CHEMISTRY AND BIOCHEMISTRY

College of Science and Engineering

Dean: Dr. Carmen Domingo

Department of Chemistry and Biochemistry

TH 806
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Chair: Teaster Baird, Jr.
Graduate Coordinators: Andrew Ichimura, Bruce Manning

Program Scope and Career Outlook

The Department of Chemistry and Biochemistry offers an outstanding educational environment for undergraduate and graduate students. Our mission is to educate, train, and produce versatile chemists and biochemists who understand both the theoretical basis and practical applications of their discipline. Department faculty provide quality instruction across a wide range of sub-disciplines. Our degree programs are designed to prepare students for various professional positions (i.e., biotechnology and pharmaceutical companies, chemical manufacturing, and other laboratory-based industries), health professions (i.e., medical, pharmacy, and dental school), graduate study, and teaching positions.

Students receive significant hands-on experience with modern instrumentation in our relatively small-sized lab classes, and the opportunity to participate in research projects under the direct supervision of our faculty. The department houses a variety of state-of-the-art research instrumentation, laboratory facilities, and computational labs. These include a Nuclear Magnetic Resonance (NMR) facility, a Mass Spectrometry (MS) facility, a Scanning Electron Microscopy (SEM) facility, and the Computational Chemistry and Visualization (CCV) laboratory.

The Bachelor of Arts in Chemistry program is particularly well-suited for those students whose career goals involve the integration of chemistry with other fields. This program can be combined with another degree or minor to develop the unique synthesis of experience needed for careers in health professions, forensic science, environmental science, regulatory affairs, chemical engineering, patent law, management, sales, marketing, technical writing, scientific journalism, library science, and art restoration. This program also provides excellent preparation for high school science teachers. Students planning to become K–12 chemistry or science teachers should note that additional preparation beyond the major is required to meet the breadth requirements and should consult with the credential advisor in the Department of Chemistry and Biochemistry to review the state-mandated requirements.

The Bachelor of Science in Chemistry, which is approved by the American Chemical Society (ACS), prepares students to pursue a career in chemically-oriented industry or to begin graduate study in chemistry and other molecular sciences. The degree provides a solid foundation in mathematics and physics, breadth in chemical sub-disciplines (analytical, biochemical, inorganic, organic, and physical chemistry), and excellent hands-on training in laboratory and instrumental techniques.

The Bachelor of Science in Biochemistry is designed for students who wish to be particularly well qualified at the rapidly expanding interface between biology and chemistry. The degree includes extensive laboratory training, provides exceptional preparation for careers in biotechnology, and enjoys a favorable reputation among biotechnology companies in the Bay Area. This degree also provides a strong foundation for a graduate degree in biochemistry.

The Master of Science degree in Chemistry and the Master of Science degree in Chemistry with a concentration in Biochemistry are programs of study with research at the core. As the student focuses in depth on an independent scientific investigation, solid research and communication skills are developed. The goal of both M.S. degree programs is to provide students with a thorough grounding in laboratory and research skills, and in-depth training in their areas of specialization. Our M.S. program provides excellent training for

1. careers in all aspects of the chemical industry (biotechnology, environment, process and analytical, basic research);
2. science educators seeking to increase their skill and knowledge base; and
3. students whose goal is advanced study at the Ph.D. level.

The M.S. in Chemistry program is approved by the ACS.

Significant features of our department include high-quality teaching, one-on-one advising for all of our majors, and opportunities for students to participate in research under the direct supervision of active faculty members who are recognized authorities in their field. Students interested in becoming involved in research should consult with an advisor and review faculty research interests on our department website (www.chembiochem.sfsu.edu (http://www.chembiochem.sfsu.edu)). Examples of research projects currently under investigation by our faculty members and their research students include:

Analytical Chemistry

Identification and quantitation of organic pollutants via Gas Chromatography/Mass Spectrometry (GC/MS) and Direct Sampling Mass Spectrometry (DSMS). Application of X-Ray Fluorescence spectrometry (XRF) to the determination of toxic elements in foods, supplements, and other products. Development of novel analytical techniques for separation and detection of redox-sensitive trace species.

Biochemistry

Structural and functional characterization of acetyltransferases involved in protein modification, antibiotic resistance, cellular homeostasis, and metabolic flux. Active-site mechanism, structure, and engineering of enzymes relevant to human environmental toxicology using single-turnover stopped-flow absorbance and fluorescence spectroscopy, rapid-quench, electrochemical, calorimetric, and structural studies of enzyme active sites, protein-ligand, and protein-protein interactions. Characterization of enzymes involved in the nitric oxide and hydrogen sulfide cellular signaling pathways. Structural and functional studies of metalloproteins involved in redox reactions, oxygen activation, oxygen transport, and signal transduction. Computational studies of carcinogen modified bases to understand the role of structural features in human DNA repair and recognition, and on the effects of toxic metals on DNA repair efficiency. Protein structure-function relationships, particularly substrate specificity, catalysis and inhibition in serine proteases; engineering serine proteases to alter substrate specificity and protease-inhibitor interactions with implications for proteolytic drug development. Investigations of photosensitizers and their interactions with nitric oxide for their use in biomedical applications. Investigations of biofluids to uncover markers for disease.

Biophysical Chemistry

Biophysical spectroscopic methods, including nanosecond time-resolved polarized absorption spectroscopy, to characterize biological function and examine the molecular basis of disease. Chromatin folding, dynamics, and stability.

Chemical Education

Identify student experiences and instructional practices that promote student success in chemistry courses and persistence in STEM majors. Design experiences to engage students in applying course-based chemistry knowledge to address community questions and societal needs.

Environmental Chemistry

Detection of trace levels of volatile organic compounds and heavy metals in urban air, water, and soil samples. Determination of structures and speciation of metals and trace elements adsorbed on environmental surfaces by X-ray absorption spectroscopy. Modeling speciation, precipitation, and adsorption reactions of trace elements in environmental systems. Development and characterization of reactive metallic and mineral-based remediation materials for soil and water contaminants. Investigation of the composition and degradation of organic matter in marine systems through quantification and modeling of natural carbon isotopes.

Organic/Bioorganic Chemistry

Organic synthesis, the chemistry of fulvenes, total synthesis of flavonoid anticancer agents, singlet oxygen chemistry and organic peroxides. Molecular imaging, synthesis and biological evaluation of natural products, synthetic organometallic chemistry. Design, synthesis, and optimization of novel enzyme and channel inhibitors to treat human disease. Mechanisms of fundamental organic reactions by computational and experimental approaches, design and synthesis of substrate analogs to elucidate the catalytic mechanisms of enzymes, new synthetic methods for heterocyclic molecules.

Materials and Inorganic Chemistry

Synthesis and characterization of semiconducting thin films with applications to solar cells, water splitting, water remediation, and CO_2 reduction. Growth and nucleation of crystalline TiO_2 by atomic force microscopy (AFM) and in situ grazing incidence X-ray diffraction (GIXRD). Computational approaches to speed the development of solid-state batteries, photocatalysts, and quantum computers using Density Functional Theory and Molecular dynamics.

Natural Products Chemistry

Isolation and characterization of novel compounds from marine microorganisms from sediments, algae, and sponges with anti-cancer, or anti-malarial properties.

Physical Chemistry

Synthesis and characterization of heteroatom-substituted zeolites by XRD, solid-state MAS–NMR, and optical spectroscopy, with applications to photocatalysis of carbon dioxide to fuels. Photophysics and electron spin resonance (ESR) investigation of thin films for applications in photovoltaics and photocatalysis.

Professor

TEASTER BAIRD JR. (2002), *Professor of Biochemistry*; B.S. (1992), Tougaloo College; Ph.D. (1997), Duke University.

JANE G. DeWITT (1995), *Professor of Chemistry*; B.S. (1986), University of California, Santa Barbara; Ph.D. (1993), Stanford University.

IHSAN ERDEN (1981), *Professor of Chemistry*; B.S. (1971), M.S. (1973), Ph.D. (1977), University of Goettingen.

RAYMOND ESQUERRA (2000), *Professor of Biochemistry*; B.S. (1990), Stanford University; Ph.D. (1997), University of California, Santa Cruz.

GEORGE GASSNER (2000), *Professor of Biochemistry*; B.S. (1989), University of Minnesota; Ph.D. (1995), University of Michigan, Ann Arbor.

NANCY C. GERBER (1996), *Professor of Chemistry and Biochemistry*; B.S. (1985), University of Florida; B.S. (1988), Ph.D. (1993), University of Illinois, Champaign-Urbana.

ANTON GULIAEV (2007), *Professor of Biochemistry*; M.S. (1993), Moscow State University, Moscow, Russia; Ph.D. (1999), Bowling Green State University.

TOMOKO KOMADA (2004), *Professor of Marine Biogeochemistry*; B.A. (1993), International Christian University, Tokyo; M.S. (1996), Ph.D. (2002), Rutgers University.

BRUCE MANNING (1999), *Professor of Chemistry*; B.S. (1985), University of Massachusetts; Ph.D. (1993), University of California, Davis.

PETER T. PALMER (1994), *Professor of Chemistry*; B.S. (1983), Canisius College; Ph.D. (1988), Michigan State University.

URSULA SIMONIS (1993), *Professor of Chemistry*; Diploma in Chemistry (1982), Ph.D. (1985), Westfalische Wilhelms Universitat, Munster, Germany.

WEIMING WU (1995), *Professor of Chemistry*; B.S. (1986), Nanjing University, China; Ph.D. (1992), University of Illinois.

Associate Professor

TARO AMAGATA (2008), *Associate Professor of Chemistry*; B.S. (1993), M.S. (1995), Ph.D. (1998), Osaka University of Pharmaceutical Sciences.

MARC ANDERSON (2007), *Associate Professor of Chemistry*; B.S. (1995), University of Colorado, Boulder; Ph.D. (2001), University of California, Santa Cruz.

ANDREW S. ICHIMURA (2001), *Associate Professor of Chemistry*; B.S. (1986), Bates College; Ph.D. (1992), University of Massachusetts.

Assistant Professor

NICOLE ADELSTEIN (2015), *Assistant Professor of Chemistry*; B. A. (2006), Reed College; M.S. (2010), Ph.D. (2012), University of California, Berkeley.

AURA ALEGRA EROY-REVELES (2011), *Assistant Professor of Chemistry*; B.A. (2001), Amherst College; Ph.D. (2008), University of California, Santa Cruz.

MISTY L. KUHN (2014), *Assistant Professor of Chemistry and Biochemistry*; B.A. (2002), Hanover College; Ph.D. (2009), Loyola University Chicago.

JINGJING QIU (2018), *Assistant Professor of Chemistry*; B.S. (2010), Xiamen University; Ph.D. (2015), University of Florida.

Majors

- Bachelor of Arts in Chemistry (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/ba-chemistry/)
- Bachelor of Science in Chemistry (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/bs-chemistry/)
- Bachelor of Science in Biochemistry (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/bs-biochemistry/)

Minor

- Minor in Chemistry (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/minor-program-chemistry/)

Masters

- Master of Science in Chemistry (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/ms-chemistry/)
- Master of Science in Chemistry: Concentration in Biochemistry (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/ms-chemistry-concentration-biochemistry/)

CHEM 100 Preparation for Chemistry (Units: 3)
Prerequisites: Category I or II placement for QR/Math. Category III or IV placement for QR/Math must co-enroll in MATH 122 and an associated B4 course; or in MATH 123 and MATH 124; or in MATH 107 or MATH 197; or have completed these courses with grades of C or better.

Elementary concepts of chemistry. Development of skills in applying mathematics to solving problems in chemistry. Preparation for CHEM 115 or CHEM 180. (Plus-minus ABC/NC grading only)

CHEM 101 Survey of Chemistry (Units: 3)
Prerequisites: Category I or II placement for QR/Math. Category III or IV placement for QR/Math must have completed MATH 197 with a grade of C or better or satisfied the B4 requirement. An ELM score of 50 or higher or exemption; or MATH 70 or ESM 70 with a grade of C or better. High school chemistry recommended.

Principles of general and organic chemistry and biochemistry. Suitable for Pre-Nursing, Exercise Science, and Health Science majors. Not preparation for CHEM 115.
Course Attributes:

- B1: Physical Science

CHEM 102 Survey of Chemistry Laboratory (Unit: 1)
Laboratory to accompany or follow CHEM 101. Extra fee required. (Charges for missing or damaged laboratory locker items apply)
Course Attributes:

- B3: Lab Science

CHEM 115 General Chemistry I: Essential Concepts of Chemistry (Units: 5)
Prerequisites: Category I or II placement for QR/Math, or ELM score of 50 or higher or exemption, or MATH 70 or ESM 70 with a grade of C or better. Category III or IV for QR/Math placement or students who have not completed MATH 70 with a grade of C or better must have completed MATH 197 with a grade of C or better, or have satisfied the B4 requirement. Satisfactory score on the Chemistry readiness assessment. CHEM 100 is recommended for students needing additional preparation for the assessment and CHEM 115.

Essential concepts of atomic properties, atomic interactions, reaction chemistry, stoichiometry, thermodynamics, chemical kinetics, and equilibria. Lecture, 3 units; seminar, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

CHEM 130 General Organic Chemistry (Units: 3)
Prerequisite: CHEM 115* with a grade of C or better.

Common organic compounds and basic principles. For laboratory, see CHEM 234. Cannot be used for the Chemistry or Biochemistry degrees.

CHEM 180 Chemistry for the Energy and the Environment (Units: 3)
Prerequisites: Category I or II placement for QR/Math placement, or an ELM score of 50 or ELM exemption, or MATH 70 with a grade of C or better. Category III or IV for QR/Math placement must have completed MATH 197 with a grade of C or better or satisfied the GE Area B4 requirement. High school chemistry recommended.

Study of the fundamental chemical principles that underlie chemical processes in the environment and the chemical processes that are important to the generation of energy. Suitable for Engineering and Environmental Studies majors. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)
Course Attributes:

- B1: Physical Science
- B3: Lab Science
- Environmental Sustainability

CHEM 215 General Chemistry II: Quantitative Applications of Chemistry Concepts (Units: 3)
Prerequisite: CHEM 115* with a grade of C or better.

Quantitative aspects of chemistry with an emphasis on kinetics, equilibria (acid-base, solubility, and buffer), thermodynamics, and electrochemistry.

CHEM 216 General Chemistry II Laboratory: Quantitative Applications of Chemistry Concepts (Units: 2)
Prerequisite: CHEM 215 with a grade of C or better (may be taken concurrently).

Determination of thermodynamic quantities including rate laws, acid dissociation constants, preparation and analysis of buffer solutions, and synthesis and analysis of a molecular complex. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

CHEM 233 Organic Chemistry I (Units: 3)
Prerequisites: Priority enrollment for Chemistry and Biochemistry majors; CHEM 115* and CHEM 215* with grades of C or better; other majors permitted on a space-available basis.

Principles of organic chemistry emphasizing the structure, properties, and reactions of alkanes, cycloalkanes, alkyl, halides, alcohols, ethers, and alkenes. Stereochemistry. Mechanisms of substitution and elimination reactions. Primarily for students majoring in Chemistry and Biochemistry.

CHEM 234 Organic Chemistry I Laboratory (Units: 2)
Prerequisite: CHEM 233 or CHEM 130 with a grade of C or better (may be taken concurrently).

Techniques and selected experiments in organic chemistry. Lecture, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply)

CHEM 251 Mathematics and Physics for Chemistry (Units: 3)
Prerequisites: CHEM 215, MATH 226, MATH 227, PHYS 220, PHYS 222, PHYS 230, and PHYS 232 with grades of C or better; or consent of the instructor; concurrent enrollment in CHEM 351 is strongly recommended.

Integrated mathematics and physics for physical chemistry including fluids, wave motion, thermodynamics, partial derivatives, multiple integrals, introductory vector calculus, and introductory differential equations. (Plus-minus letter grade only)

CHEM 300 General Physical Chemistry I (Units: 3)
Prerequisites: CHEM 321*, CHEM 335*, MATH 227*, and PHYS 121* or PHYS 230* or PHYS 240* with grades of C or better; CHEM 340 or CHEM 349 recommended. For Chemistry, Biochemistry, and Biology majors.

Chemical thermodynamics, kinetic theory of gases, and properties of solutions. Designed for students in Biology, pre-professional curricula, Biochemistry, and Chemistry majors.

CHEM 301 General Physical Chemistry II (Units: 3)
Prerequisite: CHEM 300 with a grade of C or better or consent of the instructor.

Quantum mechanics, spectroscopy, biophysical spectroscopy, intermolecular forces, macromolecules, and statistical thermodynamics.

CHEM 321 Quantitative Chemical Analysis (Units: 3)
Prerequisites: CHEM 215* and CHEM 216* with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors.

Foundation course in analytical chemistry with a focus on quantitative analysis. Topics include uncertainties, statistics, equilibria, titrimetric methods, electrochemistry and potentiometry, molecular and atomic spectroscopy, mass spectroscopy, and chromatography. (Plus-minus letter grade only)

CHEM 322 Quantitative Chemical Analysis Laboratory (Units: 2)
Prerequisite: CHEM 321 with a grade of C or better (may be taken concurrently). Intended for Chemistry, Biochemistry, and Biology majors.

Practical experience in performing accurate and precise measurements of chemical species in a variety of real-world samples using gravimetric, titrimetric, potentiometric, spectroscopic, and chromatographic methods. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 325 Inorganic Chemistry (Units: 3)
Prerequisites: CHEM 215 and CHEM 335 with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors.

Theories of chemical bonding and their application to inorganic systems with an emphasis on transition metal complexes. Molecular Symmetry. Acid/base, redox, and solid-state chemistry. An introduction to organometallic and bioinorganic chemistry.

CHEM 335 Organic Chemistry II (Units: 3)
Prerequisite: CHEM 233* with a grade of C or better.

Continuation of CHEM 233.

CHEM 336 Organic Chemistry II Laboratory (Units: 2)
Prerequisites: CHEM 234 and CHEM 335 (may be taken concurrently) with grades of C or better. Intended for science majors.

Techniques and experiments in organic synthesis, isolation, purification, and characterization. Activity, 1 unit; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 338 Organic Chemistry II: Laboratory Honors (Units: 3)
Prerequisites: CHEM 233 and CHEM 234 with grades of B or better; concurrent enrollment in CHEM 335. Substitute for CHEM 336.

Experiments in organic synthesis and analysis plus a research project directed by faculty. Lecture, 1 unit; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 340 Biochemistry I (Units: 3)
Prerequisites: CHEM 215*, CHEM 233*, and CHEM 335* with grades of C or better. Intended for Chemistry, Biochemistry, and Biology majors.

Introduction to Biochemistry including protein structure and function, carbohydrate metabolism, enzyme kinetics and thermodynamics, and electron transport chain.

CHEM 341 Biochemistry II (Units: 3)
Prerequisite: CHEM 340 with a grade of C or better.

Biosynthesis and degradation of lipids, amino acids, and nucleotides. Protein synthesis, folding, and degradation. DNA and RNA structure. DNA replication and transcription.

CHEM 343 Biochemistry I Laboratory (Units: 3)
Prerequisites: Restricted to Chemistry and Biochemistry majors; CHEM 216*, CHEM 234*, and CHEM 340* (may be taken concurrently) or CHEM 349* (may be taken concurrently) with grades of C or better; CHEM 321 is recommended.

Chemical and enzymatic experiments involving proteins, carbohydrates, and nucleic acids with emphasis on enzyme kinetics. Utilization of standard and modern biochemical techniques. Lecture, 1 unit; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 349 General Biochemistry (Units: 3)
Prerequisites: CHEM 215* with a grade of C or better, and CHEM 130* with a grade of C or better or CHEM 335* with a grade of C- or better. Not intended for B.S. Biochemistry or Chemistry majors. Students who have completed CHEM 340 may not take CHEM 349 for credit.

Survey of major areas in Biochemistry including enzymology, bioenergetics, and carbohydrate, lipid, and nucleic acid metabolism.

CHEM 351 Physical Chemistry I: Thermodynamics and Kinetics (Units: 3)
Prerequisites: Restricted to upper-division standing; CHEM 233, CHEM 251 (may be taken concurrently), and CHEM 321 with grades of C or better; or consent of the instructor.

Thermodynamics and kinetic theory. Lecture, 2 units; laboratory, 1 unit.

CHEM 353 Physical Chemistry II: Quantum Chemistry and Spectroscopy (Units: 3)
Prerequisites: Restricted to upper-division standing; CHEM 233, CHEM 251, and CHEM 321 with grades of C or better; or consent of the instructor.

Quantum chemistry, spectroscopy of atoms and molecules, and statistical thermodynamics. Lecture, 2 units; activity, 1 unit.

CHEM 370 Computer Applications in Chemistry and Biochemistry (Units: 3)
Prerequisites: CHEM 321 and CHEM 233 with grades of C or better.

Data acquisition, manipulation, and presentation with an emphasis on software used in chemistry and biochemistry laboratories. Computational chemistry and molecular visualization software for small and large molecules. Development of interactive molecular visualization web pages. Lecture, 2 units; laboratory, 1 unit.

CHEM 380 Chemistry Behind Environmental Pollution (Units: 3)
Prerequisites: GE Areas A1*, A2*, A3*, and B4* all with grades of C- or better; CHEM 115 or CHEM 180 with a grade of C- or better; or consent of the instructor.

Traditional and contemporary topics in environmental chemistry. Understanding and appreciation of various chemical processes and principles underlying environmental problems facing society.
Course Attributes:

- Environmental Sustainability
- UD-B: Physical Life Science

CHEM 390GW Contemporary Chemistry and Biochemistry Research - GWAR (Units: 3)
Prerequisites: Upper-division Chemistry and Biochemistry majors; GE Area A2; CHEM 216 or CHEM 234 with a grade of C or higher.

Improve skills in written and oral communication with an emphasis on the communication skills expected of professional chemists and biochemists. Lecture, 2 units; laboratory, 1 unit. (ABC/NC grading only)
Course Attributes:

- Graduation Writing Assessment

CHEM 420 Environmental Analysis (Units: 3)
Prerequisites: CHEM 321 and CHEM 322 with grades of C or better.

Practical analysis of real-world samples and environmental pollutants. Statistics, QA/QC, heavy metal analysis via atomic spectroscopy, and organic pollutant analysis via GC/MS. Lecture, 2 units; laboratory, 1 unit. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 422 Instrumental Analysis (Units: 4)
Prerequisites: CHEM 321 and CHEM 322 with grades of C or better.

Instrumental methods for chemical and biochemical analysis including basic electronics, molecular and atomic spectroscopy, IR and Raman spectroscopy, mass spectrometry, and chromatography. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 426 Advanced Inorganic Chemistry Laboratory (Units: 2)
Prerequisites: CHEM 321, CHEM 322, and CHEM 325 with grades of C or better; or consent of the instructor.

Modern techniques in inorganic chemistry with an emphasis on synthesis, characterization, and reactivity of metals in a variety of materials including biological and environmental samples. Laboratory. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 433 Advanced Organic Chemistry (Units: 3)
Prerequisite: CHEM 335* with a grade of C or better.

Theoretical aspects of organic chemistry, molecular structure, and reaction mechanisms.

CHEM 443 Biophysical Chemistry Laboratory (Units: 4)
Prerequisites: CHEM 343 with a grade of C or better and CHEM 301 or CHEM 353 (may be taken concurrently).

Experiments using modern techniques in biochemistry, bioinformatics, molecular biology, and biophysics for the study of biological macromolecules. Lecture, 2 units; laboratory, 2 units. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 451 Experimental Physical Chemistry Laboratory (Units: 2)
Prerequisites: CHEM 321, CHEM 322, CHEM 351, CHEM 353 or CHEM 300 and CHEM 301, with grades of C or better, or consent of instructor.

Emphasis on molecular spectroscopy, thermodynamics, kinetics, electrochemistry, applications of computational chemistry, and error analysis. 2 laboratory periods per week. Extra fee required. (Charges for missing or damaged laboratory locker items apply) (Plus-minus letter grade only)

CHEM 477 Organic Chemistry of Drug Synthesis and Activity (Units: 3)
Prerequisites: CHEM 335* with a grade of C or better; concurrent enrollment in CHEM 340* or CHEM 349*.

Survey of organic chemistry topics related to modern pharmaceuticals including heterocyclic chemistry (synthesis and presence in drugs), metabolism, drug-delivery, an overview of various classes of drugs, and antibody-drug conjugates.

CHEM 645GW Research Trends in Chemistry and Biochemistry - GWAR (Units: 3)
Prerequisites: GE Area A2; CHEM 340; GPA of 3.0 or better.

Self-directed learning experience for undergraduates in modern research topics in chemistry and biochemistry. (Plus-minus ABC/NC grading only)
Course Attributes:

- Graduation Writing Assessment

CHEM 667 Optical Engineering for the Biological Sciences (Units: 3)
Prerequisites: MATH 226; BIOL 230 or CHEM 215 with a grade of C or better; or consent of the instructor.

A hands-on introduction to applying advances in low-cost computers and digital cameras to microscope design. Emphasis on learning the fundamentals of optical engineering and image processing used in digital microscopy, as well as essential skills in optical design, instrumentation, machining, and fabrication. Includes building a lensless microscope capable of capturing and processing images of plankton. Lecture, 1 unit; laboratory, 2 units. (Plus-minus letter grade; RP grading only)
(This course is offered as BIOL 667 and CHEM 667. Students may not repeat the course under an alternate prefix.)

CHEM 677 Introduction to Optical Engineering for the Biological Sciences (Units: 3)
Prerequisites: MATH 226; CHEM 215; BIOL 230 with C or better; consent of the instructor.

A hands-on introduction to applying advances in low-cost computers and digital cameras to microscope design. Learn the fundamentals of optical engineering and image processing used in digital microscopy. Includes building an inexpensive lensless microscope capable of capturing and processing images of plankton. The completed microscope will be used to conduct a research project. Learn essential skills in optical design, instrumentation, and fabrication. Lecture, 1 unit; laboratory, 2 units. (Plus-minus letter grade; RP grading only)
(This course is offered as BIOL 677 and CHEM 677. Students may not repeat the course under an alternate prefix.)

CHEM 680 Chemical Oceanography (Units: 3)
Prerequisite: CHEM 215 or equivalent.

Investigation of the composition and dynamics of the ocean through chemistry. (Plus-minus letter grade only)

CHEM 685 Projects in the Teaching of Chemistry and Biochemistry (Unit: 1)
Prerequisites: A grade of B or better in the course in which student will be instructing; consent of the instructor,

Instructional methods and techniques for effective student teaching, leading class discussions and activities, and carrying out class demonstrations. May be repeated for a total of 4 units.

CHEM 686 Experiences in Teaching Chemistry and Biochemistry (Unit: 1)
Prerequisites: A grade of B or better in the course in which the student will be instructing; CHEM 685 (may be taken concurrently); or consent of the instructor.

Activity practicum for students serving as Learning Assistants (LAs) in STEM courses. LAs will directly assist STEM instructors in facilitating active learning in their classrooms. May be repeated for a total of 6 units.

CHEM 693 Cooperative Education Program (Units: 6-12)
Prerequisite: Consent of the instructor.

Supervised chemistry laboratory employment. Enrollment by prior arrangement with the employer and department. A final written report is required. A maximum of 2 units (1 unit for each semester) may be used to meet elective requirements in the Chemistry major programs. May be repeated for up to 24 units. (CR/NC grading only)

CHEM 694 Cooperative Education in Chemistry (Unit: 1)
Prerequisites: Upper-division standing or consent of the instructor. Enrollment by prior arrangement with supervising faculty member and industry sponsor. See department adviser for details.

Supervised chemistry laboratory experience in the industry. A final written report is required. May be repeated for a total of 3 units. (Plus-minus letter grade only)

CHEM 699 Independent Study (Units: 1-6)
Prerequisite: Consent of the department and instructor.

Laboratory or library research work focused on chemistry and biochemistry problems directed by a department faculty. For advanced, superior students majoring or minoring in Chemistry or Biochemistry. Final written report required. May be repeated. (Plus-minus letter grade only)

CHEM 741 Electron Microscopy (Units: 4)
Prerequisite: Graduate or senior standing and consent of the instructor.

Introduction to electron microscopy with a focus on instrumentation, image formation and interpretation, x-ray microanalysis, sample preparation, artifacts, and related techniques. Laboratory work includes operation of the electron microscope, x-ray microanalysis, and the preparation of biological and inorganic specimens for scanning and transmission electron microscopy. Seminar, 2 units; laboratory, 2 units. Extra fee required. (Plus-minus letter grade only)
(This course is offered as BIOL 741, CHEM 741, and ERTH 741. Students may not repeat the course under an alternate prefix.)

CHEM 800 Special Topics in Chemistry (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Advanced and current study in various chemistry and biochemistry specialties. Topics to be specified in the Class Schedule. May be repeated when topics vary.

CHEM 806 Exploratory Data Science for Scientists (Units: 4)
Prerequisite: Graduate standing; or upper-division standing and CSC 306 or equivalent.

Introduction to the fundamentals of data science through its applications in biology and chemistry research. Exploration of data preparation, analysis, and reporting using real-world scientific datasets. Lecture, 3 units; activity, 1 unit.
(This course is offered as BIOL 806 and CHEM 806. Students may not repeat the course under an alternate prefix.)

CHEM 807 Coding Community for Data Science Components of Independent Research Projects (Unit: 1)
Prerequisites: Graduate standing; BIOL 806/CHEM 806 or equivalent (concurrent enrollment recommended); or consent of the instructor.

Applications of data science principles to independent research for a master's thesis. May be repeated for a total of 3 units.
(This course is offered as CHEM 807 and BIOL 807. Students may not repeat the course under an alternate prefix.)

CHEM 808 Professional Prospects for Quantitative Biologists, Data Scientists, and Bioinformaticians (Unit: 1)
Prerequisite: BIOL 806*/CHEM 806*.

Connect with data scientists from Bay Area industries, universities, and government agencies. Data scientists will be invited to campus to discuss current trends in the industry, specific positions and roles achievable for students post-graduation, CV composition, job interview skills, and professional experiences in a broad set of workplaces. Practice professional communication skills and experience post-graduate workplace culture. (CR/NC grading only)
(This course is offered as BIOL 808 and CHEM 808. Students may not repeat the course under an alternate prefix.)

CHEM 820 NMR Applications and Techniques (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

FT NMR concepts and operating techniques; 1D and 2D experiments; relaxation and dynamics. Spectral interpretation. Lecture, 2 units; laboratory, 1 unit.

CHEM 821 Mass Spectrometry - Principles and Practice (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Fundamental principles and modern practice of mass spectrometry, instrumentation (mass analyzers, ionization modes, sample introduction systems) and applications (qualitative and quantitative analysis, environmental and biomedical applications). (Plus-minus letter grade only)

CHEM 832 Organic Synthesis (Units: 3)
Prerequisite: Graduate standing in Chemistry or consent of the instructor.

Problems relating to current organic synthetic methods. Synthesis and reactions of the major classes of mono- and polyfunctional compounds.

CHEM 834 Organic Spectroscopic Methods (Units: 3)
Prerequisites: Graduate Chemistry students; CHEM 301 or CHEM 353; or consent of the instructor.

Relations between molecular structure and spectroscopic behavior. Mass spectrometry, infrared, electronic, and magnetic resonance spectroscopy.

CHEM 841 Enzymology (Units: 3)
Prerequisites: Graduate Chemistry students; CHEM 341, CHEM 301 or CHEM 353; or consent of the instructor.

The relationships between enzyme structure and catalytic activity, including enzyme kinetics and mechanisms.

CHEM 842 Bioorganic and Medicinal Chemistry (Units: 3)
Prerequisite: Graduate Chemistry students or consent of the instructor.

Molecular recognition, enzymatic reaction mechanisms, catalytic antibodies/polymers, enzymes in organic synthesis, pharmacodynamics, and drug action, drug design for pharmacokinetic problems.

CHEM 846 Biology and Chemistry of Signaling Pathways (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.

An interdisciplinary presentation of the mechanisms by which extracellular stimuli trigger intracellular biochemical reactions that lead to alterations in cellular function. (Plus-minus letter grade)
(This course is offered as BIOL 732 and CHEM 846. Students may not repeat the course under an alternate prefix.)

CHEM 850 Valency and Spectroscopy (Units: 3)
Prerequisites: Graduate Chemistry students; passing score on the ACS diagnostic examination in quantum chemistry; or consent of the instructor.

Quantum mechanics of atomic and molecular structure using computers and group theory. Elementary microwave, infrared, optical, and magnetic resonance spectroscopy.

CHEM 851 Biochemical Spectroscopy (Units: 3)
Prerequisites: Graduate chemistry students; passing ACS diagnostic examination in quantum chemistry; a biochemistry course; or consent of the instructor.

Quantum chemistry elements. Principles, techniques, and biochemical applications of spectroscopy.

CHEM 852 Statistical Mechanics: Molecular Relaxation (Units: 3)
Prerequisites: CHEM 351 and CHEM 353 or equivalents.

Ensembles in statistical thermodynamics. Irreversible statistical mechanics and correlation functions. Brownian motion. Relaxation processes probed by dynamic light scattering, hydrodynamics, magnetic resonance, and transient electric birefringence.

CHEM 870 Computational Methods in Chemistry (Units: 3)
Prerequisites: Upper-division or graduate standing; one year of undergraduate physical chemistry.

Introduction to quantum chemical and classical mechanical methods for the computation of molecular structure, molecular spectroscopy, liquid state transport properties, and molecular reactivity for small and large molecules, including solids and interactions at surfaces. Hands-on use of four software packages: Gaussian 09, AMBER molecular dynamics, LAMMPS dynamics for mesoscopic systems, and BEST for molecular hydrodynamics. (Plus-minus letter grade only)

CHEM 879 Research Methods I (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.

Development of background, specific research aims, methods, and outcomes. Includes literature review, writing assignments, and oral presentations. (Plus-minus letter grade, RP grading only)

CHEM 880 Research Methods II (Units: 3)
Prerequisites: Restricted to graduate standing; CHEM 879; or consent of the instructor.

Exploration of current areas and methods of chemical research. Scientific writing and presentations emphasizing students' independent research projects. (Plus-minus letter grade, RP grading only)

CHEM 885 Teaching College Chemistry (Units: 3)
Prerequisite: Graduate standing or consent of the instructor.

Examination of the role of preparation, assessment, and feedback in teaching college-level chemistry laboratory and discussion sections. Emphasis on effective classroom techniques and organizational strategies. (Plus-minus letter grade only)

CHEM 895 Research Project (Units: 3)
Prerequisites: Consent of the instructor; approval of Advancement to Candidacy (ATC) and Culminating Experience (CE) forms by Graduate Studies.

Supervised independent and original laboratory investigation. Guidelines are available through the Department of Chemistry & Biochemistry. (CR/NC grading only)

CHEM 897 Research (Units: 1-9)
Prerequisites: Graduate Chemistry students; CHEM 880 (may be taken concurrently); or consent of the instructor.

Independent and original laboratory, computational, or theoretical research under faculty supervision. May be repeated for a total of 9 units. (Plus-minus letter grade, RP grading only)

CHEM 898 Master's Thesis (Units: 3)
Prerequisites: Consent of the instructor; approval of Advancement to Candidacy (ATC) for the Master of Science in Chemistry and Culminating Experience (CE) forms by Graduate Studies.

(CR/NC grading only)