Minor
Major (BA/BS)
Combined BA/MA
Master of Arts
Master of Science
Doctor of Philosophy

Objectives

Undergraduate Major
The chemistry major offers a broad training in modern chemistry, covering the major subfields—biochemistry, inorganic, organic, and physical—and at the same time allows students to pursue their special interest(s). Chemistry is the central science and the chemistry major provides a solid preparation for professional work in chemistry and allied fields; for study at the graduate level in chemistry and in other related fields (biochemistry, environmental science, pharmacology, polymer science, etc.); for professional schools (e.g., medicine, dentistry); and for developing an understanding of the technological and scientific issues challenging our society today—useful professionally in law and business, as well as in everyday life. Chemistry majors are given the opportunity to develop extensive, practical experience through laboratory courses using macro- and microscale techniques. Chemistry majors are encouraged to participate in independent research, which is an important part of a scientific education.

Graduate Program in Chemistry
The graduate program in chemistry, leading to the MA, MS, and PhD degrees, includes course work, seminar participation, research, and teaching, and is designed to lead to a broad understanding of the subject. Entering students may be admitted to either the master's or the doctoral program. All students will be required to demonstrate knowledge in advanced areas of chemistry. The doctoral program is designed to be flexible so that individual programs of study may be devised to satisfy the particular interests and needs of each student. In each case, this program will be decided by joint consultation between the student, the graduate studies committee, and the thesis supervisor, when selected. The doctoral program will normally include a basic set of courses in the student's own area of interest, to be supplemented by advanced courses in chemistry and, where appropriate, biochemistry, biology, mathematics, and physics.

How to Become a Major

The most important qualification for becoming a chemistry major is interest in and enjoyment of chemistry. In chemistry, as in other sciences, courses build on each other; therefore, it is important to begin early. Most students (but not all) take general chemistry and calculus in their first year. The chemistry major requires PHYS 11a,b or PHYS 15a,b (Basic Physics I,II), which is a prerequisite for physical chemistry and advanced experimental chemistry. Completing PHYS 11a,b or PHYS 15a,b by the end of the sophomore year (strongly recommended) will allow students to take physical chemistry and advanced experimental chemistry during their junior year. During the fall term, interested students meet with chemistry faculty and majors at a "meet the majors" gathering called to discuss the major in chemistry. Students should consult with their faculty advisers to develop a program of courses to shape their needs and interests. To apply for the honors program, a student must select a research adviser and submit a proposed plan to the department by September 15 of his or her senior year.

How to Be Admitted to the Graduate Program

The general requirements for admission to the Graduate School, given in an earlier section of this *Bulletin*, apply to candidates for admission to the graduate program in chemistry. In addition, the undergraduate curriculum of applicants should include courses in inorganic, organic, and physical chemistry.

Faculty

Irving Epstein, Chair
Nonlinear chemical dynamics. Spatial pattern formation, oscillations, and chaos in reaction-diffusion systems. Mathematical modeling of biochemical kinetics and neural systems. Networks.

Jeffrey Agar (on leave fall 2008)
Development of mass spectrometry methods for the comprehensive identification of proteins and their post-translational modifications. Current projects involve the role of protein modification in memory and neurodegeneration.

Li Deng
Asymmetric catalysis and asymmetric synthesis. Solid phase synthesis and combinatorial chemistry. Chiral recognition. Chemical approaches toward understanding protein functions.

Milos Dolnik
Pattern formation in reaction-diffusion systems. Mathematical modeling of complex chemical reactions and gene networks. Deterministic chaos.

Bruce Foxman, Undergraduate Advising Head
X-ray structure determination. Coordination polymers. Chemical, physical, and crystallographic studies of solid-state reactions. Automatic solution of crystal structures using novel computer techniques.

Anne Gershenson (on leave fall 2008)
Protein dynamics, stability, and folding. Optical spectroscopy of single molecules. Protein engineering and directed evolution.

Liz Hedstrom
Relationship between protein structure and function in enzyme catalysis and inhibitor action. Understanding the effects of mutations in vivo.

Judith Herzfeld
Solid-state NMR studies of the structure and functional mechanisms of membrane proteins. Statistical thermodynamics of proton transfer and transport in aqueous systems and proteins.

Peter Jordan
Statistical mechanics of membranes and of membrane transport. Modeling of ion and water pores. Molecular dynamics. Modeling peptide-membrane interaction.

Philip Keehn (on leave 2008–2009)
Synthetic methods, organic synthesis of strained rings, and theoretically interesting molecules. Host-guest complexes. Plant medicinals. Applications of NMR spectroscopy to organic systems. Photooxidation.

Isaac Krauss
Study of organic synthesis, including its interface with other areas of chemical science, including organometallics and chemical biology.

Oleg Ozerov
Organometallic chemistry. Structure, bonding, and reactivity relationships. Catalytic applications of organotransition metal complexes. Ligand promoted reactivity at transition metal centers.

Gregory Petsko
Protein crystallography, especially direct observation of transient species by low-temperature and Laue methods. Signal transduction in the process of quiescence. Protein dynamics. Protein engineering. Structure/function of proteins involved in neurodenegerative diseases such as Parkinson's Disease and Alzheimer's Disease. Yeast genetics.

Susan Pochapsky
Self-assembly of chemical and biological systems. Transient interactions in solution by NMR. NMR of soluble proteins. Protein stability and folding by NMR and mutagenesis.

Thomas Pochapsky
Biological redox enzymes structure and mechanism. Transient interactions in solution by NMR. Biomimetic energy conversion.

Jason Pontrello
Small molecule organic synthesis. Solid-phase synthesis. Polymer chemistry.

Arthur Reis
Forensic science and DNA replication. Single mtDNA molecule amplification for single nucleotide polymorphism (SNP) determination in human biological samples that impact our understanding of aging, and use in forensic assays.

Dagmar Ringe
Protein crystallography and structural enzymology. Structure and function of PLP dependent enzymes, DNA binding proteins, and enzymes that utilize bimetallic centers for catalysis. Evolution of metabolic pathways. Rational drug design.

Timothy Rose
Physical and environmental chemistry, materials science, electrochemistry, photochemistry; undergraduate laboratory development.

Barry Snider
Development of new synthetic methods. Mechanisms of synthetically important reactions. Total synthesis of natural products.

Christine Thomas
Synthesis of new ligands and transition metal complexes with the ultimate goal of uncovering new approaches to the catalytic activation and functionalization of small molecules and organic substrates.

Bing Xu
Biofunctional magnetic nanoparticles. Development of new bioanalytical protocols and techniques for studying biological activity. Molecular hydrogels and interactions with biological systems in vitro and in vivo. Develop new biomaterials.

Anatol Zhabotinsky
Oscillating chemical reactions and pattern formation in reaction-diffusion systems. Mathematical modeling of biochemical kinetics and neural systems.

Requirements for the Minor

The minor in chemistry consists of:

A. Six full-credit (four-semester-hour) courses and three half-credit (two-semester-hour) courses:

CHEM 11a and b (or CHEM 15a and b)
CHEM 18a and b (or CHEM 19a and b)
CHEM 25a
CHEM 29a

B. Three additional full-credit (four semester-hour) chemistry courses that meet the major requirements; BCHM 100a, 101a, 103b, or 104b may be substitued for one of these courses.

Requirements for the Major

Bachelor of Arts
A. Two semesters of general chemistry lectures (CHEM 11a,b; or CHEM 15a,b) with laboratory (CHEM 18a,b; CHEM 19a,b).

B. Five semester lecture courses, at least four of them in CHEM, chosen from among CHEM 25a,b and courses in CHEM or BCHM numbered 30 or higher (including BIOL 105b and NBIO 148b). Courses must include at least one in each of the following three groups: inorganic chemistry (CHEM 121a, 122b, 123b), organic chemistry (CHEM 25a,b), physical chemistry (CHEM 141a, 142a, 143b).

C. CHEM 29a plus three laboratory courses chosen from CHEM 29b, 39b, 59a, or 59b.

D. MATH 10a,b and PHYS 11a,b or PHYS 15a,b, which are prerequisites for physical chemistry and advanced experimental chemistry. *Students are urged to complete PHYS 11a,b or PHYS 15 a,b by the end of their sophomore year.* Students with AP credit for MATH 10a,b are advised to take at least one additional MATH course at Brandeis, as is generally expected by professional schools. A recently taken math course may also strengthen preparation for physical chemistry. MATH 15a or MATH 20a is suitable for either the medical school requirements or preparation for physical chemistry.

E. Additional requirements for degree with departmental honors: two semesters of CHEM 99d (Senior Research); GPA of 3.00 or higher in all courses taken to meet the major requirements, including laboratories. Students must petition the department by September 15 of their senior year to enter the senior honors program. Students interested in taking a program of study approved by the American Chemical Society should consult their faculty advisers.

F. Students planning to pursue graduate study in chemistry should be sure that their program of study includes at least two semesters each of organic chemistry lectures (CHEM 25a,b) and laboratory (CHEM 29a,b), physical chemistry lectures (CHEM 141a, 142a, or 143b), as well as BCHM 100a. Degree requirements can be satisfied by any combination of physical chemistry courses (CHEM 141a, 142a, or 143b); however, in general, thermodynamics (CHEM 141a) should be one of them. Students should discuss their choice of a second physical chemistry course with the undergraduate advising head. Physics laboratory (PHYS 19a,b) is also advisable.

G. All transfer students must pass satisfactorily a minimum of three chemistry or biochemistry courses at Brandeis at a level of CHEM 25 or higher with one of the three being CHEM 39b, 59a, or 59b.

H. A student may graduate with a double major in biology and chemistry if the major requirements in each department are fully met.

I. A student may graduate with a double major in chemistry and biochemistry if the major requirements in each department are fully met.

Bachelor of Science
A. Two semesters of general chemistry lectures (CHEM 11a,b; or CHEM 15a,b) with laboratory (CHEM 18a,b; or CHEM 19a,b).

B. Two semesters of organic chemistry lectures (CHEM 25a,b) with laboratory (CHEM 29a,b).

C. Two semesters of physical chemistry lectures (CHEM 141a, 142a, or 143b).

D. One semester of inorganic chemistry lectures (CHEM 121a, 122b, or 123b).

E. Three four-credit laboratory courses (CHEM 39b; CHEM 59a,b; or one arranged with a laboratory instructor).

F. Two additional 100-level CHEM courses. (Either CHEM 33a or a 100-level BCHM course may be substituted for one of the two 100-level CHEM courses.)

G. MATH 10a,b and PHYS 11a,b or PHYS 15a,b, which are prerequisites for physical chemistry and advanced experimental chemistry. *Students are urged to complete PHYS 11a,b or PHYS 15a,b by the end of their sophomore year.* Students with AP credit for MATH 10a,b are advised to take at least one additional MATH course at Brandeis, as is generally expected by professional schools. A recently taken math course may also strengthen preparation for physical chemistry. MATH 15a or 20a is suitable for either the medical school requirements or preparation for physical chemistry.

H. Additional requirements for degree with departmental honors: Two semesters of CHEM 99d (Senior Research) and a GPA of 3.00 or higher in all courses taken to meet the major requirements, including laboratories. Students must petition the department by September 15 of their senior year to enter the senior honors program. Students interested in taking a program of study approved by the American Chemical Society should consult their faculty advisers.

I. For students planning to pursue graduate study in chemistry, BCHM 100a and physics laboratory (PHYS 19a,b) are also advisable. Degree requirements can be satisfied by any combination of physical chemistry courses (CHEM 141a, 142a, or 143b); however, in general, thermodynamics (CHEM 141a) should be one of them. Students should discuss their choice of a second physical chemistry course with the undergraduate advising head.

J. All transfer students must pass satisfactorily a minimum of three chemistry or biochemistry courses at Brandeis at a level of CHEM 25 or higher with one of the three being CHEM 39b, 59a, or 59b.

K. Provisions H and I of the BA requirements also apply to BS degrees.

Combined BA/MA Program

Candidates for departmental honors may be admitted to a special four-year BA/MA program upon recommendation of the department and the Graduate School. Application must be made by May 1 preceding the senior year. Students must complete requirements A–E as described in the requirements for the BA.

Additionally, the following requirements must also be completed:

A. One 130-level organic chemistry course.

B. One 140-level physical chemistry course. The overall BA/MA course selection must include at least two of CHEM 141a, 142a, and 143b.

C. One 100-level chemistry course OR one of CHEM 39b, 59a or 59b.

D. Two other 100-level courses from the School of Science.

The above five courses may not also be counted toward the BA requirements. Grades of B– or better are required in the 100-level science courses. Candidates should carefully read the section "Dual Bachelor's/Master's Degree Programs" under the heading "Special Academic Opportunities," which appears earlier in this *Bulletin*. Most notable are the three-year residence requirement and the required total of thirty-eight courses, only four of which may come from AP/IB credits, consistent with university regulations.

Special Notes Relating to Undergraduates

Either CHEM 11a,b lecture and CHEM 18a,b laboratory *or* CHEM 15a,b lecture and CHEM 19a,b laboratory will satisfy the general chemistry requirements of most medical schools. The organic chemistry requirements of most medical schools will be satisfied by CHEM 25a,b lecture and CHEM 29a,b laboratory.

Special Notes Relating to Graduate Students

Chemistry colloquia are lectures given by faculty and invited speakers. Participation in this noncredit activity is required of all graduate students.

Requirements for the Degree of Master of Arts

Program of Study
Each candidate is required to successfully complete one year of study at the graduate level in chemistry, or, with prior permission of the graduate studies committee, in related fields. The program will include laboratory work and, normally, six term courses at the graduate level. The detailed program of study will be chosen jointly by the candidate and the graduate studies committee.

Library Training Requirement
All graduate students are required to complete a designated library training program in their first year.

Placement and Evaluation of Progress
Each student is expected to demonstrate a satisfactory knowledge of undergraduate chemistry in placement examinations in physical, organic, and inorganic chemistry. These examinations occur twice a year, before the start of each term. The results of these examinations will determine the student's initial program of course work and will be considered by the graduate studies committee in evaluating the student's progress.

Residence Requirement
The minimum residence requirement for the MA degree is one year.

Requirements for the Degree of Master of Science

Program of Study
In general, each student will be required to pass a minimum of six graduate-level courses, of which one must be outside the student's field of research. If a student fails to pass a placement examination after two attempts, a graduate course in that area of chemistry must be passed before the end of the second year. A list of courses appropriate for this purpose is available upon request. It is expected that students will choose a research adviser during the first year.

Library Training Requirement
All graduate students are required to complete a designated library training program in their first year.

Placement and Evaluation of Progress
Each student is expected to demonstrate a satisfactory knowledge of undergraduate chemistry in placement examinations in physical, organic, and inorganic chemistry. These examinations occur twice a year, before the start of each term. The results of these examinations will determine the student's initial program of course work and will be considered by the graduate studies committee in evaluating the student's progress.

Residence Requirement
The minimum residence requirement for the MS degree is two years.

Seminar
Each student in residence is required to attend and participate in the seminar in their chosen major throughout the period of graduate study. Each student is expected to present one seminar during their residence.

Dissertation and Defense
An MS dissertation is required and must describe the results of an original investigation and demonstrate the competence of the candidate in independent investigation, critical ability, and effectiveness of expression. The thesis must be approved by the research adviser and a second reader appointed by the graduate studies committee. Two copies of the thesis must be submitted to the department in final form by the same deadline that PhD candidates need to deposit dissertations (refer to the Academic Calendar).

Special Notes Relating to the Master's Degrees

The MA degree is awarded as a first step toward the PhD. The MS degree is designed for advanced students who do not wish to complete the PhD degree.

Students may normally hold only one master's degree in the department. For example, a student who has received an MA degree may not apply for the MS degree.

Students in the MA or MS program are not eligible for scholarship or fellowship support.

Requirements for the Degree of Doctor of Philosophy

Program of Study
A balanced program of study will be prepared by the student and the graduate studies committee. In general, students will be required to take a minimum of six graduate-level courses, of which one must be outside the student's field of research. If a student fails to pass a placement examination, a graduate course in that area of chemistry must be passed before the end of the second year. A list of courses appropriate for this purpose is available upon request. For students entering with a master's degree or the equivalent, two to four courses may be transferred for credit. It is expected that doctoral students will choose a research adviser during the first year.

Placement and Evaluation of Progress
Each student is expected to demonstrate a satisfactory knowledge of undergraduate chemistry in placement examinations in physical, organic, and inorganic chemistry. These examinations are set twice a year, before the start of each term. The results of these examinations will determine the student's initial program of course work and will be considered by the graduate studies committee in evaluating the student's progress.

Readmission to the PhD degree program will be based on the student's record in course work during the first year and his or her performance on the placement examinations. Further progress will be evaluated on a yearly basis by the graduate studies committee.

Qualifying Examinations
The graduate student must demonstrate proficiency in his or her major field by passing the qualifying exam in that field. Depending on the field, the qualifying exam takes the form of cumulative examinations or propositions. Cumulative examinations (given six times each year on unannounced topics) are taken starting in the first semester of graduate work. Proficiency is demonstrated by passing six exams within a reasonable period of time. Propositions are generally assigned during the third semester of graduate work and form the basis of a combination of written and oral examinations. Either three propositions are assigned or two propositions are supplemented by a research proposal. Students in all fields must maintain satisfactory progress by passing these examinations.

Residence Requirement
The minimum residence requirement for the PhD degree is three years.

Seminar
Each student in residence is required to attend and participate in the seminar in their chosen major throughout the period of graduate study. Each student is expected to present two seminars during their residence.

Teaching Requirement
It is required that all graduate students participate in undergraduate teaching during the course of their studies.

Library Training Requirement
All graduate students are required to complete a designated library training program in their first year.

Dissertation and Defense
A dissertation is required that describes the results of an original investigation and demonstrates the competence of the candidate in independent investigation, critical ability, and effectiveness of expression. The student must successfully defend the dissertation in a final oral examination.

Requirements for the Degree of Doctor of Philosophy in Chemistry with Specialization in Quantitative Biology

Program of Study
Students wishing to obtain the specialization must first gain approval of the graduate studies committee. This should be done as early as possible; ideally, during the first year of graduate studies. In order to receive the PhD in chemistry with additional specialization in quantitative biology, candidates must:

A. Complete the requirements for the PhD described above.

B. Complete the course requirements of the quantitative biology specialization as outlined in that section of this *Bulletin*.

Any alteration to the quantitative biology course requirements must be approved by the graduate studies committee and by the quantitative biology program faculty advisory committee.

Courses of Instruction

(1–99) Primarily for Undergraduate Students

CHSC 3b Solving Environmental Challenges: The Role of Chemistry
[sn]
Does not meet the requirements for the major in chemistry.
Provides a basic understanding of the chemistry of natural environmental cycles, and how these cycles are adversely affected by society. Student teams develop case studies on "hot topics" such as mercury, brominated flame retardants, MBTE, perchlorate, dioxin, and others. Usually offered every second year.
Mr. Peavey

CHSC 6a Forensic Science: Col. Mustard, Candlestick, Billiard Room
[sn qr]
Prerequisites: High school chemistry and biology. Does NOT meet requirements for the major in chemistry.
Examines the use of chemical analytical instrumentation, pathology, toxicology, DNA analysis, and other forensic tools. Actual and literary cases are discussed. Error analysis, reliability, and predictability of results are considered. Usually offered every year.
Mr. Reis

CHSC 8b Chemistry and Art
[qr sn]
Does NOT meet requirements for the major in chemistry. Lab fee: $25.
Topics include a scientific description of the materials and methods used in making works of art; light and color; pigments and dyes; restoration and conservation; scientific examination of artworks; the identification of fakes; and scientific probes of influence and style. Usually offered every second year.
Mr. Henchman

CHEM 11a General Chemistry I
[qr sn]
This course may not be taken for credit by students who have passed CHEM 15a in previous years.
A basic course in chemical principles, with examples drawn from the chemistry of living systems as well as from environmental chemistry and materials science. Topics covered include stoichiometry, acid-base chemistry, chemical equilibrium, atomic structure and periodicity, molecular structure and bonding, and states of matter. Three class hours and one ninety-minute recitation per week. In addition, daily tutoring sessions will be available for students seeking extra help. The corresponding lab is CHEM 18a. Usually offered every year.
Mr. Petsko

CHEM 11b General Chemistry II
[qr sn]
Prerequisite: A satisfactory grade (C– or better) in CHEM 11a or the equivalent. This course may not be taken for credit by students who have passed CHEM 15b in previous years.
A basic course in chemical principles, with examples drawn from the chemistry of living systems as well as from environmental chemistry and materials science. Topics covered include kinetics, properties of solutions, thermodynamics, electrochemistry, coordination compounds, nuclear chemistry, and descriptive chemistry. Three class hours and one ninety-minute recitation per week. In addition, daily tutoring sessions will be available for students seeking extra help.The corresponding lab is CHEM 18b. Usually offered every year.
Mr. Epstein

CHEM 15a Honors General: Principles of Material Evolution I
[qr sn]
This course may not be taken for credit by students who have passed CHEM 11a in previous years.
An enriched version of general chemistry for students with good preparation. Introduces the chemical principles governing the evolution of our material world through the condensation, coexistence, and aqueous stages. Three class hours and one recitation per week. The corresponding laboratory is CHEM 19a. Usually offered every year.
Ms. Herzfeld

CHEM 15b Honors General: Principles of Material Evolution II
[qr sn]
Prerequisite: A satisfactory grade (C– or better) in CHEM 15a or the equivalent. This course may not be taken for credit by students who have passed CHEM 11b in previous years.
A continuation of CHEM 15a. Introduces the chemical principles governing the evolution of our material world through the photonic, biotic, and anthropic stages. Three class hours and one recitation per week. The corresponding laboratory is CHEM 19b. Usually offered every year.
Ms. Herzfeld

CHEM 18a General Chemistry Laboratory I
Corequisite: CHEM 11a. Dropping CHEM 11a necessitates written permission from the lab instructor to continue with this course. May yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $45 per semester. This course may not be taken for credit by students who have passed CHEM 19a in previous years.
Introduction to basic laboratory methods and methods of qualitative and quantitative analyses. Included in the analytical methods are gas chromatography-mass spectroscopy and infrared measurements. A synthesis project that includes analyzing the product by titration. Calorimetric experiment using probes interfaced with computers. Identification of unknowns based on physical and chemical properties. Analysis of the metal content of substances by atomic absorption. One laboratory lecture per week. One afternoon of laboratory per week. Usually offered every year.
Mr. Dolnik

CHEM 18b General Chemistry Laboratory II
Prerequisites: A satisfactory grade (C– or better) in CHEM 18a and CHEM 11a. Corequisite: CHEM 11b. Dropping CHEM 11b necessitates written permission from the lab instructor to continue with this course. May yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $45 per semester. This course may not be taken for credit by students who have passed CHEM 19b in previous years.
The second semester of the general chemistry laboratory program. Continued use of probes interfaced with computers to monitor pH and electrical conductivity changes in titrating weak monoprotic and polyprotic amino acids, to monitor pressure changes as part of a kinetics study, and to monitor voltage changes of electrochemical cells with temperature so as to establish thermodynamic parameters for redox reactions. Also included is identification of unknowns based on selective precipitation and chromatography. Usually offered every year.
Mr. Dolnik

CHEM 19a Honors General Chemistry Laboratory I
Corequisite: CHEM 15a. Dropping CHEM 15a necessitates written permission from the lab instructor to continue with this course. May yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $45 per semester. This course may not be taken for credit by students who have taken CHEM 18a in previous years.
An advanced version of CHEM 18a. One afternoon of laboratory per week. One laboratory lecture per week. Usually offered every year.
Mr. Dolnik

CHEM 19b Honors General Chemistry Laboratory II
Prerequisite: A satisfactory grade (C– or better) in CHEM 19a. Corequisite: CHEM 15b. Dropping CHEM 15b necessitates written permission from the lab instructor to continue with this course. May yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $45 per semester. This course may not be taken for credit by students who have taken CHEM 18b in previous years.
Continuation of CHEM 19a. An advanced version of CHEM 18b. Usually offered every year.
Mr. Dolnik

CHEM 25a Organic Chemistry, Lectures
[sn]
Prerequisite: A satisfactory grade (C– or better) in CHEM 11b or 15b or the equivalent.
Structure, reactions, preparations, and uses of the compounds of carbon. Three class hours and one ninety-minute recitation per week. Usually offered every year.
Mr. Snider

CHEM 25b Organic Chemistry, Lectures
[sn]
Prerequisite: A satisfactory grade (C– or better) in CHEM 25a or its equivalent.
A continuation of CHEM 25a. Three class hours and one ninety-minute recitation per week. Usually offered every year.
Staff

CHEM 29a Organic Chemistry Laboratory I
Prerequisite: A satisfactory grade (C– or better) in CHEM 18b or 19b or the equivalent. Corequisite: CHEM 25a. Dropping CHEM 25a necessitates written permission from lab instructor to continue with this course. May yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $45 per semester.
Gives experience in the important techniques of organic chemical laboratory practice of isolation and purification of organic compounds by crystallization, distillation, and chromatography, and their characterization using analytical and instrumental methods. One afternoon of laboratory per week. One ninety-minute laboratory lecture per week. Usually offered every year.
Staff

CHEM 29b Organic Chemistry Laboratory II
Prerequisite: A satisfactory grade (C– or better) in CHEM 29a or the equivalent. Corequisite: CHEM 25b. Dropping CHEM 25b necessitates written permission from lab instructor to continue with this course. May yield half-course credit toward rate of work and graduation. Two semester-hour credits. Laboratory fee: $45 per semester.
A continuation of CHEM 29a with an emphasis on the synthesis of typical organic compounds. One afternoon of laboratory per week. One ninety-minute laboratory lecture per week. Usually offered every year.
Staff

CHEM 33a Environmental Chemistry
[sn]
Prerequisite: A satisfactory grade (C– or better) in CHEM 11b or CHEM15b or the equivalent.
The course surveys the important chemical principles and reactions that determine the balance of the molecular species that exist in the environment and how human activity affects this balance. Topics include the critical role of energy resources and production on energy sustainability, climate change, pollution, and the chemistry controlling the composition, acidity, and nutrients in the hydrosphere and lithosphere. Factors leading to changes in the natural equilibrium such as acid rain, excessive fertilization, and release of toxic metals and pesticides are presented. The class evaluates current issues of environmental concern such as ozone depletion, global warming, radioactivity, green chemistry, gasoline additives, and chemical pollutants to develop a balanced view between the rewards achieved and the risks posed to the environment and man by current technology. The goal is to provide the background and tools necessary for assessing the chemistry of the environment for use in seeking optimal solutions to complex environmental problems. Usually offered every year.
Mr. Rose

CHEM 39b Intermediate Chemistry Laboratory
[sn wi]
Prerequisites: Satisfactory grades (C– or better) in CHEM 121a or 122b, or permission of the instructor. Four semester-hour credits. Laboratory fee: $45 per semester.
In this lab the emphasis is on synthetic inorganic chemistry. Compounds are synthesized and characterized by a wide range of instrumental methods of analysis (including GC-MS, IR, NMR). The lectures cover the appropriate background for synthetic experiments and the use of instrumental methods. One afternoon of lab per week and one one-hour lecture per week. Usually offered every second year.
Mr. Ozerov

CHEM 59a Advanced Experimental Chemistry
[sn]
Prerequisites: A satisfactory grade (C– or better) in CHEM 18b or equivalent; CHEM 141a, 142a or 143b (may be taken concurrently) or equivalent. Laboratory fee: $45 per semester.
CHEM 59a and b form a two-semester sequence, either half of which may be taken independently. CHEM 59a introduces the student to a number of topics of current interest in physical chemistry and provides experimental verification of chemical principles in thermodynamics, kinetics, macromolecules, semiconductors, nanochemistry, photochemistry, and electrochemistry. The properties, reactions, and structure of compounds are understood by evaluating their physiochemical responses to changes in experimental conditions. The experiments use spectroscopy, chromatography, electrochemical and other instrumental methods employed in the modern chemical laboratory. The program includes the methodology of quantitative measurement, statistical data analysis, and report writing. One one-hour lecture and one afternoon of laboratory per week. Usually offered every second year.
Staff

CHEM 95a Directed Studies in Chemistry
Prerequisites: CHEM 25a and 29a, or equivalent. Does not meet the major requirements in chemistry. Laboratory fee: $45 per semester. May not be repeated for credit. A designated library training component must be completed as soon as it is offered.
Readings and/or independent laboratory work. Periodic conferences with advisor and a final written report. CHEM 95a and b may be taken individually as one-semester courses or together as a year-long sequence. Usually offered every year.
Staff

CHEM 95b Directed Studies in Chemistry
See CHEM 95a for course description. Usually offered every year.
Staff

CHEM 99d Senior Research
Prerequisites: CHEM 59a, 59b, or 141a, or equivalent, which may be taken concurrently. Open only to senior honors candidates. Does not meet the major requirements in chemistry. Laboratory fee: $45 per semester. A designated library training component must be completed as soon as it is offered. At the end of the first semester, the introduction to the research thesis with extensive bibliography is due.
A year-long course focused on a research project with a member of the department. Successful completion of the course involves writing a detailed report on the project. Usually offered every year.
Staff

(100–199) For Both Undergraduate and Graduate Students

CHEM 110b Instrumental Analytical Chemistry
[sn]
Prerequisites: Satisfactory grade(s) in CHEM 41a and b, CHEM 59a and b, or equivalent. Laboratory fee: $45 per semester.
Techniques of instrumental chemical analysis. Application of instrumental methods to the separation and analysis of complex mixtures. Students rotate through ongoing research laboratories. Data treatment includes computers in the analytical chemistry laboratory. Two afternoons per week; approximately two hours of laboratory lecture and six hours of laboratory per week. Offered on request.
Staff

CHEM 121a Inorganic Chemistry I, Lectures
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b.
Simple bonding theory. Symmetry, structure, and bonding in inorganic compounds. Solid-state chemistry; ionic and electronic conductors. Applications of group theory and bonding theory to main group compounds and transition metal complexes. Coordination chemistry: isomerism, structure, and reactions. Usually offered every year.
Mr. Foxman

CHEM 122b Inorganic Chemistry II, Lectures
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b.
Molecular orbital theory in organometallic chemistry. Acid-base concepts. Introduction to the synthesis, structure, and applications of organotransition metal compounds. Usually offered every year.
Ms. Thomas

CHEM 123b Bioinorganic Chemistry
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b.
Bioinorganic chemistry involves the study of metal species in biological systems. Nearly one-third of proteins contain a metal cofactor. These cofactors catalyze an enormous breadth of chemical reactions, including many not yet accessible through conventional syntheses. Usually offered every second year.
Mr. Agar

CHEM 129b Special Topics in Inorganic Chemistry: Introduction to X-ray Structure Determination
[sn]
Topics include basic diffraction and space group theory, practical manipulations of crystals and X-ray diffraction equipment, solving crystal structures, and interpretation of structural chemistry. Course features self-paced exercises on PCs. Usually offered every second year.
Mr. Foxman

CHEM 130a Advanced Organic Chemistry: Structure
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b, or the equivalent.
Chemical bonding and structure, stereochemical principles and conformational analysis, organic reaction mechanisms, structures and activities of reactive intermediates, and pericyclic reactions. Usually offered every year.
Mr. Deng

CHEM 131a Advanced Organic Chemistry: Topics in Structure and Reactivity
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b, or the equivalent.
Broad coverage of a variety of transformations involving additions, eliminations, substitutions, oxidations, reductions, and rearrangements. Usually offered every year.
Staff

CHEM 132b Advanced Organic Chemistry: Spectroscopy
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b, or the equivalent.
Application of spectroscopy to the elucidation of structure and stereochemistry of organic compounds, with emphasis on modern NMR and MS methods. Usually offered every year.
Mr. Xu

CHEM 134b Advanced Organic Chemistry: Synthesis
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b, or the equivalent.
Modern synthetic methods are covered, with an emphasis on mechanism and stereochemical control. Discusses the formation of carbon-carbon single and double bonds and carbocycles and procedures for oxidation, reduction, and functional group interchange. Examines selected total syntheses. Usually offered every year.
Mr. Snider

CHEM 135a Advanced Organic Chemistry: Synthesis II
[sn]
Prerequisite: CHEM 25b or permission of the instructor.
The application of asymmetric and catalytic methods in organic synthesis is illustrated, with an emphasis on metal catalysts and stereoselectivity. Hydrogenation, hydride addition, epoxidation, dihydroxylation, olefin metathesis, C-H activation, and C-C bond forming reactions are covered. Lectures will include treatment of the interplay between mechanistic study and reaction design. Usually offered every second year.
Mr. Krauss

CHEM 137b The Chemistry of Organic Natural Products
[sn]
Prerequisite: A satisfactory grade in CHEM 25a and b, or the equivalent.
Natural products chemistry is surveyed within a biosynthetic framework. Occurrence, isolation, structure elucidation, biosynthesis, and biomimetic synthesis are covered with an emphasis on modern methods of establishing biosynthesis and biomimetic syntheses. Usually offered every second year.
Mr. Snider

CHEM 141a Thermodynamics and Statistical Thermodynamics
[sn]
Prerequisites: Satisfactory grade in CHEM 11a, 15a and CHEM 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or 15a,b or equivalent. Organic chemistry is also recommended.
Classical and statistical thermodynamics; principles, tools, and applications in chemistry and biology. Usually offered every year.
Mr. Pochapsky

CHEM 142a Quantum Mechanics and Spectroscopy
[sn]
Prerequisites: A satisfactory grade in CHEM 11a, 15a and CHEM 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or 15a,b or equivalent. Organic chemistry is also recommended.
Solutions to the Schrödinger equation of relevance to spectroscopic methods such as UV/visible spectroscopy, nuclear magnetic resonance and infrared spectroscopy; introduction to quantum mechanical calculations and computational methods, density matrix, and operator formalisms. Usually offered every year.
Ms. Gershenson

CHEM 143b Kinetics, Dynamics, and Transport
[sn]
Prerequisites: A satisfactory grade in CHEM 11a, 15a and CHEM 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or 15a,b or equivalent. Organic chemistry is also recommended.
Macroscopic kinetics: elementary reactions and rate laws. Kinetic study of reaction mechanisms: techniques for kinetic measurements, fast reactions, treatment of kinetic data. Microscopic kinetics: molecular dynamics, transition state theory, reactions in the gas phase and in solution. Catalytic and chain reactions, enzyme kinetics. Nonlinear dynamics: chemical oscillations and waves. Usually offered every other year.
Staff

CHEM 144a Computational Chemistry
[sn]
Prerequisites: A satisfactory grade in CHEM 11a, 15a and CHEM 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or 15a,b or equivalent. Organic chemistry is also recommended.
Topics in computational chemistry: applications of quantum mechanics to structural and spectroscopic analysis of small molecules; molecular dynamics and Monte Carlo simulations of biomacromolecules. Standard computational programs are used by students to perform homework exercises. Usually offered every other year.
Mr. Jordan

CHEM 146a Single Molecule Spectroscopy
[sn]
Prerequisites: A satisfactory grade in CHEM 11a, 15a and CHEM 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or PHYS 15 a,b, or equivalent.
Studies single-molecule spectroscopy techniques including fluorescence microscopy experiments, laser tweezers, magnetic tweezers, and atomic force microscopy, along with their applications to chemical and biological systems. Usually offered every second year.
Ms. Gershenson

CHEM 147b Mass Spectrometry
[sn]
Prerequisite: A satisfactory grade in CHEM 11b, 15b or equivalent or permission of the instructor. Organic chemistry is also recommended.
The process of ionization, ion separation, and ion detection is taught at the theoretical level, and applied to the understanding of modern mass spectrometry. Usually offered every second year.
Mr. Agar

CHEM 150b Special Topics in Chemistry
[qr sn]
Topics vary from year to year. Usually offered every third year.
Staff

(200 and above) Primarily for Graduate Students

CHEM 200a Advanced Chemistry Laboratory I
Usually offered every year.
Staff

CHEM 200b Advanced Chemistry Laboratory II
Usually offered every year.
Staff

CHEM 200e Advanced Chemistry Laboratory III
Usually offered every year.
Staff

CHEM 220c Inorganic Chemistry Seminar
Required of graduate students in inorganic chemistry every semester.
Staff

CHEM 224b Chemistry of Organometallic Compounds
The chemistry of organotransition metal complexes, including their structures, bonding, reactivity, and use in industrial processes and organic synthesis. Usually offered every second year.
Mr. Ozerov

CHEM 230c Organic Chemistry Seminar
Required of graduate students in organic chemistry every semester.
Staff

CHEM 240c Physical Chemistry Seminar
Required of graduate students in physical chemistry every semester.
Staff

CHEM 243b Statistical Thermodynamics
Elementary statistical mechanics of ensembles of molecules and applications to thermodynamic systems. Usually offered every third year.
Mr. Jordan

CHEM 245a Ultrafast Spectroscopy
Ultrafast laser-based spectroscopy techniques and their applications to chemical and biological systems are presented. Topics include the generation of femtosecond laser pulses, pump-probe spectroscopy, time and frequency domain spectroscopy, and ultrafast dynamics of chemical reactions and biomolecular motions. Usually offered every third year.
Ms. Gershenson

CHEM 246b Advanced NMR Spectroscopy
A detailed discussion of modern NMR methods will be presented. The course is designed so as to be accessible to nonspecialists, but still provide a strong background in the theory and practice of modern NMR techniques. Topics include the theory of pulse and multidimensional NMR experiments, chemical shift, scalar and dipolar coupling, NOE, spin-operator formalism, heteronuclear and inverse-detection methods, Hartmann-Hahn and spin-locking experiments. Experimental considerations such as pulse sequence design, phase cycling, and gradient methods will be discussed. Guest lecturers will provide insight into particular topics such as solid-state NMR and NMR instrumental design. Usually offered every third year.
Mr. Pochapsky

CHEM 250c Biophysical Chemistry Seminar
Required of graduate students in biophysical chemistry every semester.
Staff

CHEM 298a Independent Study
Usually offered every year.
Staff

CHEM 401d Dissertation Research
Independent research for the PhD degree. Specific sections for individual faculty members as requested.
Staff

Chemistry Colloquium

Lectures by faculty and invited speakers. Required of all graduate students. Noncredit.

Courses of Related Interest

BCHM 100a
Introductory Biochemistry

BCHM 101a
Advanced Biochemistry: Enzyme Mechanisms

BCHM 102a
Quantitative Approaches to Biochemical Systems

BCHM 103b
Advanced Biochemistry: Information Transfer Mechanisms

BCHM 104b
Physical Chemistry of Macromolecules

QBIO 110a
Numerical Modeling of Biological Systems

QBIO 120b
Quantitative Biology Instrumentation Laboratory

NBIO 136b
Computational Neuroscience