Chemistry

The Department of Chemistry maintains pedagogical and research strengths in organic, inorganic, theoretical and experimental physical chemistry, analytical chemistry, chemical biology and nanochemistry. Faculty, post-doctoral fellows, graduate and undergraduate students collaboratively pursue interdisciplinary research within the department, enhanced by the partnerships with colleagues in the medicine, biology, geology, physics and engineering.

For additional information, please visit the department's website: http://www.brown.edu/academics/chemistry/

Chemistry Concentration Requirements

The Chemistry concentration offers courses and research opportunities that range from fundamental studies involving the characterization and preparation of synthetic and naturally occurring molecules, to interdisciplinary studies at the interfaces of chemistry with biology, medicine, physics, engineering, and nanoscience. As early as their first year, undergraduates are able to work with faculty members on cutting edge research projects. The Sc.B. degree provides a thorough foundation for further graduate study or for entry-level technical positions in the molecular sciences. Students seeking the Sc.B. may either pursue the standard Chemistry concentration or one of two possible tracks: Chemical Biology or Materials Chemistry. Students may also pursue the A.B. degree in Chemistry, which provides a core education in the discipline.

Standard program for the A.B. degree

CHEM 0330	Equilibrium, Rate, and Structure	1
CHEM 0350	Organic Chemistry I	1
CHEM 0360	Organic Chemistry II	1
CHEM 0500	Inorganic Chemistry	1
CHEM 0600	Preparative Chemistry Lab	.5
CHEM 1140	Physical Chemistry: Quantum Chemistry [1]	1
CHEM 1150	Physical Chemistry: Thermodynamics and Statistical Mechanics [1]	1
CHEM 1160	Physical Chemistry Laboratory [1]	1
One upper level CHEM elective. [2]		1
Total Credits		**8.5**

1 Note that the physical chemistry courses (CHEM 1140, CHEM 1150, CHEM 1160) have mathematics and physics prerequisites.

2 Upper level chemistry course are any 1000- and 2000- CHEM course. BIOL 0280 is credited as an upper level chemistry elective for chemistry concentration purposes. You should discuss your elective choices with your Concentration Advisor to craft a course of study that is appropriate for your interests.

Standard program for the Sc.B. degree

The Chemistry Department offers three options for the Sc.B. Chemistry Concentration – a straight Chemistry option, a Chemical Biology track and a Materials Chemistry track. These tracks are not separate concentrations – your degree will still be an Sc.B. in Chemistry. The Chemical Biology track is designed for students who have a strong interest in the interface of chemistry with biology. The Materials Chemistry track is designed for students who have a strong interest in the interface of chemistry with nanoscience and materials science. It is recommended that courses in the concentration be taken for a letter grade, and any decision to take a concentration course S/NC should be made after consultation with a concentration advisor.

Concentrating in Chemistry – Three tracks

The required/recommended courses for the three tracks are given below.

ScB Chemistry:

CHEM 0330	Equilibrium, Rate, and Structure	1
CHEM 0350	Organic Chemistry I	1
CHEM 0360	Organic Chemistry II	1
CHEM 0500	Inorganic Chemistry	1
CHEM 0600	Preparative Chemistry Lab	.5
Two semesters of independent study:		2
CHEM 0980	Undergraduate Research [1]	
or CHEM 0981	Undergraduate Research - Writing Designated	
CHEM 1140	Physical Chemistry: Quantum Chemistry	1
CHEM 1150	Physical Chemistry: Thermodynamics and Statistical Mechanics	1
CHEM 1160	Physical Chemistry Laboratory	1
MATH 0180 or equivalent [2]		1
Two Physics courses, typically 0030/0040 or 0050/0060		2
Six electives (at least three must be upper level CHEM courses) [3]		6
Total Credits		**18.5**

ScB Chemistry - Chemical Biology Track:

CHEM 0330	Equilibrium, Rate, and Structure	1
CHEM 0350	Organic Chemistry I	1
CHEM 0360	Organic Chemistry II	1
CHEM 0400	Biophysical and Bioinorganic Chemistry	1
or CHEM 0500	Inorganic Chemistry	
CHEM 0600	Preparative Chemistry Lab	.5
Two semesters of independent study:		2
CHEM 0980	Undergraduate Research [1]	
or CHEM 0981	Undergraduate Research - Writing Designated	
CHEM 1140	Physical Chemistry: Quantum Chemistry	1
CHEM 1230	Chemical Biology	1
CHEM 1240	Biochemistry	1
BIOL 0280	Biochemistry	1
MATH 0180 or equivalent [2]		1
Two Physics courses, typically 0030/0040 or 0050/0060		2
Select three of the following: [4]		3
BIOL 0470	Genetics	
BIOL 0500	Cell and Molecular Biology	
BIOL 0510	Introductory Microbiology	
BIOL 0530	Principles of Immunology	
BIOL 0800	Principles of Physiology	
NEUR 1020	Principles of Neurobiology	
Two other electives [3]		2
Total Credits		**18.5**

ScB Chemistry - Materials Chemistry Track:

CHEM 0330	Equilibrium, Rate, and Structure	1
CHEM 0350	Organic Chemistry I	1
CHEM 0360	Organic Chemistry II	1
CHEM 0500	Inorganic Chemistry	1
CHEM 0600	Preparative Chemistry Lab	.5
Two semesters of independent study:		2
CHEM 0980	Undergraduate Research [1]	
or CHEM 0981	Undergraduate Research - Writing Designated	
CHEM 1060	Advanced Inorganic Chemistry [5]	1
CHEM 1140	Physical Chemistry: Quantum Chemistry	1
CHEM 1150	Physical Chemistry: Thermodynamics and Statistical Mechanics [5]	1
CHEM 1700	Nanoscale Materials: Synthesis and Applications	1
MATH 0180 or equivalent [2]		1
Two Physics courses, typically 0030/0040 or 0050/0060 [5]		2

One of the following courses		1
BIOL 1090	Polymer Science for Biomaterials (or)	
BIOL 1120/	Biomaterials (or)	
BIOL 1140	Tissue Engineering (or)	
ENGN 1470	Composite Materials (or)	
ENGN 1490	Biomaterials (or)	
Four electives, at least two must be upper level CHEM courses. [3]		4
Total Credits		**18.5**

1 **Two** semesters of undergraduate research are required for the concentration. Chem0980 and 0981 are courses which may be repeated for credit.

2 NOTE: MATH 0180 has additional prerequisites.

3 Upper level chemistry courses are any 1000- and 2000-level CHEM course. BIOL 0280 is credited as an upper level chemistry elective for the chemistry concentration. Non CHEM electives are typically foundational courses or upper level science/math courses with a significant molecular focus or those that cover tools/techniques that are of utility to a chemist. You should discuss your elective choices with your Concentration Advisor to craft a course of study that is appropriate for your interests.

4 NOTE: Many of the BIOL courses have BIOL 0200 as a prerequisite.

5 For students with a more Engineering bent, the following substitutions can be made - ENGN 0030/ENGN 0040 can be substituted for PHYS; ENGN 0410 can be substituted for CHEM 1060; ENGN 0720 for CHEM 1150.

In each of these cases, /CHEM 0980 /CHEM 0981 should be carried out with a faculty member with an appointment in the Chemistry Department. Research with faculty advisors outside the Chemistry Department is also possible after consultation with a Concentration Advisor.

Honors Requirements for Chemistry

All Chemistry concentrators who have grades of A or S with distinction in a majority of their concentration courses after their seventh semester are eligible for Honors; no separate application is necessary.

The requirements for Honors in Chemistry are:

* Grades of A or S with distinction in a majority of courses taken for the concentration.

* Two semesters of Undergraduate Research CHEM 0980, CHEM 0981 or equivalent. Guidelines and requirements associated with Undergraduate Research are in the Undergraduate Concentration Handbook which can be found at the department website (http://www.brown.edu/academics/chemistry/undergraduate/).

* A Senior Thesis in a form approved and recommended by the research advisor. Additional information about thesis guidelines will be provided to seniors by the Director of Undergraduate Studies.

* A Senior Poster presentation at the chemistry department's spring undergraduate poster session.

Biochemistry & Molecular Biology Concentration Requirements

How does life work at the molecular level? This question is at the core of the concentration program Biochemistry and Molecular Biology. In earlier years of this discipline, the focus was on structure and function of proteins, nucleic acids, lipids, carbohydrates and small molecules such as vitamins. Today the logical approach and tools of biochemical science are being expanded to new areas in neuroscience, developmental biology, immunology, pharmacology and synthetic biology (the design of analogs of biological systems). Training in biochemistry begins with a foundation in mathematics, physics, chemistry and biology. Some courses offered in other departments, including engineering, geology and computer science, are also useful. A key component of this program is the year of hands-on research carried out in collaboration with a faculty member here at Brown. Faculty sponsors are drawn from both the Chemistry Department and the Division of Biology and Medicine, and include basic science and clinical faculty.

Standard program for the Sc.B. degree

Students must take twenty courses in biology, chemistry, mathematics, and physics, including the following core requirements, some of these may be fulfilled with AP credits.

Three courses in mathematics including two courses in MATH 0090/0100 or MATH 0170/0180 with a third class in statistics, math, or computer science [1]		3
Options for statistics courses include: [1]		
APMA 0650	Essential Statistics	
APMA 1650	Statistical Inference I	
APMA 1655	Honors Statistical Inference I [3]	
BIOL 0495	Statistical Analysis of Biological Data	
CLPS 0900	Statistical Methods	
PHP 1501	Essentials of Data Analysis	
PHP 1510	Principles of Biostatistics and Data Analysis	
Two courses in physics, typically: [1]		2
PHYS 0030	Basic Physics A	
or PHYS 0050	Foundations of Mechanics	
or ENGN 0030	Introduction to Engineering	
PHYS 0040	Basic Physics B	
or PHYS 0060	Foundations of Electromagnetism and Modern Physics	
or ENGN 0040	Engineering Statics and Dynamics	
Three courses in physical and organic chemistry:		3
CHEM 0330	Equilibrium, Rate, and Structure	
CHEM 0350/0360	Organic Chemistry I	
One course in biophysical chemistry:		1
CHEM 0400	Biophysical and Bioinorganic Chemistry	
Four courses in biochemistry:		4
BIOL 0280	Biochemistry	
BIOL 0285	Inquiry in Biochemistry: From Gene to Protein Function	
Plus two of three upper level biochemistry courses:		
BIOL 1270	Advanced Biochemistry	
or CHEM 1230	Chemical Biology	
or CHEM 1240	Biochemistry	
The two semester research requirement may be satisfied by any two of the following. Students should discuss alternative arrangements or special situations directly with their concentration advisor to obtain prior approval.		2
BIOL 1950	Directed Research/Independent Study	
BIOL 1960	Directed Research/Independent Study	
CHEM 0980	Undergraduate Research	
CHEM 0980S	Undergraduate Research - Writing Designated and Mandatory S/NC	
CHEM 0981	Undergraduate Research - Writing Designated	
Select biology or chemistry COEX courses (BIOL 0190R, BIOL 0190S, BIOL 0440, BIOL 0600, BIOL 0940G, CHEM 0500)		
A summer research experience with faculty in Biology or Chemistry at Brown equivalent or greater in scope and scale to work the student would pursue in a Biology or Chemistry independent study course to satisfy one semester of the research requirement.		

Suggested Elective Courses:

Students are required to take five courses from the chart below or, with approval from a concentration advisor, from any science or mathematics course relevant to biochemistry, cell and molecular biology.		5
Applied Mathematics Electives:		
APMA 0330	Methods of Applied Mathematics I	
APMA 0410	Mathematical Methods in the Brain Sciences	
APMA 0650	Essential Statistics	
Biology Electives:		
BIOL 0030	Principles of Nutrition	
BIOL 0150D	Techniques in Regenerative Medicine: Cells, Scaffolds and Staining	
BIOL 0170	Biotechnology in Medicine	
BIOL 0190R	Phage Hunters, Part I	
BIOL 0190S	Phage Hunters, Part II	
BIOL 0200	The Foundation of Living Systems	
BIOL 0380	The Ecology and Evolution of Infectious Disease	
BIOL 0415	Microbes in the Environment	
BIOL 0440	Inquiry in Plant Biology: Analysis of Plant Growth, Reproduction and Adaptive Responses	
BIOL 0470	Genetics	
BIOL 0500	Cell and Molecular Biology	
BIOL 0510	Introductory Microbiology	
BIOL 0530	Principles of Immunology	
BIOL 0800	Principles of Physiology	
BIOL 1050	Biology of the Eukaryotic Cell	
BIOL 1090	Polymer Science for Biomaterials	
BIOL 1100	Cell Physiology and Biophysics	
BIOL 1110	Topics in Signal Transduction	
BIOL 1120	Biomaterials	
BIOL 1150	Stem Cell Engineering	
BIOL 1200	Protein Biophysics and Structure	
BIOL 1210	Synthetic Biological Systems	
BIOL 1260	Physiological Pharmacology	
BIOL 1290	Cancer Biology	
BIOL 1300	Biomolecular Interactions: Health, Disease and Drug Design	
BIOL 1310	Developmental Biology	
BIOL 1330	Biology of Reproduction	
BIOL 1520	Innate Immunity	
BIOL 1540	Molecular Genetics	
BIOL 1560	Virology	
BIOL 1600	Development of Vaccines to Infectious Diseases	
BIOL 2110	Drug and Gene Delivery	
BIOL 2350	The Biology of Aging	
Chemistry Electives:		
CHEM 0500	Inorganic Chemistry	
CHEM 1140	Physical Chemistry: Quantum Chemistry	
CHEM 1150	Physical Chemistry: Thermodynamics and Statistical Mechanics	
CHEM 1220	Computational Tools in Biochemistry and Chemical Biology	
CHEM 1230	Chemical Biology	
CHEM 1240	Biochemistry	
CHEM 1450	Advanced Organic Chemistry	
CHEM 2420	Organic Reactions	
Computer Science Electives:		
CSCI 0080	A First Byte of Computer Science	
CSCI 0111	Computing Foundations: Data	
CSCI 0150	Introduction to Object-Oriented Programming and Computer Science	
CSCI 0160	Introduction to Algorithms and Data Structures	
CSCI 0170	Computer Science: An Integrated Introduction	
CSCI 0180	Computer Science: An Integrated Introduction	
CSCI 0190	Accelerated Introduction to Computer Science	
CSCI 1810	Computational Molecular Biology	
Engineering Electives:		
ENGN 0410	Materials Science	
Neuroscience Electives: [2]		
NEUR 0010	The Brain: An Introduction to Neuroscience	
NEUR 1020	Principles of Neurobiology	
NEUR 1030	Neural Systems	
NEUR 1040	Introduction to Neurogenetics	
NEUR 1670	Neuropharmacology and Synaptic Transmission	
NEUR 1740	The Diseased Brain: Mechanisms of Neurological and Psychiatric Disorders	
Physics Electives:		
PHYS 0160	Introduction to Relativity, Waves and Quantum Physics	
Public Health Electives:		
PHP 1501	Essentials of Data Analysis	
Total Credits		**20**

1 Note that the mathematics and physics requirements may be satisfied by Advanced Placement credit.

2 or any NEUR course in Cell, Genetics, Molecular Biology, or Development.

3 Students may opt to enroll in APMA 1655 for more in depth coverage of APMA 1650.

Honors Requirements for Biochemistry

All ScB Biochemistry concentrators are candidates for Honors; no separate application is necessary.

The requirements for Honors in Biochemistry are:

* Students must have a majority of either As or S with distinction grades in concentration courses.

* Two semesters of Independent Study (CHEM 0980, CHEM 0980S, CHEM 0981, BIOL 1950, or BIOL 1960). Guidelines and requirements associated with Independent Study are in the Undergraduate Concentration Handbook which can be found at the department website (http://www.brown.edu/academics/chemistry/undergraduate/).

* A Thesis in a form approved by the research advisor, and recommended by the research advisor. Additional information about thesis guidelines will be provided by the Concentration Advisor in the first half of the fall semester.

* An oral presentation of the thesis in a fifteen-minute senior talk followed by a five-minute question and answer period.

Chemical Physics Concentration Requirements

Chemical Physics is an interdisciplinary field at the crossroads of chemistry and physics and is administered jointly by the two departments. The concentration provides students with a broad-based understanding in fundamental molecular sciences, as well as a background for graduate

studies in physical chemistry, chemical physics, or molecular engineering. Concentrators are required to take twenty courses in chemistry, physics, and mathematics, although approved courses in applied mathematics, biology, computer science, geological sciences, or engineering may be substitutes. Chemical Physics concentrators are also advised to take at least six courses in the humanities and social sciences. Chemical Physics concentrators at all levels (first-year through seniors) are actively involved in research with faculty members in both departments.

Standard program for the Sc.B. degree

Twenty-one semester courses[1] in chemistry, physics, and mathematics, with a minimum of four semester courses in mathematics. The expectation is that courses required for a concentration in Chemical Physics will be taken for a letter grade. Core courses are:

CHEM 0330	Equilibrium, Rate, and Structure	1
CHEM 0350	Organic Chemistry I	1
CHEM 0500	Inorganic Chemistry	1
CHEM 1140	Physical Chemistry: Quantum Chemistry	1
PHYS 0070	Analytical Mechanics	1
PHYS 0160	Introduction to Relativity, Waves and Quantum Physics	1
PHYS 0470	Electricity and Magnetism	1
Select one of the following laboratory courses:		1
CHEM 1160	Physical Chemistry Laboratory	
PHYS 0560	Experiments in Modern Physics	
PHYS 1560	Modern Physics Laboratory	
Select one course in statistical mechanics:		1
CHEM 1150	Physical Chemistry: Thermodynamics and Statistical Mechanics	
PHYS 1530	Thermodynamics and Statistical Mechanics	
MATH 0190	Single Variable Calculus, Part II (Physics/ Engineering)	1
MATH 0200	Multivariable Calculus (Physics/ Engineering)	1
MATH 0520	Linear Algebra	1
Seven courses, primarily at the 1000 or 2000 level, in chemistry or physics.		7
Select two semesters of independent study:		2
PHYS 1990	Senior Conference Course	
CHEM 0980	Undergraduate Research	
Total Credits		**21**

1 Other approved courses in applied mathematics, biology, computer science, geological sciences, or engineering may be substituted for some of the twenty-one.
Students are advised to take at least six courses in the humanities and social sciences.

Honors Requirements for Chemical Physics

All Chemical Physics concentrators who have grades of A or S with distinction in a majority of their concentration courses will be considered for Honors; no separate application is necessary.

The requirements for Honors in Chemical Physics are:

* Grades of A or S with distinction in a majority of courses taken for the concentration.

* Two semesters of Independent Study (CHEM 0980 or equivalent. Guidelines and requirements associated with Independent Study are in the Undergraduate Concentration Handbook which can be found at the department website (http://www.brown.edu/academics/chemistry/undergraduate/).

* A Thesis in a form approved and recommended by the research advisor. Additional information about thesis guidelines will be provided to seniors by the Concentration Advisor.

* A Poster presentation at the chemistry department's spring undergraduate poster session.

Chemistry Graduate Program

The Department of Chemistry offers graduate programs leading to the Master of Arts (A.M.); the Master of Science (Sc.M.); a the Doctor of Philosophy (Ph.D.) degree.

Research in Chemistry stretches from the exploration of physical phenomena of individual molecules, to the creation of new molecules, to material science, and indeed to the foundations of life. The Department of Chemistry reflects this profound importance and diversity by offering excellent research opportunities in areas including organic and inorganic chemistry, chemical biology, analytical chemistry, nanochemistry and theoretical and experimental physical chemistry. In addition, graduate students have the opportunity to participate in interdisciplinary research in molecular biology, chemical engineering and the Institute for Molecular and Nanoscale Innovation. The faculty student ratio is approximately 3:1 with most research groups numbering no more than six graduate students.

For more information on admission and program requirements, please visit the following websites:

http://www.brown.edu/academics/gradschool/programs/chemistry (http://www.brown.edu/academics/gradschool/programs/chemistry/)

Courses

CHEM 0080A. First Year Seminar- Energy.
An introductory study of the scientific foundation of energy, fundamental physical, chemical, and thermodynamic aspects of common (fossil, nuclear) as well as novel (fuel cells, solar, wind, etc.) energy sources. Concentrates on scientific principles, but includes discussion on resources and reserves, environmental impact, current usage, and future needs. For students of all disciplines who are interested in obtaining an understanding of scientific principles of energy. Enrollment limited to 19 first year students.

CHEM 0080B. Molecular Structures in Chemistry and Biology.
This course will consist of a survey of historical developments and concepts of three dimensional structures of molecules. The course will conclude with a survey of the current state of the art of structure determination and 3D structure motifs for small molecules, nanomaterials and biological macromolecules. This freshman only seminar will be strictly limited to a maximum of 19 students.

Fall	CHEM0080B	S01	17560	TTh	9:00-10:20(05)	(P. Williard)

CHEM 0080C. Drug Discoveries in the Pharmaceutical Industry.
A Freshman seminar that provides a survey of past and current approaches that enable the discovery and development of therapeutic agents. Topics ranging from target validation to the development of therapeutics (small molecules, biologics, and stem cells) will be discussed. Enrollment limited to 19 first-year students.

CHEM 0080F. Kitchen Chemistry.
Have you ever wondered why olive oil is a liquid but butter is solid? Or why bread and cookies rise when baked? This Kitchen Chemistry course is an experimental approach to chemistry, as seen in cooking. We will examine topics such as trans fats, baking soda as a leavening agent in baking, ripening of fruit, artificial sweeteners, GMOs, and enzymatic and non-enzymatic browning of foods. Edible experiments will be used to discuss the science behind recipes. Enrollment limited to 14 first year students. Instructor permission is required.

CHEM 0090. Kitchen Chemistry.
Kitchen Chemistry is a course that highlights the chemistry underlying food and cooking. We will examine topics such as trans fats, baking soda as a leavening agent in baking, chemical basis for ripening of fruit, pectin as a cellular glue, artificial sweeteners, GMOs, and enzymatic and non-enzymatic browning of foods. In-class demonstrations and edible experiments will be used to discuss the science behind cooking. Content will be discussed using a variety of contexts including primary scientific literature, public policy reports, mainstream media, and food blogs. This class is appropriate for all students interested in chemistry.

CHEM 0100. Introductory Chemistry.
Explores stoichiometry, atomic and molecular structure, chemical bonding, solutions, gases, chemical reactions, equilibria, thermochemistry. S/NC.

Fall	CHEM0100	S01	10120	MWF	11:00-11:50(16)	(M. Lueckheide)

CHEM 0330. Equilibrium, Rate, and Structure.
Explores the electronic structure of atoms and molecules, thermodynamics, solution equilibrium, electrochemistry, chemical kinetics, and reaction mechanisms. To successfully register for this course , please include all three components: lecture, lab, and conference. Students who previously passed 0330 lab may be excused from repeating the lab portion of the course, please register for L11 as your lab section. Required background: CHEM 0100 or AP Chemistry 4 or CHEM Placement Test 8 or IBH Chemistry.

Fall	CHEM0330	S01	10121	MWF	10:00-10:50(14)	(R. Stratt)
Fall	CHEM0330	S02	10122	TTh	10:30-11:50(13)	(B. Rubenstein)
Spr	CHEM0330	S01	26149	TTh	10:30-11:50(09)	(O. Chen)

CHEM 0330L. Equilibrium, Rate, and Structure Lab.
Please see course description for CHEM 0330.

Fall	CHEM0330LL01		18449	M	1:00-4:50	(L. Wang)
Fall	CHEM0330LL02		18450	M	2:00-5:50	(L. Wang)
Fall	CHEM0330LL03		18451	T	1:00-4:50	(L. Wang)
Fall	CHEM0330LL04		18452	T	2:30-6:20	(L. Wang)
Fall	CHEM0330LL05		18453	W	1:00-4:50	(L. Wang)
Fall	CHEM0330LL06		18454	W	2:00-5:50	(L. Wang)
Fall	CHEM0330LL07		18455	Th	1:00-4:50	(L. Wang)
Fall	CHEM0330LL08		18456	Th	2:30-6:20	(L. Wang)
Fall	CHEM0330LL09		18457	F	1:00-4:50	(L. Wang)
Fall	CHEM0330LL10		18458	F	2:00-5:50	(L. Wang)
Fall	CHEM0330LL11		18459	Arranged		'To Be Arranged'

CHEM 0332. Equilibrium, Rate and Structure - Tutorial.
The CHEM 0332 tutorial program offers students the opportunity to master the concepts taught in the fall semester CHEM 0330: Equilibrium, Rate and Structure course by focusing on active problem solving. Students who struggle in the fall CHEM 0330 course may be invited to join the tutorial program. Students accepted into the tutorial program begin by reviewing compound and reaction stoichiometry at the beginning of the spring semester. Tutorial students enroll in CHEM 0332 during the spring semester to complete their studies of equilibrium, acid-base equilibria, thermodynamics, atomic and molecular structure and kinetics. Students in the CHEM 0332 tutorial program complete weekly problem sets during the spring semester and participate in two mandatory, regularly scheduled problem sessions during each week of the spring semester.
To qualify for consideration, a student must be on track to pass the laboratory component but is below a passing overall score after the last midterm. Accepted students receive a grade of incomplete for the Fall CHEM 0330 course. Upon successful completion of the CHEM 0332 tutorial program in the spring semester, the INC in Fall CHEM 0330 is replaced by the student's tutorial program grade with the laboratory component imported from the fall course.

CHEM 0350. Organic Chemistry I.
Investigates the constitution and properties of organic compounds, with considerable attention to structural motifs, isomerism and chirality, acid/base chemistry, elementary reaction mechanisms (alkene/alkyne addition, nucleophilic substitutions, eliminations, etc.) and synthetic schemes. The laboratory work comprises microscale preparative and analytical techniques fundamental to the manipulation of representative organic compounds. Prerequisite: CHEM 0330 Students must register for the main lecture section and one lab section. Students who previously passed the CHEM 0350 lab may be excused from repeating the lab portion of the course, please register for lab section L11 as your lab section.

Spr	CHEM0350	S01	26154	MWF	9:00-9:50(02)	(M. Zimmt)
Spr	CHEM0350	S02	26155	TTh	9:00-10:20(05)	(C. Morton)

CHEM 0350L. Organic Chemistry I Lab.
Please see course description for CHEM 0350.

CHEM 0360. Organic Chemistry II.
Sequel to CHEM 0350. Investigates the constitution and properties of organic compounds at a fundamental level with an introduction to physical organic, bioorganic, and synthetic organic chemistry. Laboratory work is concerned with the identification and characterization of organic compounds, including modern instrumental methods. Prerequisite: CHEM 0350.
Students must register for a lecture section and a lab.
If you previously passed CHEM 0360 laboratory you may be excused from repeating the lab portion of the course, please register for lab section 11.

Fall	CHEM0360	S01	17718	MWF	9:00-9:50(09)	(M. Zimmt)
Fall	CHEM0360	S02	17720	TTh	9:00-10:20(05)	(A. Basu)

CHEM 0360L. Organic Chemistry II Lab.
Please see course description for CHEM 0360.

Fall	CHEM0360LL01		18480	M	1:00-4:50	(J. Morin)
Fall	CHEM0360LL02		18481	M	2:00-5:50	(J. Morin)
Fall	CHEM0360LL03		18482	T	1:00-4:50	(J. Morin)
Fall	CHEM0360LL04		18483	T	2:30-6:20	(J. Morin)
Fall	CHEM0360LL05		18484	W	1:00-4:50	(J. Morin)
Fall	CHEM0360LL06		18485	W	2:00-5:50	(J. Morin)
Fall	CHEM0360LL07		18486	Th	1:00-4:50	(J. Morin)
Fall	CHEM0360LL08		18487	Th	2:30-6:20	(J. Morin)
Fall	CHEM0360LL09		18488	F	1:00-4:50	(J. Morin)
Fall	CHEM0360LL10		18489	F	2:00-5:50	(J. Morin)
Fall	CHEM0360LL11		18490	Arranged		'To Be Arranged'

CHEM 0400. Biophysical and Bioinorganic Chemistry.
Examines aspects of physical and inorganic chemistry relevant to biochemistry: thermodynamics of hydrophobic and hydrophilic interactions, electrically charged membranes, coordination chemistry, active and passive transport, enzyme kinetics and mechanisms, metal-based drugs, and physical methods. Prerequisite: CHEM 0360. Prerequisite or corequisite: PHYS 0040 or 0060.

Spr	CHEM0400	S01	26157	TTh	10:30-11:50(09)	(S. Sun)

CHEM 0500. Inorganic Chemistry.
Examines the chemistry of main group and transition metal elements with treatment of covalent bonding and molecular structure. Emphasis will be placed on the methods of studying inorganic compounds and reactions, as well as their pervasiveness in real-world applications. Students will have the opportunity to develop their scientific writing through a peer-reviewed review paper project connecting inorganic chemistry to a topic of their choice. Prerequisite: CHEM 0360.

Spr	CHEM0500	S01	26160	MWF	11:00-11:50(04)	(M. Lueckheide)

CHEM 0600. Preparative Chemistry Lab.
This course is designed to develop advanced skills in chemical synthesis and analysis as preparation for work in a modern synthetic chemistry research environment. Students will perform synthesis of new chemical compounds using advanced techniques including air-free Schlenk and glovebox techniques, microwave synthesis, photocatalytic methods, and others. Students will also learn how to characterize their synthesized compounds using 2D NMR, ESI mass spectrometry, EPR spectroscopy, and other methods. The course consists of 1 hour of lecture per week discussing various techniques and applications and 4 hours of laboratory time. This course counts for 0.5 credits.

Spr	CHEM0600	S01	26161	M	1:00-4:50	(M. Lueckheide)
Spr	CHEM0600	S02	26162	W	1:00-4:50	(M. Lueckheide)

CHEM 0980. Undergraduate Research.
Independent research in chemistry mentored by a faculty member. The student will carry out original research in chemistry or chemical education. Students should consult with their faculty mentor to discuss the selection of a research project and setting objectives for the semester. This course may be repeated for credit. Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course. Instructor override required.

CHEM 0980S. Undergraduate Research - Writing Designated and Mandatory S/NC.
Independent research in chemistry mentored by a faculty member.The student will carry out original research in chemistry or chemical education. Students should consult with their faculty mentor to discuss the selection of a research project and setting objectives for the semester. Students in this independent undergraduate research course will be expected to work on several scaffolded writing assignments throughout the semester. Students will receive feedback on their writing that they can incorporate into a revised version of the assignment or a future submission. Students who will not be engaged in this level of scientific writing should enroll in the traditional undergraduate research course, CHEM0980. This course may be repeated for credit. Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course. Instructor override required.This course is Mandatory S/NC.

CHEM 0981. Undergraduate Research - Writing Designated.
Independent research in chemistry mentored by a faculty member. The student will carry out original research in chemistry or chemical education. Students should consult with their faculty mentor to discuss the selection of a research project and setting objectives for the semester. Students in this independent undergraduate research course will be expected to work on several scaffolded writing assignments throughout the semester. Students will receive feedback on their writing that they can incorporate into a revised version of the assignment or a future submission. Students who will not be engaged in this level of scientific writing should enroll in the traditional undergraduate research course, CHEM 0980. This course may be repeated for credit. Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course. Instructor override required.

CHEM 0999. Chemistry and Art.
"Chemistry and Art" is an interdisciplinary course that explores different chemical concepts and techniques through the lenses of art and art history. The topics covered include paint and painting, stained glass; pottery and porcelains; gemstones and jewelry; color and art conservation. Drawing from early artistic texts, we will take a historically informed approach, connecting medieval stained-glass techniques, early pigmentation sourcing, and Qin dynasty pottery work to modern chemical explanations. Throughout the course, lectures, discussions, hands-on activities, and writing are totally integrated and the chemistry principles and techniques behind art objects and art-making are introduced through a series of case studies.

Fall	CHEM0999	S01	17721	W	3:00-5:30(10)	(L. Wang)

CHEM 1060. Advanced Inorganic Chemistry.
Covers the physical and chemical properties of transition metal compounds as well as current research topics in inorganic chemistry. Laboratory is designed for the practice of modern inorganic chemistry through the synthesis and spectroscopic characterization of air-sensitive transition metal compounds. Prerequisite: CHEM 0500.

Fall	CHEM1060	S01	17722	MW	8:30-9:50(09)	(O. Chen)

CHEM 1140. Physical Chemistry: Quantum Chemistry.
An introduction to the quantum theory of chemical systems. Elements of quantum mechanics; electronic structure of atoms and molecules; study of molecular structure and behavior by spectroscopy; chemical bonding are all explored. Prerequisites: CHEM 0330, MATH 0180 or equivalent, PHYS 0030 and PHYS 0040 or PHYS 0050 and PHYS 0060 or PHYS 0070 and PHYS 0470 or ENGN 0030 and ENGN 0040.

Fall	CHEM1140	S01	17723	MWF	10:00-10:50(14)	(P. Weber)

CHEM 1150. Physical Chemistry: Thermodynamics and Statistical Mechanics.
Examines the question: Where does chemical equilibrium come from? Focuses on macroscopic perspectives on chemical systems and the molecular origins of macroscopic behavior along with elements of statistical mechanics, the laws of thermodynamics, and the relationships between the two. Prerequisite: CHEM 1140

Spr	CHEM1150	S01	26163	MWF	10:00-10:50(03)	(B. Rubenstein)

CHEM 1160. Physical Chemistry Laboratory.
An introduction to modern instrumentation and experimental techniques as applied to physical chemistry. Experiments will emphasize application of the ideas of spectroscopy, kinetics, statistical mechanics, and thermodynamics to systems of chemical and biochemical interest. Prerequisites: CHEM 1140 or permission of the instructor.

Spr	CHEM1160	S01	26164	M	1:00-4:50	(P. Weber)
Spr	CHEM1160	S02	26165	W	1:00-4:50	(P. Weber)

CHEM 1170. Environmental Chemistry.
A laboratory course using analytical methods to help in the study and description of several realistic environmental problems. Illustrates scientific methodology and measurement techniques as they apply to these important problems. A problem-solving course employing a kind of environmental chemical detective work. Two laboratory sessions per week. Prerequisites: MATH 0100 or the equivalent, or permission of the instructor. Enrollment limited to 8. Instructor permission required.

CHEM 1220. Computational Tools in Biochemistry and Chemical Biology.
Introduction to computational tools used to analyze protein sequences and structures, DNA sequence analysis, RNA structure, biochemical pathways and the analysis of microarray data. Extensive use of programs such as AMBER, BLAST, PSIBLAST and a discussion of their limitations.

CHEM 1230. Chemical Biology.
This course covers topics at the interface of chemistry and biology and, specifically, the use of chemical tools to probe biological systems. Using examples from the recent literature, we will discuss using the central methods of chemistry, namely the ability to design and synthesize compounds with a particular set of properties, to analyze biological problems. Specific topics include molecular recognition of DNA, artificial enzymes, small molecule sensors, and in vivo imaging of proteins, nucleic acids, and cell-surface carbohydrates. Prerequisites: CHEM 0360 and BIOL 0280.

Spr	CHEM1230	S01	26166	TTh	9:00-10:20(05)	(M. Kizer)

CHEM 1240. Biochemistry.
Examines the chemical, mechanistic, and structural basis for enzymatic catalysis. Uses examples from the recent literature to examine how the experimental and conceptual tools of chemical synthesis, isotopic labeling, stereochemistry, enzymology, kinetics, and protein structure can be brought to bear to unravel the chemical and physical principles underlying the enormous catalytic acceleration and exquisite structural specificity of enzyme-catalyzed reactions. Prerequisites: CHEM 0360, BIOL 0280.

Fall	CHEM1240	S01	17725	TTh	9:00-10:20(05)	(J. Morin)

CHEM 1450. Advanced Organic Chemistry.
Lectures cover topics of current interest in organic reaction mechanisms, synthesis, and structure determination. Prerequisite: CHEM 0360.

Spr	CHEM1450	S01	26167	TTh	2:30-3:50(11)	(B. McDonald)

CHEM 1560A. Molecular Modeling.
No description available.

CHEM 1560C. Advanced Spectroscopy.
No description available.

CHEM 1560E. Biological Mass Spectrometry.
This seminar course will survey the instrumentation, methods, and applications of modern biological mass spectrometry. Through lecture and interactive discussions, we will explore the fundamentals of mass spectrometry. We will then proceed to cover a series of topics relevant to protein and peptides analysis. The seminar will conclude with an exploration of recent developments in instrumentation or applications of particular interest to the participants. Recommended pre-requisites: CHEM 0360, BIOL 0280, PHYS 0040. Enrollment limited to 20.

CHEM 1560F. Organic Structure Analysis.

CHEM 1560G. Nuclear Magnetic Resonance.
These special topics courses cover the basics of modern NMR spectroscopy. Topics to be included are as follows: modern Fourier transform methodology, modern NMR instrumentation, and a comprehensive discussion of one and two dimensional experiments that are routinely performed. Topics such as coherence transfer and pulsed field gradients will also be included. Experimental methods covered in detail include COSY, TOCSY, HSQC, HMBC, NOSEY, ROSEY, EXSY and DOSY methodology. This course will not focus on structure determination or spectral interpretation but rather on experimental methodology.

Spr	CHEM1560G	S01	26168	MWF	11:00-11:50(04)	(P. Williard)

CHEM 1560H. Chemical Glycobiology.
This course examines the chemistry and biology of carbohydrates in living systems. Topics to be covered may include - principles of carbohydrate recognition, enzymes involved in synthesis and modification of carbohydrates, carbohydrates in bacterial/viral and other cellular interactions, glycomics, carbohydrate synthesis. Prerequisites: CHEM 0360 and BIOL 0280. Instructor permission required. Attendance at the first class meeting is required for enrollment.

Fall	CHEM1560H	S01	17726	MWF	10:00-10:50(14)	(M. Kizer)

CHEM 1560I. DNA Damage and Repair.
This course analyzes the chemistry of DNA damaging agents and the molecular mechanisms of DNA replication and DNA repair. We will also analyze the mutagenic and toxic consequences of modifications to DNA structure. Specific topics include the reactions of alkylating agents, ultraviolet radiation, and oxidizing radicals with DNA; additionally, chemotherapeutics that modify DNA will be discussed. Multiple cellular repair pathways will be covered including base excision repair, nucleotide excision repair, mismatch repair, and direct reversal. Prerequisites: CHEM 0350, CHEM 0360, BIOL 0280, BIOL 1270, or by permission.

CHEM 1560J. Topics in Bioinorganic Chemistry.
Covers current topics of bioinorganic chemistry with review of fundamental inorganic and biological chemistry. Topics include metal ion transport and storage, oxygen metabolism, electron transfer, respiration and photosynthesis, metal ion receptors and signaling, hydrolytic chemistry, metallo-neurochemistry, and medicinal bioinorganic chemistry. Students are strongly urged to complete both CHEM 0500 and CHEM 0360 prior to this special topics course.

CHEM 1560K. Computational Chemistry: Accelerating Chemical Discovery via Computation and Data Science.
Introduction to computational tools for studying the structure of molecules, chemical bonding and chemical reactions. A survey of computational approaches for calculating electron distribution such as molecular mechanics, semi-empirical and ab initio methods (Hartree-Fock, configuration interaction, perturbation theory and density functional theory) will be given. Methods for calculating dynamics of atoms in molecular vibration and chemical reactions will be covered. The course is intended for seniors and graduate students in all subdivisions of chemistry. The goal is to make students capable of using research level tools and carry out simple calculations related to their research interests.

CHEM 1560M. Applied Materials Chemistry.
Materials chemistry is the study of the synthesis, structure, properties, and application of solid materials. Our technology-driven world is fueled by advances in materials chemistry with examples of application in areas such as microelectronics, polymers, and energy technology. This course will explain the application of materials chemistry through the materials properties and characterization, detailing how the crystalline and molecular structure of materials can be related to electronic, optical, thermal, and mechanical properties.

CHEM 1560N. Organometallic Chemistry.
Modern organometallic chemistry continues to find unique applications including next generation lighting displays, therapeutics and imaging, energy science, and green chemical synthesis. In this course we will briefly review fundamentals of inorganic chemistry (MO theory, ligand field theory, Pearson's HSAB theory), and then delve into the structure, bonding, synthesis, reactivity, and mechanisms associated with organometallic complexes and their associated applications. Significant emphasis will be placed on effective oral and written communication skills, with frequent peer and instructor feedback provided. Prerequisites: CHEM 0360, CHEM 0500. PLEASE NOTE: This class is WRIT designated for Undergraduates Only. Graduate students should register for CHEM 2310. Undergraduates should register for CHEM 1560N.

Fall	CHEM1560N	S01	17727	TTh	10:30-11:50(13)	(J. Robinson)

CHEM 1560P. Applications of Modern Physical Methods in Synthesis.
The modern synthetic chemist leverages a wide range of physical methods to answer research questions in diverse application areas ranging from renewable energy, medicine, materials, complex molecule synthesis, and others. Students will develop a working knowledge of modern techniques applied to synthesis, learning fundamental principles, experimental limitations, and interpretation of experimental results. Selected techniques may include: Nuclear Magnetic Resonance (NMR), Electron Paramagnetic Resonance (EPR), Fluorimetry, Absorption Spectroscopy (UV-Vis, IR, X-ray), Diffraction (X-ray), Magnetometry, Electrochemistry, and Mass-Spectrometry. Emphasis will be placed on how techniques are relevant in current research areas, and the instrumental capabilities available at Brown University.

Spr	CHEM1560P	S01	26169	TTh	1:00-2:20(08)	(J. Robinson)

CHEM 1560Q. Accelerating Chemical Discovery.
For centuries, chemists have relied upon chemical intuition to guide their chemical discovery. However, with the advent of high-throughput synthesis and characterization techniques and spectroscopies that produce TBs of images, chemists are now being inundated with data. This course will equip you with the tools of data science and computational chemistry so that you can fully leverage your data for discovery. It consists of four key modules: Intro to Data Science, Chemical Discovery (RDKit, chemical databases, and machine learning), Modern Spectroscopy (image recognition and computational chemistry), and Atomistic Simulation (computational catalysis and molecular dynamics simulations) that will challenge you to solve practical chemistry problems via data science and/or simulation. While previous computing knowledge will be an advantage, it will not be required. Recommended prerequisites: CHEM0330/0350/0360, PHYS0030/0040, MATH0100. CHEM1140/1150/2770/2780/2020 would be beneficial, but are not required.

CHEM 1560R. Reimagining the Role of Chemists.
Reimagining the Role of Chemists teaches chemistry in the context of today's issues. This course investigates chemistry's entanglements with colonialism, anti-black racism, and environmental injustice. In the hopes of regrounding chemistry, reorienting its values, and reimagining its future, we engage with diverse histories, perspectives, and impacts that have often been rendered invisible. Together, we will consider how to transition from a false pretense of objectivity to a just and beneficial practice of chemistry.

Spr	CHEM1560R	S01	26170	TTh	10:30-11:50(09)	(J. Morin)

CHEM 1560S. The Chemistry of Polymeric Organic Materials.
The 21st century has seen the transition of carbon-based polymers from commodity bulk materials to sophisticated and intricately engineered materials with applications in biotechnology, energy harvesting and storage, separations, and sensing schemes. At the heart of these thrusts have been developments in the synthesis of organic polymers and methods for their fabrication into materials and devices. The aim of this course is to build a fundamental knowledge of polymer chemistry and survey their application to functional materials and devices. Topics covered in this course can be broken into three major categories: 1. Synthesis and characterization of polymers; 2. Processing and characterization of polymeric materials; 3. Applications of organic materials to modern challenges.

Fall	CHEM1560S	S01	17728	MWF	1:00-1:50(08)	(B. McDonald)

CHEM 1620B. Spectroscopy.
Prerequisite: CHEM 1140 or equivalent.

CHEM 1620C. Topics in Modern Physical Chemistry.
No description available.

CHEM 1660. Instrumental Analysis with Environmental Applications.
This course covers the principles and practical applications of important analytical chemistry tools used to study environmental problems, including discussions of method selection and statistical treatment of data. Students will strategize and implement a study of a field site. Includes lab sessions with hands-on experience of instrumental analysis using atomic and molecular spectroscopic techniques, separations by gas and liquid chromatography, and electrochemical methods. Prerequisite: CHEM 0330 or GEOL 1370. Enrollment limited to 20. Instructor permission required.

CHEM 1700. Nanoscale Materials: Synthesis and Applications.
Focuses on synthesis, properties, and applications of nanoscale materials. It begins with the introduction to size-dependent properties and to general characterization methods of nanomaterials. It then outlines the synthesis, surface chemistry and self-assembly of nanomaterials. It further reviews catalytic, optical and magnetic properties of nanomateirals. Finally, the course highlights the applications of nanomaterials in information storage, energy conversion, and biomedicine. Prerequisites : CHEM0350, PHYS 0030 or 0050, BIOL0280 recommended.

Fall	CHEM1700	S01	17729	MWF	11:00-11:50(16)	(S. Sun)

CHEM 2010. Advanced Thermodynamics.
Fundamental principles of macroscopic equilibrium thermodynamics. The three laws of thermodynamics, the thermodynamic potentials, temperature scales, heat engines and refrigerators, entropy, kinetic theory, and transport phenomena. Applications to solids, fluids, and magnetic systems; Gibbs relations, first and second order phase traditions, thermal radiation, gas expansions.

CHEM 2020. Statistical Mechanics.
Introduction to modern equilibrium statistical mechanics, including the classical and quantum descriptions of ideal gases, the molecular basis of thermodynamics, the concepts of ensembles and fluctuations, and the implications of quantum mechanical indistinguishability. Applications include chemical and phase equilibria, the transition-state theory of chemical reaction rates, and the theory of liquids.

Spr	CHEM2020	S01	26171	MWF	9:00-9:50(02)	(E. Sprague-Klein)

CHEM 2210. Chemical Crystallography.
Introduces the principles of crystallography (plane groups, point groups, space groups, Bravais lattice, crystal classes), crystallographic methods (single-crystal, powder XRD, macromolecular), strategies for data collection, methods for data reduction, and structure interpretation; reviews modern crystal structure databases (CSD, ICSD) and search engines; reviews the historical development of crystallography and the scope, potential and application of X-ray analysis.

CHEM 2310. Organometallic Chemistry.
Modern organometallic chemistry continues to find unique applications including next generation lighting displays, therapeutics and imaging, energy science, and green chemical synthesis. In this course we will briefly review fundamentals of inorganic chemistry (MO theory, ligand field theory, Pearson's HSAB theory), and then delve into the structure, bonding, synthesis, reactivity, and mechanisms associated with organometallic complexes and their associated applications. Significant emphasis will be placed on effective oral and written communication skills, with frequent peer and instructor feedback provided. Prerequisites: CHEM 0360, CHEM 0500. PLEASE NOTE: This class is WRIT designated for Undergraduates Only. Graduate students should register for CHEM 2310. Undergraduates should register for CHEM 1560N.

Fall	CHEM2310	S01	17731	TTh	10:30-11:50(13)	(J. Robinson)

CHEM 2320. Solid State Chemistry.
This course focuses on descriptive understanding of structures and properties of inorganic materials. It covers symmetry operations in crystals, crystal structure, physical properties of inorganic materials, materials phase diagram and preparation, and solid state electrochemistry for battery, fuel cell and supercapacitor applications. Prerequisites: CHEM 0500 and 1060 or equivalents or written permission. Recommended for seniors and first-year graduate students.

CHEM 2410. Organic Mechanisms.
This course examines methods for deteremining organic reaction mechanisms. Types of experiments introduced may include kinetics, free energy relationships, isotope effects, molecular orbital theory, spectroscopy, and product distribution analysis. Reactions typically covered inlcude pericyclic reactions, reactive intermediates, organometallic reactions, and substituion/addltion/elimination. The course makes extensive use of the primary literature, with a strong emphasis on the development of effective communication strategies. Completion of CHEM0500, and CHEM1140 is strongly recommended.

Fall	CHEM2410	S01	17732	TTh	1:00-2:20(06)	(M. Xian)

CHEM 2420. Organic Reactions.
Study of organic reactions and reaction mechanisms. Discussion and analysis of organic transformations. Topics can include arrow pushing strategies and synthetic methods.

Spr	CHEM2420	S01	26172	MW	8:30-9:50(02)	(A. Basu)

CHEM 2430. Synthetic Organic Chemistry.
Methods, strategies, and mechanisms. Topics may include the chemistry of anions, cations, and radicals, concerted reactions, conformational analysis, and stereochemistry.

Spr	CHEM2430	S01	26173	TTh	10:30-11:50(09)	(M. Xian)

CHEM 2770. Quantum Mechanics.
The course discusses the foundations of quantum mechanics and applications to chemical systems and phenomena. Using a rigorous mathematical treatment and Dirac notation, important time-independent model systems include two-level systems, one- and three-dimensional problems and angular momentum. Elements of time-dependent quantum mechanics focus on wavepacket motions. The semester will close out with a discussion of the spin and symmetry postulates.

CHEM 2780. Quantum Mechanics.
The second semester sequel of Quantum Mechanics covers many body systems and matter-radiation interactions. It starts with a discussion of the symmetry postulates of quantum mechanics, followed by applications to the electronic structure of atoms and molecules, including angular momenta, the nature of chemical bonds, the Born-Oppenheimer approximation and conical intersections as well as molecular vibrations. The semester closes out with a discussion of time-dependent perturbation theory and spectroscopy, including the quantum adiabatic theorem, as well as the theory of electron and x-ray scattering.
Prerequisite: CHEM 2770.

Spr	CHEM2780	S01	26174	TTh	10:30-11:50(09)	(Y. Bai)

CHEM 2810. Departmental Seminars.
No description available.

CHEM 2820. Departmental Seminars.
No description available.

CHEM 2870. Departmental Colloquia.
Open to first year chemistry graduate students only.

Fall	CHEM2870	S01	17734	F	3:00-5:30(11)	(S. Delaney)
Fall	CHEM2870	C01	17735	T	3:30-4:50	(S. Delaney)
Spr	CHEM2870	S01	26175	F	3:00-5:30(15)	(L. Wang)
Spr	CHEM2870	C01	26176	W	3:00-4:30	(L. Wang)

CHEM 2880. Departmental Colloquia.
No description available. Open to graduate students only.

CHEM 2920C. Topics in Modern Spectroscopy.
No description available.

CHEM 2970. Preliminary Examination Preparation.
For graduate students who have met the tuition requirement and are paying the registration fee to continue active enrollment while preparing for a preliminary examination.

Fall	CHEM2970	S01	16542	Arranged	'To Be Arranged'
Spr	CHEM2970	S01	25208	Arranged	'To Be Arranged'

CHEM 2980. Research.
Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course.

CHEM 2981. Research.
Section numbers vary by instructor. Please check Banner for the correct section number and CRN to use when registering for this course. CHEM 2981 is mandatory S/NC.

CHEM 2990. Thesis Preparation.
For graduate students who have met the residency requirement and are continuing research on a full time basis.

Fall	CHEM2990	S01	16543	Arranged	'To Be Arranged'
Spr	CHEM2990	S01	25209	Arranged	'To Be Arranged'

CHEM XLIST. Courses of Interest to Students wishing to Study Chemistry.