Washington University in St. Louis

Chemistry

For students interested in discovering insights into nature, exploring new ways to meet the needs of our technological society, and learning new methods for creating novel compounds and useful materials, chemistry is an excellent major to pursue.

Chemistry is a multifaceted science that extends into biology, medicine, physics, mathematics, business and commerce. Studying chemistry provides students with the opportunity to explore the structure and constitution of the microworlds of atoms and molecules, the chemical and physical transformations that occur there, and the principles that govern these changes.

Our program provides a strong foundation in the core areas of chemistry: organic, physical, inorganic, nuclear and theoretical. Special emphases in the department include such emerging interdisciplinary fields as organometallic, bioorganic, biophysical, macromolecular, polymer, environmental and materials chemistry. The department has close research ties with the departments of Physics; Earth, Environmental, and Planetary Sciences; Biology; Biomedical Engineering; Energy, Environmental & Chemical Engineering; and Mechanical Engineering & Materials Science. It also works closely with various departments at the Washington University School of Medicine.

Undergraduate majors in chemistry study chemistry with renowned scientists who are teacher-scholars dedicated to the students' learning experiences. The department is small and has world-class instruments and facilities, which allow students to receive individualized instruction and to participate in cutting-edge science. Each student works closely with a faculty member to design and carry out an original research project. Students may participate in interdisciplinary research at the School of Medicine or the McKelvey School of Engineering. Research internships at local companies can also be arranged.

A variety of creative and productive careers are available to graduates with a degree in chemistry. Graduates may pursue a career in chemistry or in such related professions as biochemistry, medicine and chemical engineering. Most students continue on to graduate or medical school, and some students go on to business or law school. Positions in government, industry and education are also feasible career paths.

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Faculty

Chair

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Charles Allen Thomas Professor
PhD, University of Illinois, Urbana-Champaign

Professor and Chancellor Emeritus

Mark Wrighton (https://chemistry.wustl.edu/people/mark-stephen-wrighton/)
James and Mary Wertsch Distinguished University Professor
PhD, California Institute of Technology

Endowed Professor

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PhD, Washington University

Professors

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Joint Professor

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PhD, Washington University
(Internal Medicine)

Majors

The Major in Chemistry

Total units required: 53

Required courses: To prepare for a major in chemistry, students will take the following:

Code	Title	Units
Chem 111A	General Chemistry I	3
Chem 112A	General Chemistry II	3
Chem 151	General Chemistry Laboratory I	2
Chem 152	General Chemistry Laboratory II	2
Chem 261	Organic Chemistry I with Lab	4
Chem 262	Organic Chemistry II with Lab	4
Math 131	Calculus I	3
Physics 191	Physics I	3
Physics 191L	Physics I Laboratory	1
Physics 192	Physics II	3
Physics 192L	Physics II Laboratory	1
Math 132	Calculus II	3
Math 233	Calculus III	3
Total Units		**35**

Note: In certain instances, students may substitute Chem 105 Introductory General Chemistry I and Chem 106 Introductory General Chemistry II for Chem 111A General Chemistry I and Chem 112A General Chemistry II. Please consult the department's director of undergraduate studies for details.

Majors in chemistry must take a minimum of 18 units of advanced courses in chemistry or biochemistry, among which the following must be included:

Code	Title	Units
Chem 401	Physical Chemistry I	3
Chem 402	Physical Chemistry II	3
Chem 461	Inorganic Chemistry	3
Total Units		**9**

In addition, 9 units in chemistry at the 300 level or above must be taken (not including Chem 490 Introduction to Research or Chem 495 Advanced Undergraduate Research in Chemistry). Biol 451 General Biochemistry may be used to complete 3 of the required 9 units.

At least 3 of these 9 advanced units must be in a laboratory course chosen from the following list:

Code	Title	Units
Chem 358	Organic Chemistry Laboratory II	4
Chem 435	Nuclear and Radiochemistry Lab	3
Chem 445	Instrumental Methods: Physical Chemistry	3
Chem 462	Synthetic Polymer Chemistry Laboratory	3
Chem 470	Inorganic Chemistry Laboratory	3

Physics 217 Introduction to Quantum Physics and additional mathematics courses are also recommended. Chem 181 First-Year Opportunity: Applications in Chemistry, a seminar to introduce first-year students to research activities in the department, is optional. A working knowledge of computer programming and of a foreign language, such as German or Russian, is encouraged but not required.

Students have the advantage of planning their programs with their advisors in accordance with their personal interests. Some graduate courses are also available to seniors.

All chemistry course work must be taken in residence at Washington University to be applied toward the chemistry major. A minimum grade of C- must be earned in each course to count toward the chemistry major.

Note: Per the College of Arts & Sciences guidelines, for students who also pursue a minor or more than one major or minor program, only introductory (100- and 200-level) courses may be counted, when relevant, toward the requirements of both programs. All advanced (300- and 400-level) courses must be unique to each program. In other words, no advanced course may be "double-counted" for the course work needed to fulfill either program's minimal requirements. Should a student's major and minor programs require the same course, a departmentally sanctioned elective must be chosen to replace the course in one of the programs.

The Major With a Concentration in Biochemistry

Total units required: 59

Chemistry majors with a concentration in biochemistry should add Biol 2960 Principles of Biology I and Biol 2970 Principles of Biology II as prerequisites to the major and specify a minimum of 18 units in advanced courses in biology and chemistry, among which the following must be included:

Code	Title	Units
Chem 481	General Biochemistry I	3
Chem 482	General Biochemistry II	3
Chem 401	Physical Chemistry I	3
Chem 402	Physical Chemistry II	3
Chem 461	Inorganic Chemistry	3
Total Units		**15**

In addition, at least one advanced lab must be chosen from the following list:

Code	Title	Units
Chem 358	Organic Chemistry Laboratory II	4
Chem 435	Nuclear and Radiochemistry Lab	3
Chem 445	Instrumental Methods: Physical Chemistry	3
Chem 462	Synthetic Polymer Chemistry Laboratory	3
Chem 470	Inorganic Chemistry Laboratory	3
Biol 4522	Laboratory in Protein Analysis, Proteomics and Protein Structure	3
Biol 4523	Molecular Methods in Enzyme Analysis	4

All chemistry course work must be taken in residence at Washington University to be applied toward the chemistry major. A minimum grade of C- must be earned in each course to count toward the chemistry major.

Note: Per the College of Arts & Sciences guidelines, for students who also pursue a minor or more than one major or minor program, only introductory (100- and 200-level) courses may be counted, when relevant, toward the requirements of both programs. All advanced (300- and 400-level) courses must be unique to each program. In other words, no advanced course may be "double-counted" for the course work needed to fulfill either program's minimal requirements. Should a student's major and minor programs require the same course, a departmentally sanctioned elective must be chosen to replace the course in one of the programs.

Additional Information

Latin Honors for the Major in Chemistry:

Total units required: 56

To qualify for Latin Honors, students must complete a minimum of 21 units in advanced courses in chemistry or biochemistry, among which the following must be included:

Code	Title	Units
Chem 401	Physical Chemistry I	3
Chem 402	Physical Chemistry II	3
Chem 461	Inorganic Chemistry	3

The student must also take two additional advanced courses in chemistry.

Students must also complete **two** additional laboratories. Students must choose one synthetic laboratory:

Code	Title	Units
Chem 358	Organic Chemistry Laboratory II	4
Chem 462	Synthetic Polymer Chemistry Laboratory	3
Chem 470	Inorganic Chemistry Laboratory	3

and one physical laboratory:

Code	Title	Units
Chem 435	Nuclear and Radiochemistry Lab	3
Chem 445	Instrumental Methods: Physical Chemistry	3

Neither Chem 490 Introduction to Research nor Chem 495 Advanced Undergraduate Research in Chemistry can be used to satisfy the advanced laboratory requirements, but Chem 495 Advanced Undergraduate Research in Chemistry can be used to satisfy an elective.

Latin Honors for the Major in Chemistry With a Concentration in Biochemistry:

Total units required: 62

To qualify for Latin Honors, students must complete a minimum of 21 units in advanced courses, including **one** of the following six courses:

Code	Title	Units
Biol 334	Cell Biology	3
Biol 349	Microbiology	4
Chem 453	Bioorganic Chemistry	3
Chem 464	Inorganic Biochemistry	3
Chem 483	Protein Biochemistry	3
Chem 485	Nucleic Acids	3

or a second laboratory course in advanced chemistry or biology chosen from the following list:

Code	Title	Units
Chem 358	Organic Chemistry Laboratory II	4
Chem 435	Nuclear and Radiochemistry Lab	3
Chem 445	Instrumental Methods: Physical Chemistry	3
Chem 462	Synthetic Polymer Chemistry Laboratory	3
Chem 470	Inorganic Chemistry Laboratory	3
Biol 4522	Laboratory in Protein Analysis, Proteomics and Protein Structure	3
Biol 4523	Molecular Methods in Enzyme Analysis	4

Departmental Honors for the Majors in Chemistry and Chemistry With a Concentration in Biochemistry: To graduate "with distinction," a student must maintain a Chemistry grade point average of 3.5 and complete at least one semester of Chem 490 research. To graduate "with high distinction," a student must maintain a Chemistry GPA of 3.65 and complete at least two semesters of chemistry research, one of which must be Chem 495. To graduate "with highest distinction," a student must maintain a Chemistry GPA of 3.8 and complete at least two semesters of chemistry research, one of which must be Chem 495. Chemistry research is defined as a research project performed under the direction of a Chemistry faculty member or a research project approved by the Chemistry Department Undergraduate Work Committee. A Chemistry GPA is calculated from the grades received in chemistry courses and chemistry prerequisites. The level of Departmental Honors that a student achieves will appear on the student's final transcript.

Minors

The Minor in Chemistry

Units required: 27 in chemistry; 17 in math and physics

Required courses:

Code	Title	Units
Chem 111A	General Chemistry I	3
Chem 112A	General Chemistry II	3
Chem 151	General Chemistry Laboratory I	2
Chem 152	General Chemistry Laboratory II	2
Chem 261	Organic Chemistry I with Lab	4
Chem 262	Organic Chemistry II with Lab	4
Math 131	Calculus I	3
Math 132	Calculus II	3
Math 233	Calculus III	3
Physics 191	Physics I	3
Physics 191L	Physics I Laboratory	1
Physics 192	Physics II	3
Physics 192L	Physics II Laboratory	1
Total Units		**35**

Note: In certain instances, students may substitute Chem 105 Introductory General Chemistry I and Chem 106 Introductory General Chemistry II for Chem 111A General Chemistry I and Chem 112A General Chemistry II. Please consult with the department's director of undergraduate studies for details.

Elective courses:

Student must complete 9 units of chemistry encompassing three courses in at least two subdisciplines. Biol 451 General Biochemistry may be used to satisfy one course of the three required. Courses must be at the 300 level or above, but Chem 490 Introduction to Research is specifically excluded.

All chemistry course work must be taken in residence at Washington University to be applied toward the chemistry minor. A minimum grade of C- must be earned in each course to count toward the chemistry minor.

Note: Per the College of Arts & Sciences guidelines, if a student has a major and a minor or has two minors, only introductory (100- and 200-level) courses may be counted, when relevant, toward the requirements of both programs. All advanced (300- and 400-level) courses must be unique to each program. In other words, no advanced course may be

"double-counted" for the course work needed to fulfill either program's minimal requirements. Should a student's major and minor programs require the same course, a departmentally sanctioned elective must be chosen to replace the course in one of the programs.

Courses

Visit online course listings to view semester offerings for L07 Chem (https://courses.wustl.edu/CourseInfo.aspx?sch=L&dept=L07&crslvl=1:4).

L07 Chem 105 Introductory General Chemistry I
This course traces the development of chemistry from early atomic theory to modern descriptions of structure, bonding, and intermolecular interactions. Over the course of the semester, the students learn how macroscopic observations of stoichiometry, chemical reactions, the properties of elements and compounds, and chemical periodicity developed into the microscopic understanding of molecular structure and bonding. The semester begins with fundamentals related to stoichiometry, chemical reactions, solution chemistry, and gas properties, with an emphasis on quantitative problem solving. The octet rule, Lewis structures, and valence-shell-electron-pair repulsion (VSEPR) theory are then introduced as early efforts to describe the stability and structures of molecules. The localized electron model (LEM) and molecular-orbital theory (MOT) are next described as modern descriptions of chemical bonding. The course concludes with intermolecular forces such as hydrogen bonding and van der Waals interactions. This course will be a serious introductory series that requires and develops algebraic-computation and problem-solving skills. Pre-requisite: Two years of high-school math, and one year of high-school chemistry or physics, or by permission of the instructors.
Credit 3 units. A&S IQ: NSM, AN Arch: NSM Art: NSM BU: SCI

L07 Chem 106 Introductory General Chemistry II
This course covers chemical equilibrium, thermodynamics, and kinetics at a fundamental level, with an emphasis on in-class problem solving. Gas-phase reactions, heterogeneous (multi-phase) reactions, acid-base reactions, and solubility equilibria are introduced first. Chemical thermodynamics is then taught in its relation to chemical equilibrium. The course finishes with chemical kinetics and rate laws. The content is similar to that of Chem 112A, but advanced applications are omitted to allow for more in-class guided active learning. Prerequisites: two years of high-school math, one year of high-school chemistry or physics, and Chem 105 or Chem 111A, or by permission of the instructors.
Credit 3 units. A&S IQ: NSM, AN BU: SCI

L07 Chem 111A General Chemistry I
Systematic treatment of fundamental chemical and physical principles and their applications to the properties and transformations of materials, including the concept of energy and its uses, atomic and molecular structure, periodic classification of the elements, chemical bonding, gas laws, and laws of chemical combination.
Credit 3 units. A&S IQ: NSM, AN Arch: NSM Art: NSM BU: SCI

L07 Chem 112A General Chemistry II
An introduction to the principles of chemical equilibrium and chemical change. Topics include chemical equilibria, acid/base chemistry, and other ionic equilibria, electrochemistry, elementary chemical thermodynamics and kinetics. Three lecture hours and a problem-solving subsection. Prerequisite, Chemistry 111A and prior completion (or concurrent registration in) Math 131 (Calculus I) or permission of the instructor.
Credit 3 units. A&S IQ: NSM, AN Arch: NSM Art: NSM BU: SCI

L07 Chem 125 Introductory General Chemistry I PB
This course covers the systematic treatment of fundamental chemical principles and their applications. Emphasis is on atomic and molecular theories, laws of chemical combination, periodic classification of the elements, and properties of gases, liquids, solids, and solutions. Prerequisites: Math U20 141 and Math U20 142 or equivalent, one year of high school chemistry, or permission of department. This course is restricted to students admitted to the Post-Baccalaureate Premedical Program or in University College. All other students should enroll in Chem 105 or Chem 111.
Credit 3 units. BU: SCI

L07 Chem 126 Introductory General Chemistry II PB
Continuation of General Chemistry I. Considers oxidation-reduction, chemical equilibria, electro-chemical cells, and the chemistry of representative elements. Prerequisite: L07-125 or U05-105. Students desiring to satisfy lab science requirements must also enroll in L07-156 or U05-152. This course is restricted to students admitted to the Post-Baccalaureate Premedical program. Others may register with instructor permission, and on a space available basis.
Credit 3 units. BU: SCI

L07 Chem 151 General Chemistry Laboratory I
This course provides an introduction to basic laboratory techniques, the experimental method, and the presentation of scientific data, as well as direct experience with chemical principles and the properties and reactions of substances. The topics and experiments in this course complement the material covered in the Chem 105/111A lecture course.
Credit 2 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 152 General Chemistry Laboratory II
Continuation of Chem 151. Topics and experiments complement material covered in Chem 106/112A lecture course.
Credit 2 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 155 General Chemistry Laboratory I PB
This course provides an introduction to basic laboratory techniques and the experimental method as well as direct experience with chemical principles and the properties and reactions of substances. The topics and experiments in this course complement the material covered in Chem 125. Prerequisite: Concurrent enrollment in Chem 125 or permission of instructor. The first two lab lectures will be longer than the regular lectures, but without lab session. The lab sessions will convene for the first time beginning with the third class meeting. This course is restricted to students admitted to the Post-Baccalaureate Premedical program or in University College. All other students should enroll in Chem 151.
Credit 2 units. Arch: NSM Art: NSM

L07 Chem 156 General Chemistry Laboratory II PB
This course provides an introduction to basic laboratory techniques, the experimental method, and the presentation of scientific data. Additionally, students obtain direct experience with chemical principles and the properties and reactions of substances. The topics and experiments in this course complement the material covered in the Chem 126. Prerequisite: Concurrent enrollment in Chem 126 or permission of instructor. This course is restricted to students admitted to the Post-Baccalaureate Premedical Program or in University College. All other students should enroll in Chem 152.
Credit 2 units.

L07 Chem 181 First-Year Opportunity: Applications in Chemistry
This seminar involves a weekly lecture by a chemistry faculty member or another scientist from academia or industry about their current research activities. The goal is to provide students with a sampling of current research activities dealing with fundamental and applied problems in science and society that are being approached from a chemical point of view. Students will see how fundamental chemical principles can be obtained from experiment and theory and used to both better understand and improve the world in which we live. Each week, a different scientist presents a lecture or offers an additional activity. This course is intended primarily for first-year students who anticipate majoring in science, but interested upperclass students should also find the lectures interesting and stimulating. Students are expected to attend all lectures and associated activities during the semester. Credit/no credit only.
Credit 1 unit. A&S: FYO A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 182 Chemistry for Concerned Citizens: Topics in Energy, the Environment, and More
This course is designed to provide an overview of chemistry as it relates to problems in environmental science, energy and related topics. It is constructed such that all students, irrespective of their major area of study, can learn about chemistry in these contexts. The course is intended to be highly interdisciplinary; therefore, it covers subjects including chemistry, physics, engineering, geology, biology, environmental policy and others.
Credit 3 units. A&S IQ: NSM, AN Arch: NSM Art: NSM

L07 Chem 183 First-Year Opportunity: Chemistry and Energy
This seminar is intended for first-year undergraduates to learn about the role that chemistry can play in addressing one of the greatest challenges we face: climate change. Chemistry has played a vital role in providing the energy needs of society, and advances in chemistry can help to develop abundant and economically viable energy technologies that do not have adverse consequences on the environment. Chemistry has long been central to the use of fossil fuel, and there remain opportunities to improve the efficiency of fossil energy resources, thereby contributing to lower carbon dioxide emission per unit of energy generated. Chemistry is critical to the development of renewable energy resources, especially solar energy for the generation of electricity and fuels. Material covered will include the challenges associated with meeting the world's increasing energy needs while reducing the emission of carbon dioxide. This class will cover the role of chemistry in energy technologies, including the storage of energy.
Credit 1 unit. A&S: FYO

L07 Chem 225 Introduction to Medicinal Chemistry PB
This is an introductory course covering the basic concepts of drug structure, interactions and metabolism relevant to medicinal chemistry. The course will provide an understanding of the structure and physicochemical properties of drugs and their targets and how these determine the drug's mechanism of action and the body's response. In addition, basic concepts of drug design and development will be covered. Prerequisites: A background in general chemistry is required. Knowledge of organic or biochemistry is not required. Organic and biochemistry concepts needed for an understanding of the material will be taught as part of the course. Priority given to students enrolled in the Post-Baccalaureate Premedical Program or in University College.
Credit 3 units. BU: SCI

L07 Chem 261 Organic Chemistry I with Lab
This is the first part of a two-semester survey of organic chemistry. The course will include an introduction to organic structures, reactions, and reaction mechanisms. The laboratory will meet on alternate weeks and include an introduction to laboratory methods in organic chemistry, including separation and methods of purification of organic compounds. Prerequisites: Chem 106 or Chem 112 and Chem 152.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L07 Chem 262 Organic Chemistry II with Lab
A course covering certain areas of organic chemistry in more detail than the prerequisite course, with special emphasis on the mechanisms and the synthetic applications of organic reactions and on the organic chemistry of biological compounds. The laboratory meets eight times and includes organic synthesis and spectroscopic techniques. Required course for chemistry majors. Prerequisite: Chem 261.
Credit 4 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 265 Organic Chemistry I With Lab PB
This is the first part of a two-semester survey of organic chemistry. The course will include an introduction to organic structures, reactions, and reaction mechanisms. The laboratory portion of the course will have eight experiments and include an introduction to laboratory methods in organic chemistry, including separation and methods of purification of organic compounds. Prerequisites: Chem 126 and Chem 156. This course is restricted to students admitted to the Post-Baccalaureate Premedical program or in University College. All other students should enroll in Chem 261.
Credit 4 units. Arch: NSM Art: NSM BU: SCI

L07 Chem 2651 Organic Chemistry I PB (Lecture Only)
This is the lecture-only version of the first part of a two-semester survey of organic chemistry. The course will include an introduction to organic structures, reactions, and reaction mechanisms. Prerequisites: Chem 126 and Chem 156. This course is restricted to students admitted to the Post-Baccalaureate Premedical program or in University College.
Credit 3 units. Arch: NSM Art: NSM BU: SCI

L07 Chem 266 Organic Chemistry II w/ Lab PB
A course covering certain areas of organic chemistry in more detail than the prerequisite course, with special emphasis on the mechanisms and synthetic applications of organic reactions and on the organic chemistry of biological compounds. The laboratory meets eight times and includes organic synthesis and spectroscopic techniques. Prerequisite: Chem 265. This course is restricted to students admitted to the Post-Baccalaureate Premedical Program or in University College. All other students should enroll in Chem 262.
Credit 4 units. BU: SCI

L07 Chem 2661 Organic Chemistry II PB (Lecture Only)
This course is the lecture-only version of Chem 266, covering certain areas of organic chemistry in more detail than the prerequisite course, with special emphasis on the mechanisms and synthetic applications of organic reactions and on the organic chemistry of biological compounds. Prerequisites: Chem 265 or Chem 2651. This course is restricted to students admitted to the Post-Baccalaureate Premedical Program or in University College.
Credit 3 units. BU: SCI

L07 Chem 290 First-Year and Sophomore Research
This course presents an introduction to research for first- and second-year students. Students are mentored by a faculty advisor. Prerequisite: Permission of the sponsor and the Department of Chemistry. Credit/no credit only.

Credit variable, maximum 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 299 Chemical Laboratory Safety
This course presents an overview of current laboratory safety, regulatory, and compliance practices. Safety and compliance issues that impact chemical, biological, and materials research will be covered.
Credit 0.5 units. A&S IQ: NSM Art: NSM

L07 Chem 358 Organic Chemistry Laboratory II
Initially, problem solving in organic chemistry is emphasized through an introduction to the methods of qualitative organic analysis, including the use of chromatographic and spectroscopic techniques. Each student then selects an independent synthetic project to perform. Prerequisite: Chem 262. Six laboratory hours per week. Lectures held three hours a week for the first half of the semester.
Credit 4 units. A&S IQ: NSM, WI Arch: NSM Art: NSM

L07 Chem 400 Physical Science in 12 Problems
Exercises related to general chemistry, classical mechanics, quantum mechanics, statistical mechanics, thermodynamics, and kinetics, will be solved with numerical software. Each exercise will be accompanied by a lecture, a software template solving a problem and presenting a related take-home problem. The software will allow us to focus on, and treat in a transparent fashion, physical problems without the unworldly idealizations and contrivances found in textbooks. Prerequisites: General Chemistry and/or Physics, and prior or concurrent enrollment in either Chem 401 or Phys 217. The lectures will be in-person however a complete set of taped lectures will also be available. A remote help session will be scheduled at a mutually agreed to time. There are no quizzes, exams or a final.
Credit 1 unit. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 401 Physical Chemistry I
Introduction to quantum chemistry with applications to electronic structure and elementary spectroscopy. Prerequisites: Chem 111A and 112A, Math 233; prior completion of Physics 191 and 192 is strongly encouraged (but concurrent enrollment in Physics I will be accepted); or permission of instructor. Required course for all chemistry majors.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L07 Chem 402 Physical Chemistry II
This course presents an introduction to chemical thermodynamics, statistical mechanics, and transport phenomena, and it is a required course for all Chemistry majors. Prerequisites: Chem 111A-112A, Chem 401, and Math 233; or permission of instructor. Prior completion of Physics 191-192 is strongly encouraged, but prior completion of Physics 191 and concurrent enrollment in Physics 192 will be accepted.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L07 Chem 426 Inorganic Electrochemistry and Photochemistry
An understanding of electrochemical processes is critical in describing the behavior of batteries, fuel cells, and other important devices used in energy conversion and environmental remediation. This course will cover modern inorganic electrochemistry, photochemistry, and photoelectrochemistry from a microscopic perspective of solid-electrolyte interfaces. The course material will start with the thermodynamics of solid-electrolyte interfaces and the kinetics of electron transfer across these interfaces. Electroanalytical techniques, including cyclic voltammetry and potential-step experiments, will be described to understand the mechanism of electrochemical and photochemical reactions. Lectures will include applications of electrochemical cells in catalysis, materials synthesis, and solar-fuel generation. Prerequisites: Chem 461 or Chem 465 or consent of instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 430 Simulation in Chemistry and Biochemistry
This course explores a wide range molecular modeling techniques and applications of computational chemistry to problems in chemistry and biochemistry. Topics include ab initio quantum mechanics, semi-empirical MO theory, molecular mechanics, molecular dynamics simulation, coarse-grained models, electrostatic methods and biomolecular structure prediction. A major component of the course is weekly laboratory sessions using common software programs in the field, including Spartan, Q-Chem, Gaussian, VMD, TINKER, APBS, AutoDock, SDA7 and others. Many of the lab exercises target proteins, nucleic acids and other biological structures. As a final lab experience, students complete an independent project using tools covered in the course.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 435 Nuclear and Radiochemistry Lab
Application of radiochemistry to problems in chemistry, physics, and nuclear medicine, with emphasis on particle detectors and experimental techniques. Prerequisites: 3 units of physical chemistry or quantum mechanics, or permission of instructor. One lecture hour and five hours of laboratory a week.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 436 Introduction to the Atomic Nucleus
Introduction to the interaction of radiation with mater, the production and decay of radioactive nuclides, the structure and properties of nuclei, and various applications of nuclear science (including nuclear power) are all presented. Lectures will be in-person (if allowed), but a complete set of taped lectures will also be available. A weekly (in-person or remote) help session will be scheduled at a mutually agreed-upon time. There will be about six timed quizzes, one midterm, and one final, all of which must be taken in person on mutually agreed-upon dates. Prerequisites: General Chemistry and/or Physics, and prior or concurrent enrollment in either Chem 401 or Physics 217.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 445 Instrumental Methods: Physical Chemistry
A course providing direct hands-on experience with the principles of physical chemistry (thermodynamics, quantum, kinetics) and associated experimental methods and instrumentation, including optical, infrared, and nuclear and electron spin resonance, electrochemistry, calorimetry, laser kinetics, and basic electronics. Prerequisite: Chem 401 or concurrent enrollment in Chem 402.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM

L07 Chem 451 Organic Chemistry III
A lecture course that builds on the material in Chem 261 and Chem 262, covering in more detail certain topics in those courses while also introducing new topics. A transition to graduate-level study in organic chemistry; recommended for chemistry, biochemistry and biology majors. Prerequisite: Chem 262.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 452 Synthetic Polymer Chemistry
This course that describes various methods for the synthesis and characterization of polymers. Copolymers, control of architecture, polymer reactivity, polymer properties, structure/property relationships, and applications of polymers will be discussed. Current topics of interest from the recent literature will also be covered. Prerequisite: Chem 262 or permission of instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 453 Bioorganic Chemistry
This course presents a molecule-centered perspective on the current state of the art in antibiotic drug discovery and natural products chemistry. The molecular mechanisms of antibiotic drug action and pathogen resistance will be covered along with the biosynthetic origins of antibiotics from plants and microbes. The course is taught from the perspective of understanding how organic chemistry plays out in biological systems, with an emphasis on small organic molecules and enzymes. Curved arrow mechanisms will be used frequently in learning activities and assignments. Thus, Chem 262 (Organic Chemistry 2) is a mandatory prerequisite for this course. A working knowledge of protein structure and function is helpful. Students are encouraged (but not required) to take Chem 481 (General Biochemistry 1) and/or Chem 482 (General Biochemistry 2) in preparation for this course. Students will be responsible for writing a review article on an assigned antibiotic molecule and presenting their paper to the class.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 453W Bioorganic Chemistry
A molecule-centered perspective is presented on the current state of the art in antibiotic drug discovery and natural products chemistry. The molecular mechanisms of antibiotic drug action and pathogen resistance will be covered along with the biosynthetic origins of antibiotics from plants and microbes. The course is taught from a perspective of understanding how organic chemistry plays out in biological systems, with an emphasis on small organic molecules and enzymes. Curved arrow mechanisms will be used frequently in learning activities and assignments. Thus, Chem 262 (Organic Chemistry 2) is a mandatory prerequisite for this course. A working knowledge of protein structure and function is helpful. Students are encouraged but not required to take Chem 481 (General Biochemistry 1) and/or Chem 482 (General Biochemistry 2) in preparation for this course. Students will be responsible for writing a review article on an assigned antibiotic molecule and presenting their paper to the class. This course satisfies the Writing Intensive requirement.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM BU: SCI

L07 Chem 458 Chemical Reaction Mechanism Journal Club
This seminar meets for one hour each week. During the meetings, student participants are responsible for presenting topics from the current literature. The format of the presentation varies from informal talks to student-authored problem sets. Attendance at meetings is strongly recommended for all students who are currently taking the organic cumulative examinations. Prerequisite: Chem 262.
Credit 1 unit. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 459 Organometallic Chemistry
Survey of organometallic compounds with discussion of their synthesis, structure, spectroscopy and reactivity. Prerequisite: Chem 252.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 460 Organic & Inorganic Reaction Mechanisms
This course covers the fundamentals of the study of the mechanisms of reactions of organic, organometallic, and inorganic molecular compounds, primarily in the solution phase, and it surveys examples through case studies. A basic knowledge of organic chemistry is assumed. Prerequisites: Grade of B- or better Chem 261 and Chem 262 or the equivalent.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L07 Chem 461 Inorganic Chemistry
Inorganic chemistry encompasses the structure, properties, and reactivity of inorganic molecules and solids. This course will focus on the symmetry, bonding, electronic structure, spectroscopy, and reactivity of inorganic coordination complexes in which ligands are bound to one or more metal centers. The course will start with using group theory to classify molecules based on the symmetry elements they possess. A series of different bonding models including VSPER, valence bond theory, molecular orbital theory, crystal field theory, and ligand field theory will be used to describe the structure and bonding of inorganic molecules, coordination complexes, and organometallic compounds. These models will serve as a basis for interpreting and predicting the electronic and vibrational spectra of inorganic compounds.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 462 Synthetic Polymer Chemistry Laboratory
Chem 462 is an upper-level undergraduate and graduate level laboratory course that complements Chem 452 Synthetic Polymer Chemistry. This twice-a-week lab provides hands-on training in the design, synthesis, and characterization of polymers and polymeric materials through four standard experiments (each one week) and one independent project (over five to six weeks). The independent project involves using an article from the literature as the basis for developing a short proposal. At the end of the course, students give oral presentations of their proposals, which are reviewed by their classmates. Prerequisite or Concurrent: Chem 452 or permission from instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L07 Chem 462W Synthetic Polymer Chemistry Laboratory -- Writing Intensive
Chem 462W is an upper-level undergraduate and graduate level laboratory course that complements Chem 452, Synthetic Polymer Chemistry. This twice-a-week lab provides hands-on training in the design, synthesis, and characterization of polymers and polymeric materials through four standard experiments (each one week) and one independent project (over five to six weeks). The independent project involves using an article from the literature as the basis for developing a short proposal. At the end of the course, students give oral presentations of their proposals, which are reviewed by their classmates. Prerequisite or Corequisite: Chem 452 or permission of instructor. This course satisfies the writing-intensive requirement.
Credit 3 units. A&S IQ: NSM, WI BU: SCI

L07 Chem 464 Inorganic Biochemistry
A class in biological chemistry that emphasizes the role of metals in electron transfer and enzymatic catalysis. After a brief survey of essential concepts from biology, coordination chemistry and spectroscopy, topics include: electron transfer systems; oxygen transport and activation; metal ion acquisition, transport and homeostasis; enzymes catalyzing atom transfer reactions and radical-mediated processes. Prerequisites: Chem 252; Chem 461 recommended but not required.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 465 Solid-State and Materials Chemistry
A description of how the structures of crystalline solids at different length scales control their chemical and physical properties is critical for understanding how these materials are applied in a variety of technologies ranging from solar cells to lithium batteries. This course begins with basic crystallography and introduces common inorganic structure types as well as common defects in crystalline solids. With the aid of computer models, students will learn to analyze and index x-ray powder-diffraction patterns that provide a fingerprint to identify a crystal. The relation between the crystal structure of a solid and its resulting electronic structure, chemical reactivity, and physical properties (e.g., optical, electrical, and mechanical) will be discussed throughout the semester with an emphasis on how crystal defects alter these properties. The course will conclude with the use of phase diagrams to assess the composition and microstructure of metals and ceramics.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 470 Inorganic Chemistry Laboratory
A laboratory course emphasizing both the synthesis of inorganic compounds and the study of their physical properties. Laboratory exercises will introduce novel synthetic techniques including high-temperature synthesis and vacuum-line manipulations. Compounds will be spectroscopically characterized by UV-visible absorption, gas-phase infrared, and multinuclear and dynamic NMR spectroscopies. Measurements of electrochemical behavior, magnetic susceptibility, and electrical conductivity will be performed. Prerequisite: Chem 461 or permission of instructor. A Writing Intensive option is available with the permission of the instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 470W Inorganic Chemistry Laboratory — Writing Intensive
A laboratory course emphasizing both the synthesis of inorganic compounds and the study of their physical properties. Laboratory exercises will introduce novel synthetic techniques including high-temperature synthesis and vacuum-line manipulations. Compounds will be spectroscopically characterized by UV-visible absorption, gas-phase infrared, and multinuclear and dynamic NMR spectroscopies. Measurements of electrochemical behavior, magnetic susceptibility, and electrical conductivity will be performed. Prerequisite: Chem 461 or permission of instructor. This course satisfies the Writing Intensive requirement.
Credit 3 units. A&S IQ: NSM, WI Arch: NSM Art: NSM

L07 Chem 475 Chemical Biology
This course is a survey of modern chemical biology focusing on the application of a broad array of chemical tools to biological problems. The course is roughly divided into four sections; biopolymers; computational methods and bioinformatics; tools for chemical biology; and applications of chemical biology. A mandatory discussion section accompanies the course and is used to review current and classical literature in the field. Prerequisites: Chem 262 and Biol 2970, or permission of the instructor.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 481 General Biochemistry I
Topics include the properties and structures of biomolecules, including amino acids, nucleotides, lipids, carbohydrates, proteins and nucleic acids. Additional topics include enzyme kinetics and mechanisms, membrane structure and properties, protein folding, an introduction to metabolism, oxidative phosphorylation, and photosynthesis. This course is the first semester of an integrated two-semester sequence. The second course is Chem 482. Prerequisites: Biol 2970, Chem 262.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 482 General Biochemistry II
Biochemistry explores the chemistry of life processes at the molecular level. This course is the second semester of a two-semester General Biochemistry sequence (Chem481/482 or Bio4810/4820). Prerequisites include Chem481/Bio4810 and Chem262 or instructor permission. The first semester of the Biochemistry sequence covered the basics of the topic with an emphasis on the structures, functions, and interactions of biomolecules including proteins, nucleic acids, carbohydrates, and lipids. This second semester course will emphasize metabolism, the biosynthetic (anabolism) and degradation (catabolism) pathways that provide the energy of life and define the molecules associated with healthy and disease states.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 483 Protein Biochemistry
The focus of this course is protein biochemistry, and is intended to build upon General Biochemistry (Chem 481). In this course we will focus on protein structure, folding, and techniques to purify and characterize protein activity. We will progress from initial studies to first understand protein fold and function to current efforts to better characterize protein structure-function relationships. We will also highlight human diseases that are underpinned by protein misfolding. This course will focus on reading and understanding primary literature, including landmark papers along with more recent work. During the second half of the semester, each student will select a paper and prepare a written analysis of that paper. The student will then present the paper and lead a journal club style discussion of the paper. Prerequisites: Chem 481 or instructor's permission.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM BU: SCI

L07 Chem 485 Nucleic Acids
This course presents the structure, synthesis, properties, and interactions of nucleic acids and the design and synthesis of nucleic acid-based and/or targeted drugs, probes, and tools. Topics include primary, secondary, and tertiary structure; topological and thermodynamic properties; biological and chemical synthesis; DNA chips; PCR; site-directed natural and unnatural mutagenesis; chemical evolution (SELEX); ribozymes; phage display; carcinogen, drug, and protein interactions; affinity cleaving; ultraviolet light and ionizing radiation damage; DNA repair of mutagenesis; and the design and synthesis of anti-sense and anti-gene probes and drugs. Extensive use is also made of molecular modeling and the protein databank of nucleic acid structures. Prerequisites: Chem 261 and Chem 262 or equivalents.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 488 Modern Spectroscopy
This course focuses on the fundamental principles and methodologies associated with numerous optical spectroscopy techniques that are commonly utilized in physical and life sciences research laboratories. In order to develop a solid understanding of the material as well as best practices, and the strengths and limitations of the techniques, this course combines lectures with laboratory experiments. Students also learn how to analyze and interpret data and succinctly describe their results. During one lecture each week the underlying principles of a specific type of spectroscopy are presented. The second lecture each week is spent covering the general details of the instrumentation and methods for acquiring spectra on different types of samples. The students then acquire spectra using the spectroscopic methods presented during the laboratory session. The students independently analyze the data and write brief reports of their findings. During the last two weeks of class, pairs of students are given an unknown, and they need to identify and characterize the sample. Students then write and submit a final report describing this independent research and their findings.
Credit 3 units. A&S IQ: NSM Arch: NSM Art: NSM

L07 Chem 490 Introduction to Research
Third- and fourth-year students register for this course to perform research on a selected topic in chemistry. A student planning to register for Chem 490 with a Department of Chemistry research mentor should obtain approval from that faculty member before registering, but a formal proposal is not required. For research experiences with mentors outside of the chemistry department, the student must submit the Chem 490 Project Proposal Form, which identifies the faculty mentor and includes a short description of the proposed chemical research. The form is available on the chemistry department website and should be submitted to the director of undergraduate studies in the chemistry department for approval. Credit/no credit only.
Credit variable, maximum 6 units. A&S IQ: NSM

L07 Chem 495 Advanced Undergraduate Research in Chemistry
Registration for this course allows for advanced research mentored by a Department of Chemistry faculty member. Chemical research with a faculty member outside of the chemistry department may be allowed with prior approval. At the end of the semester, the mentor will chair a faculty committee to evaluate an oral presentation by the student, and a letter grade will be assigned. A concise written report may also be requested by the mentor or committee in addition to the oral examination. Before registration can be allowed, the student must fill out the Chem 495 Application Form, available on the chemistry department website, and submit it to the director of undergraduate studies. This form, which is required for all Chem 495 registrants, includes a short description of the proposed research and a list of the committee members. This course may provide a Capstone Experience, but it does not fulfill the Writing Intensive requirement. The units earned may be applied as elective advanced credits toward a chemistry major with Latin honors eligibility. The course may be taken only once for credit. Prerequisite: Chem 490 and/or other advanced electives or research experience as specified by the mentor.
Credit 3 units. A&S IQ: NSM

L07 Chem 500 Independent Work
Independent mentored work in Chemistry, such as (but not limited to) a detailed literature search and report on a topic of current interest. Prerequisite: Permission of the faculty mentor.
Credit variable, maximum 6 units.

L07 Chem 510 Chemical Dynamics of Biological Pathways
This course will provide a highly advanced evaluation of cellular metabolism. The course will interrogate metabolic pathways and associated enzymatic mechanisms by tracking stable isotope labeling patterns as measured by liquid chromatography/mass spectrometry. The course will not contain any background treatment of mass spectrometry or basic metabolism. To be enrolled, students must already have an in-depth understanding of these topics. Major objectives of the course are: (1) to learn how to use labeling patterns qualitatively to understand chemical mechanisms at the arrow-pushing level as well as metabolic regulation, (2) to learn metabolic flux analysis, (3) to understand the complex metabolic interactions between cells and organs, and (4) to understand how metabolic reprogramming of specific cell types supports physiologic coordination at the organismal level. Pre-reqs: Chem 482 (Biol 4820) AND permission of instructor, Chem 550.
Credit 3 units.

L07 Chem 5147 Contrast Agents for Biological Imaging
Contrast Agents in Biological Imaging will build the chemistry foundations for the design and use of contrast agents in imaging applications such as nuclear medicine, magnetic resonance imaging (MRI) and optical imaging. The course will include lectures on the design of radiopharmaceuticals for gamma scintigraphy and positron emission tomography, MRI contrast agents and agents for optical imaging, including bioluminescence and fluorescence microscopy. Prereqs: one year of general chemistry, one semester of organic chemistry.
Same as L41 Biol 5147
Credit 3 units.

L07 Chem 515 Biological Chemistry Seminar
This course is required for all graduate students following the biological chemistry track. The course will consist of tutorials for first year graduate students and research presentations by second year students. Prerequisites: enrollment in the biological chemistry track or permission of the instructor.
Credit 1 unit.

L07 Chem 520 Nucleic Acid Chemistry
Structure, synthesis, properties, and interactions of nucleic acids, and the design and synthesis of nucleic acid-based and/or targeted drugs, probes and tools. Topics: primary, secondary, and tertiary structure; topological and thermodynamic properties; biological and chemical synthesis; DNA chips; PCR; site-directed natural and unnatural mutagenesis; chemical evolution (SELEX); ribozymes; phage display; carcinogen, drug and protein interactions; affinity cleaving; ultraviolet light and ionizing radiation damage, DNA repair of mutagenesis; design and synthesis of anti-sense and anti-gene probes and drugs. Extensive use is also made of molecular modeling and the protein databank of nucleic acid structures. Prerequisite, Chem 251 and Chem 252 or equivalent).
Credit 3 units.

L07 Chem 533 Time-Dependent Quantum Mechanics & Spectroscopy
This graduate-level course lays the foundations of time-dependent quantum mechanics and applications to contemporary optical spectroscopies, particularly ultrafast techniques. Formal theoretical descriptions for nonlinear spectroscopic techniques including transient absorption, photon echo, and two-dimensional spectroscopies will be developed. Practical aspects of these experiments including modern laser systems, instrument design, data collection, data processing, and data analysis will also be discussed. Discussion of current literature in the field will be an important component of the course. Prerequisite courses: Chem 401 or permission from the instructor.
Credit 3 units.

L07 Chem 536 Radiochemistry for the Life Sciences
This course will provide an introduction to nuclear science (e.g. radioactive decay, nuclear stability, interactions of radiation with matter) and followed by an overview of how radiochemistry is used in the life sciences. Lectures on radiolabeling chemistry with radionuclides used in medical imaging (single photon emission computed tomography (SPECT) and positron emission tomography (PET) and their applications will be presented. In addition, lectures on radiochemistry with tritium (H-3) and C-14 will also be included. Additional applications include environmental radiochemistry as applied to nuclear waste disposal and biofuels.
Credit 2 units.

L07 Chem 540 Inorganic/Organometallic Chemistry Seminar
Students present informal seminars on topics of current interest from the chemical literature or from their own dissertation research.
Credit 1 unit.

L07 Chem 541 Advanced Inorganic Chemistry
Study of physical inorganic concepts with an emphasis on modern experimental methods applied to inorganic and bioinorganic systems. The spectral and magnetic properties of inorganic and bioinorganic compounds will be discussed. Topics in group theory will be covered, including symmetry of molecules and ions, the application of group theory in molecular structure determination, chemical bond theory and spectroscopy for inorganic materials as molecular species and in crystal lattices. Prerequisite: Chem 461, or consent of instructor.
Credit 3 units.

L07 Chem 542 Special Topics in Inorganic Chemistry
This course focuses on an important current topic in inorganic chemistry. Open to undergraduates with permission of the instructor. Chemistry 461 recommended.
Credit 3 units.

L07 Chem 543 Physical Properties of Quantum Nanostructures
This course will explore the physical properties of semiconductor nanomaterials with dimensions that are small enough to give rise to quantum-confinement effects. These effects strongly influence the electronic structures, absorption/emission behavior, and charge-carrier dynamics within quantum wells, rods, wires, dots, and nanotubes. The course begins with an overview of the electronic structure of bulk semiconductors. The theoretical and experimental bases for quantum-confinement effects, which are of considerable fundamental and applied interest, will then be developed. A significant emphasis will be placed on the optical absorption and photoluminescence properties of semiconductor quantum nanostructures. Recent advances and observations as reported in the literature will be emphasized throughout the semester. Prerequisites: Chem 461 and Chem 465, or permission of the instructor. While the course is steered to graduate students in the Chemistry Department, Chemistry undergraduate students, graduate or undergraduate students in Physics, Electrical & Systems Engineering, Energy, Environmental & Chemical Engineering, Mechanical Engineering & Materials Science may also find this course valuable.
Credit 3 units.

L07 Chem 550 Mass Spectrometry
The first focus of the course is an overview of the subject and its history. The second covers the fundamentals of ionization to produce molecular ions. Ionization methods include electron ionization, chemical ionization, electrospray, and matrix-assisted laser desorption. Thermodynamic principles of ionization including ionization energies, proton affinities, and gas-phase acidities provide a fundamental basis for ionization. The third major focus is interpretation of EI and product-ion spectra from MS/MS. Mechanisms of gas-phase ion decomposition reactions, rates and thermodynamics of gas-phase ion processes, and ion-molecule reactions are discussed in terms of interpreting spectra. A major emphasis is the spectra of peptides and proteins, providing a basis for the field of proteomics and related "omics" areas. The fourth focus is the fundamentals of instrumentation design and implementation: quadrupole, time-of-flight, ion trap, orbitraps, and Fourier transform instruments. Combined or hyphenated GC/MS, LC/MS, and tandem mass spectrometry are also discussed. Applications in a variety of areas are worked in as the course progresses: structure determination of synthetic, natural products, metabolites, and biomolecules, exact mass measurements (high resolution MS), peptide and protein and other biomolecule sequencing, sensitive detection, trace analysis, and mixture analysis. Prerequisite: Chem 252 or permission of instructor.
Credit 3 units.

L07 Chem 5511 Mechanistic Organic Chemistry
The first half of a sequence of two semesters, followed by Chem 554 in the Spring, encompassing important topics in physical organic chemistry. The first semester is devoted to the fundamental concepts of mechanistic organic chemistry. The major classes of organic reactions are surveyed from a mechanistic perspective . Prerequisite: Chem. 262 or permission of the instructor.
Credit 3 units.

L07 Chem 5522 Synthetic Methods
A lecture course presenting a detailed survey of synthetically useful reactions of carbonyl compounds and their derivatives, with particular attention to their stereoselectivity aspects and asymmetric methodology. The course is intended to provide the necessary background for more advanced work in organic synthesis.
Credit 3 units.

L07 Chem 554 Molecular Orbital Theory
Lectures will cover the background, practice and applications of computational chemistry to the modeling of the structures and chemical reactions of organic molecules. Different levels of calculation will be presented, from molecular mechanics calculations and Hhckel molecular orbital theory, through semi-empirical and ab initio self-consistent field calculations with correlation energy corrections, and density functional theory. Hands-on experience performing calculations is an important element in this course.
Credit 3 units.

L07 Chem 555 Special Topics in Organic Chemistry
This course focuses on an important current topic in organic chemistry. Open to undergraduates with the permission of the instructor.
Credit 3 units.

L07 Chem 557 Advanced Organic Synthesis
The objective of this course is to teach students the art of planning a total synthesis. Key synthetic concepts, strategies and tactics, as well as a variety of reactions and synthetic methods, will be illustrated using examples from total syntheses of the main groups of natural products - terpenes, steroids, and alkaloids. Prerequisite: Chem 451 or permission of instructor.
Credit 3 units.

L07 Chem 558 Spectral Methods in Organic Chemistry
A detailed treatment of the structure and stereochemistry of organic compounds with particular emphasis on ultraviolet, visible, infrared, nuclear magnetic resonance, and mass spectroscopic techniques for structure determination.
Credit 3 units.

L07 Chem 559 Organic Chemistry Seminar
The organic chemistry graduate students enrolled will each present one seminar on a topic of current interest in the literature.
Credit 1 unit.

L07 Chem 562 Statistical Thermodynamics
Statistical mechanical methods will be used to characterize equilibrium and non-equilibrium thermodynamic systems. Computer programming assignments are given. An initial familiarity with ideal equilibrium systems will be assumed. Prerequisite Chem 401 or its equivalent or permission of the instructor.
Credit 3 units.

L07 Chem 571 Quantum Chemistry and Spectra
This course covers the development and application of quantum mechanics as applied to molecular structure and properties. Material to be discussed will include the fundamentals of quantum mechanics; representations; matrix formalisms; applications to model systems; perturbation theory; variational methods; many-electron wavefunctions; Hartree-Fock theory and post-Hartree Fock methods; density functional theory; additional topics and applications. Prereq: Chem 401.
Credit 3 units.

L07 Chem 5721 Quantum Chemistry in Practice
A spectrum of modern computational tools -- from semiempirical, self-consistent field theory, and density functional theory one-electron pictures to perturbative and simulation many-electron pictures -- will be used to determine potential energy surfaces, spectroscopic cross-sections, and oxidation -reduction energetics.
Credit 3 units.

L07 Chem 576 Magnetic Resonance
Quantum mechanical and classical aspects of paramagnetism and of nuclear and electronic magnetic resonance. Phenomenological equations of motion, spin intractions, spin temperature, thermal relaxation, dynamic polarization, multiple resonance phenomena.
Credit 3 units.

L07 Chem 5762 Electron Spin Resonance
Principles of magnetic resonance of paramagnetic species, structure and dynamics of organic free radicals and transition metal ions in the condensed phase. Detection of transient paramagnetic species generated in photochemical reactions and photo physical processes. Prereq, Chem 401.
Credit 3 units.

L07 Chem 578 Nuclear Magnetic Resonance Spectroscopy
A course dealing with the quantum and classical description of the nuclear magnetic resonance of an isolated system of two spin-1/2 nuclei. The design of pulsed NMR spectrometers and the Fourier analysis of time-dependent observable magnetization in 1 and 2 dimensions are treated in detail, NMR relaxation in liquids and solids is included phenomenologically. Prerequisite: Physical Chemistry or permission of the instructor.
Credit 3 units.

L07 Chem 580 Special Topics in Physical Chemistry: NMR for Biological Solids
The course will cover theoretical and practical aspects of nuclear magnetic resonance (NMR) spectroscopy. Specific focus will be given to solid-state NMR and its application for studying amorphous biological solids, including how solid-state NMR can complement other biochemical and biophysical approaches. Prerequisites: undergraduate-level course in quantum mechanics (Chem 401)
Credit 3 units.

L07 Chem 581 Advanced Quantum Chemistry
A study of the theory and methods of quantum mechanics, with applications to problems of chemical interest. Prerequisite, Chem 571 or permission of the instructor.
Credit 3 units.

L07 Chem 584 Molecular Spectroscopy
Cursory overview of electromagnetic radiation and its interaction with atoms and molecules. The course will assume a general knowledge of quantum chemistry, (i.e., Chem 401), although a quick review of eigenfunctions and states will be given. We will cover Rotational Spectroscopy, Vibrational Spectroscopy, Electronic Spectroscopy, and Time-resolved Spectroscopy. In so doing, attention will be focused on diatomic molecules, although some examples of polyatomics will be given with emphasis placed on how structure contrbutes to spectra. Emphasis is placed on creating intuition into spectroscopy, not necessarily the quantum-mechanical rigor or detailed calculations of molecular spectroscopy. Prequisite, Chem 401 or permission of the instructor.
Credit 3 units.

L07 Chem 585 Molecular Reaction Dynamics
This course addresses the question, "what happens in a chemical reaction?" at the atomic/molecular level. Topics: Non-reactive and reactive molecular collisions, scattering and resonances, unimolecular and bimolecular reactions, potential energy surfaces, reaction rate calculations and models, state to state experiments and stereodynamics, energy transfer mechanisms, time resolved and frequency resolved dynamics, condensed phase dynamics, control of chemical reactions. Requirements: Chem 401 is a pre-requisite and prior completion or current registration in Chem 402 is required. However, equivalent courses will be considered at the discretion of the instructor.
Credit 3 units.

L07 Chem 586 Commercialization of Science and Technology
Commercialization of Science and Technology is an interdisciplinary course that investigates the issues and decisions that inventor/scientists, engineers, and entrepreneurs encounter when taking early stage scientific discoveries from the laboratory to applied use. The course employs case studies, invited speakers, and team projects to engage graduate and professional students in interdisciplinary collaboration, idea generation and the feasibility of applying scientific discoveries in commercial marketplaces. Participants learn about the basics of commercialization and entrepreneurship and how these relate to their personal goals and scientific interests. The course is ideal for anyone interested in working as an academic, chief scientist, entrepreneur, manager, consultant, or investor.
Same as L31 Physics 586
Credit 3 units.

L07 Chem 599 Chemical Laboratory Safety
An overview of current laboratory safety, regulatory, and compliance practices. Safety and compliance issues that impact chemical, biological, and materials research will be covered. Required for entering chemistry graduate students.
Credit 0.5 units.
