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010. Academic Based Community Service-Chemistry Outreach. (A)

L/R 012. Environmental Chemistry. (C) Physical World Sector. All classes. The course requires math literacy at the high school algebra level (2 years) and a willingness to learn Excel. Students must also have taken one year of high school chemistry.

The course aims to teach chemical content and 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.

SM 022. Structural Biology. (C) Natural Science & Mathematics Sector. Class of 2010 and beyond. Freshman Seminar

This course will explain in non-mathematical terms how essentially all biological properties are determined by the microscopic chemical properties of proteins. It will also explain how research results, especially those of structural biology, are presented to its various audiences.

SM 025. Freshman Seminar: From Alchemy to Nanoscience. (A) Jeffrey Winkler.

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 dyestuffs 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 andBoyle) scientists and modern thinkers (Priestly, Lavoisier, Dalton, Mendeleev and others). This class, which is designed for non-science as well as potentialscience majors, will involve discussions on readings, as well as field trips tosome Philadelphia locations that are notable in the history of chemistry.

053. General Chemistry Laboratory I. (C) Lab fee $150.

A general laboratory course covering aspects of qualitative and quantitative analysis, determination of chemical and physical properties, and chemical synthesis.

054. General Chemistry Laboratory II. (C) Lab fee $150.

Continuation of CHEM 053.

L/R 101. General Chemistry I. (C) Physical World Sector. All classes.

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 preprofessional 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 Chemistry 100.

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L/R 102. General Chemistry II. (C) Physical World Sector. All classes.Prerequisite(s): CHEM 101.

Continuation of Chemistry 101. The second term stresses the thermodynamic approach to chemical reactions, electrochemical processes, and reaction rates and mechanisms. It includes special topics in chemistry.

L/R 115. Honors Chemistry I. (A) Physical World Sector. All classes. Offered for freshman only.

An advanced course for students who have had AP Chemistry in high school. Included in the course coverage are: quantum mechanics of atoms, molecules and crystalline solids; statistical mechanics of gases, liquids, and solids; and coordination chemistry.

L/R 116. Honors Chemistry II. (B) Physical World Sector. All classes.Prerequisite(s): Advanced High School Chemistry (AP or equivalent).

An advanced course for students who have had very strong background in Chem- istry in High School (AP, IB, or equivalent). Advanced material from the general chemistry curriculum will be covered in the context topics selected from current research areas. A continuation of CHEM115, CHEM116 will focus on topics in biochemistry and biophysical chemistry relating to thermodynamics,equilibrium, kinetics, and electrochemistry.

L/R 221. Physical Chemistry I. (A) Prerequisite(s): CHEM 102, MATH 114, PHYS 150.

Introductory quantum mechanics, atomic and molecular structure, chemical bonding, and microscopic understanding of physical and chemical properties of molecules.

L/R 222. Physical Chemistry II. (B) Prerequisite(s): CHEM 221, PHYS 151.

Continuation of CHEM 221. Principles and applications of thermodynamics, and a molecular-based understanding of macroscopic properties.

223. Experimental Physical Chemistry I. (B) Prerequisite(s): CHEM 221. Lab fee $300.

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.

L/R 241. Principles of Organic Chemistry. (C) Prerequisite(s): CHEM 102.

Fundamental course in organic chemistry based upon the modern concepts of structure and mechanism of reactions.

L/R 242. Principles of Organic Chemistry II. (C) Prerequisite(s): CHEM 241.

Continuation of CHEM 241.

L/R 243. Organic Chemistry II: Principles of Organic Chemistry with applications in Chemical Biology. (B) Dr. David Chenoweth & Dr. E. James Petersson.Prerequisite(s): CHEM 241.

This course is functionally equivalent to Chem 242 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 sulfidesin lipids; 2) carboxylic acids and amines in amino acids; 3) aromatic compounds and heterocycles in nucleic acids; and 4) ketones and aidehydes in carbohydrates. The synthesis and mechanism of action of pharmaceuticals that feature these functional groups will also be discussed. Additionally, Chem 243 makes use of 3D structure tutorials, recitation sections and visits from biomedical scientists who make use of chemistry in their work.

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245. Experimental Organic Chemistry I. (C) Prerequisite(s): CHEM 241. Corequisite(s): CHEM 242.Lab fee $300.

A basic laboratory course in which both the theoretical and practical aspects of a variety of organic reactions and multistep syntheses are emphasized. Modern chromatographic, instrumental, and spectroscopic techniques are applied to experimental organic chemistry. Course should be taken concurrently with CHEM 242 or in the semester immediately following.

PLEASE NOTE THE FOLLOWING: For the Summer and LPS offering of CHEM 245, it is a 2-semester course. Part 1 is taken in the first term for 0.0 CU and then Part 2 is taken in the second term immediately following the first for 1.0 CU.

246. Advanced Synthesis and Spectroscopy Laboratory. (A) Prerequisite(s): CHEM 242 and 245. Corequisite(s): CHEM 261 should be taken concurrently or previously completed successfully.Lab fee $300.

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.

251. Principles of Biological Chemistry. (C) Prerequisite(s): CHEM 102 and 241. Corequisite(s): Chemistry 242 required.

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 should be taken concurrently with Chem 242.

L/R 261. Inorganic Chemistry I. (A) Corequisite(s): CHEM 241 may be taken concurrently.

An introductory survey of the bonding, structure, and reactions of important metal and nonmetal compounds.

299. Directed Study and Seminar. (C) Prerequisite(s): Permission of undergraduate chairman.

Directed study projects and seminars as individuals or small groups under the supervision of a faculty member.

399. Independent Research. (C) Prerequisite(s): Permission of undergraduate chairman; a B average in chemistry, mathematics, and physics.

Independent project under the direction of a faculty member.

441. Advanced Organic Chemistry: Reactions, Mechanisms,and Stereoelectronic Effects. (A) Prerequisite(s): CHEM 242.

Study of important types of reactions and functional groups, with emphasis on synthetic usefulness, mechanisms, and stereoelectronic principles.

443. Modern Organic Synthesis. (A) Prerequisite(s): CHEM 241 and 242.

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.

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451. Biological Chemistry I. (A) Prerequisite(s): CHEM 242, 221 (may be concurrent), and 251 or permission of instructor.

Structure, dynamics, and function of biological macromolecules. Properties of macromolecular assemblies, membranes and their compartments. (Formerly, CHEM 450-I).

521. Statistical Mechanics I. (A) Prerequisite(s): CHEM 222.

Principles of statistical mechanics with applications to systems of chemical interest.

452. Biological Chemistry II. (B) Prerequisite(s): CHEM 242, 221, and 251 or permission of instructor.

Physical and chemical description of macromolecular information transfer. Gene organization, replication, recombination, regulation and expression. (Formerly, CHEM 450-II).

462. Inorganic Chemistry II. (C) Prerequisite(s): CHEM 261 or its equivalent and permission of instructor.

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.

495. (PHRM495) High Throughput Discovery: A Multidisciplinary Approach to Cancer.. (B) Dr.'s Jeffrey Field, David Schultz, and Simon Berritt.

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/penn-chemistry-upennmerck-high-throughput- xperimentation-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 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.

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522. Statistical Mechanics II. (B) Prerequisite(s): CHEM 521.

A continuation of CHEM 521. The course will emphasize the statistical mechanical description of systems in condensed phases.

523. Quantum Chemistry I. (A) Prerequisite(s): CHEM 222.

The principles of quantum theory and applications to atomic systems.

524. Quantum Chemistry II. (B) Prerequisite(s): CHEM 523.

Approximate methods in quantum theory and applications to molecular systems.

525. Molecular Spectroscopy. (C)

A modern introduction to the theory of the interaction of radiation and matter and the practice of molecular spectroscopy. Conventional microwave, magnetic resonance, optical, photoelectron, double-resonance, and laser spectroscopic techniques will be included.

526. Chemical Dynamics. (B)

Theoretical and experimental aspects of important rate processes in chemistry.

555. (BMB 554) Macromolecular Crystallography: Methods and Applications. (A)

The first half of the course covers the principles and techniques of macro- molecular structure determination using X-ray crystallography. The second half of the course covers extracting biological information from X-ray crystal structures with special emphasis on using structures reported in the recent literature and presented by the students.

557. Mechanisms of Biological Catalysis. (C) Prerequisite(s): One year of organic chemistry and a biochemistry course, or permission of instructor.

Reaction mechanisms in biological (enzymes, abzymes, ribozymes) and biomimetic systems with emphasis on principles of catalysis, role of coenzymes, kinetics, and allosteric control.

559. (BMB 559) Biomolecular Imaging. (B)

This course considers the noninvasive, quantitative, and repetitive imaging of targeted macromolecules and biological processes in living cells and organisms.Imaging advances have arisen from new technologies, probe chemistry, molecular biology, and genomic information. This course covers the physical principles underlying many of the latest techniques, and defines experimental parameters such as spatial and temporal resolution, gain, noise, and contrast. Applications to cellular and in vivo imaging are highlighted for confocal, two-photon, and force microscopies; single-molecule, CARS, and fluorescence correlation spectroscopy; FRET and fluorescence bleaching; mass spectroscopy; MRI, PET and SPECT. The role of molecular imaging agents comprised of proteins, organic or inorganic materials is widely discussed.

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567. (BMB 567) Bio-inorganic Chemistry. (C)

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 trans port; (iii) diatomic and monoatomic 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.

564. Organometallics. (C)

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, alkylidene 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.

565. Main Group Chemistry. (C)

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 thes compounds are critically examined.

600. Tutorial Studies. (C) Both terms. May be repeated for credit with permission of instructor

Readings and discussion on various topics with various faculty members.

602. Proposal Writing for Chemists. (A) Feng Gai.

652. Principles of Scattering. (A) Prerequisite(s): One year of physical chemistry.

Scattering of radiation from gases, liquids, and solids. Applications to molecular structure and biological systems.

721. Mathematics for Chemistry. (C) J. SUBOTNIK.

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.

723. Dynamics of Polymers. (C) Z. FAHKRAAI.

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 co-polymers and ionomers.

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741. Spectroscopy. (C) Prerequisite(s): CHEM 441 and CHEM 541.

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.

742. Medicinal Chemistry and Drug Design. (C) DONNA HURYN.

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 (GRCR?s, 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.

743. Heterocyclic Chemistry. (C) M. JOULLIE.

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.

744. Bioinspired Synthesis. Methods, Tactics, and Strategies.. (C) VIRGIL PERCEC.

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.

745. Total Synthesis. (C) AMOS B. SMITH III.

751. Chemical Biology. (C) EJ PETERSSON.

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.

764. Materials Chemistry. (C) C. MURRAY.

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761. Coordination Chemistry. (C) NEIL TOMSON.

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 advanced in bonding theory, and inorganic reaction mechanisms.

762. X-ray I. (C) PATRICK CARROLL.

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.

763. X-ray II. (C) PATRICK CARROLL.Prerequisite(s): CHEM 762.

Continuation of X-ray I course, CHEM 741

765. Chemistry of the f-Block Elements. (C) ERIC SCHELTER.

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.

802. Chem Teaching Methods. (L)

999. Independent Study and Research. (C) May be taken for multiple course unit credit

(1) Advanced study and research in various branches of chemistry. (2) Seminar in current chemical research. (3) Individual tutorial in advanced selected topics.

Undergraduate BIOCHEMISTRY Courses (BCHE)

299. Undergraduate Research Projects. (C) 10-20 h., 1-2 c.u., admission by permission of the biochemistry undergraduate chairman.

Independent Research.

300. Senior Research Projects. (C) 10-20 h., 1-2 c.u., admission by permission of the biochemistry undergraduate chairman.

SM 404. Biochemistry Laboratory. (E) Year long course --initial registration must occur in Fall term, 0 c.u. for first term and 2 c.u. for second term, 15h. CHEM 451 or permission of instructor required.

Independent research projects in the laboratories of individual faculty members. A list of possible research supervisors is available in the Biochemistry office (351 Chemistry). In addition to their laboratory projects, students will attend a weekly seminar in which their own and related work will be discussed.

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580. (PHYS580) Biological Physics. (C) Prerequisite(s): Physics 150-151 or 170-171, Math 104-114 or Math 104-115. Recommended: concurrent Physics 230 or prior Physics 250, basic background in chemistry and biology.