CHEMISTRY (CHEM)

CHEM 0240 First-Year Seminar: From Alchemy to Nanoscience
The imperative to transform matter, find its roots in alchemy and the search for the Philosopher's Stone, which was thought to contain the secret of turning base metals into gold and also the secret of immortality. We will examine the evolution of the way in which people have thought about matter and its transformations; from the manufacturing of explosives to dyes to pharmaceuticals and perfumes. We will do some simple experiments that demonstrate some of these principles. We will follow the development of the chemical sciences from the works of early alchemists to Renaissance (Newton and Boyle) scientists and modern thinkers (Priestly, Lavoisier, Dalton, Mendeleev and others). This class, which is designed for non-science as well as potential science majors, will involve discussions on readings, as well as field trips to some Philadelphia locations that are notable in the history of chemistry.
Fall
1 Course Unit

CHEM 0250 Structural Biology
This course will explore how biological properties are determined by the microscopic chemical properties of proteins and biomacromolecules. We will discuss how research results, especially those of structural biology, are presented to its various audiences.
Fall or Spring
0.5 Course Units

CHEM 1000 Academic Based Community Service-Chemistry Outreach
Chemistry service-learning course that provides undergraduate students with opportunities to improve their scientific communication abilities and teaching skills. Undergraduate students will work in groups to develop short science experiments and teaching materials, and students in grades 6-12 from urban public schools in West Philadelphia will visit the Penn campus to perform the experiments. There are typically 6 – 8 visits over the course of the semester, and during these visits, the undergraduates will serve as instructors, teaching their experiment to the visiting students. Undergraduate students will also analyze and discuss journal articles and publications to explore pedagogy and best practices in science communication, as well as develop and demonstrate skills in reflecting critically on issues that arise in your service learning experiences through written post-teaching reflections.
Fall
1 Course Unit

CHEM 1011 Introduction to General Chemistry I
Chem1011 is an introductory college-level course in chemistry intended for students with less preparation in high school chemistry and mathematics. The course content parallels that of Chem1012, but with emphasis placed on developing problem-solving strategies and developing the underlying chemical principles. The course will take an 'atoms first' approach to introductory chemistry, where topical coverage includes an overview of quantum theory, atomic structure, the periodic table, chemical bonding, elementary chemical reactions, stoichiometry, ideal gases, and intermolecular interactions. Topics from mathematics and physics that are necessary to chemical problem-solving will be included as needed. Prerequisite: Students with credit for CHEM 101 may not enroll in CHEM 100. Credit will not be awarded for both CHEM 100 and 101.
Fall
Corequisite: MATH 1300
1 Course Unit

CHEM 1012 General Chemistry I
Basic concepts and principles of chemistry and their applications in chemistry and closely-related fields. The first term emphasizes the understanding of chemical reactions through atomic and molecular structure. This is a university level course, treating the material in sufficient depth so that students can solve chemical problems and can understand the principles involved in their solution. It includes an introduction to condensed matter. This course is suitable for majors or non-majors and is recommended to satisfy either major or pre-professional requirements for general chemistry. This course is presented for students with high school chemistry and calculus. Students with a lesser background than this should take CHEM 1011. Prerequisite: Students with credit for CHEM 1011 may not enroll in CHEM 1012. Credit is not awarded for both CHEM 1012 and 1011.
Fall or Spring
1 Course Unit

CHEM 1021 Introduction to General Chemistry II
Chem1021 will be the second course in a two-semester sequence in general chemistry, where an introductory foundation in the energetic and dynamic nature of chemical reactivity will be developed. The course will survey general principles of thermodynamics, phase transitions, equilibrium, acid/base chemistry, and chemical kinetics as applied to elementary chemical reactions. Using this foundation, structure and function of organic compounds and solid-state structure will be surveyed upon which the former fundamental principles will be deployed to predict reactivity/stability.
Spring
Prerequisite: CHEM 1011 AND MATH 1300
1 Course Unit

CHEM 1022 General Chemistry II
Continuation of General Chemistry I. The second term stresses the thermodynamic approach to chemical reactions, electrochemical processes, and reaction rates and mechanisms. It includes special topics in chemistry.
Fall or Spring
1 Course Unit

CHEM 1101 General Chemistry Laboratory I
A general laboratory course covering aspects of qualitative and quantitative analysis, determination of chemical and physical properties, and chemical synthesis.
Fall or Spring
.5 Course Units

CHEM 1102 General Chemistry Laboratory II
Continuation of CHEM 053.
Fall or Spring
.5 Course Units

CHEM 1151 Honors Chemistry I
This course will focus on introducing students to the following topics: the nature of the chemical bond (forces, potentials, and quantum mechanics), covalent and non-covalent interactions, properties of gasses, liquids, and solids. Students in section 001 will be introduced to modern computational chemistry methods and section 002 introduces students to modern experimental techniques. Prerequisite: AP Chemistry exam score of 5.
Fall
Corequisite: MATH 1410
1 Course Unit
## CHEM 1161 Honors Chemistry II
An advanced course for students who have had very strong background in Chemistry in High School (AP, IB, or equivalent). Advanced material from the general chemistry curriculum will be covered in the context of recent research areas. A continuation of Honors Chemistry I, Honors Chemistry II will focus on topics in biochemistry and biophysical chemistry relating to thermodynamics, equilibrium, kinetics, and electrode chemistry. Prerequisite: Advanced High School Chemistry (AP or equivalent).
- Spring
- 1 Course Unit

## CHEM 1200 Environmental Chemistry
The course aims to teach chemical principles in the context of significant environmental issues. Topics to be covered include: composition of the atmosphere; protecting the ozone layer; chemistry of global warming; traditional hydrocarbon fuels and energy utilization; water supply, its contaminants, and waste water treatment; acid rain; nuclear energy; and new energy sources. Students will develop critical thinking ability, competence to better assess risks and benefits, and skills that will lead them to be able to make informed decisions about technology-based matters.
- Fall or Spring
- 1 Course Unit

## CHEM 2210 Physical Chemistry I
Introduction to quantum mechanics, atomic and molecular structure, chemical bonding, and microscopic understanding of physical and chemical properties of molecules.
- Fall
- Prerequisite: CHEM 1021 AND MATH 1410 AND PHYS 0150
- 1 Course Unit

## CHEM 2220 Physical Chemistry II
Continuation of Physical Chemistry I. Principles and applications of thermodynamics, and a molecular-based understanding of macroscopic properties.
- Spring
- Prerequisite: CHEM 2210 AND PHYS 0151
- 1 Course Unit

## CHEM 2230 Experimental Physical Chemistry I
Important methods, skills, and apparatus used for the acquisition and interpretation of quantitative information about chemical systems will be discussed in principle and used in the laboratory.
- Spring
- Prerequisite: CHEM 2210
- 1 Course Unit

## CHEM 2410 Principles of Organic Chemistry I
Fundamental course in organic chemistry based upon the modern concepts of structure and mechanism of reactions.
- Fall or Spring
- Prerequisite: CHEM 1021
- 1 Course Unit

## CHEM 2411 Principles of Organic Chemistry I with Laboratory
Fundamental course in organic chemistry based upon the modern concepts of structure and mechanism of reactions. Laboratory included.
- Prerequisite: CHEM 1021 AND CHEM 1022 AND CHEM 1161
- Co requisite: CHEM 2412
- 1.5 Course Unit

## CHEM 2412 Principles of Organic Chemistry I Laboratory
Lab for CHEM 2411
- Corequisite: CHEM 2411
- 0 Course Units

## CHEM 2420 Principles of Organic Chemistry II
Continuation of CHEM 241.
- Fall or Spring
- Prerequisite: CHEM 2410
- 1 Course Unit

## CHEM 2421 Principles of Organic Chemistry II with Laboratory
Continuation of Organic Chemistry I with Lab.
- Prerequisite: CHEM 2411
- Co requisite: CHEM 2422
- 1.5 Course Unit

## CHEM 2422 Principles of Organic Chemistry II Laboratory
Lab for CHEM 2421
- Prerequisite: CHEM 2411
- Co requisite: CHEM 2421
- 0 Course Units

## CHEM 2425 Organic Chemistry II: Principles of Organic Chemistry with applications in Chemical Biology
This course is functionally equivalent to Organic Chemistry II as the second term of introductory Organic Chemistry, placing the content in the context of biology and medicine. Topics include: 1) alkyl compounds, ethers, epoxides and sulfides in lipids; 2) carboxylic acids and amines in amino acids; 3) aromatic compounds and heterocycles in nucleic acids; and 4) ketones and aldehydes in carbohydrates. The synthesis and mechanism of action of pharmaceuticals that feature these functional groups will also be discussed. Additionally, this course makes use of 3D structure tutorials, recitation sections and visits from biomedical scientists who make use of chemistry in their work.
- Spring
- Prerequisite: CHEM 2410
- 1 Course Unit

## CHEM 2460 Advanced Synthesis and Spectroscopy Laboratory
Advanced laboratory work on the synthesis, structure, and properties of organic and inorganic compounds. Infrared, ultraviolet, and nuclear magnetic resonance spectroscopy. Lectures cover the theoretical basis and applications of modern spectroscopic methods.
- Fall
- Prerequisite: (CHEM 2420 OR CHEM 2425) AND CHEM 2450 AND CHEM 2610
- Co requisite: CHEM 2610
- 1 Course Unit

## CHEM 2510 Principles of Biological Chemistry
Fundamentals of biological chemistry, including the structure of biological macromolecules and their mechanism of action, intermediary metabolism, and the chemical basis of information transfer. Course can be taken concurrently with CHEM 242 or CHEM 243.
- Fall or Spring
- Prerequisite: CHEM 1021 AND CHEM 2410 AND (CHEM 2420 OR CHEM 2425)
- 1 Course Unit

## CHEM 2610 Inorganic Chemistry I
An introductory survey of the bonding, structure, and reactions of important metal and nonmetal compounds.
- Fall
- Prerequisite: CHEM 2410 AND (CHEM 2420 OR CHEM 2425)
- 1 Course Unit
CHEM 2999 Directed Study and Seminar
Independent project under the direction of a faculty member conducting chemistry research.
Fall or Spring
1 Course Unit

CHEM 3999 Independent Research
Independent project under the direction of a faculty member conducting chemistry research.
Fall or Spring
1 Course Unit

CHEM 4950 High Throughput Discovery: A Multidisciplinary Approach to Cancer.
The newly developed massively parallel technologies have enabled the simultaneous analysis of many pathways. There are several large scale international efforts to probe the genetics and drug sensitivity of cancer cell lines. However, there are some rare cancers that have not been analyzed in depth. One of these rare cancers is malignant peripheral nerve sheet tumors (MPNST). MPNST, although a rare cancer, are common in patients with neurofibromatosis type. In the course, students will take part in a high throughput discovery effort in two phases. Phase 1 is a training phase, which will consist of quantitative profiling the sensitivity of MPNST cell lines to a library of >120 common and experimental cancer drugs. These will be conducted in the UPenn High Throughput Screening Core. (http://www.med.upenn.edu/cores/High-ThroughputScreeningCore.shtml). While we call this a training phase, the data from this will be subject to rigorous quality control for eventual publication and development of a public database for rare tumors. Phase 2 is an independent research project. Examples of projects include, but are not limited to: Combinatorial screens (synthetic lethal); siRNA screens; novel compound screens; determining mechanisms of cell death; developing tools for data analysis and database development. During phase 2, students will also modify compounds of interest using the Penn Chemistry: Upenn/Merck High Throughput Experimentation Laboratory (https://www.chem.upenn.edu/content/pen-chemistry-upennermck-high-throughput-experimentation-laboratory), and then retest them for activity to determine structure activity relationships. We will sponsor phase 2 projects relevant to neurofibromatosis. However, in phase two two students can also research other areas if they develop sponsorships from professors. We expect the course to be a hypothesis engine that generates ideas for further research. Prerequisites include a strong foundation in biology and chemistry. Students will prepare an abstract proposal by week three on their phase 2 project, and a report, in scientific paper style, due on the last day of the semester.
Spring
Also Offered As: PHRM 4950
1 Course Unit

CHEM 5210 Statistical Mechanics I
Principles of statistical mechanics with applications to systems of chemical interest.
Fall
Prerequisite: CHEM 2220
1 Course Unit

CHEM 5220 Statistical Mechanics II
A continuation of CHEM 521. The course will emphasize the statistical mechanical description of systems in condensed phases.
Spring
Prerequisite: CHEM 5210
1 Course Unit

CHEM 5230 Quantum Chemistry I
The principles of quantum theory and applications to atomic systems.
Fall
Prerequisite: CHEM 2210
1 Course Unit

CHEM 5240 Quantum Chemistry II
Approximate methods in quantum theory and applications to molecular systems. Topics may include: electronic structure, configuration interaction, DFT, TD-DFT and response theory, electronic dynamics, semiclassical dynamics, vibrational density of states.
Spring
Prerequisite: CHEM 5230
1 Course Unit

CHEM 5250 Molecular Spectroscopy
This course is broken into two sections: (1) optics, and (2) theory of spectroscopy including the discussion of techniques and examples. In the first section you will be introduced to both linear and nonlinear optics, through thinking about how to design optical components in the laboratory setting, the second part of the course is a more traditional spectroscopy course, where different spectroscopies in the visible and infrared spectral region will be discussed. This part of the course will focus on understanding what we can learn from using spectroscopy and what sort of dynamical processes can be observed with different spectroscopic techniques. Topics to be covered include, but are not limited to: optics, time-dependent perturbation theory, lineshapes, density matrix, group theory, selection rules.
Fall or Spring
0.5 Course Units

CHEM 5260 Chemical Dynamics
Theoretical and experimental aspects of important rate processes in chemistry.
Spring
1 Course Unit

CHEM 5410 Physical Organic Chemistry
Undergraduate organic chemistry is a prerequisite. Overview of the principles governing organic bonding, structure, and properties. Quantum calculations as well as laboratory thermodynamic and kinetic measurements used in understanding organic chemical reactions will be surveyed. Mechanisms will be discussed but will not be covered in detail. As such, registration in Chem 441 (Mechanisms) or the completion of it’s equivalent is strongly recommended (see instructor).
Spring
0.5 Course Units

CHEM 5420 Modern Organic Synthesis
Introduction to advanced organic synthesis. Study of important synthetic reactions including: oxidations, reductions, and methods for the formation of carbon-carbon bonds, with an emphasis in chemoselectivity, stereoselectivity and asymmetric synthesis. Survey of modern methods for the synthesis of small, medium and large ring systems. Analysis of modern synthetic strategies, with illustrative examples from total synthesis of natural and unnatural products.
Fall
Prerequisite: CHEM 5440
1 Course Unit
CHEM 5440 Organic Reaction Mechanisms
Study of important types of reactions and functional groups, with emphasis on synthetic usefulness, mechanisms, and stereoelectronic principles.
Fall
Prerequisite: CHEM 2420
1 Course Unit

CHEM 5510 Biological Chemistry I
Structure, dynamics, and function of biological macromolecules. Properties of macromolecular assemblies, membranes and their compartments. (Formerly, CHEM 450-I).
Fall
Prerequisite: (CHEM 2420 OR CHEM 2425) AND CHEM 2210 AND CHEM 2510
1 Course Unit

CHEM 5520 Biological Chemistry II
Physical and chemical description of macromolecular information transfer. Gene organization, replication, recombination, regulation and expression. (Formerly, CHEM 450-II).
Spring
Prerequisite: (CHEM 2420 OR CHEM 2425) AND CHEM 2220 AND CHEM 2510
1 Course Unit

CHEM 5530 Methods for in vivo biochemical discovery
The course surveys the chemical machinery of the cell, post-translational modifications of proteins and catalytic machinery of enzymes. Through this survey, students will become familiar with the cellular proteome and its fascinating functions and dysfunctions that drive normal physiology and disease states of the cell. Current technologies for in vivo function assignment and unbiased drug-target discovery will be reviewed. Example topics include gene editing, protein profiling, targeted degradation, high-throughput drug screening and quantitative analysis of proteomes/metabolomes from native biological systems. The course couples in-class lecture and discussion with research demonstrations of select methods used for discovery.
Fall or Spring
0.5 Course Units

CHEM 5550 Macromolecular Crystallography: Methods and Applications
This is an introductory course on methods and applications of macromolecular structure determination using X-ray crystallography. The course will be broken up into three parts: 1) Principles of X-ray crystallography involving didactic lectures on the technique with weekly problem sets; 2) Workshops on macromolecular structure determination involving hands-on experience with the technology; 3) Student “journal club” presentations on current high impact publications involving X-ray crystal structure determination. Prerequisite: Undergraduate calculus and trigonometry.
Fall
Also Offered As: BMB 5540
1 Course Unit

CHEM 5570 Mechanisms of Biological Catalysis
Reaction mechanisms in biological (enzymes, abzymes, ribozymes) and biomimetic systems with emphasis on principles of catalysis, role of coenzymes, kinetics, and allosteric control.
Fall or Spring
Prerequisite: CHEM 2420 AND (CHEM 2510 OR BIOL 2810)
1 Course Unit

CHEM 5580 Biomolecular Spectroscopy and Microscopy
Chem 558 covers basic fluorescence spectroscopy and microscopy, as well as advanced topics such as single molecule spectroscopy and nonlinear and super-resolution microscopies. There are weekly homework assignments that include problems based on the lectures as well as journal club style reports on by pairs of students on papers relevant to the course material.
Fall
Also Offered As: BMB 5580
0.5 Course Units

CHEM 5620 Inorganic Chemistry II
A detailed treatment of the theory and application of modern physical methods for the elucidation of structure and mechanism in inorganic and organometallic chemistry. An introduction to symmetry and group theory is followed by the application of these concepts to vibrational and electronic spectroscopy of inorganic complexes. Magnetic resonance is discussed in detail, including topics such as EPR, fourier transform methods, dynamic systems, and 2-dimensional NMR.
Fall or Spring
Prerequisite: CHEM 2610
1 Course Unit

CHEM 5640 Organometallics
This course is focused on molecular species that contain metal-carbon bonds, and the role of these compounds in catalytic processes and organic synthesis. Aspects of the synthesis, structure and reactivity of important classes of organometallic compounds such as metallo alkyl, aryl, alkene, alkylidenes and alkylidyne complexes are surveyed for the d and f block metals. Emphasis is placed on general patterns of reactivity and recurring themes for reaction mechanisms.
Fall or Spring
1 Course Unit

CHEM 5650 Main Group Chemistry
This course encompasses a comprehensive survey of the chemistry and properties of the p-block elements of the periodic table. Topics include syntheses, structures and reactivities of important compounds. In addition, alternative bonding theories which have been used to explain the unique properties of these compounds are critically examined.
Fall or Spring
1 Course Unit

CHEM 5670 Bio-inorganic Chemistry
The course covers selected topics in bioinorganic chemistry; special emphasis is placed on dioxygen chemistry and electron transfer processes. Course topics include: (i) oxygen uptake and utilization; (ii) diatomic oxygen transport; (iii) diatomic and monatomic oxygen incorporation into substrates; (iv) metalloenzyme-catalyzed C-C bond formation; (v) the metallobiochemistry of DNA; (vi) metal-sulfide proteins; (vii) manganese-containing metalloproteins; (viii) Photosystem II: light-driven electron transfer and the biological water-splitting reaction; (ix) biological electron transfer; (x) electron transfer theory; (xi) mechanisms of energy storage and release; and (xii) long-distance electron transfer reactions.
Fall or Spring
Also Offered As: BMB 5670
1 Course Unit
**CHEM 6010 Chemical Information**

This course examines the structure and organization of the chemical literature and introduces techniques of searching this literature, focusing on the logic and thought processes necessary for effective information retrieval. Each technique is illustrated using information tools available at the University of Pennsylvania, and we take an "under the hood" look at the organization and functionality of each tool introduced.

Students should choose a course section based on their preferred area of chemistry research: organic, inorganic, biological, and physical chemistry; all four sections are taught at a level appropriate for graduate students and advanced undergraduates. Topics vary by section, but all students learn the basics of subject, author, structure, and reaction searching, and a unit on ethics in publication and scholarly communication completes the course.

Fall or Spring

0.5 Course Units

**CHEM 6520 Proposal Writing for Biological and Physical Chemists**

Students will learn the key components in proposal writing and develop the skills needed to prepare a compelling and original graduate research proposal. The course involves significant writing, in-class discussions, and presentations.

Fall

0.5 Course Units

**CHEM 6620 Proposal Writing for Inorganic and Organic Chemists**

The ability to communicate original, written research proposals is essential to the modern chemist. This course, for graduate students in the organic and inorganic divisions, will promote development of proposal writing skills. Students will develop original ideas, practice written work, graphic design and peer review. Outcomes of the course will include writing (and submission, when eligible) of an NSF GRFP application and a ‘proposed work’ section of a candidacy exam report.

Fall

0.5 Course Units

**CHEM 7210 Mathematics for Chemistry**

This course examines the basic mathematics needed for physical chemistry, including (but not limited to) a brief review of linear algebra, Fourier transforms, delta functions, optimization, and the residue theorem. Depending on the year, selected other topics will also be included.

Fall or Spring

0.5 Course Units

**CHEM 7230 Dynamics of Polymers**

This course discussed the structure of polymers from a statistical physics point of view as well as dynamical response of polymeric systems such as mechanical response of polymer melts, polymer glass transition, properties of polymers in solutions, and properties of block copolymers and ionomers.

Fall or Spring

0.5 Course Units

**CHEM 7410 Spectroscopy**

The course will provide a continuation of material covered in Chemistry 441 and Chemistry 541, as well as spectroscopy of organic compounds focused mainly on NMR. Topics will include advanced organic mechanisms, electronic structure calculations of organic molecules related to their structure, reactivity, and spectroscopic properties, and Organic Spectroscopic methods for the determination of structure using NMR.

Spring

Prerequisite: CHEM 5440 AND CHEM 5410

0.5 Course Units

**CHEM 7420 Medicinal Chemistry and Drug Design**

This course focuses on concepts and strategies in medicinal chemistry, and how it is applied to modern drug discovery and development. Topics include the drug discovery process, drug targets (GRC?), enzymes, channels etc.), physical chemistry of molecular interactions between drug and target, drug design, methods for hit and lead identification, lead optimization, chemical biology, natural products chemistry and combinatorial and diversity oriented synthesis. This course is geared to upper level undergraduate students in chemistry or biochemistry, and first year chemistry graduate students. A strong understanding of organic chemistry is required.

Fall or Spring

0.5 Course Units

**CHEM 7430 Heterocyclic Chemistry**

The course deals with topics in Heterocyclic Chemistry. It covers nitrogen-containing monocyclic hetero rings, examining the most recent syntheses, the reactions and their mechanisms. The course will focus on recent variations and improvements of known heterocycles as well as their synthetic utility. Students will be expected to read critically a recent article on heterocyclic chemistry and do a presentation to the class.

Fall or Spring

0.5 Course Units

**CHEM 7440 Bioinspired Synthesis. Methods, Tactics, and Strategies.**

This class will discuss selected topics related to Bioinspired synthesis, methods, tactics and strategies. Target molecules, methods and strategies are designed by using biological systems as models.

Fall or Spring

0.5 Course Units

**CHEM 7450 Total Synthesis**

The focus of this course comprise the development of two synthetic strategies to access architecturally complex natural products of biological significance exploiting innovative chemistry. Lectures towards this end are given. As a project, each student is given a different complex natural product and expected at the end of the course to develop two strategies, one based on asymmetric induction to provide the absolute stereochemical structure, the second where the absolute stereochemistry derives from commercially available starting materials.

Fall or Spring

0.5 Course Units

**CHEM 7460 Intermediate Organic Chemistry**

This course will include a review of basic reaction mechanisms, stereoelectronic effects, functional groups and acid-base chemistry. The course will emphasize the writing of mechanisms using the curved-arrow notation and organic reactions. Bonding and electronic structure theories and more involved mechanisms will be discussed. Students are expected to have a good working knowledge of reactions, functional groups, stereochemistry and mechanisms from undergraduate organic chemistry. Students will be expected to review basic concepts in Organic Chemistry and spectroscopy. The course will include lectures and recitations, and students are expected to attend and participate.

Fall or Spring

1 Course Unit
Chemistry (CHEM)

CHEM 7510 Chemical Biology
This course focuses on current topics in Chemical Biology, particularly experiments in which 1) chemical synthesis enables one to probe or control biological systems, or 2) manipulation of biological systems facilitates novel chemical syntheses. The course is broadly divided into two sections, one dealing with the study of individual proteins and nucleic acids, and one dealing with complex cellular systems. As the goal of the course is to familiarize students with innovative recent experimental approaches and to stimulate them to conceive of their own new methodology, students will be responsible for delivering presentations on topics selected from the literature, designing experiments to address currently unsolved problems in Chemical Biology (in take-home examinations), and generating several novel research proposal ideas, one of which will be elaborated into a full proposal.
Fall or Spring
Also Offered As: BMB 7510
1 Course Unit

CHEM 7610 Coordination Chemistry
Ligands have a remarkable ability to alter the properties of metal ions, and the study of this coordination chemistry underlies many modern advances in science, including energy harvesting and storage, chemical catalysis, and sustainability. This course explores the relationships between the identities of ligands and the physical manifestations that result from their binding to metal centers. Topics to be covered include: symmetry and chirality in molecular complexes, variations in coordination number, ligand field effects, recent advances in bonding theory, and inorganic reaction mechanisms.
Fall or Spring
0.5 Course Units

CHEM 7620 X-ray I
An introduction to the theory and practice of structure determination by X-ray crystallography. Topics discussed include point group and space group symmetry, structure factor theory, data collection methods and a survey of solution methods. The course culminates with a series of real-world structure determinations worked through in-class using the XSeed program package.
Fall or Spring
0.5 Course Units

CHEM 7630 X-ray II
Continuation of X-ray I course, CHEM 741
Fall or Spring
Prerequisite: CHEM 7620
0.5 Course Units

CHEM 7640 Materials Chemistry
This course will provide an introduction of structure-property relationships in materials chemistry on length scales from atomic dimension up to the microscale and then draw on examples of Chemical design for "Energy and Environmental Sustainability." We will introduce the "12 Principles of Green Chemistry" and "12 Principles of Green Engineering" as a guide to modern materials chemistry design and follow a trajectory that proceeds with increasing length scales of ordering in the solid state. We will introduce techniques of x-ray, neutron, electron, and ion beam based scattering, real space imaging and spectroscopies and use these to explore non-crystalline materials (amorphous, glasses, and time permitting quasicrystals and aperiodic systems) and crystalline solids. Studies will proceed from atomic scales through nanoscale, mesoscale, and micro-scale discussing the emergence of band structure and delocalized electronic and optical properties that emerge due to the finite scale of ordering and influence of the surface. Select examples will be drawn from advances in materials for in solar energy utilization with photochemistry and photoelectrochemistry and materials for photovoltaic and enabling advances electrochemical energy conversion and storage.
Spring
1 Course Unit

CHEM 7650 Chemistry of the f-Block Elements
The course encompasses the descriptive chemistry, and topics related to, the f-block including the rare earth metals and actinides. Coverage includes coordination chemistry and periodic trends, electronic structure and magnetism, and modern applications of f-block chemistry including lanthanide ions as spectroscopic probes, separations chemistry, materials chemistry and applications, organo-f-element chemistry, the chemistry of the actinides and transactinides, and reactivity/catalysis with f-block compounds.
Fall or Spring
0.5 Course Units

CHEM 7660 Electrochemistry: Methods and Chemical Applications
The goal of this course is for students to gain an understanding of the principles of electrochemistry along with some practical experience. Potentiometric methods will be discussed in the context of electrochemical equilibrium. Amperometric analytical methods – chronoamperometry, chronocoulometry, stripping voltammetry, cyclic voltammetry, pulse polarography, AC impedance, and hydrodynamic methods – will be described from the perspective of mathematical models of mass transport and electrode kinetics. As time permits, special topics and applications, such as electrochemical energy conversion, spectroelectrochemistry, photovoltaic solar cells, ultramicroelectrodes, microfluidics, corrosion, electrochemical synthesis, and scanning electrochemical microscopy, will be covered. To complement and reinforce the material learned in class, students will fabricate electrodes, perform cyclic voltammetry and other experiments, and analyze electrochemical data. Equipment will be available in the instructor’s research laboratory to do these experiments in small groups on students’ own time outside of class. The instructor will provide out-of-class assistance to students who are not yet familiar with the use of electrochemical equipment.
1 Course Unit
CHEM 7670 Applications of Group Theory
This course will provide a fundamental understanding of symmetry, the character tables, how to derive these, and apply them in spectroscopy, and molecular orbital diagrams. The course will require some fundamental understanding of matrix algebra, and apply concepts of symmetry to derive character tables, predict spectroscopic properties of molecules, and derive molecular orbitals diagrams including hybridized orbitals.
0.5 Course Units

CHEM 9999 Independent Study and Research
(1) Advanced study and research in various branches of chemistry. (2) Seminar in current chemical research. (3) Individual tutorial in advanced selected topics.
Fall or Spring
0.5-4 Course Units