An interdepartmental program

Business

Courses of Study:
Minor

Objectives

The Business Program (BUS) introduces undergraduates to the functions and problems of business enterprise and helps them to acquire skills essential to a business career. Administered and staffed by the Brandeis International Business School and the School of Arts and Sciences, the curriculum allows students to combine perspectives and methods from liberal arts disciplines with an intensive education in business thinking and practice.

How to Become a Minor

The business program is designed to be accessible to any Brandeis undergraduate and to serve students with a broad range of interests. It welcomes all students who wish to augment their liberal arts education with a brief but sophisticated overview of business issues. Economics majors may complete this program, but students in the International Business Program (IB) may not complete BUS. Students who entered Brandeis before fall 2003 may elect to complete either the IB or the BUS program; for other students, this program replaces the IB. Satisfactory completion of the business program is noted on the student's permanent record and transcript.

Committee

Benjamin Gomes-Casseres, Chair
(International Business School)

Shih-Fen Chen
(International Business School)

F. Trenery Dolbear
(Economics; International Business School)

Richard Gaskins
(American Studies)

Andrew Molinsky
(International Business School; Psychology)

Paroma Sanyal
(Economics)

Dessima Williams
(Sociology; The Heller School)

Faculty

Benjamin Gomes-Casseres, Chair
(International Business School)

Edward Bayone
(International Business School)

Shih-Fen Chen
(International Business School)

Egidio Diodati
(International Business School)

F. Trenery Dolbear
(Economics; International Business School)

Richard Keith
(International Business School)

Requirements for the Minor

A. Two core courses in economics and in business: ECON 2a and BUS 10a (formerly ECON 37b).

B. One core course in accounting and statistics: BUS 4a or BUS 6a. Students who take a statistics course in another department (e.g., ECON 83a, PSYC 51a, MATH 36a, b, or another statistics course approved by the program advising head) should take BUS 6a. Students who do not take any statistics course should take BUS 4a.

C. One course providing an alternative perspective on business: Any cross-listed course (e.g., not BUS), except for ECON courses.

D. Two electives: One should be a BUS course (except BUS 92a or BUS 98a) and the other can be any BUS or cross-listed course, including ECON courses (but not including statistics courses).

Special Notes

No more than two courses may be double-counted for another major or minor. Upon approval of the program advising head, more advanced BUS courses in the International Business School may be used as substitutes for BUS courses in the program.

Student may elect to specialize in various fields, such as globalization and business, finance, entrepreneurship, business and society, and business and government. The program advising head will advise on appropriate courses for specialization. This specialization does not appear on the student's transcript.

Courses of Instruction

(1-99) Primarily for Undergraduate Students

BUS 4a Measuring Business Performance
[ss]
Prerequisite: ECON 2a. A core course for the business minor. Open only to students in the business minor who are not economics majors.
An introduction to the accounting and quantitative skills that are central to business decision making. Includes financial statement preparation and analysis, accounting ethics, and basic statistical methods. Usually offered every year.
Staff

BUS 6a Financial Accounting
[ss]
Prerequisite: ECON 2a. This course may not be repeated for credit by students who have taken FIN 212 a(formerly IEF 204a) or ECON 12a in previous years.
Develops basic concepts and accounts and applies them to income measurement, capital values, and costs. Through the use of cases, develops the basis for rational choice and control of business activity. Usually offered every semester.
Mr. Keith

BUS 10a Functions of Capitalist Enterprise
[ss]
Prerequisite: ECON 2a (may be taken concurrently) or permission of the instructor. This course may not be repeated for credit by students who have taken ECON 37b in previous years.
Introduces the internal complexity of modern businesses and the various roles they play in society. First examines the internal workings of firms—marketing, operations, finance, and other functions. Subsequently, the relationships between businesses and their context—the economy, social issues, and government are studied. Usually offered every year.
Mr. Bayone

BUS 30a Creating New Ventures
[ss]
Prerequisite: ECON 2a. An elective course for the business minor. This course may not be repeated for credit by students who have taken IEF 135b or IEF 235b in previous years.
Focuses on the issues, ideas, and approaches of successful "bootstrap" ventures, management buyouts, and early stage operations. Topics include identifying and evaluating potential opportunities, working with investors, hiring, managing cash, and creating a sales and marketing force. Usually offered every year.
Mr. Reed

BUS 40a Business and the Internet
[ss]
Prerequisite: ECON 2a. An elective course for the business minor. This course may not be repeated for credit by students who have taken IEF 148a in previous years.
The Internet is changing business and reshaping competition. Which rules of business economics will apply to the Net Economy and which new ones will arise? These issues are explored, but as there are yet few clear answers students are expected to be actively involved in shaping our collective learning. Usually offered every year.
Mr. Gomes-Casseres

BUS 70a Business in the Global Economy
[ss]
Prerequisite: ECON 2a. This course may not be repeated for credit by students who have taken ECON 33a in previous years.
Modern firms frequently cross national borders to find new markets and resources. Their strategies are then shaped by the international economy and by the policies of national governments. Using case discussion, students explore why and how United States, Japanese, and European firms operate outside their home countries. Usually offered every fourth year.
Staff

BUS 75a Issues in Business and Management
[ss]
Seniors will have priority for admission. Students must complete all other required business minor courses before taking BUS 75a. This course may not be repeated for credit by students who have taken ECON 19b in previous years.
Explores issues central to the success of American business. Representative issue: Why have some companies developed strong export markets while others focus almost exclusively on domestic sales? Special attention is given to ethical issues and the role of the corporation and its employees as citizens of their own nation and of the world of nations. Although the topics may vary from year to year, the course may NOT be repeated for credit. Usually offered every year.
Staff

BUS 92a Work in the Global Business Environment: Internship and Seminar
Normally students must arrange an internship placement prior to registration and the internship is concurrent with the seminar. Students wishing to fulfill the internship component of the course in a semester when the seminar is not offered must obtain approval from the instructor prior to the internship. A structured journal documenting the internship experience is required as a basis for seminar participation. This course may not be repeated for credit by students who have taken IB 92b in previous years.
Encourages students to pool experiences and lessons drawn from various business environments and to analyze and discuss them in the context of related readings. Usually offered every spring.
Mr. Dolbear

BUS 98a Independent Study
Normally available for a student who has taken a course and wishes to pursue further reading or research in that field or study a subject not listed among the department course offerings. Usually offered every year.
Staff

Core Courses

BUS 4a
Measuring Business Performance

BUS 6a
Financial Accounting

BUS 10a
Functions of Capitalist Enterprise

ECON 2a
Introduction to Economics

Elective Courses

BUS 30a
Creating New Ventures

BUS 40a
Business and the Internet

BUS 70a
Business in the Global Economy

BUS 75a
Issues in Business and Management

BUS 92a
Work in the Global Business Environment: Internship and Seminar

BUS 98a
Independent Study

Cross-Listed Courses

AMST 189a
Legal Foundations of American Capitalism

ECON 8b
The Global Economy

ECON 57a
Environmental Economics

ECON 71a
Introduction to Finance

ECON 76b
Labor Economics

ECON 77a
Introduction to Regulation and Public Policy

ECON 80a
Microeconomic Theory

ECON 135a
Industrial Organization

ECON 172b
Money and Banking

ECON 174a
Corporate Finance

ECON 177b
Economic Regulation and Deregulation

PHIL 13b
The Idea of the Market: Economic Philosophies

The following courses are eligible as "alternative perspectives on business" (refer to requirement item C on previous page):

AAAS 126b
Political Economy of the Third World

AMST 188b
Justice Brandeis and Progressive Jurisprudence

ANTH 163b
Production, Consumption, and Exchange

COSI 33b
Internet and Society

HIST 160b
American Legal History II

HIST 179a
Globalization: Critical Historical Perspectives

HS 104b
American Health Care

HS 110a
Wealth and Poverty

JOUR 103b
Advertising and the Media

LGLS 129b
Law, Technology, and Innovation

POL 166b
Seminar: Issues in International Political Economy

POL 172b
Introduction to International Political Economy

PSYC 150b
Organizational Behavior

SOC 107a
Global Apartheid and Global Social Movements

SOC 117a
Sociology of Work

Department of

Chemistry

Courses of Study:
Minor
Major (B.A./B.S.)
Combined B.A./M.S.
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 allowing 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 M.S. and Ph.D. 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. The Ph.D. is offered with specializations in inorganic, organic, and physical chemistry. All students will be required to demonstrate knowledge in advanced areas of inorganic, organic, and physical 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.

Ph.D. in Chemistry with Specialization in Chemical Physics
The Graduate Program in Chemical Physics is an interdisciplinary specialization designed to meet the needs of students who wish to prepare themselves for the study of scientific problems using the methods and theories of modern physics and physical chemistry. This objective is attained by (1) formal course work in chemistry, physics, and, possibly, mathematics; (2) participation in relevant graduate seminars; (3) a program of supervised research involving chemical physics; and (4) independent study. The program is designed to be flexible in providing individual programs of study to satisfy the particular interests and needs of each student. Final programs of study and research will be arrived at by the student, the student's research supervisor, and the chemical physics committee. Only candidates for the Ph.D. degree will be accepted. A master's degree is not offered, but students who satisfy the appropriate requirements will be eligible for the M.S. degree in chemistry.

How to Become an Undergraduate 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 (Basic Physics I,II), which is a prerequisite for physical chemistry (CHEM 41a,b) and advanced experimental chemistry (CHEM 59a,b) (although the premedical program will accept either PHYS 10a,b or PHYS 11a,b). Completing PHYS 11a,b by the end of the sophomore year will allow students to take CHEM 41 and 59 during their junior year. Every October, 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 advisors to develop a program of courses to shape their needs and interests. To apply for the Honors Program, a student must select a research advisor and submit a proposed plan to the department by September 10 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

Thomas Pochapsky, Chair
Biological redox enzymes structure and mechanism. Transient interactions in solution by NMR. NMR structures of proteins.

Iu-Yam Chan
Magnetic resonance and optical spectroscopy under pressure. Dynamics of quantum tunneling reactions.

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

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

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

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
Protein dynamics, stability, and folding. Optical spectroscopy of single molecules. Protein engineering and directed evolution.

James Hendrickson
Synthesis of natural products. Computerization of synthesis design and development of new synthetic reactions.

Judith Herzfeld
Solid-state NMR studies of the structure and functional mechanisms of membrane proteins. Statistical thermodynamics of spontaneous order in crowded solutions of self-assembling proteins and surfactants.

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

Philip Keehn
Synthetic methods, organic synthesis of strained rings, and theoretically interesting molecules. Host-guest complexes. Plant medicinals. Applications of NMR spectroscopy to organic systems. Photooxidation.

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

Gregory Petsko (Director, Rosenstiel Center)
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 Parkinson's disease. Yeast genetics.

Arthur Reis
Forensic science.

Dagmar Ringe (Rosenstiel Center)
Protein crystallography and structural enzymology. Rational drug design. Structure and function of PLP dependent enzymes, DNA binding proteins, and enzymes that utilize bimetallic centers for catalysis.

Timothy Rose
Physical science.

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

Thomas Tuttle
Chemistry of liquid solutions. Composition and structures of species in metal solutions in polar solvents. Application of spectroscopy, e.g., magnetic resonance, optical and spectropolarimetry, to elucidation of the composition and structure of solutions. Theory of chemical species in solution.

Jinquan Yu
Asymmetric activation of sp″ C-H bonds and synthetic methods, biomimetic catalysis of iron containing systems and chemical probes for life processes.

Anatol Zhabotinsky
Chemical and biological kinetics. Oscillating chemical reactions. Chemical waves and pattern formation. Metabolic regulation. Dynamics of synaptic transmission.

Requirements for the Undergraduate Major

Degree of Bachelor of Arts

A. Two semesters of general chemistry lectures (CHEM 10a,b; 11a,b; or 15a,b) with laboratory (CHEM 18a,b; 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 40 or higher (including BIBC 105b and NBIO 148b). Courses should include at least one in each of the following subfields: inorganic chemistry (CHEM 121a, 122b), organic chemistry (CHEM 25a,b), physical chemistry (CHEM 41a,b).

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

D. MATH 10a,b or 11a,b, and PHYS 11a,b or 15a,b, which are prerequisites for CHEM 41a,b and CHEM 59a,b.

E. Additional requirements for degree with departmental honors: Two semesters of CHEM 99d (Senior Research); grade point average of 3.00 or higher in all courses offered for the major, including laboratories. Students must petition the department by September 10 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 advisors.

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 41a,b) and laboratory (CHEM 59a,b), or intermediate chemistry laboratory (CHEM 39b), and BCHM 100a. 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.

Degree of Bachelor of Science

A. Two semesters of general chemistry lectures (CHEM 10a,b; 11a,b; or 15a,b) with laboratory (18a,b; 19a,b).

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

C. Two semesters of physical chemistry lectures (CHEM 41a,b).

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

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

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

G. MATH 10a,b and PHYS 11a,b.

H. Additional requirements for degree with departmental honors: Two semesters of CHEM 99d (Senior Research) and a grade point average of 3.00 or higher in all courses offered for the major including laboratories. Students must petition the department by September 10 of their senior year to enter the senior honors program.

I. For students planning to pursue graduate study in chemistry, BCHM 100a and physics laboratory PHYS 19a,b (Physics Laboratory I, II) are advisable.

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.

Combined B.A./M.S. Program

Candidates for departmental honors may be admitted to a special four-year B.A./M.S. program upon recommendation of the department and the Graduate School. Application must be made by May 1 proceeding the senior year. Students must complete requirements A-E as described in the requirements for degree of Bachelor of Arts. Additionally, a 130-level organic course, a 140-level physical course, and two other 100-level courses from the School of Science must be taken. At least four of these courses may not be counted towards the major requirement. Grades of B- or better are required in the 100-level science courses.

Requirements for the Undergraduate Minor

The minor in chemistry consists of the equivalent of six full-credit (four-semester-hour) courses and three half-credit (two-semester-hour) courses:

CHEM 11a and 11b (or CHEM 10a and 10b, or 15a and 15b)
CHEM 18a and 18b (or 19a and 19b)
CHEM 25a
CHEM 29a

Three additional full-credit (four-semester-hour) chemistry courses that meet the major requirements. BCHM 101a, 101b, or 104b may count as one of the three courses.

Special Notes Relating to Undergraduates

Either CHEM 10a,b lecture and CHEM 18a,b laboratory, *or* 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 colloquium 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 Science

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 to reflect the candidate's area of interest as well as a perspective of other areas.

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 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.

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

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

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 seven graduate-level courses, of which two must be outside the student's field of research. If a student fails to pass a placement examination after two attempts, a graduate course must be taken in that area of chemistry 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 advisor during the first year, normally in the second term.

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.

Re-admission to the Ph.D. 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 by taking the doctoral qualifying examinations in his or her major field: organic, physical, or inorganic chemistry. In the organic chemistry program, a cumulative examination procedure is used. Each year, six one-hour examinations (on unannounced topics) are given. The qualifying examination requirement is satisfied by passing six cumulative exams. In physical chemistry and inorganic chemistry, the student is assigned a set of propositions generally during the third term of graduate work. In physical chemistry the set consists of three propositions; the student takes a written examination on one proposition and is examined orally on all three. In inorganic chemistry the student is assigned two propositions. The student takes a written examination on one proposition and is examined orally on a research proposal (supplied either by the student or faculty) and the remaining proposition. Students in all fields must maintain satisfactory progress by passing these examinations.

Residence Requirement
The minimum residence requirement 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.

Language and Computer Programming Requirements
Each student in the organic and inorganic Ph.D. programs must demonstrate a useful reading knowledge of scientific French, German, or Russian within the first two years of residence. Each student in the physical chemistry Ph.D. program must demonstrate a working knowledge of Fortran, Basic, or C.

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 Chemical Physics

Program of Study
It is expected that some candidates for the Ph.D. degree in chemistry with specialization in chemical physics may require a longer period of time in course work than will students in either of the fields of physics or chemistry. In general, the program for the Ph.D. in chemistry with specialization in chemical physics will include eight term graduate courses: four in physical chemistry, one in either organic or inorganic chemistry, and three in physics. No specific course work in mathematics is required, but students are expected to be familiar with the techniques necessary for the proper pursuit of their research.

Students may satisfy their program's course requirements in part or in its entirety by passing (or giving evidence of ability to pass) the final examination in the appropriate number of such courses. Courses in areas related to chemistry and physics may also be considered by the chemical physics committee in partial fulfillment of the requirements.

Placement and Evaluation of Progress
Each student is expected to demonstrate a satisfactory knowledge of undergraduate chemistry, physics, and mathematics by the performance in three placement examinations: organic or inorganic chemistry and one each in physical chemistry and physics/mathematics. These examinations are set twice a year, before the start of each semester. The results of these examinations will

determine the student's initial program of course work and also be considered by the chemical physics committee in evaluating the student's progress.

Qualifying Examinations
Qualifying examinations in chemical physics are generally taken during the third term of graduate work. The student is assigned a set of three propositions; the student takes a written examination on one proposition and is examined orally on the remaining two.

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

Language and Computer Programming Requirements
There is no foreign language requirement for the Ph.D. degree in chemical physics. Each student must demonstrate a working knowledge of Fortran, Basic, or C.

Seminar
Each student in residence is required to attend and to participate in the Chemical Physics Seminar. Participation in other seminars in physics and chemistry is also recommended.

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

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

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.

Courses of Instruction

(1-99) Primarily for Undergraduate Students

CHSC 5a The Magnitude of Things and How on Earth They Matter
[qr sn]
Does NOT meet requirements for the major in chemistry.
Four statements concerning the age, condition, and destiny of earth as affected by humans are used to implement examinations of relevant issues. These examinations require knowledge in several scientific disciplines that will be provided as the substance of the course. Usually offered every second year.
Mr. Tuttle

CHSC 6a Forensic Science: Col. Mustard, Candlestick, Billiard Room
[qr sn]
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 the chemistry of 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
[qr sn]
This course may not be taken for credit by students who have passed CHEM 10a or 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 90-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. Epstein

CHEM 11b General Chemistry
[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 10b or 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 90-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. Pochapsky

CHEM 15a Honors General Chemistry: Principles of Material Evolution
[qr sn]
Signature of the instructor required for final registration. This course may not be taken for credit by students who have passed CHEM 10a or 11a in previous years.
An advanced 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 Chemistry: Principles of Material Evolution
[qr sn]
Prerequisite: a satisfactory grade (C- or better) in CHEM 15a or the equivalent. Signature of the instructor required for final registration. This course may not be taken for credit by students who have passed CHEM 10b or 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 methods for characterizing pure substances 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. Analysis of the metal content of substances by visible absorbance and 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 10a or 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 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 microscale syntheses of coordination compounds is included followed by characterization of the compounds. 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 10b, 11b, 15b, or the equivalent.
Structure, reactions, preparations, and uses of the compounds of carbon. Three class hours and one 90-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, 90-minute recitation per week. Usually offered every year.
Mr. Hendrickson

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.
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 90-minute laboratory lecture per week. Usually offered every year.
Mr. Keehn

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.
A continuation of CHEM 29a with an emphasis on the synthesis of typical organic compounds. One afternoon of laboratory per week. One 90-minute laboratory lecture per week. Usually offered every year.
Mr. Keehn

CHEM 33a Environmental Chemistry
[sn]
Prerequisite: One year of general chemistry, CHEM 10a,b; 11a,b; or 15a,b; or the equivalent.
Surveys our understanding of the undisturbed environment and how it developed, and addresses environmental problems arising from human activities. Relevant chemistry of the atmosphere and hydrosphere will be emphasized, with brief discussions of related science of the geosphere and biosphere. Usually offered every third year.
Mr. Rose

CHEM 39b Intermediate Chemistry Laboratory
[sn]
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 the 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 the synthetic experiments and the use of the instrumental methods. One afternoon of lab per week and one one-hour lecture per week. Usually offered every second year.
Mr. Ozerov

CHEM 41a Physical Chemistry, Lectures I
[sn]
Prerequisites: Satisfactory grades (C- or better) in CHEM 10b, 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or 15a,b. Organic chemistry is also recommended.
Kinetic theory of gases, topics in chemical thermodynamics; introductory aspects of statistical thermodynamics. Three lecture hours per week. Usually offered every year.
Ms. Gershenson

CHEM 41b Physical Chemistry, Lectures II
[sn]
Prerequisites: Satisfactory grades (C- or better) in CHEM 10b, 11b, 15b or equivalent; MATH 10a,b or equivalent; PHYS 11a,b or 15a,b. Organic chemistry is also recommended.
Topics include quantum mechanics, spectroscopy, and chemical kinetics. Three lecture hours per week. Usually offered every year.
Ms. Gershenson

CHEM 59a Advanced Experimental Chemistry
[sn]
Prerequisites: A satisfactory grade (C- or better) in CHEM 18b or equivalent; CHEM 41a or 41b (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 as well as providing experimental verification of chemical principles in thermodynamics, kinetics, macromolecules, semiconductors, nanochemistry, 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, materials testing, 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.
Mr. Rose

CHEM 59b Advanced Experimental Chemistry
[sn]
Prerequisites: A satisfactory grade (C- or better) in CHEM 18b or equivalent; CHEM 41a or b (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 59b exposes students to a variety of physiochemical phenomena, but with a strong central theme in spectroscopy. Starting with a general discussion of interaction of radiation with matter, it develops into fluorescence spectroscopy leading to rotational relaxation of proteins in solution, Raman scattering by vibrating molecules, laser spectroscopy of molecular iodine, nanosecond kinetics of excimer formation, and circular dichroism investigation of a helix-coil transition of a polypeptide. One, one-hour lecture and one afternoon of laboratory per week. Usually offered every second year.
Mr. Chan

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 95b 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
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 95b may be taken individually as one-semester courses or together as a year-long sequence. Usually offered every year.
Staff

CHEM 99d Senior Research
Prerequisites: CHEM 41a, 59a or 59b, 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 will involve the writing of 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]
Prerequisite: Satisfactory grade(s) in CHEM 41a and b, CHEM 59a and b, or equivalent. Laboratory fee: $45.
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 111a Computational Chemistry
[sn]
Prerequisite: Satisfactory grades in CHEM 41a and b, or equivalent. Does not meet the major requirements in chemistry.
Selected topics in computational chemistry, including one or two of the following: small molecule modeling; biomolecular modeling; quantum mechanical modeling. Usually offered every second year.
Mr. Jordan

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.
Mr. Ozerov

CHEM 130a Advanced Organic Chemistry: Structure
[sn]
Prerequisite: A satisfactory grade in an undergraduate organic chemistry course.
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. Yu

CHEM 131a Advanced Organic Chemistry: Topics in Structure and Reactivity
[sn]
Prerequisite: A satisfactory grade in an undergraduate organic chemistry course.
Broad coverage of a variety of transformations involving additions, eliminations, substitutions, oxidations, reductions, and rearrangements. Usually offered every year.
Mr. Keehn

CHEM 132b Advanced Organic Chemistry: Spectroscopy
[sn]
Prerequisite: A satisfactory grade in an undergraduate organic chemistry course.
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. Snider

CHEM 134b Advanced Organic Chemistry: Synthesis
[sn]
Prerequisite: A satisfactory grade in an undergraduate organic chemistry course.
Modern synthetic methods are covered, with an emphasis on mechanism and stereochemical control and organometallic methods. Formation of carbon-carbon single and double bonds and carbocycles and procedures for oxidation, reduction, and functional group interchange are discussed. Selected total syntheses are examined. Usually offered every second year.
Mr. Deng

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 is covered with an emphasis on modern methods of establishing biosynthesis and biomimetic syntheses. Usually offered every second year.
Mr. Snider

CHEM 141a Chemical Thermodynamics
[sn]
Prerequisite: Satisfactory grade in undergraduate physical chemistry. Familiarity with multivariable calculus.
Statistical, classical, and irreversible thermodynamics; principles, tools, and applications. Usually offered every year.
Mr. Jordan

CHEM 141b Kinetics
[sn]
Prerequisite: A satisfactory grade in undergraduate physical chemistry.
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 year.
Mr. Epstein

CHEM 142a Quantum Chemistry
[sn]
Prerequisite: Passing grades in CHEM 41a and b, or equivalent.
This class will discuss solutions of the Schroedinger equation for simple systems; operator techniques and approximation methods; atoms; diatomic molecules; polyatomic molecules; introduction to quantum chemical calculation; density matrix formalism. Usually offered every second year.
Mr. Chan

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

CHEM 229b Special Topics in Inorganic Chemistry: Introduction to X-Ray Structure Determination
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 will feature self-paced exercises on PCs. Usually offered every second year.
Mr. Foxman

CHEM 231c Organic Chemistry Seminar
Required of graduate students in organic chemistry every semester.
Staff

CHEM 232b Heterocyclic Chemistry
The nature of aromatic heterocycles will be surveyed, followed by detailed discussion of their characteristic reactions and modes of synthesis. The course is organized to show a general predictive framework behind the details. Emphasis is placed on the mechanisms of heterocycle reactions. Usually offered every second year.
Mr. Hendrickson

CHEM 234b Chemistry of Organometallic Compounds
The chemistry of organo-transition metal complexes, including their structures, bonding, reactivity, and use in industrial processes and organic synthesis. Usually offered every second year.
Mr. Ozerov

CHEM 235b 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 241c 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 second year.
Ms. Gershenson

CHEM 250c Chemical Physics Seminar
Required of graduate students in chemical physics every semester.
Staff

CHEM 298a Independent Study
Usually offered every year.
Staff

CHEM 401d Dissertation Research
Independent research for the Ph.D 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

NBIO 136b
Computational Neuroscience