CHEMISTRY

https://chemistry.jhu.edu/

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 LCQ ion trap mass spectrometer with electrospray ionization (APCI available as an option).
- Finnigan LCQ 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 two 600, and an 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 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.

Programs

- Chemistry, Bachelor of Arts (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/chemistry/chemistry-bachelor-arts/)
- Chemistry, PhD (https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/degree-programs/chemistry/chemistry-phd/)

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

Courses

AS.030.101. Introductory Chemistry I. 3 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.
Area: Natural Sciences

AS.030.102. Introductory Chemistry II. 3 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
Prerequisite(s): AS.030.101 OR AS.030.107;Students enrolled in AS.030.103 may not enroll in or receive credit for AS.030.102.
Area: Natural Sciences

AS.030.103. Applied Chemical Equilibrium and Reactivity w/lab. 4 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.phpStudents 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.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences

AS.030.104. Applications of Chemistry in Medicine. 1 Credit.
Chemistry is one of the oldest scientific disciplines through major contributions have been made in various fields such as health care, medicine, pharmaceutical sciences, materials and polymer science and forensic chemistry, to name a few. The development of new drugs involves chemical analysis and synthesis of new compounds. Chemistry also plays a vital role in the development and growth of several consumer-based industries such as pigments and paints, pharmaceuticals, cosmetics and oil and natural gas. In this program, students will be introduced to applications of chemistry in medicine and pharmaceutical sciences. Prerequisite: Background in chemistry and biology. Learning Objectives (LO) In this program, students will: ? Expand the breadth and depth of understanding of specific applications of chemistry in medicine, including acids and bases, buffers, spectroscopy, nuclear chemistry, chemical analysis and drug synthesis and purification? Research problems related to applications of chemistry in medicine? Demonstrate ability to interpret and explain different aspects of chemical and physical properties of drugs ? Provide working knowledge of biochemistry and how it is directly related to understanding disease and drug therapy ? Discuss and describe various instrumental and spectroscopic tools to detect and treat diseases

AS.030.105. Introductory Chemistry Laboratory I. 1 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.
Prerequisite(s): Students must have completed or be enrolled in AS.030.101 OR EN.510.101 to register for AS.030.105.;Students enrolled in AS.030.105 may not enroll in AS.030.115, AS.030.103, or AS.030.107.;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences

AS.030.106. Introductory Chemistry Laboratory II. 1 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.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;AS.030.107 OR (AS.030.105 AND (AS.030.101 OR EN.510.101));Students enrolled in AS.030.103 may not enroll in or receive credit for AS.030.106.
Area: 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.Students who have received an AP4 or higher are not considered eligible for this course and should not enroll.
Prerequisite(s): AS.030.101 OR AS.030.102

AS.030.113. Chemistry with Problem Solving II. 2 Credits.
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.

AS.030.204. Chemical Structure and Bonding w/Lab. 4 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.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;AS.030.102 OR AS.030.103 OR an AP score of 5
Area: Natural Sciences
Writing Intensive

AS.030.205. Introductory Organic Chemistry I. 4 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.
Prerequisite(s): AS.030.102 OR AS.030.103 OR EN.510.101 OR AS.030.204.
Area: Natural Sciences

AS.030.206. Organic Chemistry II. 4 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.
Prerequisite(s): AS.030.205
Corequisite(s): Students may not simultaneously enroll for AS.030.212 and AS.030.206.
Area: Natural Sciences

AS.030.212. Honors Organic Chemistry II. 4 Credits.
Second semester undergraduate organic chemistry from a more advanced prospective, emphasizing connections to modern examples from biochemistry (protein and DNA structure, chemical logic of metabolism, enzyme mechanisms), catalysis, materials (polymer synthesis, supramolecular chemistry), medicine (drug structure and function) and more. The standard topics of second semester organic chemistry (e.g. reactivity of aromatic and carbonyl-containing molecules) will all be covered, but amplified and enriched with topics as noted. Students may not simultaneously enroll in AS.030.212 and AS.030.206. Prereq: Must receive a B or better in the first semester (AS.030.205)
Prerequisite(s): Must receive a B or better in the first semester (AS.030.205)
Area: Natural Sciences

AS.030.225. Introductory Organic Chemistry Laboratory. 3 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.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;AS.030.205, earned credit or concurrent enrollment.; ((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.
Corequisite(s): Students may not simultaneously enroll for AS.030.225 and AS.030.227
Area: Natural Sciences

AS.030.227. Chemical Chirality: An Introduction in Organic Chem. Lab, Techniques. 3 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.
Prerequisite(s): AS.030.205 may be taken at the same time or prior to enrolling in AS.030.227.;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Corequisite(s): Students may not simultaneously enroll for AS.030.225 and AS.030.227.
Area: Natural Sciences

AS.030.228. Intermediate Organic Chemistry Laboratory. 3 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
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;AS.030.205 AND (AS.030.225 OR AS.030.227);(AS.030.206 OR AS.030.212)
Area: Natural Sciences

AS.030.245. Quantitative Analytical Laboratory. 3 Credits.
This is a 3 credit lab that will serve as an introduction into analytical techniques and quantitative methods. There will be a 1 hour of pre-lab lecture component to this course to discuss the lab for that day.
Prerequisite(s): ((AS.030.101 & AS.030.102) OR AS.030.103) AND AS.030.205

AS.030.301. Physical Chemistry I. 3 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.
Area: Natural Sciences

AS.030.302. Physical Chemistry II. 3 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
Area: Natural Sciences

AS.030.305. Physical Chemistry Instrumentation Laboratory I. 3 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.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module..
Area: Natural Sciences

AS.030.306. Physical Chemistry Instrumentation Laboratory II. 3 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.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.;AS.030.301 OR AS.030.302;AS.030.305
Area: Natural Sciences

AS.030.315. Biochemistry I. 4 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
Prerequisite(s): AS.030.206 OR AS.030.212;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences

AS.030.356. Advanced Inorganic Lab. 3 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.
Prerequisite(s): AS.030.228
Area: Natural Sciences

AS.030.371. Chemistry for Connoisseurs. 3 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 as they arise. Students will have the chance to research topics of interest. The course material will be enriched by the contributions from special guest lecturers and occasional field trips.
Prerequisite(s): AS.030.205 or equivalent
Area: Natural Sciences
Writing Intensive

AS.030.403. Optoelectronic Materials and Devices: Synthesis, Spectroscopy, and Applications. 3 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 describerecent 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.
Area: Natural Sciences

AS.030.404. Electrochemical Systems for Energy Conversion and Storage. 3 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
Area: Natural Sciences

AS.030.405. Introduction to Computational Chemistry. 3 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.

AS.030.415. Bioinorganic and Organometallic Chemistry. 3 Credits.
This course will cover key concepts of Bioinorganic chemistry (including metalloenzymes, synthetic catalysts, drugs, and molecular sensors) and Organometallic Chemistry (types of ligands, interactions with metals) and their applications in catalysis and bioinorganic chemistry. A background in organic chemistry and physical chemistry I is strongly recommended.
Prerequisite(s): (AS.030.101 AND AS.030.102) AND (AS.030.205 AND AS.030.206)

AS.030.417. Metallo(bio)chemistry of Molecular Oxygen. 1.5 Credits.
This advanced (but descriptive) course focuses on how transition metals of the first row, i.e., iron, manganese and copper), process molecular oxygen (O2) in metalloenzymes and coordination complexes. Chemical behavior discussed will be reversible O2-binding (e.g., blood dioxygen carriers and their synthetic analogs), insertion of one or both atoms of molecular oxygen into organic substrates (i.e., oxygenase activity), or oxidase (bio)chemistry, wherein the metal ion center facilitates O2-reduction to hydrogen peroxide or water. The focus will be on the metal's role and mechanism of action. Practical societal applications will also be discussed.
Prerequisite(s): AS.030.449 or equivalent

AS.030.421. Data Science Tools for the Chemical and Materials Sciences. 3 Credits.
Advances in measurement techniques and simulations have driven an explosion in the variety, quality, and quantity of data collected when investigating chemical and materials processes. Advances in computing have led to the practicality of machine learning (ML) and related analytical methods to explore and extract meaning from this cornucopia of data, and data science has been called the fourth pillar of the scientific method. This course will provide an introduction to modern tools of data science, including the Python programming language, Jupyter notebooks, ML algorithms and their practical implementation, and high performance computing, with specific emphasis on applying these tools to data of chemical relevance, including UV/Vis, IR and NMR spectra, 3-D micro computed tomography, and physical property data including specific heat, magnetization, and resistivity.

AS.030.424. Molecular Synthetic Biology. 3 Credits.
Synthetic Biology is changing the world around us. This course is designed to help you to understand these powerful emerging technologies and the science behind it, and to help prepare you if you want to contribute toward these exciting developments.
Prerequisite(s): AS.030.315 OR AS.020.305
Writing Intensive

AS.030.441. Spectroscopic Methods of Organic Structure Determination. 3 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.
Area: Natural Sciences

AS.030.442. Organometallic Chemistry. 3 Credits.
An introduction to organometallic chemistry beginning with structure, bonding, and reactivity and continuing into applications to fine chemical synthesis and catalysis. Required Course Background: Organic chemistry-I and -II. Level: Upper level Undergraduate AND Graduate Students
Area: Natural Sciences

AS.030.449. Chemistry of Inorganic Compounds. 3 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.
Area: Natural Sciences

AS.030.451. Spectroscopy. 3 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.
Area: Natural Sciences

AS.030.452. Materials & Surface. 3 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.
Area: Natural Sciences

AS.030.453. Intermediate Quantum Chemistry. 3 Credits.
The principles of quantum mechanics are developed and applied to chemical problems.
Prerequisite(s): (AS.030.301 OR AS.030.370 OR AS.250.372) AND AS.030.302
Area: Natural Sciences

AS.030.454. Electrochemistry for Energy Conversion and Storage. 1.5 Credits.
This half-semester course introduces fundamental concepts in electrochemistry and the application of electrochemical methods for chemical research. The goal of this course is to enable students to practice electrochemistry in laboratory for any field. We will discuss how to use electrochemistry as an analytical technique in your toolbox for understanding chemical reactions as well as the role of electrochemistry in energy conversion and storage.
Prerequisite(s): AS.030.204 OR AS.030.449 OR AS.030.472 OR Instructor Permission.

AS.030.456. Chemical Applications of Group Theory. 3 Credits.
This class will introduce group theory in the chemical/physical context. In addition to the fundamentals of (practical/applied) group theory, this course will explore how the tools of group theory enable powerful, general statements to be made about the behavior of chemical systems from the atomics scale to the macroscale, often without requiring detailed calculations or knowledge of most microscopic details. It is particularly targeted at upper level chemistry and physics undergraduates who have a basic knowledge of quantum mechanics and a brief familiarity with linear algebra.
Area: Natural Sciences

AS.030.501. Independent Research in Physical Chemistry I. 3 Credits.
Research under the direction of members of the physical chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.502. Independent Research in Physical Chemistry. 1 - 3 Credits.
Research under the direction of members of the physical chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.503. Independent Research in Inorganic Chemistry I. 3 Credits.
Research under the direction of members of the inorganic chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.504. Independent Research in Inorganic Chemistry. 1 - 3 Credits.
Research under the direction of members of the inorganic chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.505. Independent Research in Organic Chemistry I. 3 Credits.
Research under the direction of members of the organic chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.506. Independent Research in Organic Chemistry I. 1 - 3 Credits.
Research under the direction of members of the organic chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.507. Independent Research in Biochemistry. 3 Credits.
Research under the direction of members of the biochemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.509. Independent Research in Biochemistry II. 3 Credits.
Research under the direction of members of the biochemistry faculty. Recommended Course Background: AS.030.507-AS.030.508 and permission of instructor.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.510. Independent Research in Biochemistry II. 1 - 3 Credits.
Research under the direction of members of the biochemistry faculty. Recommended Course Background: AS.030.507-AS.030.508 and permission of instructor.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.511. Independent Research in Materials Chemistry. 0 - 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.512. Independent Research in Materials Chemistry. 1 - 3 Credits.
Research under the direction of the materials chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.513. Independent Research in Medical Science. 3 Credits.
Research under the direction of members of the medical faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.514. Independent Research in Medical Science. 3 Credits.
Research under the direction of members of the medical faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.516. Independent Research in Chemical Biology II. 1 - 3 Credits.
Research under the direction of Chemical Biology faculty. Permission of instructor required.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.
Writing Intensive

AS.030.521. Independent Research in Inorganic Chemistry II. 3 Credits.
Research under the direction of the inorganic chemistry faculty. Recommended Course Background: AS.030.503-AS.030.504 and permission of instructor.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.522. Independent Research in Inorganic Chemistry II. 1 - 3 Credits.
Research under the direction of the inorganic chemistry faculty. Recommended Course Background: AS.030.503-AS.030.504 and permission of instructor.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.523. Independent Research in Physical Chemistry II. 3 Credits.
Research under the direction of the physical chemistry faculty. Recommended Coures Background: AS.030.501-AS.030.502 and permission of instructor.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.525. Independent Research in Organic Chemistry II. 3 Credits.
Research under the direction of the organic chemistry faculty. Recommended Course Background: AS.030.505-AS.030.506 and permission of instructor.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.526. Independent Research in Organic Chemistry II. 1 - 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.527. Independent Study. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.530. Independent Research in Inorganic and Materials Chemistry. 1 - 3 Credits.
Research under the direction of members of the Inorganic Chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.540. Independent Research in Solid State and Materials Chemistry. 1 - 3 Credits.
Research under the direction of memebers of the Physical Chemistry faculty.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.593. Research-Organic Chemistry I. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.597. Research - Summer. 3 Credits.
Prerequisite(s): You must request Independent Academic Work using the Independent Academic Work form found in Student Self-Service: Registration > Online Forms.

AS.030.601. Statistical Mechanics.
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.

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.

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.

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.

AS.030.615. Bioinorganic Chemistry.

AS.030.616. The Chemistry of Transition Metals in Biology.
This course will cover fundamental principles in inorganic chemistry, biochemistry, and spectroscopy that are important to the field of bioinorganic chemistry. Current topics in bioinorganic chemistry will be covered, including metalloenzyme structure and function and related synthetic model systems. An emphasis will be placed on the role of transition metals in these systems, and their chemical mechanisms. The collection and interpretation of data from modern bioinorganic spectroscopic tools (e.g. UV-vis, EPR, raman, Mössbauer, X-ray absorption) will be discussed in the context of these current topics.

AS.030.617. Metallo(bio)chemistry of Molecular Oxygen.
This advanced (but descriptive) course focuses on how transition metals of the first row, i.e., iron, manganese and copper), process molecular oxygen (O2) in metalloenzymes and coordination complexes. Chemical behavior discussed will be reversible O2-binding (e.g., blood dioxygen carriers and their synthetic analogs), insertion of one or both atoms of molecular oxygen into organic substrates (i.e., oxygenase activity), or oxidase (bio)chemistry, wherein the metal ion center facilitates O2-reduction to hydrogen peroxide or water. The focus will be on the metal's role and mechanism of action. Practical societal applications will also be discussed.

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.

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.

AS.030.621. Literature-Organic Chemistry.

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.

AS.030.623. Molecular Synthetic Biology.
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.

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

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

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.
Area: Natural Sciences

AS.030.633. Bioorganic and Natural Product Chemistry.
This is a natural products chemistry course organized according to the major natural product groups and emphasizing their origins, fundamental chemistry and applications in medicine. The organization is part traditional lecture and part case studies, like law school or business school, involving your participation in independent research, short essays and presentations. The last Workshops will be elective on your part as to topic with approval from C.A.T. Mixed in will be examples of organic and chemoenzymatic synthesis and biomimetic synthesis, relevant aspects of cofactor and enzyme function and their engineering, spectroscopic and kinetic tools.

AS.030.635. Principles of Magnetic Resonance.
This course develops the basic theoretical concepts underlying the fields of NMR (Nuclear Magnetic Resonance) and EPR (electron spin/paramagnetic resonance). From this foundation, a broad range of different applications will be surveyed. This includes applications to multidimensional solution state NMR spectroscopy, EPR spectroscopy, as well as hybrid electron/nuclear magnetic resonance applications such as dynamic nuclear polarization (DNP).

AS.030.636. Principles of Multidimensional NMR Spectroscopy.
This course is intended to be of general interest to those wanting to broaden their spectroscopy skills and will cover the theoretical and practical aspects of multidimensional NMR spectroscopy. This includes approaches to optimization of data acquisition and post-acquisition data processing as well as the development of the theoretical background needed to understand and design NMR pulse sequences.

AS.030.648. Biocatalysis: Fundamentals, Recent Advances, and Industrial Applications.
Biocatalysis is a rapidly evolving field that adapts biology's mechanisms for innovation to offer revolutionary solutions for chemical production. This course features an in-depth coverage of various topics in biocatalysis with examples of how biocatalysis has reshaped various aspects of modern industries including food manufacturing, pharmaceuticals, consumer products, and biomaterials. This course also provides an overview of common enzyme classes used in bioindustries with extensive discussions of their catalytic mechanisms and engineering. Integrated within the course will be reviewing of important literatures, assessment of critical industrial biocatalytic processes, and hands-on experience of common bioinformatic and computational tools for new enzyme discovery.

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 to determination (mostly concerned with snall 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 crystallixation, 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.
Area: Natural Sciences

AS.030.676. Modern Synthetic Methods in Total Synthesis.
An exploration of modern synthetic methods in the context of total synthesis.

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.

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.

AS.030.681. Nucleic Acids: Fundamental Chemistry and Applications.
The course will begin with an overview of nucleic acid structure, synthesis and reactivity. Subsequent topics will include nucleic acid damage & repair, expanding the genetic code, the role of nucleic acids in epigenetics and applications in biotechnology, such as the development of nucleic acid sensors.

AS.030.691. Hardware, Software and Materials Chemistry.
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 http://occamy.chemistry.jhu.edu.. Cross-listed with Physics and Astronomy

AS.030.800. Summer Independent Research.
This course is for active Chemistry PhD students during summer terms

AS.030.802. Independent Research.
Research under the direction of the chemistry faculty.

AS.030.897. Dissertation Research.
Open to AS Chemistry Graduate Students only.

Cross Listed Courses

Biophysics

AS.250.310. Exploring Protein Biophysics using Nuclear Magnetic Resonance (NMR) Spectroscopy. 3 Credits.
NMR is a spectroscopic technique which provides unique, atomic level insights into the inner workings of biomolecules in aqueous solution and solid state. A wide variety of biophysical properties can be studied by solution state NMR, such as the three dimensional structures of biological macromolecules, their dynamical properties in solution, interactions with other molecules and their physical and chemical properties which modulate structure-function relationships (such electrostatics and redox chemistry). 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, and the global properties of a molecule can be deconstructed in terms of detailed, atomic level information. In addition, interactions between nuclei can be exploited to enhance the information content of NMR spectra via multidimensional (2D and 3D) spectroscopy. Since these properties can be studied in solution, NMR methods serve as an effective complement to X-Ray crystallography and electron microscopy. 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.
Prerequisite(s): ((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.;Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.

AS.250.315. Biochemistry I. 3 Credits.
Foundation for advanced classes in Biophysics and other quantitative biological disciplines. 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. Co-listed with AS.030.315
Prerequisite(s): If you have completed AS.250.307 you may not register for AS.250.315.;(AS.030.206 OR AS.030.212) AND (AS.250.372 OR AS.030.301)
Area: Natural Sciences

AS.250.316. Biochemistry II. 3 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.
Prerequisite(s): (AS.250.315 OR AS.030.315 OR AS.020.305) AND (AS.030.206 OR AS.030.212) or permission of the instructor.

AS.250.372. Biophysical Chemistry. 4 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, partition functions, 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 Pythonand will use it for data fitting and for statistical and mathematical analysis. Background: Calculus, Introductory Organic Chemistry, and Introductory Physics.
Prerequisite(s): Students must have completed Lab Safety training prior to registering for this class. To access the tutorial, login to myLearning and enter 458083 in the Search box to locate the appropriate module.
Area: Natural Sciences

Extradepartmental Studies

PH.550.631. Biological Basis of Public Health. 3 Credits.
Discusses molecular, biochemical, cellular and immunological methodology and approaches for the mechanistic understanding, treatment and prevention of human diseases, and for understanding disease susceptibility. The focus will be on the application of biological methods and approaches to such critical issues as infectious disease, cancer, neurodegenerative disease, COPD, environmental toxicant effects on early development, and reproductive anomalies and their treatment. Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

PH.550.855. MA Public Health Biology Thesis. 5 - 6 Credits.
Provides an opportunity for students to, in consultation with a faculty mentor from the Dept of Biochem and Molecular Bio, Environmental Health or Molecular Microbiology and Immunology, prepare a critical, scholarly paper on an agreed upon subject area.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

First Year Seminars

AS.001.104. FYS: The Science of Color. 3 Credits.
This First-Year Seminar 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.
Area: Natural Sciences

AS.001.105. FYS: The Science Behind the Fiction. 3 Credits.
In this First-Year Seminar, we will seek to answer questions including: could you forge Beskar? What would it take to make a light saber? Is "Image, enhance" really possible? What is possible today? What might be possible in the future? And, what may never be possible, as it violates the laws of nature as we know them? We will take an empiricist approach, gathering data on the needed properties via screenings and related research, and then applying physical principles to reveal feasibility.
Area: Natural Sciences, Social and Behavioral Sciences

AS.001.152. FYS: When Chemistry Changed History. 3 Credits.
The past is littered with discoveries that have altered the course of civilization. In this First-Year Seminar, we will take a deep dive into chemical discoveries that changed history, discussing how they work as well as their impact on society. Topics will range from dirt warfare, to the link between gun powder and workers' rights, to how cats biochemically domesticated humans.
Area: Humanities, Natural Sciences

Molecular Microbiology and Immunology

PH.260.655. Pandemics of the 20Th Century. 1 Credit.
Provides students with an overview of protein bioinformatics including computational and experimental approaches. Introduces amino acid and protein physical properties as well as the alignment and evolution of protein sequences. Presents protein structure and methods of structure determination as well as the use of protein databases and software for visualizing proteins and generating publication quality figures. Discusses methods for secondary and tertiary protein structure prediction including homology modeling. Also covers methods for modeling small/molecule-protein interactions within the context of rational drug discovery and design. Finally, introduces students to experimental and computational aspects of mapping protein interaction networks.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

PH.260.844. Causation. 3 Credits.
Acquaints students with the central concept of causation across the biomedical and public health disciplines. Discusses how cause and effect relationships govern today's research and evidence-based decision-making based on the social, physical, political, and economic determinants of health. Compares how fields and sub-disciplines in biomedicine and public health approach causation using research case examples that illustrate major morbidity and mortality-related health problems. Examines strategies to mitigate the limitations of causal inference.
Course location and modality is found on the JHSPH website (https://www.jhsph.edu/courses/).

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