The Department of Chemistry, in conjunction with other departments of the university, offers a broad education and the opportunity to do research in chemistry and related fields. The great diversity of the field of chemistry, ranging between physics and biology, is reflected in the research interests of the faculty. Undergraduate chemistry majors usually go on to graduate study in chemistry, chemical engineering, biology, oceanography, geochemistry, biophysics, environmental sciences, or medicine, while others enter the chemical industry. The Ph.D. in chemistry leads to professional careers in colleges and universities, research institutes, industry, and government laboratories.

Facilities
The department is well-equipped with instrumentation, both shared and in individual faculty research laboratories, to perform modern chemical research. The Departmental Instrumentation Facility houses the following pieces of major instrumentation:

- Bruker Avance 400 MHz FT-NMR spectrometers (2), one located in the Instrumentation Facility in Remsen Hall and the other on the first floor of the new chemistry building.
- Bruker Avance 300 MHz FT-NMR spectrometer.
- Bruker Avance III 400 MHz FT-NMR spectrometer and Fourier 300 FT-NMR spectrometer with an automatic sample changer are located in the undergraduate teaching laboratory.
- VG70S magnetic sector mass spectrometer, with EI, and CI ionization.
- VG70SE magnetic sector mass spectrometer, with FAB ionization.
- Finnigan LQ ion trap mass spectrometer with electrospray ionization (APCI available as an option).
- Finnigan LQ Duo ion trap mass spectrometer with electrospray ionization (for inorganic and organometallic use).
- Finnigan LQ Fleet ion trap Mass Spectrometer with ESI ionization and HPLC inlet.
- Bruker Autoflex III Maldi-ToF-ToF Mass spectrometer with Maldi ionization and collision cell.
- Shimadzu QP2010SE GC-MS with EI ionization.
- Waters Acquity / Xevo G2 UPLC-Q-ToF MS with ESI and APCI ionisation.
- Bruker EMX EPR spectrometer equipped with a liquid helium cryostat and variable temperature controller.
- Thermo Nicolet Nexus 670 FT-IR spectrophotometer with a Nicolet Golden Gate ATR accessory.
- Jasco P-1010 polarimeter.
- Xcalibur3 X-ray diffractometer with CCD area detector (located on the second floor of the new chemistry building).
- Protein Technologies Symphony Quartet Peptide Synthesizer.
- SuperNova X-ray diffractometer (dual hi-flux micro-focus Mo and Cu sources ) with Atlas CCD area detector (located on the second floor of the new chemistry building).

NMR spectrometers suitable for studies of biological macromolecules are located in the Biomolecular NMR Center, located in an underground facility in front of the new chemistry building. The instruments include 500, 600, and 800 MHz FT-NMR spectrometers.

A variety of different mass spectral techniques are available in the expanding Mass Spectrometry Facility. High-resolution mass spectra of submitted samples are obtained on a service basis by a staff member using two magnetic sector instruments equipped with EI, CI, and FAB ionization methods. MALDI-TOF, GC/MS, and electrospray instruments are also available and operated by students and researchers following training by the facility staff.

The X-ray Diffractometer Facility is operated by a staff member. The instruments are suitable for detailed molecular-level structural characterization of new organic or inorganic compounds.

The department has an established in-house peptide synthesis facility. This facility is equipped with a four-channel peptide synthesizer from Protein Technologies, an Agilent HPLC equipped with both a diode array and a fluorescence detector, and a lyophilizer.

The department shares with the Physics and Astronomy Department the use of the Physical Sciences Machine Shop, located in the Bloomberg Center. Electronics construction and repair is handled by a staff member in the Departmental Instrumentation Facility.

Undergraduate Program
Programs for undergraduate majors can be tailored to individual interests so that a major in chemistry is excellent preparation not only for further work in chemistry, but also for any field that rests on a chemical foundation. It is a good choice for a premedical student interested in medical research.

Requirements for the B.A. Degree
(Also see Requirements for a Bachelor’s Degree. (http://e-catalog.jhu.edu/undergrad-students/academic-policies/requirements-for-a-bachelors-degree))

 Majors must complete all courses required for the major for a letter grade and receive a grade of C- or higher. Requirements of the chemistry major are:

Core Courses

<table>
<thead>
<tr>
<th>Course ID</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
</tr>
<tr>
<td>&amp; AS.030.105</td>
<td>and Introductory Chemistry Laboratory I</td>
</tr>
<tr>
<td>AS.030.102</td>
<td>Introductory Chemistry II</td>
</tr>
<tr>
<td>&amp; AS.030.106</td>
<td>and Introductory Chemistry Laboratory II</td>
</tr>
<tr>
<td>or AS.030.103</td>
<td>Applied Chemical Equilibrium and Reactivity w/lab</td>
</tr>
<tr>
<td>AS.030.204</td>
<td>Chemical Structure and Bonding w/Lab ^</td>
</tr>
<tr>
<td>AS.030.205</td>
<td>Introductory Organic Chemistry I</td>
</tr>
<tr>
<td>AS.030.206</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>or AS.030.212</td>
<td>Honors Organic Chemistry II with Applications in Biological and Materials Chemistry</td>
</tr>
<tr>
<td>AS.030.227</td>
<td>Chemical Chirality: An Introduction in Organic Chem. Lab, Techniques</td>
</tr>
<tr>
<td>or AS.030.225</td>
<td>Introductory Organic Chemistry Laboratory</td>
</tr>
<tr>
<td>AS.030.228</td>
<td>Intermediate Organic Chemistry Laboratory</td>
</tr>
<tr>
<td>AS.030.301</td>
<td>Physical Chemistry I</td>
</tr>
<tr>
<td>AS.030.305</td>
<td>Physical Chemistry Instrumentation Laboratory I</td>
</tr>
<tr>
<td>AS.030.302</td>
<td>Physical Chemistry II</td>
</tr>
<tr>
<td>AS.030.306</td>
<td>Physical Chemistry Instrumentation Laboratory II</td>
</tr>
<tr>
<td>AS.030.356</td>
<td>Advanced Inorganic Lab</td>
</tr>
</tbody>
</table>

Outside Courses
A typical program might include the following sequence of courses:

**Sample Program**

A typical program might include the following sequence of courses:

**Freshman**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Spring Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.030.101 Introductory Chemistry I</td>
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<td>AS.030.102 Introductory Chemistry II</td>
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<tr>
<td>AS.030.105 Introductory Chemistry Laboratory I</td>
<td>1</td>
<td>AS.030.106 Introductory Chemistry Laboratory II</td>
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</tbody>
</table>

**Sophomore**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Spring Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.030.205 Introductory Organic Chemistry I</td>
<td>4</td>
<td>AS.030.206 Organic Chemistry II</td>
</tr>
<tr>
<td>AS.030.225 Introductory Organic Chemistry Laboratory I</td>
<td>3</td>
<td>AS.030.228 Intermediate Organic Chemistry Laboratory</td>
</tr>
<tr>
<td>AS.171.101 General Physics:Physical Science Major I</td>
<td>4</td>
<td>AS.171.102 General Physics:Physical Science Major II</td>
</tr>
<tr>
<td>AS.173.111 General Physics Laboratory I</td>
<td>1</td>
<td>AS.173.112 General Physics Laboratory II</td>
</tr>
</tbody>
</table>

**Junior**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Spring Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.030.301 Physical Chemistry I</td>
<td>3</td>
<td>AS.030.204 Chemical Structure and Bonding w/Lab</td>
</tr>
<tr>
<td>AS.030.305 Physical Chemistry Instrumentation Laboratory I</td>
<td>3</td>
<td>AS.030.302 Physical Chemistry II</td>
</tr>
<tr>
<td>Science or math elective</td>
<td>3</td>
<td>AS.030.306 Physical Chemistry Instrumentation Laboratory II</td>
</tr>
</tbody>
</table>

**Senior**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Spring Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.030.356 Advanced Inorganic Lab</td>
<td>3</td>
<td>Upper level chemistry elective (optional)</td>
</tr>
<tr>
<td>Upper level chemistry elective</td>
<td>3</td>
<td>Science or math elective (optional)</td>
</tr>
</tbody>
</table>

**Honors in Chemistry**

To recognize exceptional performance, both in formal course work and in research, chemistry majors can receive a degree with honors. Honors in Chemistry may be achieved by one of two paths. 1: A student with a GPA of 3.75 or higher in (N) and (Q) courses or 2: A student with a 3.5 GPA in (N) and (Q) courses and with at least 2 semesters of research with a Chemistry faculty member or an approved advisor. These students must write a summary of their research and fill out the Honors Clearance form and the GPA checksheet (see: http://www.advising.jhu.edu/honors.php). Turn in these forms to the Director of Undergraduate Studies.
Graduate Programs

Each student’s background and interests determine the course of study. The normal program leads to the Ph.D. degree. A student is not usually accepted for a terminal M.A. degree.

Requirements for the M.A. and Ph.D. Degrees

Normally, the minimum course requirement for both the M.A. and the Ph.D. degrees is six one-semester graduate courses in chemistry and related sciences. Exceptionally well-prepared students may ask for a reduction of these requirements.

Requirements for the Ph.D. degree include a research dissertation worthy of publication, and a knowledge of chemistry and related material as demonstrated in an oral examination. Each student must teach for at least one year.

Requirements for the M.A. degree, in addition to completion of formal course work and research, include a satisfactory performance on an oral examination.

Financial Aid and Admissions

Fellowships, research appointments, and teaching assistantships are available for graduate students. There are no fixed admission requirements. Undergraduate majors in chemistry, biology, earth sciences, mathematics, or physics may apply, as well as well-qualified individuals who will have received a B.A. degree.

For further information about graduate study in chemistry visit the Chemistry Department website at https://chemistry.jhu.edu/.

For current faculty and contact information go to http://chemistry.jhu.edu/people/

Faculty

Chair
David R. Yarkony

D. Mead Johnson Professor: theoretical chemistry—electronic structure theory, multi-configuration self-consistent-field methods, excited state chemistry, electronic energy transfer in chemical reactions, spin-forbidden processes, and electronically nonadiabatic processes.

Professors

Kit H. Bowen
E. Emmet Reid Professor: experimental chemical physics—photoelectron spectroscopy of negative ions, structure and dynamics of gas phase, weakly bound molecular clusters.

Paul J. Dagdigian
Arthur D. Chambers Professor: experimental chemical physics—dynamics of gas-phase chemical reactions, collisional energy transfer, molecular electronic spectroscopy, laser-induced fluorescence and ionization.

D. Howard Fairbrother
Physical chemistry—the structure of chemically protective surfaces, chemistry of adhesives, environmental surface chemistry.

David Goldberg
Inorganic and bioinorganic chemistry—structure/function relationships in heme proteins, artificial enzyme design, biomimetic molybdenum and tungsten coordination compounds, redox active ligands, synthesis of tetrapyrrolic macrocycles (phthalo-cyanine and porphyrin-based systems) for small-molecule activation and materials applications.

Marc M. Greenberg
Vernon K. Krieble Professor: organic and bioorganic chemistry—application of chemical, biochemical, and biological techniques to studies on DNA damage and repair, independent generation and study of reactive intermediates, development and application of methods for modified oligonucleotide synthesis, design of mechanistically inspired enzyme inhibitors radiosensitizing agents, and sensors.

Rigoberto Hernandez
Gompf Family Professor: theoretical and computational chemistry—statistical mechanics of chemical systems; molecular dynamics in complex environments; nonequilibrium dynamics of polymers, proteins, surfaces, colloids; transition state theory of driven chemical reactions; adaptive steered molecular dynamics of proteins; sustainable nanotechnology.

Kenneth D. Karlin
Ira Renssen Professor: inorganic and bioinorganic chemistry—synthetically derived structural, spectroscopic and functional models for copper and iron proteins, copper-dioxygen reversible binding and metal-mediated substrate oxidation, O2-reduction with copper cluster compounds, porphyrin-iron and copper chemistry relevant to hemecopper oxidases, metal-catalyzed ester and amide hydrolysis, metal complex protein and DNA interactions.

Thomas Lectka
Jean and Norman Scowe Professor: organic chemistry—the design and synthesis of theoretically interesting nonnatural products with applications in bioorganic and physical organic chemistry, materials science and supramolecular chemistry, novel approaches to asymmetric catalysis, theoretical organic chemistry.

Tyrel McQueen
Solid state inorganic—electronically and magnetically active materials—condensed matter physics.

Steven Rokita
Organic and bioorganic chemistry, sequence and conformation specific reactions of nucleic acids; enzyme-mediated activation of substrates and coenzymes; aromatic substitution and quinone methide generation in bioorganic chemistry, biological dehalogenation.

Harris J. Silverstone
Theoretical chemistry—development of mathematical techniques for applying quantum mechanics to chemical problems, high-order perturbation theory, semiclassical methods, divergent expansions, photoionization, LoSurdo-Stark effect, magnetic resonance spectral simulation, hyperasymptotics.

John P. Toscano
Organic chemistry—organic chemistry, fundamental chemistry and biochemistry of nitroxy1 (HNO) including the design of new precursors to HNO, new analytical tools for its detection, and the characterization of HNO-induced protein modifications-time-resolved IR spectroscopy of organic reactive intermediates.

John D. Tovar
Organic chemistry—organic electronics, conjugated and conducting polymers, electrochemistry, nanostructured materials, polymer chemistry bioinspired self—assembly, and supramolecular chemistry.

Craig A. Townsend
Alsoph H. Corwin Professor: organic and bioorganic chemistry—biosynthesis and chemistry of natural products, stereo-chemical and D. Howard Fairbrother

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Craig A. Townsend
Alsoph H. Corwin Professor: organic and bioorganic chemistry—biosynthesis and chemistry of natural products, stereo-chemical and
mechanistic studies of enzyme action, small molecule/DNA interactions, application of spectroscopic techniques to the solution of biological problems.

**Associate Professors**

Arthur Bragg  
Experimental physical chemistry—chemical dynamics and charge/energy transfer in condensed-phase systems, ultrafast spectroscopy.

Joel R. Tolman  
Biophysical chemistry—protein-protein interactions, protein dynamics and structure, NMR methodology.

**Assistant Professors**

Lan Cheng  
Theoretical chemistry—electronic structure theory for treating relativistic and electron-correlation effects, relativistic theory for magnetic properties, computational chemistry and spectroscopy for heavy-element compounds

Stephen D. Fried  
Biochemistry and biophysics—mechanisms of protein folding and assembly in vivo, design and evolution of protein-based materials

Thomas Kempa  
Materials chemistry—solid-state materials chemistry and experimental physical chemistry.

Rebekka S. Klausen  
Organic and materials chemistry—the design and synthesis of well-defined organosilicon and organic materials, electronic characterization of novel materials.

V. Sara Thoi  
Inorganic chemistry—coordination chemistry, materials synthesis, electron and ion transport, photochemistry, and electrocatalysis.

**Research and Teaching Professors**

Jaime Combariza  
Research Professor.

Christopher Falzone  
Teaching Professor.

Jane Greco  
Associate Teaching Professor.

Louise Pasternack  
Teaching Professor.

**Adjunct, Emeritus, and Joint Appointments**

David E. Draper  
Professor Emeritus.

David Gracias  
Assistant Professor (Chemical and Biomolecular Engineering).

Howard E. Katz  
Professor (Materials Science and Engineering).

Brown L. Murr  
Professor Emeritus.

Alex Nickon  
Vernon Krieble Professor Emeritus.

Douglas Poland  
Professor Emeritus.

Lawrence M. Principe  
Professor (joint appointment in History of Science and Technology).

Dean W. Robinson  
Professor Emeritus.

**Lecturers**

Larissa D'Souza  
Senior Lecturer.

Eric Hill  
Lecturer.

Sunita Thyagarajan  
Lecturer.

For current course information and registration go to https://sis.jhu.edu/classes/

**Courses**

**AS.030.101. Introductory Chemistry I. 3.0 Credits.**

The fundamental principles of chemistry, including atomic and molecular structure, bonding, elementary thermodynamics, equilibrium and acids and bases, are introduced in this course. Can be taken with Introductory Chemistry Laboratory – I unless lab has been previously completed.

Note: Students taking this course and the laboratory 030.105 may not take any other course in the summer sessions and should devote full time to these subjects. High school physics and calculus are strongly recommended as prerequisites. First and second terms must be taken in sequence. Students not enrolled in college (unless they are rising freshmen) may not take this course.

Instructor(s): D. Goldberg; S. Thyagarajan  
Area: Natural Sciences.

**AS.030.102. Introductory Chemistry II. 3.0 Credits.**

Continuation of AS.030.101 emphasizing chemical kinetics, chemical bonding. Topics: energy levels and wave functions for particle-in-a-box and hydrogen atom and approximate wave functions for molecules including introduction to hybrid orbitals. Note: Appropriate adjusting caps should be used to ensure both sections are approximately the same size.

**Prerequisites:** Students enrolled in AS.030.103 may not enroll in or receive credit for AS.030.102; AS.030.101 OR AS.030.107.

Instructor(s): J. Greco  
Area: Natural Sciences.

**AS.030.103. Applied Chemical Equilibrium and Reactivity w/lab. 4.0 Credits.**

This course is designed for students who have scored a 4 or 5 on the AP Chemistry Exam or who have scored a 6 or 7 HL IB Chemistry Exam. This course will review an advanced introductory chemistry sequence in a single semester. Chemical equilibrium, reactivity and bonding will be covered. These topics will be explored through laboratory experiments and problem solving, and discussing these principles in the context of current research. For details on chemistry placement and exam credit policies, please see http://www.advising.jhu.edu/placement_chemistry.php Students who have previously enrolled in AS.030.101 or AS.030.105 may not earn credit for AS.030.103 and students enrolled in AS.030.103 may not enroll in or receive credit for AS.030.102/AS.030.106.

Instructor(s): T. Mcqueen  
Area: Natural Sciences.
AS.030.105. Introductory Chemistry Laboratory I. 1.0 Credit.
Laboratory work includes quantitative analysis and the measurement of physical properties. Open only to those who are registered for or have successfully completed Introductory Chemistry 030.101.
Prerequisites: Students enrolled in AS.030.105 may not enroll in AS.030.115, AS.030.103, or AS.030.107.;Students must have completed or be enrolled in AS.030.101 OR EN.510.101 to register for AS.030.105.
Instructor(s): E. Hill; S. Thyagarajan
Area: Natural Sciences.

AS.030.106. Introductory Chemistry Laboratory II. 1.0 Credit.
Laboratory work includes some quantitative analysis and the measurement of physical properties. Open only to those who are registered for or have completed Introductory Chemistry II (AS.030.102).
Permission required for pre-college students.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.;Students enrolled in AS.030.103 may not enroll in or receive credit for AS.030.106.;AS.030.107 OR ( AS.030.105 AND ( AS.030.101 OR EN.510.101 ) )
Instructor(s): J. Greco
Area: Natural Sciences.

AS.030.107. Chemical Principles w/lab: An Integrated Studio Course. 4.0 Credits.
An introduction to the fundamental principles of chemistry. The main topics to be covered are fundamental chemical reactions, stoichiometry and the balancing of chemical equations, solutions, gas laws, chemical equilibrium, acids and bases, and elementary chemical thermodynamics. Laboratory experiments and laboratory techniques will be incorporated into the course. Course will be run in three 2 hour blocks per week some of which will be used for lab. This course is equivalent to AS.030.101 and AS.030.105.
Prerequisites: This course is equivalent to AS.030.101 and AS.030.105.;Students enrolled in AS.030.107 may not enroll in AS.030.101, AS.030.105, AS.030.115, or AS.030.103.
Instructor(s): J. Greco
Area: Natural Sciences.

AS.030.110. Mini-term: Introduction to Bioorganic Chemistry. 1.0 Credit.
Meets M-F June 22nd - July 2nd. This interdisciplinary course is an introductory-level class to relate biological phenomena with basic principles of chemistry. Organic chemistry or biochemistry in college is one of the most stressful classes to some students and sometimes they are pushed by assignments and tests during the entire semester without having a chance to enjoy fun side of chemistry. This course will introduce some basic concepts of chemistry and organic chemistry and applications of those concepts into biological systems, in more enjoyable way with a smaller group of students than regular courses. The course aims biology-majors to get a molecular view and chemistry-majors to have fun to find how their chemical knowledge can be used to explain biological process. Also other students will learn about both and have an idea what interdisciplinary science is.
Instructor(s): H. Chung
Area: Engineering, Natural Sciences.

AS.030.112. Chemistry with Problem Solving I.
This course is for students who have had moderate or limited exposure to the subject. Special emphasis is placed on scientific problem-solving skills. There are two discussion sections per week, including one devoted exclusively to interactive quantitative problem solving. A typical student may have taken a year of descriptive chemistry as a high school sophomore, but has not been exposed to the problem-solving mathematical approach used in university-level science courses. Taken concurrently with AS.030.101 and AS.030.102.
Prerequisites: AS.030.101 OR AS.030.102
Instructor(s): A. Gittens; R. Harris.

AS.030.113. Chemistry with Problem Solving II.
This course is for students who have had moderate or limited exposure to the subject. Special emphasis is placed on scientific problem-solving skills. There are two discussion sections per week, including one devoted exclusively to interactive quantitative problem solving. A typical student may have taken a year of descriptive chemistry as a high school sophomore, but has not been exposed to the problem-solving mathematical approach used in university-level science courses. Taken concurrently with AS.030.101 and AS.030.102.
Instructor(s): S. Thyagarajan.

AS.030.114. Freshman Seminar: The Making of a Chemist. 3.0 Credits.
Students will be introduced to professional culture and practice in academic and industrial chemical research laboratories. Through reading and analysis of a few series of seminal papers from the 1800’s to the present leading to Nobel Prizes in Chemistry or Physics, students will learn how scientific inquiry and writing has evolved over time. Through discussion and practice, students will learn how to communicate chemistry in social media, scientific publications, scientific talks, and public lectures.
Instructor(s): R. Hernandez
Area: Natural Sciences
Writing Intensive.

AS.030.117. Chemistry in Art and Archaeology. 3.0 Credits.
From tracing trading routes to dating artifacts, explore the central science, chemistry, as it relates to the study of antiquities. Gain a general overview of non-destructive and destructive techniques for studying artifacts. Gain practical knowledge on how to implement quantitative and qualitative instrumentation in a laboratory and museum setting including. Visit a working museum laboratory to discuss the unique joys and challenges of archaeometry. Study recent advances with primary source analytical chemical material and assess practical future implementation of new techniques. Learn to tune communication style based upon an audience within and without your main discipline.
Instructor(s): M. Gallagher
Area: Natural Sciences.

AS.030.118. The Science of Color. 3.0 Credits.
This course is designed to introduce students to the fundamental physical and chemical origins of color and how we perceive them - from the vivid palette provided by the natural world to the brightly colored clothing we wear. Beginning with the basic principles of light and color, we will embark on an interdisciplinary investigation of color, including, but not limited to: color chemistry; color in biology; the physiology of the eye; how color affects human psychology; the history of color and light; and the use of color in art. Discover the physical and chemical explanations behind several noteworthy phenomena such as sunsets, color-blindness, rainbows, fireworks, chameleons and the Aurora Borealis.
Instructor(s): J. Young
Area: Natural Sciences.
AS.030.173. Powering Tomorrow: The Chemistry Behind Alternative Energy. 3.0 Credits.
One of the most important scientific challenges society faces today is supply of green and sustainable energy. This course will highlight the contributions of chemists in current and emerging technologies of alternative energy. A general overview of solar energy, biomass conversion, nuclear power and other approaches will be presented. The underlying chemical principles of these areas, such as water oxidation, carbon dioxide reduction and generation of liquid fuels will be examined. The current sources of energy used in today’s world and their impact on the environment will also be discussed. In class sessions, students will be expected to be actively involved in the discussion of lectures and assigned readings.
Prerequisites: Corequisite: AS.030.101 or AP 4 or 5.
Instructor(s): C. Rolle
Area: Natural Sciences.

AS.030.204. How Enzymes Work. 3.0 Credits.
This course will introduce core concepts in protein-catalyzed chemistry and is intended to provide a molecular level context for students interested in learning about biochemistry and bioengineering. Topics include protein structure, origins of enzyme catalysis, and types of enzyme reactions. These concepts will be expanded upon through a survey on the basic mechanisms of a selection of enzymes important to health, energy, and the environment. The emphasis will be on how enzymes perform chemical transformation, and their roles in medicinal and industrial applications.
Instructor(s): H. Kuo
Area: Natural Sciences.

AS.030.205. Introductory Organic Chemistry I. 4.0 Credits.
The fundamental chemistry of the compounds of carbon. Methods of structure determination and synthesis. The mechanisms of typical organic reactions and the relations between physical and chemical properties and structures.
Prerequisites: AS.030.102 OR AS.030.103 OR EN.510.101 OR AS.030.204
Instructor(s): C. Falzone; C. Townsend; M. Greenberg
Area: Natural Sciences.

AS.030.202. Chemical Structure and Bonding w/Lab. 4.0 Credits.
An introduction to the synthesis, structure, and reactivity of inorganic compounds. Modern approaches to chemical bonding, including molecular orbital, ligand field, and crystal field theories, will be applied to understanding the physical and chemical properties of inorganic materials. Other topics to be discussed include magnetic properties, electronic spectra, magnetic resonance spectra, and reaction kinetics. The integrated laboratory will cover basic synthetic, measurement, and calculation methods of inorganic chemistry.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.;AS.030.102 OR AS.030.103 OR an AP score of 5
Instructor(s): T. Mcqueen; V. Thoi
Area: Natural Sciences
Writing Intensive.

AS.030.206. Organic Chemistry II. 4.0 Credits.
Continuation of AS.030.205 Organic Chemistry I with special emphasis on organic synthesis and related synthetic methods. Students may not simultaneously enroll for AS.030.212 and AS.030.206.
Prerequisites: Pre-req: AS.030.205
Corequisites: Students may not simultaneously enroll for AS.030.212 and AS.030.206.
Instructor(s): E. Hill
Area: Natural Sciences.

AS.030.207. Problem Solving Methodology in Organic Chemistry I. 2.0 Credits.
This course will focus on the skills and strategies often utilized for solving problems in organic chemistry. In a seminar-style format, we will focus on a variety of strategies and techniques that students are otherwise expected to discover independently. This optional course is designed to help students succeed in Organic Chemistry I. The course is graded on a pass/fail basis, and is designed to be fun (believe it or not). Students work together in groups to solve challenging problems, focusing on the strategies necessary to solve each problem. This course is not required in order to succeed in Organic Chemistry I, but students in the past have found it to be helpful in guiding their study efforts for Organic Chemistry I.
Corequisites: Co-req: AS.030.205
Instructor(s): C. Falzone
Area: Natural Sciences.

AS.030.208. Problem Solving Methodology in Organic Chemistry II. 2.0 Credits.
This course will focus on the skills and strategies often utilized for solving problems in organic chemistry. In a seminar-style format, we will focus on a variety of strategies and techniques that students are otherwise expected to discover independently. This optional course is designed to help students succeed in Organic Chemistry II. The course is graded on a pass/fail basis, and is designed to be fun (believe it or not). Students work together in groups to solve challenging problems, focusing on the strategies necessary to solve each problem. This course is not required in order to succeed in Organic Chemistry II, but students in the past have found it to be helpful in guiding their study efforts for Organic Chemistry II.
Corequisites: Co-req: AS.030.206
Instructor(s): E. Hill
Area: Natural Sciences.

AS.030.212. Honors Organic Chemistry II with Applications in Biological and Materials Chemistry. 4.0 Credits.
Second semester undergraduate organic chemistry from an advanced prospective with connections to modern biological and materials chemistry. The standard topics of second semester organic chemistry (e.g. reactivity of aromatic and carbonyl containing molecules) will be covered with an emphasis on reaction mechanism to facilitate learning about reactivity and enriched with modern examples. In addition, the important role that organic chemistry plays in modern biological (e.g. nucleic acids and proteins) and materials science (e.g. living polymerization and the use of organic chemistry to control macroscopic properties) will be covered. Students may not simultaneously enroll for AS.030.212 and AS.030.206. Prereq: Must receive a B or better in the first semester (AS.030.205).
Prerequisites: Must receive a B or better in the first semester (AS.030.205)
Instructor(s): M. Greenberg
Area: Natural Sciences.
AS.030.213. Metalloproteins and Their Role in Human Disease. 3.0 Credits.
Many metal ions are essential elements for human life and health. Non-redox metals serve as charge carriers and are important in osmotic balance as well as proper protein folding and structure. Redox active transition metals, such as iron and copper are important in electron transfer, oxygen transportation, respiration, and neurotransmitter homeostasis. This course is designed to introduce students to the important biological roles of metal-protein interactions and possible diseases that may occur from their malfunction.
Prerequisites: Introductory Chemistry I II - AS.030.101 AND AS.030.102
Instructor(s): D. Quist.

AS.030.225. Introductory Organic Chemistry Laboratory. 3.0 Credits.
Laboratory work includes fundamental laboratory techniques and preparation of representative organic compounds. Open only to those who are registered for or have completed Introductory Organic Chemistry. Note: This one-semester course is offered each term. Introductory Organic Chemistry I/II requires one semester of the laboratory.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class. AS.030.205; ( EN.510.101 OR (AS.030.101 AND AS.030.102) OR AS.030.107) AND (AS.030.105 AND AS.030.106) OR AS.030.103 permission of instructor for freshmen.
Corequisites: Students may not simultaneously enroll for AS.030.225 and AS.030.227
Instructor(s): J. Greco; L. D’Souza
Area: Natural Sciences.

AS.030.227. Chemical Chirality: An Introduction in Organic Chem. Lab, Techniques. 3.0 Credits.
This is a project lab designed for Chemistry Majors who are concurrently enrolled in AS.030.205. Techniques for the organic chemistry laboratory including methods of purification, isolation, synthesis, and analysis will be explored through a project focused on chemical chirality. Students may not simultaneously enroll for AS.030.225 and AS.030.227.
Prerequisites: AS.030.206 OR AS.030.212; AS.030.205
Corequisites: Students may not simultaneously enroll for AS.030.225 and AS.030.227.
Instructor(s): E. Hill
Area: Natural Sciences.

AS.030.228. Intermediate Organic Chemistry Laboratory. 3.0 Credits.
Lab skills already acquired in AS.030.225 will be further developed for synthesis, isolation, purification, and identification of organic compounds. Spectroscopic techniques, applications will be emphasized. Recommended Course Background: AS.030.225
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.
Instructor(s): E. Hill
Area: Natural Sciences.

AS.030.270. Metals & Their Impact on Industry, Drug Development & Society. 3.0 Credits.
This is a seminar-based course that is broken up into three modules. The beginning of the course will focus on a basic introduction to the periodic table, in particular the transition metals. After a basic knowledge is formed the first theme will focus on the use of metals in the medical field, for example as MRI imaging agents or heavy metal poisoning. The second portion of the course will move away from the body and focus on how metals have impacted society. For example, we will look at the influence of metals in cars, the production of plastics and household chemicals. The final section will focus on how metals have influenced world power such as the invention of the atomic bomb. This course is designed to provide an overall understand of how chemistry and metals influence our lives every day.
Instructor(s): E. Joslin
Area: Natural Sciences.

AS.030.301. Physical Chemistry I. 3.0 Credits.
The laws of thermodynamics, their statistical foundation, and their application to chemical phenomena. Students should have knowledge of general physics, general chemistry, and calculus (two semesters recommended). Freshmen by permission only.
Instructor(s): R. Hernandez
Area: Natural Sciences.

AS.030.302. Physical Chemistry II. 3.0 Credits.
Introduction to quantum mechanics, its application to simple problems for which classical mechanics fails. Topics: Harmonic oscillator, hydrogen atom, very approximate treatments of atoms and molecules, and theoretical basis for spectroscopy. Recommended Course Background: AS.030.301
Instructor(s): K. Bowen
Area: Natural Sciences.

AS.030.303. Magic Bullets: How Drugs Really Work. 1.0 Credit.
This course will be an overview of the basic science behind frequently administered drugs. Medicines such as antibiotics, antivirals, cancer drugs, painkillers, and cardiovascular drugs will be covered. The course will focus on how these molecules cause a desirable effect in the body. Those with minimal background in chemistry/biology are encouraged to enroll.
Instructor(s): D. Marous
Area: Natural Sciences.

AS.030.305. Physical Chemistry Instrumentation Laboratory I. 3.0 Credits.
This course is designed to illustrate the principles of physical chemistry and to introduce the student to techniques and instruments used in modern chemical research. Chemistry majors are expected to take this sequence of courses, rather than AS.030.307. Chemistry majors only.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.
Instructor(s): A. Bragg; D. Fairbrother
Area: Natural Sciences.
AS.030.306. Physical Chemistry Instrumentation Laboratory II. 3.0 Credits.
Designed to illustrate the principles of physical chemistry, introduce the student to spectroscopic techniques and instruments used in modern chemical research. Chemistry majors are expected to take this course rather than 030.307.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.;AS.030.301 OR AS.030.302;Prerequisite: AS.030.305
Instructor(s): T. Kempa
Area: Natural Sciences.

AS.030.307. Experiments in Physical Chemistry for Engineers. 3.0 Credits.
This is a one-semester course which selects experiments that are most relevant to chemical engineering. Chemical Engineering majors only. Recommended Course Background: AS.030.301-AS.030.302 or equivalent.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.
Instructor(s): D. Fairbrother
Area: Natural Sciences.

AS.030.315. Biochemistry I. 4.0 Credits.
Foundation for advanced classes in Biophysics and other quantitative biological disciplines. Lecture and computer laboratory. This class is the first semester of a two semester course in biochemistry. Topics in Biochemistry I include chemical and physical properties of biomolecules and energetic principles of catabolic pathways. Computer labs include extensive use of molecular graphics and modelling of reaction kinetics and pathway flux. Co-listed with AS.250.315
Prerequisites: AS.030.206 OR AS.030.212
Instructor(s): P. Fleming
Area: Natural Sciences.

AS.030.316. Biochemistry II. 3.0 Credits.
Biochemical anabolism, nucleic acid structure, molecular basis of transcription, translation and regulation, signal transduction with an emphasis on physical concepts and chemical mechanisms. Format will include lectures and class discussion of readings from the literature.
Prerequisites: AS.030.315 OR AS.250.315 OR AS.020.305
Instructor(s): S. Rokita; S. Woodson
Area: Natural Sciences.

Students gain a critical understanding of societal energy sources in scientific, economic, and political contexts. Past, present, and future energy sources are discussed in terms of their scope and limitations. Emphasis on the fundamental details of each energy technology and incisive evaluation of policy regarding energy consumption and its environmental consequences. Topics include global warming and climate change, fossil fuels, alternative energies, and energy security and productivity.
Instructor(s): E. Brigham
Area: Natural Sciences.

AS.030.345. Chemical Applications of Group Theory. 3.0 Credits.
The theory of the representations of finite and continuous groups will be applied to problems in chemistry.
Instructor(s): D. Yarkony
Area: Natural Sciences.

AS.030.356. Advanced Inorganic Lab. 3.0 Credits.
Laboratory designed to illustrate the principles and practice of inorganic chemistry through the synthesis and characterization of transition metal and organometallic compounds. Methods used include vacuum and inert atmosphere techniques. Instrumental approaches and modern spectroscopic techniques are applied to the characterization of compounds generated. It is strongly recommended that students have taken or are taking one of the following courses: AS.030.204, AS.030.442, AS.030.449, or AS.030.472.
Prerequisites: AS.030.228
Instructor(s): E. Hill
Area: Natural Sciences.

AS.030.370. Biophysical Chemistry. 4.0 Credits.
Course provides working understanding of physical chemistry of the cell, emphasizing problem solving. Topics include classical and statistical thermodynamics, thermodynamics of proteins and nucleic acids, protein folding, calorimetry, ligand binding thermodynamics, linkage, cooperativity and anticooperativity, allosteric models, lattice statistics, helix-coil transition, and polymer theory. When appropriate, students visit the laboratory to set up data collection and learn to analyze the resulting data computationally, using nonlinear least-squares methods.
Prerequisites: Prereqs: ( AS.171.101 OR AS.171.103 OR AS.171.107 ) AND ( AS.171.102 OR AS.171.104 OR AS.171.108 ) AND ( AS.030.103 OR AS.030.102 ) AND ( AS.110.106 OR AS.110.108 ) AND ( AS.110.107 OR AS.110.109 )
Instructor(s): D. Barrick
Area: Natural Sciences.

AS.030.371. Chemistry for Connoisseurs. 3.0 Credits.
This course will survey the structural and physical properties of chemicals often considered as part of the “finer things in life” including topical discussions of the chemistries of food, drink, art, cosmetics and clothing, among others. Despite the pretentious name, the general theme of the course is to put chemical identities onto the things we interact with on a daily basis but most likely take for granted at a molecular level. Current event topics in consumer chemistry will also be covered (melamine in milk, “shoe rubber” in bread, etc.). Students will have the chance to research and present topics of interest, and there will be field trips. Open to Freshmen and Sophomores ONLY.
Prerequisites: One semester of college-level organic chemistry (AS.030.205 or equivalent).
Instructor(s): J. Tovar
Area: Natural Sciences.

AS.030.400. A Survey of Medicinally and Environmentally Important Metallo-enzymes and their Mechanisms. 3.0 Credits.
Metallo-proteins are responsible for many physiological processes ranging from DNA biosynthesis, to detoxification, to respiration. The beginning of the course will review core concepts in protein chemistry including protein structures and dynamics, principles of catalysis and end enzyme kinetics, and tools to probe enzyme mechanisms. These concepts will be expanded upon in the second half of the course through focus on the molecular mechanisms of redox-active metallo-enzymes. A survey of the structure and function relationships within these enzymes will be offered with select examples of heme, iron, and copper-containing proteins that are important to drug development, energy production, and environmental sustainability.
Prerequisites: AS.030.206 OR AS.030.212
Instructor(s): H. Kuo
Area: Natural Sciences.
AS.030.402. Experimental Methods in Physical Chemistry. 3.0 Credits.
This course introduces the student to experimental methodologies used in gas phase physical chemistry. Topics to be covered include vacuum technology, charged particle optics, lasers, mass spectrometry, data acquisition, detectors, measurement of temperature and pressure, and design and fabrication of scientific apparatus. These topics will be tied together with examples of specific experimental studies.
Instructor(s): K. Bowen
Area: Natural Sciences.

AS.030.403. Optoelectronic Materials and Devices: Synthesis, Spectroscopy, and Applications. 3.0 Credits.
This course provides an introduction to the vast chemistry and physics of solid-state materials. The course begins with a fundamental description of bonding in crystalline solids and calculation of electronic band structure. We then extend our discussion to methods for the synthesis of low-dimensional materials and hierarchical structures, including quantum dots (0D), nanowires (1D), graphene and graphene analogs (2D), and thin-film superlattices. An in-depth discussion of spectroscopic and characterization techniques for solid-state materials will follow and focus on some of the foundational studies of quantum devices and cooperative phenomena. At this stage we will describe recent advances in electron-microscopy (e.g. aberration-corrected and energy filtered TEM, atom-probe tomography) that are revolutionizing the structural, compositional, and electronic characterization of materials. The course will conclude with a survey of contemporary topics in solid-state and nanomaterials science, including functional devices and circuits, assembly, energy conversion and catalysis, and biological sensing. Recommended Course Background: AS.030.301 and AS.030.402 are preferred, but instructor approval may be granted in lieu of these courses.
Instructor(s): T. Kempa
Area: Natural Sciences.

AS.030.404. Electrochemical Systems for Energy Conversion and Storage. 3.0 Credits.
This course will be focused on the fundamentals and applications of electrochemical methods in catalysis, charge transport, and energy conversion and storage. Topics that will be covered are basic electrochemical techniques, homogenous and heterogeneous (photo)electrocatalysis, fuel cells, and charge storage devices. The class will conclude with a group report and presentation on a recent development in the field of energy catalysis, conversion, and storage. Course topics include: 1) Fundamentals of electrochemistry, 2) Potential sweep methods and current-controlled techniques, 3) Impedance analysis, 4) Electrochemistry coupled with other characterization methods, 5) Electrocatalysis and photoelectrochemical catalysis, 6) Basics in fuel cells and current technologies (alkaline, polymer exchange membrane, solid oxide...), 7) Basics in batteries and current technologies (Pb acid, Li-based, other metals...) Recommended Course Background: AS.030.204 or AS.030.449 or AS.030.472, or instructor approval for undergraduate students. No pre-requisites for graduate students.
Instructor(s): V. Thoi
Area: Natural Sciences.

AS.030.405. Introduction to Computational Chemistry. 3.0 Credits.
This course provides an introduction to the state-of-the-art computational chemistry. The course integrates the basics about molecular electronic structure theories and the corresponding computational aspects and practice in chemical applications. The discussions of theories cover the modern quantum-chemical methods, ranging from mean-field methods (Hartree-Fock method and density-functional theory) to post mean-field methods for treating electron-correlation effects (configuration interaction and coupled cluster). Demonstrative calculations and computer lab practice are designed to deal with the computation of energetic properties (e.g., heat of formation, bond dissociation energy, reaction activation energy, etc) and structural properties (geometry, vibrational frequencies, etc) of representative molecular systems using standard quantum chemistry program package (the Gaussian program, most probably). The class will conclude with a report and presentation on a piece of recent computational work pertinent to the student’s research interests.
Instructor(s): L. Cheng.

AS.030.407. Modeling Matter at Nanoscales: An Introduction to Theoretical and Computational Approaches. 3.0 Credits.
The course allows students to become familiar with the essentials of concepts for modeling the structure of matter at nanoscales and the depending properties, as well as the way that they relate with measurements at human scales. Concepts on modeling, computer representation of nanosystems, origin of interactions between bodies at nanoscales and the different ways of finding the corresponding potential energy surfaces, including both classical and quantum mechanical procedures and described and even detailed when relevant. Applications can be on life materials, or other nanoscopic environments. It is designed for advanced undergraduate and graduate students in Chemistry, Physics, Biology, Pharmacy and Biochemistry, as well as physicians and engineers. Attendants must handle an essential ground in Mathematics, General Physics, Chemistry and related matters.
Instructor(s): L. Montero-Cabrera.

AS.030.420. Transforming Pharmaceutical and Materials Industries: Metal-Catalyzed Cross Coupling Reactions. 3.0 Credits.
Pharmaceutical and Material Industries have immensely benefited since the advent of metal-catalyzed cross-coupling bond forming methods. Most undergraduate organic chemistry courses do not emphasize the potential of these reactions. This course will discuss the synthesis of a variety of commercially available drugs and materials currently synthesized via transition metal-catalyzed cross-coupling methods.
Prerequisites: AS.030.205 AND AS.030.206
Instructor(s): S. Surampudi
Area: Natural Sciences.

AS.030.441. Spectroscopic Methods of Organic Structure Determination. 3.0 Credits.
The course provides fundamental theoretical background for and emphasizes practical application of ultraviolet/visible and infrared spectroscopy, proton and carbon-13 nuclear magnetic resonance and mass spectrometry to the structure proof of organic compounds.
Instructor(s): J. Tovar
Area: Natural Sciences.

AS.030.442. Organometallic Chemistry. 3.0 Credits.
An introduction to organometallic chemistry beginning with structure, bonding, and reactivity and continuing into applications to fine chemical synthesis and catalysis. Recommended Course Background: AS.030.449 or equivalent. Level: Upper level Undergraduate AND Graduate Students.
Instructor(s): S. Thyagarajan
Area: Natural Sciences.
AS.030.446. Mathematica as a Tool for Chemists. 3.0 Credits.
A systematic, hands-on introduction to Mathematica. Covers Mathematica's basic "language," analytic and numerical calculations, data manipulation, graphical representation, interactivity, programming, and document production. Prerequisite: Calculus (including power series)
Instructor(s): H. Silverstone
Area: Natural Sciences.

AS.030.449. Chemistry of Inorganic Compounds. 3.0 Credits.
Physical and chemical properties of inorganic, coordination and organometallic compounds are discussed in terms of molecular orbital, ligand field and crystal field theories. Emphasis on structure and reactivity of these inorganic compounds. Other topics: magnetic properties, electronic spectra, magnetic resonance spectra, reaction kinetics.
Instructor(s): K. Karlin
Area: Natural Sciences.

AS.030.451. Spectroscopy. 3.0 Credits.
Spectroscopy and structure of molecules starting from rotational, vibrational and electronic spectra of diatomic molecules and extending to polyatomic molecules as time permits. Recommended Course Background: AS.030.302 or permission of instructor.
Instructor(s): L. Cheng; P. Dagdigian
Area: Natural Sciences.

AS.030.452. Materials & Surface. 3.0 Credits.
The chemistry associated with surfaces and interfaces as well as a molecular level understanding of their essential roles in many technological fields. The first half of this course addresses various analytical techniques used to study surfaces including X-ray, photoelectron spectroscopy, and scanning tunneling microscopy. The second half of this course uses a number of case studies to illustrate the application of surface analytical techniques in contemporary research.
Instructor(s): D. Fairbrother
Area: Natural Sciences.

AS.030.453. Intermediate Quantum Chemistry. 3.0 Credits.
The principles of quantum mechanics are developed and applied to chemical problems. Prerequisites: ( AS.030.301 OR AS.030.370 OR AS.250.372 ) AND AS.030.302
Instructor(s): L. Cheng
Area: Natural Sciences.

AS.030.472. Advanced Inorganic & Organometallic Reactions Mechanisms. 3.0 Credits.
The beginning of the course will focus on the basics of organometallic chemistry such as molecular orbital theory, agostic bonding, electronic structure and coordination geometries. These topics would then be followed with common reactions in organometallic chemistry such as ligand substitution, oxidation addition, and reductive elimination. The final set of topics will cover the basic "tools of the trade" which will encompass kinetics, dynamic NMR spectroscopy, kinetic isotope effects and mechanistic studies.
Prerequisites: Prerequisite: AS.030.206 OR AS.030.212
Instructor(s): E. Joslin
Area: Natural Sciences.

AS.030.501. Independent Research in Physical Chemistry I. 3.0 Credits.
Research under the direction of members of the physical chemistry faculty.
Instructor(s): D. Fairbrother; D. Yarkony; L. Cheng; R. Hernandez.

AS.030.502. Independent Research in Physical Chemistry. 0.0 - 3.0 Credits.
Research under the direction of members of the physical chemistry faculty.
Instructor(s): D. Fairbrother; K. Bowen; L. Cheng; R. Hernandez.

AS.030.503. Independent Research in Inorganic Chemistry I. 3.0 Credits.
Research under the direction of members of the inorganic chemistry faculty.
Instructor(s): D. Goldberg; J. Roth; K. Karlin; T. Lectka.

AS.030.504. Independent Research in Inorganic Chemistry. 0.0 - 3.0 Credits.
Research under the direction of members of the inorganic chemistry faculty.
Instructor(s): D. Goldberg; G. Meyer; J. Roth; K. Karlin; V. Thoi.

AS.030.505. Independent Research in Organic Chemistry I. 3.0 Credits.
Research under the direction of members of the organic chemistry faculty.
Instructor(s): Staff.

AS.030.506. Independent Research in Organic Chemistry I. 0.0 - 3.0 Credits.
Research under the direction of members of the organic chemistry faculty.
Instructor(s): Staff.

AS.030.507. Independent Research in Biochemistry. 3.0 Credits.
Research under the direction of members of the biochemistry faculty.
Instructor(s): Staff.

AS.030.509. Independent Research in Biochemistry II. 3.0 Credits.
Research under the direction of members of the biochemistry faculty. Recommended Course Background: AS.030.507-AS.030.508 and permission of instructor.
Instructor(s): C. Townsend; J. Tolman.

AS.030.510. Independent Research in Biochemistry II. 0.0 - 3.0 Credits.
Research under the direction of members of the biochemistry faculty. Recommended Course Background: AS.030.507-AS.030.508 and permission of instructor.
Instructor(s): C. Falzone; C. Townsend; J. Tolman.

AS.030.511. Independent Research in Materials Chemistry. 0.0 - 3.0 Credits.
Instructor(s): T. Mcqueen.

AS.030.512. Independent Research in Materials Chemistry. 0.0 - 3.0 Credits.
Research under the direction of the materials chemistry faculty.
Instructor(s): T. Mcqueen.

AS.030.521. Independent Research in Inorganic Chemistry II. 3.0 Credits.
Research under the direction of the inorganic chemistry faculty. Recommended Course Background: AS.030.503-AS.030.504 and permission of instructor.
Instructor(s): C. Falzone; D. Goldberg; J. Roth; K. Karlin.

AS.030.522. Independent Research in Inorganic Chemistry II. 0.0 - 3.0 Credits.
Research under the direction of the inorganic chemistry faculty. Recommended Course Background: AS.030.503-AS.030.504 and permission of instructor.
Instructor(s): D. Goldberg; G. Meyer; J. Roth.
AS.030.523. Independent Research in Physical Chemistry II. 3.0 Credits. 
Research under the direction of the physical chemistry faculty. 
Recommended Course Background: AS.030.501-AS.030.502 and permission of instructor. 
Instructor(s): D. Fairbrother; K. Bowen; L. Cheng; R. Hernandez.

AS.030.524. Independent Research in Physical Chemistry II. 0.0 - 3.0 Credits. 
Research under the direction of the physical chemistry faculty. 
Recommended Course Background: AS.030.501-AS.030.502 and permission of instructor. 
Instructor(s): D. Fairbrother.

AS.030.525. Independent Research in Organic Chemistry II. 3.0 Credits. 
Research under the direction of the organic chemistry faculty. 
Recommended Course Background: AS.030.505-AS.030.506 and permission of instructor. 
Instructor(s): J. Toscano; M. Greenberg; T. Lectka.

AS.030.526. Independent Research in Organic Chemistry II. 0.0 - 3.0 Credits. 
Instructor(s): J. Toscano; M. Greenberg; T. Lectka.

AS.030.527. Independent Study. 3.0 Credits. 
Instructor(s): D. Fairbrother.

AS.030.528. Independent Study. 0.0 - 3.0 Credits. 
Instructor(s): D. Fairbrother.

AS.030.530. Independent Research in Inorganic and Materials Chemistry. 1.0 - 3.0 Credits. 
Research under the direction of members of the Inorganic Chemistry faculty. 
Instructor(s): V. Thoi.

Research under the direction of members of the Physical Chemistry faculty. 
Instructor(s): T. Kempa.

AS.030.551. Internship-Chemistry. 1.0 Credit. 
Instructor(s): Staff.

AS.030.552. Internship - Chemistry. 1.0 Credit. 
Instructor(s): Staff.

AS.030.592. Research-Inorganic Chemistry I. 3.0 Credits. 
Instructor(s): G. Meyer; M. Greenberg.

AS.030.593. Research-Organic Chemistry I. 3.0 Credits. 
Instructor(s): M. Greenberg; T. Lectka.

AS.030.597. Research - Summer. 3.0 Credits. 
Instructor(s): Staff.

An introduction to statistical mechanics of cooperative phenomena using lattice gases and polymers as the main models. Covered topics: phase transitions and critical phenomena, scaling laws, and the use of statistical mechanics to describe time dependent phenomena. 
Instructor(s): R. Hernandez.

AS.030.610. Chemical Kinetics. 
The molecular mechanism of elementary physical and chemical rate processes will be studied. Topics such as elastic scattering, collisional vibrational and rotational energy transfer, chemically reactive collisions, and the theory of unimolecular decay will be covered. 
Instructor(s): K. Bowen.

AS.030.613. Chemistry-Biology Interface Program Forum I. 
Chemistry-Biology Interface (CBI) program students and faculty will meet weekly in a forum that will host presentations from CBI faculty and students as well as invited guest speakers. These meetings will serve as a valuable opportunity for students to develop presentation skills and interact with CBI students and faculty. Enrollment is required for first- and second-year CBI students, and is recommended for advanced-year graduate students. 
Instructor(s): S. Rokita.

AS.030.614. Chemical-Biology Program Interface Forum II. 
Chemistry-Biology Interface (CBI) program students and faculty will meet weekly in a forum that will host presentations from CBI faculty and students as well as invited guest speakers. These meetings will serve as a valuable opportunity for students to develop presentation skills and interact with CBI students and faculty. Enrollment is required for first- and second-year CBI students, and is recommended for advanced year graduate students. 
Instructor(s): S. Rokita.

AS.030.615. Bioinorganic Chemistry. 
Instructor(s): D. Goldberg.

AS.030.619. Chemical Biology I. 
Parts I and II constitute the core course of the Chemistry-Biology Interface (CBI) Program. An introduction to the structure, synthesis, reactivity, and function of biological macromolecules (proteins, nucleic acids, carbohydrates, and lipids) will be provided using the principles of organic and inorganic chemistry. Discussion will incorporate a broad survey of molecular recognition and mechanistic considerations, and introduce the tools of molecular and cellular biology that are utilized in research at the interface of chemistry with biology and medicine. 
Recommended Course Background: AS.030.206 or equivalent. 
Instructor(s): S. Rokita.

AS.030.620. Chemical Biology II. 
Selected topics of current importance in chemical biology are covered. They include protein engineering and proteomics, cell signaling, protein-nucleic acid interactions (e.g. replication, transcription, DNA repair), catalytic RNA and the ribosome, biosynthesis of natural products, mechanisms of drug action, combinatorial chemistry and chemical genetics, and in vitro selection. Recommended Course Background: AS.030.619 or permission required. 
Instructor(s): S. Rokita.

AS.030.621. Literature-Organic Chemistry. 
Instructor(s): L. Cheng.

AS.030.622. Seminar: Literature of Chemistry. 
Seminars are presented by advanced graduate students on topics from current chemical journals. Most first-year graduate students are expected to attend for credit. Undergraduates may take the course on a satisfactory/unsatisfactory basis. 
Instructor(s): L. Cheng.
Principles and methods for the design and optimization of new biological systems, from a molecular perspective. Topics include: introduction to genetic parts and modern methods for their assembly; synthesis and incorporation of nucleic acids at the level of nucleotides, genes, and genomes; design of genetic programs; library generation and screening; directed evolution and its application to create new proteins and metabolic pathways; computational design of protein and RNA using physical and bioinformatic approaches; non-canonical amino acids and genetic code expansion. This course will also feature critical evaluation of the primary literature in this fast-paced field, and practical experience with relevant software and computational tools.
Instructor(s): S. Fried.

AS.030.625. Advanced Mechanistic Organic Chemistry I.
The course covers the application of techniques in physical chemistry to the study of organic reaction mechanisms. Topics include chemical bonding and structure, stereochemistry, conformational effects, molecular orbital theory, methods to determine reaction mechanisms, reactive intermediates, and photochemistry. Recommended Course Background: AS.030.205-AS.030.206
Instructor(s): J. Tovar.

AS.030.626. Advanced Mechanistic Organic Chemistry II.
This course covers advanced organic reactions and their mechanisms. Emphasis is given both to methods of postulating mechanisms for rationalizing reaction results and to the use of mechanistic thinking for designing reactions and reagents. This course is intended to be taken in sequence with AS.030.425. Recommended Course Background: AS.030.205-AS.030.206
Instructor(s): R. Klausen.

AS.030.630. Molecular Photophysics and Photochemistry.
This course will introduce fundamental physical, chemical, and analytical concepts underlying light-induced chemical and (molecular-based) material processes. The final weeks of this course will build from these core concepts to survey molecular photoresponses and their consequences or applications in environmental chemistry, chemical biology, and materials science.
Instructor(s): A. Bragg
Area: Natural Sciences.

AS.030.634. Topics in Bioorganic Chemistry.
Selected topics in modern bioorganic chemistry will be treated in greater depth emphasizing natural products chemistry, biosynthetic reaction mechanisms and drug design. Carbohydrates, lipids, polyketides, polypeptides, terpenes and alkaloids will be discussed. Specific examples of drug design will be introduced throughout and methods of synthesis, combinatorial synthesis and genetics will be described.
Instructor(s): C. Townsend.

AS.030.635. Mthds Nuc Mag/Resonance.
Instructor(s): J. Tolman.

AS.030.652. A Theoretical and Experimental Approach to X-ray Crystallography.
The X-ray course will provide a complete approach to X-ray structure determination (mostly concerned with small molecules) and its uses in Chemistry. The first segment of this course will cover all theoretical aspects of X-ray crystallography, i.e. crystals and crystallization, the nature of X-rays, the diffraction phenomenon of X-rays by crystals, symmetry and space groups, crystal structure analysis. Additionally, the course will provide laboratory experience for the students, involving hands-on instrumentation, experimental methodology to X-ray structure determination, structure solution/refinement, data analyses and publishing data. The course is aimed for graduate students with a strong interest in organic/inorganic chemistry, materials sciences, and physics.
Undergraduate students with a major in chemistry are also encouraged to participate.
Instructor(s): M. Siegler
Area: Natural Sciences.

AS.030.677. Advanced Organic Synthesis I.
The reactions and principles involved in the synthesis of simple and complex organic compounds. Discussion of famous natural product syntheses and practice in developing rational designs for organic syntheses. Problems in the design of syntheses and in the use of chemical literature.
Instructor(s): T. Lectka.

AS.030.678. Advanced Organic Synthesis II.
Advanced discussion of organic stereochemistry & its application to problems in asymmetric reactions and catalysis will be presented. Emphasis will be placed on the latest reports in the literature, especially with respect to the development of new catalytic, asymmetric processes.
Instructor(s): T. Lectka.

The course is designed to provide the essential principles and concepts underlying the modern study of the structure and properties of solids in bulk crystals, thin films, and nanoscale objects. Topics include basic crystallography, structure determination by x-ray, neutron, and electron diffraction, fundamental concepts of bonding in solids, lattice dynamics, electronic band structure, magnetism, and strongly correlated electron behavior. Particular emphasis is placed on the impact of the structure, dimensionality, and electron count on electrical and magnetic properties (electric conduction, superconductivity, thermoelectricity, etc). More course info available at <a href="http://occamy.chemistry.jhu.edu">http://occamy.chemistry.jhu.edu</a>.
Cross-listed with Physics and Astronomy.
Instructor(s): T. Mcqueen.

In this course we will survey common time-resolved spectroscopic methods used to interrogate the dynamic and static properties of chemical systems. We will explore theoretical treatments both of key molecular processes (e.g. radiative and non-radiative transitions, solvation, coherence dephasing) and the spectroscopic tools used to interrogate them. Furthermore, we will survey the technical developments that are now allowing us to capture events that occur on ever faster timescales (currently down to the attosecond regime) and across the electromagnetic spectrum (from X-rays to Terahertz). Previous or concurrent concentrated study of Quantum Mechanics (graduate level or from a physics course) would be helpful, but not strictly required.
Recommended Course Background: AS.030.301-AS.030.302
Instructor(s): A. Bragg.

AS.030.801. Independent Study.
Instructor(s): Staff.
Open to AS Chemistry Graduate Students only.
Instructor(s): G. Meyer.

Cross Listed Courses

Biophysics
AS.250.310. Exploring Protein Biophysics using Nuclear Magnetic Resonance (NMR) Spectroscopy. 3.0 Credits.
NMR is a spectroscopic technique which provides unique, atomic level insights into the inner workings of biomolecules in aqueous solution. A wide variety of biophysical properties can be studied by NMR. For example, we can use the technique to determine three dimensional structure of biological macromolecules such as proteins and nucleic acids, probe their dynamical properties in solution, study their interaction with other molecules and understand how physico-chemical properties (such as electrostatics and redox chemistry) affects and modulates structure-function relationships. NMR exploits the exquisite sensitivity of magnetic properties of atomic nuclei to their local electronic (and therefore, chemical) environment. As a result, biophysical properties can be studied at atomic resolution. That is to say, we can deconstruct global properties of a molecule in terms of detailed, atomic level information. In addition, interactions between nuclei can be exploited to enhance the information content of NMR spectra via multi-dimensional (2D and 3D) spectroscopy. Since these properties can be studied in solution, NMR methods serve as an effective complement to X-Ray crystallography, which also provides detailed, atomic level information in the solid state. In this course, we will learn about the basics of NMR spectroscopy, acquire 1D and 2D NMR spectra and use various NMR experiments to characterize and probe biophysical properties of proteins at an atomic level. Juniors and Seniors Only.
Prerequisites: ((AS.030.101 AND AS.030.105) OR (AS.030.103 OR AS.030.204)) AND (AS.030.370 OR AS.250.372) AND (AS.020.305 OR AS.030.315 OR AS.250.315) AND AS.030.205 or permission of the instructor.
Instructor(s): A. Majumdar.

AS.250.315. Biochemistry I. 4.0 Credits.
Foundation for advanced classes in Biophysics and other quantitative biological disciplines. Lecture and computer laboratory. This class is the first semester of a two semester course in biochemistry. Topics in Biochemistry I include chemical and physical properties of biomolecules and energetic principles of catabolic pathways. Computer labs include extensive use of molecular graphics and modelling of reaction kinetics and pathway flux. Co-listed with AS.030.315
Prerequisites: If you have completed AS.250.307 you may not register for AS.250.315; Prerequisites: AS.030.206 OR AS.030.212
Instructor(s): P. Fleming
Area: Natural Sciences.

AS.250.372. Biophysical Chemistry. 4.0 Credits.
Course covers classical and statistical thermodynamics, spanning from simple to complex systems. Major topics include the first and second law, gases, liquids, chemical mixtures and reactions, conformational transitions in peptides and proteins, ligand binding, and allostery. Methods for thermodynamic analysis will be discussed, including calorimetry and spectroscopy. Students will develop and apply different thermodynamic potentials, learn about different types of ensembles and partition functions. Students will learn to use Mathematica and will use it for data fitting and for statistical and mathematical analysis. Background: Calculus, Organic Chemistry, and Introductory Physics.
Instructor(s): D. Barrick
Area: Natural Sciences.