

# Department of Chemistry and Biochemistry

*Bachelor's of Science Degree Certified by the American Chemical Society*

## Chemical Science Building, Room CS-204

(909) 537-5318 Department of Chemistry and Biochemistry website  
(<http://chem.csusb.edu>)

The Department of Chemistry and Biochemistry provides:

1. Undergraduate training in chemistry and biochemistry for students planning professional careers in chemistry and allied professions such as medicine, dentistry, pharmacy, health sciences and veterinary medicine and for those contemplating graduate work for advanced degrees;
2. Appropriate courses for the teacher credential program;
3. Fundamental chemical science courses required by students majoring in related fields such as biology, health science, nursing, and geology;
4. An understanding of the achievements and contributions of chemistry as a science.

The Bachelor of Science in Chemistry satisfies the requirements for certification by the American Chemical Society.

The Bachelor of Arts in Chemistry provides greater elective flexibility for double majors and for preprofessional, interdisciplinary or other programs involving substantial preparation in chemistry.

Preprofessional students of medicine, dentistry or other science-based fields seeking a major in chemistry should See Preprofessional Programs in this catalog and consult with an advisor in the Health Professions Advising Center.

Students interested in fields such as environmental science, environmental law, business, and clinical chemistry can pursue these by following the minimum requirements of the major and appropriate electives.

## Departmental Honors

To qualify for departmental honors, students must have at least a 3.50 G.P.A. in all chemistry courses taken at CSUSB, and complete an approved, independent research project.

## Current Faculty

Andreas Beyersdorf, Assistant Professor  
B.A. 2001, Chapman University  
M.S. 2007, Ph.D. 2007, UC Irvine

Jason Burke, Assistant Professor  
B.S. 2004, University of Oregon  
Ph.D. 2012, University of California, Santa Cruz

Kimberley R. Cousins, Professor, Chair  
B.S. 1984, Duke University  
Ph.D. 1991, University of Texas, Austin

Yu Jung Kim, Associate Professor

B.S. 1995, M.S. 1995, Ph.D. 2002, University of California, Riverside

Jeremy Mallari, Assistant Professor  
B.A. 2000, B.S. 2003, California State University, San Francisco  
Ph.D. 2008, University of California, San Francisco

Larry M. Mink, Professor  
B.S. 1984, Hebrew University of Jerusalem  
M.S. 1986, Ph.D. 1990, University of California, Riverside

James A. Noblet, Professor  
B.S. 1983, University of California, Los Angeles  
M.S. 1991, California State University, Long Beach  
Ph.D. 1997, University of California, Los Angeles

Lisa Shamansky, Professor  
B.S. 1980, Indiana University, Bloomington  
Ph.D. 1986, University of Illinois, Urbana

Douglas C. Smith, Professor  
B.A. 1988, Wittenburg University, Ohio  
Ph.D. 1994, Purdue University

Brett J. Stanley, Professor  
B.S. 1987, University of Pittsburgh  
Ph.D. 1992, Utah State University

John Tate, Associate Professor  
B.Sc. 1979, Ph.D. 1982, University of Sheffield, England

Shumei Yang, Professor  
B.S. 1982, Zhengzhou University, P.R. China  
Ph.D. 1991, Iowa State University

Renwu Zhang, Associate Professor  
B.S. 1988, Anhui Normal University  
M.S. 1993, University of Science China  
Ph.D. 2002, University of Missouri

## Emeriti

John H. Craig, Professor

Kenneth A. Mantei, Professor

Dennis M. Pederson, Professor

## Undergraduate Degrees

### Bachelor of Arts

Chemistry (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/chemistry-biochemistry/chemistry/>)

with concentrations in:

- Chemistry
- Biochemistry

### Bachelor of Science

Bioinformatics (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/bioinformatics-bs/>)

Chemistry (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/chemistry-biochemistry/chemistry-bs/>)

with concentrations in:

- Chemistry
- Biochemistry

## Graduate Degree

### Master of Science

Environmental Sciences (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/chemistry-biochemistry/environmental-sciences-ms/>)

### Minor

Chemistry (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/chemistry-biochemistry/chemistry-minor/>)

## Teaching Credential Program

### Teaching Credential Subject Matter Preparation Program in Science: Chemistry

Chemistry majors pursuing a single subject teaching credential in science with a chemistry specialization will need to take the CSET Exam to verify subject matter competence. To prepare for the CSET exam, the following courses are recommended as part of, or in addition to the chemistry degree.

ASTR 1000	Introduction to Planetary Astronomy	3
ASTR 1000L	Introduction to Planetary Astronomy Lab	1
BIOL 2010	Principles of Biology I	5
BIOL 2020	Principles of Biology II	5
GEOL 1000	Introductory Geology	3
GEOL 1000L	Introductory Geology Laboratory	1
GEOL 2500	Geology of California	3
GEOL 3090	Earth: The Blue Planet	4

In addition, certain prerequisites and professional education courses are required. For information about admission to the teacher education program, education courses required, or the specific requirements of the single subject teaching credential in science program, contact the Department of Science, Mathematics, and Technology Education in the College of Education.

## Courses

### CHEM 1000. Introduction to Chemistry. Units: 3

Semester Prerequisite: One year of high school algebra. Quarter Prerequisite: Satisfactory score on the Entry Level Mathematics examination

Examination of chemistry and its value to contemporary society. Includes an introduction to important chemical principles, nomenclature, and molecular structure. Designed for those with little or no chemistry background desiring a broad overview of chemistry including liberal studies majors. Satisfies GE Category B1. Formerly offered as CHEM 100.

### CHEM 1000L. Introduction to Chemistry Laboratory. Unit: 1

Semester Corequisite: CHEM 1000

Laboratory component that complements CHEM 1000. Introductory chemistry experiments and demonstrations. Common household materials utilized. Experiments designed to practice the scientific method including recording observations and measurements and drawing conclusions. Satisfies GE Category B3. Formally CHEM 100 laboratory component, students may not receive credit for both courses. Materials fee required.

### CHEM 2050. Survey of General Chemistry. Units: 3

Semester Prerequisite: Eligibility to enroll in, or completion of, GE mathematics. Quarter Corequisite: MATH 90 or above. Quarter Prerequisite: One year of high school algebra, MATH 90 or above. Semester Corequisite: if ineligible to enroll in GE math, co-enrollment in Math 1102 or 1202 or 1302

Introduction to the fundamental concepts and basic calculations of chemistry, including the composition of matter, physical and chemical changes, nomenclature and formulas, stoichiometry, gases, solutions, acids and bases. Designed primarily for the student with little or no chemistry background who plans to take additional chemistry or other science courses. Satisfies GE Category B1. Formally offered as CHEM 205.

### CHEM 2050L. Survey of General Chemistry Laboratory. Unit: 1

Semester Corequisite: CHEM 2050

Laboratory to accompany CHEM 2050. Experiments demonstrating general chemical principles, reactivity, physical and chemical properties, qualitative and quantitative analysis, and synthesis. Satisfies GE Category B3. Formally CHEM 205 laboratory component. Materials fee required.

### CHEM 2060. Survey of Organic and Biochemistry. Units: 4

Semester Prerequisite: CHEM 2050 and CHEM 2050L; or CHEM 2100 and 2100L. Quarter Prerequisite: CHEM 205 or CHEM 215

A survey of organic and biochemistry for those interested in understanding the role of chemistry in human health and nutrition, ecosystems and the physical environment. CHEM 2060 and CHEM 2060L are equivalent to CHEM 206 and CHEM 207; students may not earn credit for CHEM 2060 if they have earned credit for CHEM 206 and 207.

### CHEM 2060L. Survey of Organic and Biochemistry Lab. Unit: 1

Semester Prerequisite: CHEM 2050 and CHEM 2050L; or CHEM 2100 and CHEM 2100L; and CHEM 2060 as a pre- or co-requisite; or consent of department. Quarter Prerequisite: CHEM 205 or CHEM 215

Laboratory experiments supporting topics in CHEM 2060. Materials fee required. CHEM 2060 and CHEM 2060L are equivalent to CHEM 206 and CHEM 207. Students may not earn credit for CHEM 2060L if they have earned credit for CHEM 206 and 207.

### **CHEM 2070. Fundamentals of General, Organic, and Biochemistry. Units: 5**

Semester Prerequisite: One year of high school algebra  
An introduction to the principles of general, organic and biochemistry for the nursing major. The course and laboratory covers the basic principles of general chemistry, organic functional groups, the properties and reactivities of the important biological molecules of carbohydrates, proteins, fats and nucleic acids, and their relationship to principles of biochemistry metabolism. Four hours lecture, three hours lab. Satisfies GE Category B1; B3. Materials fee required.

### **CHEM 2100. General Chemistry I. Units: 4**

Semester Prerequisite: One year of high school chemistry and three years of high school mathematics or their equivalents and completion of or concurrent enrollment in one of the following: MATH 1401, MATH 1403, MATH 1601, MATH 1603, MATH 2210, or MATH 2220. Quarter Prerequisite: one year of high school chemistry and three years of high school mathematics, or their equivalents; completion of, or concurrent enrollment in one of the following: MATH 110, MATH 120, MATH 192, MATH 211, or MATH 212  
Systematic study of fundamental chemical and physical principles and their application to the properties of matter, including atomic structure, molecular structure and bonding, periodic trends in the properties of the elements, gas laws, solution properties, and quantitative relationships involving chemical reactions. Satisfies GE Category B1. Formerly offered as CHEM 215.

### **CHEM 2100L. General Chemistry I Laboratory. Unit: 1**

Semester Corequisite: CHEM 2100  
Experiments supporting, demonstrating, and investigating CHEM 2100 course material including density, chemical reactivity, chemical analysis, stoichiometry, and emission. Satisfies GE laboratory requirement in Category B. Previously laboratory component of CHEM 215. Credit may not be received for both courses.

### **CHEM 2200. General Chemistry II. Units: 4**

Semester Prerequisite: CHEM 2100 with a grade of C or better and one of the following, MATH 1301, MATH 1401, MATH 1601, MATH 2210, or MATH 2220. Quarter Prerequisite: CHEM 215 with a grade of C or better and MATH 111B or 112C

This course deals with the spontaneity, extent and rate of chemical processes. Covers chemical thermodynamics, kinetics, equilibria, including acid-base and solubility equilibria, and electrochemistry. CHEM 2200 and 2200L are equivalent to Chem 216. Students may not earn credit for CHEM 2200 if they have earned credit for CHEM 216.

### **CHEM 2200L. General Chemistry II Laboratory. Unit: 1**

Semester Prerequisite: CHEM 2100L, and CHEM 2200 as a pre- or co-requisite. Quarter Prerequisite: CHEM 215  
Experiments supporting, demonstrating, and investigating CHEM 2200 course material including thermochemistry, kinetics, equilibria, solubility, acid-base reactions and electrochemistry. CHEM 2200 and 2200L are equivalent to Chem 216; students may not earn credit for CHEM 2200L if they have earned credit for CHEM 216. Materials fee required.

### **CHEM 2300. Organic Chemistry for Life Sciences. Units: 4**

Semester Prerequisite: CHEM 2200 with a grade of C or better, and CHEM 2200L. Quarter Prerequisite: CHEM 216 with a grade of C or better  
A one semester survey of organic chemistry with adequate rigor to prepare students for upper division biochemistry. Course topics include organic structure and nomenclature, isomerism, and reactivity with an emphasis on structure and reactions foundational for biochemistry. May not be appropriate for pre-health professional students. Students may not earn credit for CHEM 2300 if they have completed CHEM 2500 or CHEM 3500, or equivalent coursework.

### **CHEM 2400. Organic Chemistry I Lecture. Units: 3**

Semester Prerequisite: CHEM 2200 with a C or better, and CHEM 2200L. Quarter Prerequisite: CHEM 215 with a grade of C or better and CHEM 216 with a grade of C or better  
The chemistry of carbon compounds, including modern concepts of structure, mechanism, and reactivity. Emphasis is placed on compounds and reactions of biological interest; and includes an introduction to selected topics in biochemistry. Taking the lecture sequence (CHEM 2400 and CHEM 2500) without the lab sequence (CHEM 2400L and 2500L) is inappropriate for pre-medical, pre-dental and other pre-health professions students. Chemistry majors are expected to take the Principles of Organic Chemistry sequence (CHEM 3400 and CHEM 3500). Formerly part of the CHEM 221A, 222A, 223A sequence; students may not earn credit for CHEM 2400 if they have earned credit for CHEM 221A and 222A.

### **CHEM 2400L. Organic Chemistry I Laboratory. Unit: 1**

Semester Prerequisite: CHEM 2200 with a C or better, and CHEM 2200L, CHEM 2300 or CHEM 2400 as pre or corequisites. Quarter Prerequisite: CHEM 215, CHEM 216, CHEM 221A, and CHEM 222A  
An introduction to experimental techniques in organic chemistry including organic extraction, recrystallization, distillation, IR spectroscopy, and one step organic transformations. Part of the year-long organic chemistry lab series. Formerly part of the CHEM 221B, 222B, 223B sequence. Students earning credit for CHEM 221B and 222B may not earn credit for CHEM 2400L. Materials fee required.

### **CHEM 2500. Organic Chemistry II. Units: 3**

Semester Prerequisite: CHEM 2400 with a grade of C or better. Quarter Prerequisite: CHEM 221A & 222A with a grade of C or better  
A continuation of CHEM 2400. Topics may include carbonyl chemistry, mechanisms, synthesis, and bio-molecules. Formerly part of the CHEM 221A, 222A, 223A sequence; students may not earn credit for CHEM 2500 if they have earned credit for CHEM 222A and 223A.

### **CHEM 2500L. Organic Chemistry II Laboratory. Unit: 1**

Semester Prerequisite: CHEM 2400 with a C or better, and CHEM 2400L, CHEM 2500 as a pre or corequisite. Quarter Prerequisite: CHEM 221B and 222B with a C  
Part of the year-long organic chemistry lab series (CHEM 2400L and 2500L). An introduction to performing organic transformations as well as techniques (such as IR and NMR spectroscopy) used to characterize organic small molecules. Formerly part of the CHEM 221B, 222B, 223B sequence. Students may not earn credit for CHEM 2500L if they have earned credit for CHEM 222B and CHEM 223B. Materials fee required.

**CHEM 2901. Special Projects in Chemistry. Unit: 1**

Quarter Prerequisite: Consent of instructor  
Individual investigation, research, study or survey of selected problems. May be repeated for credit. Consent of instructor required. Formerly CHEM 295A. Materials fee required.

**CHEM 2902. Special Projects in Chemistry. Units: 2**

Quarter Prerequisite: consent of instructor  
Individual investigation, research, study or survey of selected problems. May be repeated for credit. Consent of instructor required. Formerly CHEM 295B. Materials fee required.

**CHEM 2903. Special Projects in Chemistry. Units: 3**

Individual investigation, research, study or survey of selected problems. May be repeated for credit. Consent of instructor required. Materials fee required.

**CHEM 3000. History of Science and Technology. Units: 3**

Semester Prerequisite: Completion of GE categories B-1 and B-2. Quarter Prerequisite: junior or senior standing

A survey of the historical relationship between science, technology and human civilization; society and culture - past, present and future. Emphasis on the people, major scientific discoveries and technologies that have influenced societal development from early humans to the present day. Case studies on the often non-linear way in which scientific discoveries and technological developments cause changes to human civilization and culture. A discussion of likely future scientific and technological challenges facing human kind. Satisfies GE Category B5. Formerly offered as NSCI 300. Credit may not be received for both courses.

**CHEM 3100. Chemistry and the Environment. Units: 3**

Semester Prerequisite: Completion of B-1 and B-2 categories  
Examination of current issues related to environmental chemistry including climate change, environmental justice, and soil, water, and air pollution. A primary focus will be on linkages between the environment, human activities, and socioeconomic factors. Satisfies GE Category B5. Formerly offered as CHEM 105. Students may not receive credit for both Chem 105 and Chem 3100.

**CHEM 3200. Quantitative Analysis. Units: 4**

Semester Prerequisite: CHEM 2100 and CHEM 2200 with grades of C (2.0) or better, both CHEM 2100L and 2200L with a C- (1.7) or better. Quarter Prerequisite: CHEM 216 with a grade of C (2.0) or better  
Volumetric, stoichiometric, and equilibrium calculations of acid-base, oxidation-reduction, complexation, and solubility systems. Laboratory measurements, data and error analysis. Introduction to spectrometric, electrochemical, and chromatographic methods. Three hours lecture and three hours laboratory. Formerly CHEM 345; students may not earn credit for CHEM 3200 if they have earned credit for CHEM 345. Materials fee required.

**CHEM 3400. Principles of Organic Chemistry I. Units: 5**

Semester Prerequisite: CHEM 2200 with a grade of C or better and CHEM 2200L with a grade of C- or better. Quarter Prerequisite: CHEM 215 and CHEM 216 with grades of C or better in each course  
Detailed study of organic molecules and their structures, properties, stereochemistry, reaction mechanisms, and synthesis. Three hours lecture, one hour discussion, three hours laboratory. Formerly part of the CHEM 321, 322, 323 sequence; students may not earn credit for CHEM 3400 if they have earned credit for CHEM 321 and 322. Course is intended for Chemistry and Biochemistry majors. Department consent required. Materials fee required.

**CHEM 3500. Principles of Organic Chemistry II. Units: 5**

Semester Prerequisite: CHEM 3400 with a grade of C or better. Quarter Prerequisite: CHEM 322 with a grade of C or better  
Continuation of CHEM 3400. Includes a discussion of topics such as: carbonyl chemistry, synthesis, and biological molecules. Three hours lecture and six hours laboratory. Formerly part of the CHEM 321, 322, 323 sequence; students earning credit for CHEM 322 and 323 may not earn credit for CHEM 3500. Course is intended for Chemistry and Biochemistry majors. Department consent required. Materials fee required.

**CHEM 3600. Intermediate Organic Chemistry. Units: 5**

Semester Prerequisite: CHEM 2500 and 2500L or equivalent course work. Quarter Prerequisite: CHEM 223A/B or equivalent course work  
Organic reaction mechanisms, quantitative identification of organic compounds, and instrumental organic analysis. Three hours lecture and six hours laboratory. Formerly CHEM 421; students may not earn credit for CHEM 3600 if they have earned credit for CHEM 421. Departmental consent is required. Materials fee required.

**CHEM 3900. Service Learning in Chemistry. Unit: 1**

Semester Prerequisite: Course work pertinent to the service learning activity. Quarter Prerequisite: consent of instructor and pertinent course work  
Supervised activities in chemistry or chemical education providing service to campus or community constituents. Department consent required. At least 45 hours required for credit. May be repeated for credit. Formerly CHEM 301. Graded Credit/No Credit.

**CHEM 4100. Biochemistry I. Units: 3**

Semester Prerequisite: Either CHEM 2300, CHEM 2500, or CHEM 3500 with a grade of C or better, and BIOL 2010. Quarter Prerequisite: CHEM 223A or CHEM 323 with a grade of C or better and BIOL 200  
Structure and function of proteins, carbohydrates, and lipids. Membrane transport, enzyme mechanism and kinetics. Metabolism of biomolecules, including carbohydrate metabolism, fatty acid catabolism, and amino acid catabolism, as well as the citric acid cycle and oxidative phosphorylation. Formerly part of the CHEM 436A, 437A, 438A sequence; students may not earn credit for CHEM 4100 if they have earned credit for CHEM 436A and 437A.

**CHEM 4100L. Biochemistry I Laboratory. Unit: 1**

Semester Prerequisite: CHEM 2400L with a grade of C- (1.7) or better. CHEM 4100 as pre- or co-requisite. Quarter Prerequisite: CHEM 436A Introduction to experimental techniques in biochemistry, including determination of protein concentration, gel filtration chromatography, affinity chromatography, and enzyme kinetics. Formerly CHEM 436B; students may not earn credit for CHEM 4100L if they have earned credit for CHEM 436B. Materials fee required.

**CHEM 4200. Biochemistry II. Units: 3**

Semester Prerequisite: CHEM 4100 with a grade of C- or better. Quarter Prerequisite: CHEM 437A with a grade of C- or better Fatty acid biosynthesis, amino acid biosynthesis, and nitrogen fixation. Nucleotide metabolism, DNA replication, DNA repair, transcription, protein synthesis, and gene regulation. Formerly part of the CHEM 436A, 437A, and 438A sequence; students may not earn credit for CHEM 4200 if they have earned credit for CHEM 437A and CHEM 438A.

**CHEM 4200L. Biochemistry II Laboratory. Unit: 1**

Semester Prerequisite: CHEM 4100L with a grade of C or better, CHEM 4200 is a pre or corequisite. Quarter Prerequisite: CHEM 436B and CHEM 437A

Protein purification techniques (ammonium sulfate precipitation, dialysis, and DEAE chromatography), enzyme kinetics and inhibition assays, DNA purification, and PCR. Formerly CHEM 437B. Students may not earn credit CHEM 4200L if they have earned credit for CHEM 437B. Materials fee required.

**CHEM 4300. Inorganic Chemistry. Units: 4**

Semester Prerequisite: CHEM 2500 or 3500, and CHEM 3200 with grades of C or better. Quarter Prerequisite: CHEM 223 or 323 Topics in inorganic chemistry, including molecular structure and bonding, symmetry, ionic structure and bonding, inorganic reactions, including acid base and oxidation-reduction reactions, coordination chemistry and bioinorganic chemistry. Three hours lecture and three hours laboratory. Laboratory component reinforces lecture material. Formerly Chem 475; students may not earn credit for CHEM 4300 if they have earned credit for CHEM 475. Materials fee required.

**CHEM 4350. Bioinorganic Chemistry. Units: 3**

Semester Prerequisite: CHEM 2500 or 3500 and CHEM 3200 with a grade of C (2.0) or better. Quarter Prerequisite: CHEM 223 or CHEM 323 Principles of inorganic chemistry emphasizing metals in biological systems. The first part of this course covers fundamentals of inorganic chemistry, including trends in chemical and physical properties of elements and compounds, molecular and ionic bonding, oxidation-reduction, acid-base chemistry, and coordination chemistry. The second part of this course covers physical techniques used to probe structure and activity, followed by a survey of the types of metalloproteins and their biological functions. Detailed case studies of selected metalloproteins. Formerly CHEM 470; students may not earn credit for CHEM 4350 if they have earned credit for CHEM 470.

**CHEM 4400. Physical Chemistry I. Units: 3**

Semester Prerequisite: CHEM 3200 with a grade of C (2.0) or better; MATH 2220 with a grade of C (2.0) or better; Pre- or Co-requisites: PHYS 2010 and 2010L, or PHYS 2510 and 2510L. Quarter Corequisite: PHYS 223. Quarter Prerequisite: CHEM 345 with a grade of C (2.0) or better; MATH 213 with a grade of C (2.0) or better; and must have completed PHYS 123 or may take PHYS 223 Semester Corequisite: PHYS 2010 and 2010L or PHYS 2510 and 2510L Non-ideal gases, thermodynamics, properties of solutions, phase equilibria, chemical equilibria, electrochemistry, gas kinetics, chemical kinetics and molecular reaction dynamics. Formerly part of the CHEM 455 and CHEM 456 sequence; students may not earn credit for CHEM 4400 if they have earned credit for CHEM 455.

**CHEM 4500. Physical Chemistry II. Units: 3**

Semester Prerequisite: CHEM 4400. Quarter Prerequisite: CHEM 455 Molecular energies, quantum mechanics, application of quantum theory to molecular energy levels, atomic structure, molecular orbital theory, statistical thermodynamics, complex reactions. Formerly part of the CHEM 455 and CHEM 456 sequence; students may not earn credit for CHEM 4500 if they have earned credit for CHEM 456. Students are recommended to take MATH 2310.

**CHEM 4550. Physical Chemistry Laboratory. Unit: 1**

Semester Prerequisite: CHEM 4400, and CHEM 4500 as a pre- or co-requisite Heat of combustion, Joule-Thomson effect, enthalpy of evaporation, ionic strength, UV-vis spectrum of conjugate dye, FTIR spectrum of HCl/DCI gases, kinetics of hydrolysis of sucrose, NMR study of paramagnetic susceptibility. Formerly part of the CHEM 455 and CHEM 456 sequence; students may not earn credit for CHEM 4550 if they have earned credit for CHEM 455 and 456. Materials fee required.

**CHEM 4600. Physical Chemistry for Biochemists I. Units: 3**

Semester Prerequisite: CHEM 3200 with a grade of C (2.0) or better and MATH 2220; Pre- or Co-requisites: CHEM 4100 and 4100L, and either PHYS 2010 and 2010L, or PHYS 2510 and 2510L. Quarter Prerequisite: CHEM 345, CHEM 436A, and CHEM 436B with grades of C (2.0) or better; MATH 213; and PHYS 123 or PHYS 223 Thermodynamics of single and multi-component systems, electrochemistry, properties of non-electrolyte and electrolyte solutions, phase equilibria, molecular motion and transport properties, with an emphasis on biomolecular systems. Formerly part of the CHEM 451 and CHEM 452 sequence. Students may not earn credit for CHEM 4600 if they have earned credit for CHEM 451.

**CHEM 4700. Physical Chemistry for Biochemists II. Units: 3**

Semester Prerequisite: CHEM 4600. Quarter Prerequisite: CHEM 451 Kinetics with an emphasis on biomolecular systems. Quantum mechanical and physical principles as applied to molecular structure and spectroscopy. Formerly part of the CHEM 451 and CHEM 452 sequence. Students may not earn credit for CHEM 4700 if they have earned credit for CHEM 452. Students are recommended to take MATH 2310.

### **CHEM 4750. Physical Chemistry for Biochemists Laboratory. Unit: 1**

Semester Prerequisite: CHEM 4600, and CHEM 4700 as a pre- or co-requisite

Physical chemical experiments illustrating principles of thermodynamics, kinetics, quantum chemistry and spectroscopy, with an emphasis on biomolecular systems. Formerly part of the CHEM 451 and CHEM 452 sequence. Students may not earn credit for CHEM 4750 if they have earned credit for CHEM 451 and 452. Materials fee required.

### **CHEM 5001. Topics in Chemistry. Unit: 1**

Quarter Prerequisite: Consent of instructor

Lecture course on an advanced or contemporary chemistry topic. Consent of instructor required. May be repeated for credit as topics change.

Formerly CHEM 500.

### **CHEM 5001L. Topics in Chemistry Laboratory. Unit: 1**

Quarter Prerequisite: Vary with topic, consent of instructor

Laboratory course on an advanced or contemporary chemistry topic.

Course designed to supplement either CHEM 5001 or CHEM 5002 lecture courses. Consent of instructor required. May be repeated for credit as topics change. Materials fee required.

### **CHEM 5002. Topics in Chemistry. Units: 2**

Quarter Prerequisite: Varies by topic; consent of instructor

Lecture course on an advanced or contemporary chemistry topic. Consent of instructor required. May be repeated for credit as topics change.

### **CHEM 5100. Polymer Science. Units: 2**

Semester Prerequisite: CHEM 2500 or 3500 with grades of C- (1.7) or better; PHYS 2010 or 2510 with grades of C- (1.7) or better; Math 2210 with a grade of C- (1.7) or better. Quarter Prerequisite: CHEM 223 or 323; PHYS 122 or 222; Math 212

This course will broadly cover polymer science and technology, including the synthesis, solid-state properties, degradation, processing of polymers, and advanced polymers. It will introduce the fundamentals of the chemistry, physics and engineering of polymers, encompassing both theoretical background and experimental techniques. Formerly a topic under CHEM 500; students may not earn credit for CHEM 5100 if they have earned credit for this topic under CHEM 500.

### **CHEM 5150. Materials Chemistry. Units: 2**

Semester Prerequisite: CHEM 2500 or CHEM 3500 with a grade of C or better. Prerequisite: CHEM 223A or CHEM 323 with a grade of C or better  
An introduction to the chemistry of materials. A qualitative overview of the role of chemistry in the broader discipline of materials science. The relationship between composition, structure and bonding at the atomic and molecular level and macroscopic properties. An overview of common materials characterization techniques. Coverage of the basic classes of materials, metals and alloys, ceramics and glasses, small molecular solids, polymers, semiconductors, and composite materials. Introduction to Crystal Systems and Bravais lattices. Materials manufacturing methods. As time permits, advanced topics such as superconductors, band gap theory, optical and photonic materials, biomedical applications and nanotechnology may also be covered. Formerly a topic under CHEM 500; students may not earn credit for CHEM 5150 if they have earned credit for this topic under CHEM 500.

### **CHEM 5200. Instrumental Analysis. Units: 5**

Semester Prerequisite: CHEM 3200 with a C or better, and either CHEM 2500 or CHEM 3500 with grades of C or better; PHYS 2010 and 2010L, or PHYS 2510 and 2510L. Quarter Prerequisite: CHEM 345 with a C or better and either CHEM 223 or CHEM 323 with grades of C or better; PHYS 123 or PHYS 223

Principles and techniques of instrumental chemical analysis. Methods include molecular UV-VIS absorption, fluorescence, infrared, and NMR spectroscopy; electrothermal atomic absorption spectrometry; high performance liquid chromatography; gas chromatography/mass spectrometry; capillary electrophoresis; potentiometry and voltammetry. Three hours lecture and six hours laboratory. Formerly CHEM 545; students may not earn credit for CHEM 5200 if they have earned credit for CHEM 545. Materials fee required.

### **CHEM 5300. Environmental Chemistry. Units: 3**

Semester Prerequisite: CHEM 3200, and either CHEM 2300, 2500, or 3500. Prerequisite: CHEM 345 and either CHEM 223 or CHEM 323

Chemical principles governing the natural composition and pollution of the atmosphere, hydrosphere, soils and sediment. Includes energy use and its environmental consequences, toxic chemicals, purification/remediation schemes, waste and soil management. Formerly a topic under CHEM 500; students may not earn credit for CHEM 5300 if they have earned credit for Environmental Chemistry taught as a topic under CHEM 500.

### **CHEM 5320. Atmospheric Chemistry. Units: 3**

Semester Prerequisite: One year of general chemistry and one course in organic chemistry, Recommended, one course in quantitative analysis  
An overview of the sources, sinks, chemistry and measurements of atmospheric species and their application to the natural atmosphere, climate change, air pollution, air quality management, and stratospheric ozone depletion. Projects will focus on understanding the connections between chemistry, meteorology, geography and socioeconomic factors that affect California and global air quality.

### **CHEM 5400. Chemistry of the Elements. Units: 3**

Semester Prerequisite: CHEM 3200 with a C or better, and either CHEM 2500 or 3500 with a grade of C or better. Quarter Prerequisite: CHEM 345 with a C or better, and either CHEM 223 or 323 with a grade of C or better  
Survey of the chemistry of the main group elements, including the sources, production, and properties of the elements and their compounds. Particular attention is given to the periodic trends in physical and chemical properties. Other topics include inorganic polymers and materials, and organometallic chemistry. Formerly CHEM 576; students may not earn credit for CHEM 5400 if they have earned credit for CHEM 576.

### **CHEM 5420. Pyrotechnics. Unit: 1**

Semester Prerequisite: CHEM 3200 with a C or better. Prerequisite: CHEM 345 with a C or better

The history of pyrotechnics from the discovery of gunpowder in China, and its development and use in the west as propellant and explosive in fireworks, to the chemistry, theory and practice of other high energy compositions used in fireworks today. Formerly a topic under CHEM 500; students may not earn credit for CHEM 5420 if they have earned credit for Pyrotechnics taught as a topic under CHEM 500.

**CHEM 5500. Medicinal Chemistry. Units: 2**

Semester Prerequisite: Chem 2400 or Chem 3400 with grade of C or better; Pre- or Co-Requisite of Chem 2500 or 3500, or consent of instructor. Prerequisite: CHEM 222 or CHEM 322 with a grade of C or better; Pre- or Co-requisite of CHEM 223 or CHEM 323, or consent of instructor

Examines the interplay between organic chemistry and biochemistry. Topics will include: drug absorption, distribution, and elimination; drug metabolism; theories of drug receptor interactions; and structure-activity relationships for a number of drug classes. Departmental consent required. Formerly a topic under Chem 500; students may not earn credit for CHEM 5500 if they have earned credit for Medicinal Chemistry taught as a topic under CHEM 500.

**CHEM 5550. Computational Chemistry. Units: 2**

Semester Prerequisite: Chem 2400 or 3400. Prerequisite: Chem 321 or Chem 221A/B

Application of computational approximations to model chemical structure, reactivity, and properties. Survey of commonly used computational methods: semi-empirical, ab initio, and density functional theory, including a qualitative understanding of the strengths and weaknesses of each, and how to choose the appropriate computational technique to solve a problem at hand. Significant hands-on practice using modern software. Formerly a topic under CHEM 500; students may not earn credit for CHEM 5550 if they have earned credit Computational Chemistry taught as a topic under CHEM 500.

**CHEM 5700. Biochemistry III Laboratory. Units: 2**

Semester Prerequisite: CHEM 4200L with a grade of C or better, Must be a BS Biochemistry Concentration major. Quarter Prerequisite: CHEM 437B with a grade of C or better, Must be a BS Biochemistry Concentration major

Continuation of CHEM 4200L. This is a research-based course where students will learn how to use sequence and structure analysis tools. Students will also perform site-directed mutagenesis and cell culture-based assays. Formerly 438B. Students may not earn credit for CHEM 5700 if they have earned credit for CHEM 438B. Materials fee required.

**CHEM 5751. Internship in Chemistry. Unit: 1**

Quarter Prerequisite: course work appropriate to the specific internship and consent of department

Supervised work and study in applied chemistry in an on- or off-campus setting. Final written report may be required. Department consent required. A maximum of 3 units may be applied toward the degree. Graded credit/no credit. Formerly offered as CHEM 575A.

**CHEM 5752. Internship in Chemistry. Units: 2**

Quarter Prerequisite: course work appropriate to the specific internship and consent of department

Supervised work and study in applied chemistry in an on- or off-campus setting. Final written report may be required. Department consent required. A total of three units of Internship may be applied towards obtaining a bachelors degree and a total of five units may be applied towards obtaining a masters degree. Graded credit/no credit. Formerly offered as CHEM 575B.

**CHEM 5753. Internship in Chemistry. Units: 3**

Quarter Prerequisite: course work appropriate to the specific internship and consent of department

Supervised work and study in applied chemistry in an on or off campus setting. Final written report may be required. Department consent required. A maximum of 3 units may be applied toward the degree. Graded credit/no credit. Graded credit/no credit. Formerly offered as CHEM 575C.

**CHEM 5800. Chemistry Seminar. Unit: 1**

Semester Prerequisite: Both CHEM 3200 and either CHEM 2500 or 3500 with grades of C or better, Must have completed 90 units towards degree. Quarter Prerequisite: Twelve upper-division units in chemistry, and NSCI 306 or equivalent

Discussion of selected journal articles and the primary chemical literature. Oral student presentations; faculty and guest speakers; students reflect on previous coursework. BS Chemistry Concentration students propose projects for CHEM 5850 or CHEM 5860. BA and BS Biochemistry Concentration students present topics of their own choosing. Formerly CHEM 590B. Students may not earn credit for CHEM 5800 if they have earned credit for CHEM 590B.

**CHEM 5850. Chemistry Senior Project. Unit: 1**

Semester Prerequisite: CHEM 5800; student must be a BS Chemistry Concentration major. Prerequisite: CHEM 590A

Students conduct projects proposed in CHEM 5800 and present results at end of course. Consent of instructor required. Materials fee required.

**CHEM 5860. Chemistry Senior Research. Unit: 1**

Semester Prerequisite: CHEM 5800

Students conduct research with a faculty member and present results at the end for the purpose of meeting the final requirements for the B.S. Chemistry Concentration degree. Consent of instructor required. Materials fee required.

**CHEM 5901. Directed Laboratory Research. Unit: 1**

Study and practice of an advanced laboratory technique or directed research in chemistry. May be repeated for credit. Formerly CHEM 501A. Consent of instructor required. Materials fee required.

**CHEM 5902. Directed Laboratory Research. Units: 2**

Quarter Prerequisite: the basic course covering the subject of the Advanced Laboratory Techniques course and consent of instructor. Study and practice of an advanced laboratory technique or directed research in chemistry. May be repeated for credit. Consent of instructor required. Formerly CHEM 501B. Materials fee required.

**CHEM 5903. Directed Laboratory Research. Units: 3**

Study and practice of an advanced laboratory technique or directed research in chemistry. May be repeated for credit. Consent of instructor required. Materials fee required.

**CHEM 5951. Independent Study. Unit: 1**

Semester Prerequisite: Appropriate coursework as determined by the instructor, Submission and approval of a project proposal, filed one semester in advance of when the course is taken. Quarter Prerequisite: A minimum overall grade point average of 2

Laboratory, field, or computational research, data analysis, and/or literature research conducted under the direction of a faculty member. Department consent and final written report required. Consent of instructor required. Formerly 595A. Materials fee required.

**CHEM 5952. Independent Study. Units: 2**

Semester Prerequisite: Appropriate coursework as determined by the instructor, Submission and approval of a project proposal, filed one semester in advance of when the course is taken. Quarter Prerequisite: A minimum overall grade point average of 2

Laboratory, field, or computational research, data analysis, and/or literature research conducted under the direction of a faculty member. Department consent and final written report required. Consent of instructor required. Formerly CHEM 595B. Materials fee required.

**CHEM 5953. Independent Study. Units: 3**

Semester Prerequisite: Appropriate coursework as determined by the instructor, Submission and approval of a project proposal, filed one semester in advance of when the course is taken. Quarter Prerequisite: A minimum overall grade point average of 2

Laboratory, field, or computational research, data analysis, and/or literature research conducted under the direction of a faculty member. Department consent and final written report required. Consent of instructor required. Formerly CHEM 595C. Materials fee required.

**CHEM 5971. Directed Study in Science Education. Unit: 1**

Readings, internet, library research in chemical education; or a directed project on pedagogical approaches applied to teaching chemistry; and/or exploration of content knowledge in a specific area of chemistry for delivery to a specific audience. Conducted under the direction of a faculty member. Department consent required. Formerly CHEM 597. May be repeated for credit. Graded Credit/No Credit.

**CHEM 5972. Directed Study in Science Education. Units: 2**

Readings, internet, library research in chemical education; or a directed project on pedagogical approaches applied to teaching chemistry; and/or exploration of content knowledge in a specific area of chemistry for delivery to a specific audience. Conducted under the direction of a faculty member. Department consent required. May be repeated for credit. Graded Credit/No Credit.

**CHEM 5973. Directed Study in Science Education. Units: 3**

Readings, internet, library research in chemical education; or a directed project on pedagogical approaches applied to teaching chemistry; and/or exploration of content knowledge in a specific area of chemistry for delivery to a specific audience. Conducted under the direction of a faculty member. Department consent required. May be repeated for credit. Graded Credit/No Credit.

**CHEM 5990. Undergraduate Comprehensive Examination. Units: 0**

Semester Prerequisite: Student must be a BS chemistry major within two semesters of graduation. Quarter Prerequisite: Student must be a chemistry major within three quarters of graduation

Assessment of the student's mastery of four of the five content areas of chemistry depending on the major concentration area; and/or an overall assessment of integrated undergraduate chemistry knowledge; demonstration of critical and independent thinking in chemistry. Department consent required. Formerly CHEM 599. Graded Credit/No Credit.

**CHEM 6000. Advanced Environmental Chemistry and Geosciences. Units: 4**

Semester Prerequisite: classified standing in either the Master of Science in Geology or Master of Science in Environmental Sciences program, or consent of instructor

Application of earth science principles to the properties of the natural environment and the effects of human and biological activities thereon. Topics include geohazards, erosion, geochemistry, sources and treatment of water, climate change, and the chemistry of environmental pollutants in air, water, and soil. Labs will feature hands-on studies of common methods used in environmental and geological analyses. Materials fee required. Formerly CHEM 610 and GEOL 610; students may not receive credit for both the quarter versions and this version.

**CHEM 6752. Advanced Internship. Units: 2**

Semester Prerequisite: CHEM 575, CHEM 5751, CHEM 5752, CHEM 5753, GEOL 575, GEOL 5751, GEOL 5752 or GEOL 5753. Prerequisite: CHEM 575 or GEOL 575 and consent of advisor  
Supervised work or study in private or public organizations. Department consent required. Graded Credit/No Credit. Formerly CHEM 697. Students may not receive credit for both courses.

**CHEM 6753. Advanced Internship. Units: 3**

Semester Prerequisite: CHEM 575, CHEM 5751, CHEM 5752, CHEM 5753, GEOL 575, GEOL 5751, GEOL 5752 or GEOL 5753. Quarter Prerequisite: CHEM 575 or GEOL 575 and consent of advisor  
Supervised work or study in private or public organizations. Departmental consent required. Graded Credit/No Credit. Formerly CHEM 697. Students may not receive credit for both courses.

**CHEM 6900. Graduate Seminar. Units: 2**

Current and past student project investigations in the M.S. Environmental Science and Geology programs, including presentation of project implications for the general public and professional non-scientific constituents such as business, law, policy, and public health. Formerly offered as CHEM/GEOL 690, students may not receive credit for both courses. Two hours seminar.

**CHEM 6940. Graduate Research Methods and Design. Units: 3**

Quarter Prerequisite: Classified standing in the master of science program in geology or environmental sciences, and consent of instructor  
Critical literature review and preparation of a master's thesis or project research proposal following program guidelines. Supervised by the student's thesis/project adviser. Graded credit/no credit upon approval of the student's thesis/project committee.



### **CHEM 6950. Directed Graduate Research in Chemistry. Units: 3**

Semester Prerequisite: classified standing in masters program and consent of advisor. Quarter Prerequisite: classified standing in masters program and consent of advisor

Original individual research in environmental chemistry; to be conducted under the direct supervision of a faculty member of the students committee, and if desired in collaboration with other members of the students masters committee. Materials fee required. Formerly offered as Chem 695D.

### **CHEM 6960. Graduate Project in Chemistry. Units: 3**

Semester Prerequisite: Classified standing. Quarter Prerequisite: Classified standing and consent of instructor

Original individual research in chemistry, to be conducted under the guidance of the student's graduate advisor, and if desired, in collaboration with other members of the student's master's committee. Department consent required. Graded credit/no credit. Formerly CHEM 696.

### **CHEM 6970. Graduate Thesis. Units: 3**

Semester Prerequisite: CHEM 6950. Quarter Prerequisite: CHEM 695 or GEOL 695

Independent graduate research conducted under guidance of the major advisor culminating in a written thesis. Formerly offered as CHEM 699.

### **CHEM 6990. Continuous Enrollment for Graduate Candidacy Standing. Units: 0**

Quarter Prerequisite: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

### **CHEM 6991. Continuous Enrollment for Graduate Candidacy Standing. Unit: 1**

Quarter Prerequisite: Advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

### **CHEM 6992. Continuous Enrollment for Graduate Candidacy Standing. Units: 2**

Quarter Prerequisite: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

### **CHEM 6993. Continuous Enrollment for Graduate Candidacy Standing. Units: 3**

Quarter Prerequisite: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

### **CHEM 6994. Continuous Enrollment for Graduate Candidacy Standing. Units: 4**

Quarter Prerequisite: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

### **CHEM 6995. Continuous Enrollment for Graduate Candidacy Standing. Units: 5**

Quarter Prerequisite: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

### **CHEM 6996. Continuous Enrollment for Graduate Candidacy Standing. Units: 6**

Quarter Prerequisite: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in a Continuous Enrollment for Graduate Candidacy Standing course each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. Continuous Enrollment for Graduate Candidacy Standing is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.