Chemistry and Biochemistry

College of Science and Mathematics

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Faculty

Edward J. Carroll Jr., Jeffrey Charonnat, Susan Collins, Karin Crowhurst, Daniel Curtis, Jussi Eloranta, Paula Fischhaber, Simon Garrett, Joseph Hajdu, Eric Kelson, Jheem D. Medh, Gagik Melikyan, David Miller, Thomas Minehan, John Nguyen, Dorothy Nguyen-Graff, Taeboem Oh, Sandor Reichman,Yann Schrodi, David Toppen.

Emeritus Faculty

Henry Abrash, Kenneth Hardcastle, Francis Harris, William Harrison, Margaret Holzer, I-Nan Hsu, Sandra Jewett, Paul Klinedinst, LeRoy Nyquist, Carl Olsen, Edward Rosenberg, James Schaeffer, Ricardo Silva, Dean Skovlin

Degree Programs

Undergraduate:

- **B.A., Chemistry**
- **B.S., Chemistry**
- **B.S., Biochemistry**
- **Minor in Chemistry**
- **Chemistry Subject Matter Program for the Single Subject Credential**

Graduate:

- **M.S., Biochemistry**
- **M.S., Chemistry**

The Major

Chemistry is called the central science. It addresses problems raised in related fields such as biology, geology, physics and engineering. Chemists solve such problems, by analyzing substances, synthesizing new materials, and by measuring their properties. They also investigate biochemical systems.

Careers

A degree in chemistry will enable you to work as a professional chemist, synthesizing compounds, analyzing qualitatively and quantitatively the content of various materials, and measuring the properties of chemical substances.

A degree in biochemistry will enable you to work in the developing field of genetic engineering. A degree in chemistry will help you pursue a career in the area of environmental protection, biotechnology, nanotechnology, and in many areas related to chemical and pharmaceutical areas. In addition, any of the degree options in chemistry will enable you to enter professional programs such as medical, dental or pharmacy schools.

Academic Advisement

Elective courses taken to fulfill requirements in the major should have prior approval of the student's advisor. Chemistry majors must consult with their advisors for program planning and approval each semester before being allowed to register for classes.

Each undergraduate major has an assigned a faculty advisor. Students should consult with their advisor or seek advice at the Chemistry and Biochemistry Office in Live Oak Hall 1300. Please contact the Department Office for graduate program and credential advisement.

Credential Information

The Chemistry B.A. (or alternatively, the Biochemistry B.S.) provides an option for students planning to teach chemistry and coordinated science at the secondary level. This degree program, with some supplementary courses, has been approved by the California Commission on Teacher Credentialing as an academic subject matter program for the Single Subject Credential in Science: Chemistry. For details on the Single Subject Credential program, see the Credentials and Department of Secondary Education sections in this catalog.

Department Programs

The B.A. degree is designed for students who desire (a) a strong chemistry background for careers in the health field (see advisor concerning additional necessary courses); (b) careers in industry, including textile chemistry, technical sales, government laboratories, patent law, library fields, etc., or (c) a single subject teaching credential (Science: Chemistry).

The B.S. in Chemistry is designed to prepare students who desire: (a) to pursue graduate work in chemistry; (b) to work in industry or government laboratories, or (c) to work in the fields of technical sales, hazardous materials testing and handling, chemical literature, or chemical patents.

The B.S. in Biochemistry degree is designed for students who desire: (a) pre-medical, pre-dental, pre-pharmacy or pre-veterinary preparation; (b) graduate study in biochemistry, or (c) careers in the life sciences that require an understanding of biological phenomena at the molecular level.

The curriculum for the B.S. degree in Chemistry and for the B.S. degree in Biochemistry has been reviewed by the American Chemical Society (ACS) and meets its requirements for approved programs.

The M.S. in Chemistry is designed to prepare students for research-oriented careers in chemical industry, for entry into doctoral programs at other institutions, or for teaching of chemistry at institutions such as community colleges.

The M.S. in Biochemistry allows specialization in the areas of biochemistry, molecular biology, or bioorganic and is intended for students desiring research-oriented careers in chemical, biochemical, biotech industry, post-secondary chemistry teaching or entry into Ph.D. programs.

Student Learning Outcomes of the Undergraduate Program

1. Present scientific information clearly and concisely in both written and oral forms.
2. Synthesize, isolate, purify and characterize compounds using published reactions and protocols, and can use standard laboratory equipment and modern instrumentation.
3. Adopt procedures available from the chemical literature to solve problems in chemistry, including the use of current laboratory techniques, instrumentation and computer applications, under the guidance of an instructor.
4. Have basic knowledge in analytical, inorganic, organic and physical chemistry areas.

Requirements for the B.A. Degree

1. Lower Division Required Courses (24 Units)

MATH	255A	Calculus for the Life Sciences I (3)
MATH	255B	Calculus for the Life Sciences II (3)
PHYS	100A/L	General Physics I and Lab (3/1)
PHYS	100B/L	General Physics II and Lab (3/1)
CHEM	101/L	General Chemistry I and Lab (4/1)
CHEM	102/L	General Chemistry II and Lab (4/1)

2. Upper Division Required Courses (26 Units)

CHEM	321/L	Chemical Analysis I and Lab (2/2)
CHEM	422/L	Chemical Analysis II and Lab (2/2)
CHEM	333/L	Organic Chemistry I and Lab (3/1)
CHEM	333R	Problem Solving in Organic Chemistry I (1)
CHEM	334/L	Organic Chemistry II and Lab (3/1)

CHEM	334R	Problem Solving in Organic Chemistry II (1)
CHEM	355/L	Fundamentals of Physical Chemistry and Lab (3/1)
CHEM	401	Inorganic Chemistry (3)
CHEM	495A	Directed Undergraduate Research
or CHEM	499A	Independent Study with presentation of a seminar (1)

3. Upper Division Electives (7 Units)

Chemistry electives selected with approval of major advisor from 400 or 500-level courses in Chemistry. At least 3 units must be from electives other than CHEM 495 and 499.

Total Units in the Major	57
General Education Units	36
Additional Units	27
Total Units Required for the Degree	120

Chemistry Subject Matter Program for the Single Subject Credential

The Chemistry Subject Matter Program for the Single Subject Credential sunsets on July 1, 2009. Only those students who started the program before July 1, 2005 and who can complete it before the sunset date will be eligible to receive the subject matter program verification. Please contact the department for more information.

Requirements for the B.S. Degree In Chemistry

1. Lower Division Required Courses (36 Units)

MATH	150A	Calculus I (5)
MATH	150B	Calculus II (5)
MATH	250	Calculus III (3)
MATH	280	Applied Differential Equations (3)
PHYS	225/220AL	Physics I/ Mechanics Lab. (4/1)
PHYS	226/220BL	Physics II/ Electricity and Magnetism Lab (4/1)
CHEM	101/L	General Chemistry I and Lab (4/1)
CHEM	102/L	General Chemistry II and Lab (4/1)

2. Upper Division Required Courses (39 Units)

CHEM	321/L	Chemical Analysis I and Lab (2/2)
CHEM	422/L	Chemical Analysis II and Lab (2/2)
CHEM	333/L	Organic Chemistry I and Lab (3/1)
CHEM	333R	Problem Solving in Organic Chemistry I (1)
CHEM	334/L	Organic Chemistry II and Lab (3/1)
CHEM	334R	Problem Solving in Organic Chemistry II (1)
CHEM	351	Physical Chemistry I (4)
CHEM	352/L	Physical Chemistry II and Lab (3/2)
CHEM	401/L	Inorganic Chemistry and Lab (3/1)
CHEM	411	Synthesis (3)
CHEM	464	Principles of Biochemistry (4)
CHEM	495A	Directed Undergraduate Research
or CHEM	499A	Independent Study with presentation of a seminar (1)

3. Upper Division Electives (3 Units)

Chemistry electives selected with approval of the major advisor from 400 or 500-level courses in Chemistry other than CHEM 495 and 499.

Total Units in the Major	78
General Education Units	36
Additional Units	6
Total Units Required for the Degree	120

Requirements for the Bachelor of Science Degree In Biochemistry:

1. Lower Division Required Courses (32 Units)

MATH	255A	Calculus for the Life Sciences I (3)
MATH	255B	Calculus for the Life Sciences II (3)
PHYS	100A/L	General Physics I and Lab. (3/1)
PHYS	100B/L	General Physics II and Lab. (3/1)
CHEM	101/L	General Chemistry I and Lab (4/1)
CHEM	102/L	General Chemistry II and Lab (4/1)
BIOL	106/L	Biological Principles I and Lab. (3/1)
BIOL	107/L	Biological Principles II and Lab (3/1)

2. Upper Division Required Courses (39 Units)

CHEM	321/L	Chemical Analysis I and Lab (2/2)
CHEM	422/L	Chemical Analysis II and Lab (2/2)
CHEM	333/L	Organic Chemistry I and Lab (3/1)
CHEM	333R	Problem Solving in Organic Chemistry I (1)
CHEM	334/L	Organic Chemistry II and Lab (3/1)
CHEM	334R	Problem Solving in Organic Chemistry II (1)
CHEM	355/L	Fundamentals of Physical Chemistry and Lab (3/1)
CHEM	401	Inorganic Chemistry (3)
CHEM	461	Biochemistry I (4)
CHEM	462	Biochemistry II (4)
CHEM	465	Topics in Biochemistry (3)
BIOL	380	Cell Biology (3)

3. Upper Division Electives (10 Units)

A minimum of 3 units of upper division electives selected from the following courses:

CHEM	411	Synthesis (3)
CHEM	433	Organic Analysis (3)
CHEM	471	Chemical Literature, Information Retrieval and Presentation (1)
CHEM	481	Nuclear and Radiochemistry (4)
CHEM	495A-C	Directed Undergraduate Research (1-3)
CHEM	499A-C	Independent Study (1-3)
CHEM	538	Natural Products (3)

A minimum of 7 units of electives selected with approval of major advisor from upper division courses in biology.

Total Units in the Major	81
General Education Units	36
Additional Units	3
Total Units Required for the Degree	120

Requirements for the M.S. Degree in Biochemistry

A. For Admission to the Program

1. In addition to general University requirements for admission, Bachelor's Degree with 2.75 or higher overall grade point average and a major in Chemistry, Biochemistry or other area with the appropriate science content. Applicants with an overall grade point average between 2.50 and 2.75 may be admitted if their grade point average in the last 60 units is at or above 2.75.
2. Foreign students must submit a minimum TOEFL score of 550 (paper-based test) or 213 (computer-based test) to demonstrate their proficiency in the English language.
3. Departmental approval. The Department may request additional supporting material to assess an applicant's preparation and likelihood for academic success.

B. For Classified Status

1. Demonstrated competence in biochemistry and organic chemistry, and in physical or inorganic chemistry, either through satisfactory

scores on the departmental proficiency exams or through course work in these areas.

2. General University requirements for classified status

C. Requirements for the Degree

1. A minimum of 30 units of graduate work including a thesis to be completed within five years of attaining classified status. At least 21 units must be taken in 500 or 600-level courses. Normally, degree candidates are expected to serve as teaching assistants in the Department.

a. Required Courses (12 to 18 units)

500-level Biochemistry Courses (6)

CHEM	691	Literature Seminar (1)
CHEM	692	Thesis Seminar (1)
CHEM	696	Directed Graduate Research (3-7)
CHEM	698	Thesis (1-3)

b. Electives (12-18 units)

These electives should be selected with the approval of the Graduate Coordinator from 400 and 500-level Chemistry and Biochemistry/Biology courses and must include at least one course that has a laboratory component. A maximum of 9 units of 400-level courses may be applied toward the 30 units required for the degree. A list of suitable electives can be found at the Department web site, and is also available from the Graduate Coordinator or the Department Office.

2. Oral defense of thesis.
3. Formal approval by the Graduate Thesis Committee.

Total Units for the MS Biochemistry Degree	30

Requirements for the Master of Science Degree In Chemistry

A. For Admission to the Program:

1. In addition to general University requirements for admission, a Bachelor's Degree with 2.75 or higher overall grade point average and a Chemistry major equivalent to that at CSUN. For admission to the Environmental Chemistry option, a baccalaureate degree, other than chemistry, with appropriate science background is acceptable. Applicants with an overall grade point average between 2.50 and 2.75 may be admitted if their grade point average in the last 60 units is at or above 2.75.
2. Foreign students must submit a minimum TOEFL score of 550 (paper-based test) or 213 (computer-based test) to demonstrate their proficiency in the English language.
3. Departmental approval. The department may request additional supporting material to assess an applicant's preparation and likelihood for academic success.

B. For Classified Status

1. Satisfactory scores on the Departmental proficiency exams in organic, inorganic and physical chemistry or demonstrated competence through course work in these areas.
2. General University requirements for classified status.

C. Requirements for the degree:

1. A minimum of 30 units of graduate work including a thesis. At least 21 units must be taken in 500 or 600-level courses. Normally, degree candidates are expected to serve as teaching assistants in the Department.

a. Required Courses (6 to 12 Units)

CHEM	691	Literature Seminar (1)
CHEM	692	Thesis Seminar (1)
CHEM	696A-C	Directed Graduate Research (3-7)
CHEM	698A-C	Thesis (1-3)

b. Electives (18 to 24 Units)

The electives should be selected with the approval of the Graduate Coordinator from 400 and 500-level courses and must include at least 1 course which has a lab component.

A maximum of 9 units of 400-level courses may be applied toward the 30 units required for the degree.

2. Oral defense of thesis.
3. Formal Approval by the Graduate Thesis Committee.

Total Units for the MS Chemistry Degree	30

Minor in Chemistry

1. Lower Division Required Courses (10 Units)

CHEM	101/L	General Chemistry I and Lab (4/1)
CHEM	102/L	General Chemistry II and Lab (4/1)

(PHYS 100A/B, General Physics, is recommended)

2. Upper Division Required Courses (14 Units)

CHEM	321/L	Chemical Analysis I and Lab (2/2)
CHEM	333/L	Organic Chemistry I and Lab (3/1)
CHEM	333R	Problem Solving in Organic Chemistry I (1)
CHEM	334/L	Organic Chemistry II and Lab (3/1)
CHEM	334R	Problem Solving in Organic Chemistry II (1)

3. Upper Division Electives (3-4 Units)

Select one course from the following:

CHEM	365/L	Introduction to Biochemistry and Lab (3/1)
CHEM	464/L	Principles of Biochemistry and Lab (3/1)

or a minimum of 3 units of other approved upper division Chemistry for which the student has the prerequisite.

Total Units in the Minor	25-26

Course List

CHEM 100. Principles of Chemistry (3)

Prerequisite: Qualifying score on the ELM examination or satisfying the exemption requirements. One semester course based on a systematic, semi-empirical approach to the submicroscopic world of chemistry. Development of modern ideas concerning atomic and molecular structure, principles of compound formation, and chemical reactivity are emphasized. Selected topics in applied chemistry and the application of chemical principles to life and environmental sciences are explored. Engineering and Science majors should consult with their advisors before enrolling in this course. Credit cannot be earned in both CHEM 103 and 100. Students using this course to satisfy a General Education requirement, in Natural Sciences may satisfy the corresponding lab requirement by completing CHEM 100L. Three hours lecture per week.

CHEM 100L. Principles of Chemistry Laboratory (1)

Prerequisite: Qualifying score on the ELM Examination or satisfying the ELM exemption requirement. Corequisite: CHEM 100. Optional laboratory course to accompany Chem 100 in which the fundamentals of scientific inquiry and basic laboratory techniques are presented. May be used to satisfy the laboratory requirement in Natural Sciences of General Education provided CHEM 100 is also completed. Three-hour laboratory.

CHEM 101/L. General Chemistry I and Lab (4/1)

Prerequisite: Satisfactory score on the Chemistry Placement Test (CPT) or a grade of C or higher (C- is unacceptable) in CHEM 100 taken at CSUN only. Corequisite: CHEM 101L. Basic course in the fundamental principles and theories with special emphasis on chemical calculations. Includes a discussion of the kinetic molecular theory, atomic structures, and the periodic table, solutions, and oxidation-reduction. Recitation portion deals with problem solving, review of the lecture material and

quizzes. Lab: Emphasizes basic lab skills, quantitative relationships in chemistry, and inorganic preparative procedures. Completion of CHEM 101/L satisfies General Education Natural Sciences including the corresponding lab requirement. Three hours lecture; 1 hour recitation per week; three hours lab per week.

CHEM 102/L. General Chemistry II and Lab (4/1)
Prerequisite: CHEM 101/L with a minimum grade of C- in CHEM 101. Corequisite: CHEM 102L. Continuation of CHEM 101. Introduction to kinetics, gas phase and solution equilibria, electrochemistry, chemical thermodynamics, radio, organic chemistry and the descriptive chemistry of the more familiar metals and nonmetals. Recitation portion deals with problem solving, review of the lecture material and quizzes. Lab: Consists of experiments dealing with kinetics, acid-base and solubility equilibria, selected reactions of metals and nonmetals, and qualitative elemental analysis. Completion of CHEM 102/L satisfies General Education, Natural Sciences including the corresponding lab requirement. Three hours lecture; 1 hour recitation per week; three hours lab per week.

CHEM 103. Introductory Chemistry I (4)
Prerequisite: Qualifying score on the ELM Examination or satisfying the ELM exemption requirements. Not open to engineering, biology or physical science majors. Designed to stress fundamental principles of inorganic chemistry, structure of atoms and molecules, periodic table, states of matter, chemical calculations involving stoichiometry and simple algebraic operations. Credit cannot be earned in both CHEM 103 and 100. Students using this course to satisfy a General Education Requirement in the Natural Sciences automatically satisfy the lab requirement. Three hours lecture; three hours lab component (with quiz and recitation) per week.

CHEM 104. Introductory Chemistry II (4)
Prerequisite: CHEM 103. Not open to engineering, biology or physical science majors. Continuation of CHEM 103. Properties of solutions, chemical equilibrium, acids and bases. Chemistry of simple organic compounds and common elements. Students using this course to satisfy a General Education requirement in Natural Sciences automatically satisfy the lab requirement. Three hours lecture; three hours lab component (with quiz and recitation) per week.

CHEM 110. Chemistry in Action (3)
One-semester course introducing chemistry and its relation to technological advances and their impact on our society and the environment. Students using this course to satisfy a General Education requirement in Natural Sciences may satisfy the corresponding lab requirement by completing CHEM 110L. Three hours lecture per week.

CHEM 110L. Chemistry in Action Lab (1)
Recommended Corequisite or Preparatory: CHEM 110 or 100. No credit for Science and Engineering majors. Lab-demonstration course that accompanies CHEM 110. Lab experiments and demonstrations to augment lecture material are performed. Introduction to some basic lab skills. May be used to satisfy the lab requirement in Natural Sciences of General Education provided CHEM 100 or 110 is also completed. One three-hour lab session per week.

CHEM 235. Introductory Organic Chemistry (4)
Prerequisite: CHEM 102/L or 104. No credit for Science and Engineering majors except for certain options in Biology, Geology, and Physics; consult your major department. Describes simple aliphatic and aromatic compounds with emphasis on chemistry of functional groups. Does not substitute for CHEM 333. Three hours lecture; three hours lab per week.

Upper Division

CHEM 321/L. Chemical Analysis I and Lab (2/2)
Prerequisite: CHEM 102/L. Corequisite: CHEM 321L. Emphasizes the principles of analytical reactions and the theory and applications of instruments to problems of chemical analysis. Principal topics include volumetric methods and instrumental techniques such as spectrophotometry, electro chemistry, and chromatography. Lab: Introduction to the experimental methods of analytical chemistry based on the theory covered in CHEM 321. Emphasis on the development of careful and accurate lab technique. Two hours lecture per week; two three-hour lab periods per week.

CHEM 333/L. Organic Chemistry I and Lab (3/1)
Prerequisite: CHEM 102/L. Corequisite: CHEM 333L (all majors), CHEM 333R for Chemistry and Biochemistry majors. Recommended Corequisite: CHEM 333R for all other majors. The study of the structure and properties of organic molecules, with a special emphasis on functional groups and their reactions. Attention given to the mechanisms of organic reactions and the spectroscopic techniques used to determine the structure of organic molecules. Lab: An introduction to the techniques of synthesis, purification and characterization of organic compounds. Three hours lecture per week; three hours lab per week.

CHEM 333R. Problem Solving in Organic Chemistry I (1)
Corequisite: CHEM 333. Critical analysis of topics introduced in CHEM 333. Structured group work is used to develop essential analysis and problem-solving skills. One hour per week.

CHEM 334/L. Organic Chemistry II and Lab (3/1)
Prerequisite: CHEM 333/L. Corequisite: CHEM 334L (all majors), CHEM 334R for Chemistry and Biochemistry majors. Recommended Corequisite: CHEM 334R for all other majors. Continuation of CHEM 333, with an emphasis on mechanisms of organic reactions and synthesis. Attention given to representative compounds of interest in biology and medicine. Lab: Exposure to reactions common in chemical synthesis, including arene substitution, transformations of carbonyl compounds, the Diels-Alder reaction and polymer synthesis. Three hours lecture per week; three hours lab per week.

CHEM 334R. Problem Solving in Organic Chemistry II (1)
Prerequisite: CHEM 333/L Corequisite: CHEM 334. Recommended Preparatory: CHEM 333R Critical analysis of topics introduced in CHEM 334. Structured group work is used to develop essential analysis and problem-solving skills. One hour per week.

CHEM 351. Physical Chemistry I (4)
Prerequisites: CHEM 102/L; PHYS 225; MATH 150B. Recommended Corequisite or Preparatory: MATH 250. Basic laws of thermodynamics, states and changes of state, solutions, equilibria, phase rule, kinetic molecular theory, chemical kinetics, and electrochemistry. Four lecture hours per week. (Offered fall semester)

CHEM 352/L. Physical Chemistry II and Lab (3/2)
Prerequisites: CHEM 321/L, 351; PHYS 226; MATH 250. Corequisite: CHEM 352L. Recommended Corequisite or Preparatory: MATH 280. Continuation of CHEM 351. Quantum mechanics, atomic and molecular structure, spectroscopy, and statistical mechanics. Lab: Introduction to the experimental methods of physical chemistry based on the theory covered in both semesters of the physical chemistry sequence. Three hours lecture per week; six hours lab per week. (Offered spring semester)

CHEM 355. Fundamentals of Physical Chemistry (3)
Prerequisites: CHEM 321/L; MATH 150B or 255B; PHYS 100A. Recommended Corequisite or Preparatory: PHYS 100B. No credit for Engineering or Physics majors. Short course in physical chemistry,

presenting such topics as thermodynamics, chemical equilibrium, solutions of electrolytes, reaction kinetics, quantum chemistry, spectroscopy, and the properties of macromolecules with special applications to the life sciences. Does not substitute for CHEM 351 in B.S. program. Three hours lecture per week (Offered fall semester)

CHEM 355L. Experimental Physical Chemistry Lab (1)
Recommended Corequisite or Preparatory: CHEM 355. Not open to B.S. Chemistry majors. Lab course for the non-chemistry major or B.A. chemistry major taking CHEM 355. Selected experiments illustrating some of the important physiochemical concepts covered in CHEM 355 are performed. Three hours lab per week. (Offered fall semester)

CHEM 365. Introduction to Biochemistry (4)
Prerequisite: CHEM 235 or CHEM 333. No credit for Science or Engineering majors except for certain options in Biology and Physics; consult your major department. For non-science majors, describing chemistry and metabolism of proteins, carbohydrates, lipids, vitamins, hormones, etc. three hours lecture; one three-hour lab per week.

CHEM 401. Inorganic Chemistry (3)
Prerequisite: CHEM 352 or 355. Principles of chemical bonding and molecular structure; survey of the chemistry of the elements of the periodic system. Three hours lecture per week.

CHEM 401L. Inorganic Chemistry Lab (1)
Corequisite: CHEM 401. Synthesis and characterization of inorganic and organometallic compounds. Synthetic techniques important to inorganic chemistry such as electrochemical synthesis, autoclave reactions, inert atmosphere techniques as well as inorganic spectroscopic techniques.

CHEM 411. Synthesis (3)
Prerequisite: CHEM 334. Preparation of inorganic and organic compounds and their identification, using advanced methods. One hour lecture; six lab component hours per week.

CHEM 422/L. Chemical Analysis II AND Lab (2/2)
Prerequisite: CHEM 321. Corequisite: CHEM 422L. Continuation of CHEM 321 with special emphasis on polarography and voltammetry, chromatography, spectrophotometric methods, mass spectrometry and radiochemical methods. Two hours of lecture per week; two three-hour lab periods per week.

CHEM 433. Organic Analysis (3)
Prerequisite: CHEM 334. Identification of organic compounds using advanced spectrometric techniques that include modern NMR methods. One hour lecture; six lab component hours per week.

CHEM 451. Modern Physical Chemistry (3)
Prerequisite: CHEM 352. Selected topics in modern physical chemistry, including atomic and molecular structure and spectra, the chemical bond, inter-molecular forces, interaction of matter with fields and the solid state. Three hours lecture per week.

CHEM 461. Biochemistry I (4)
Prerequisites: CHEM 321/L and 334. Study of protein structure and function enzyme mechanisms, biological membranes, carbohydrate metabolism, ATP generation and lipid metabolism. Three hours lecture; one three-hour lab component period per week. (Offered fall semester)

CHEM 462. Biochemistry II (4)
Prerequisite: CHEM 461 or instructor consent. Continuation of CHEM 461 that studies photosynthesis, amino acid metabolism, lipoproteins, metabolic inter relationships and regulation, information transfer, and biochemical basis of disease. Three hours lecture; one three-hour lab per week. (Offered spring semester)

CHEM 464. Principles of Biochemistry (3)
Prerequisite: CHEM 334. Corequisite (for Chemistry majors and minors): CHEM 464L. Properties and metabolism of the constituents of biological systems. Mechanism of enzyme action, energy relations in biological systems. Three hours lecture per week. Available for graduate credit.

CHEM 464L. Principles of Biochemistry Laboratory (1)
Prerequisite: CHEM 334. Corequisite: CHEM 464. Recommended Preparatory: CHEM 321/L. Experiments involving acid/base chemistry, peptide structure, spectrophotometric analysis, biomolecule purification and enzymology designed to develop the ability to collect, analyze and report experimental biochemical information. One three-hour lab per week. Available for graduate credit.

CHEM 465. Topics in Biochemistry (3)
Prerequisite: CHEM 462 or instructor consent. Seminar in major recent developments in biochemistry. Three hours lecture per week.

CHEM 471. Chemical Literature, Information Retrieval and Presentation (1)
Prerequisites: Open only to junior and senior Science majors and graduate students in Science. Use of the chemical literature including abstracts and computer retrieval systems. Preparation of manuscripts and oral presentations. One hour lecture per week.

CHEM 481. Nuclear and Radiochemistry (4)
Prerequisites: CHEM 352 or 355. Study of the atomic nucleus and its properties. Description of nuclear phenomena and an introduction to nuclear theory. Lab: Techniques for the study of radio-nuclides and the application of isotopic tracers to problems in biology, chemistry, geology, and physics are explored. Two hours lecture; two three-hour lab periods per week.

CHEM 495A-C. Directed Undergraduate Research (1-3)
Prerequisite: One course beyond CHEM 102 in the area related to the research. Interested students should make arrangements with the department as soon as possible, preferably during the previous semester. For students of advanced rank and proven competence in chemistry. Program of original independent research, culminating in a written report, carried out under the direction of one of the Chemistry faculty. Upon prior approval by the Department of a detailed research proposal, the research may be performed in industrial or medical labs. In such a case, the research report must be submitted to and evaluated by a designated member of the Chemistry faculty. May be repeated for credit. No credit towards M.S. degree.

CHEM 499A-C. Independent Study (1-3)
See Independent Study under courses of study.

Graduate

Graduate students should refer to Graduate Programs.

CHEM 500. Chemistry Teaching Assistant Workshop (1)
Prerequisite: Graduate student status. An instructional improvement workshop for graduate teaching assistants. Participants learn by presenting short video-taped lessons to the class and by receiving feedback on the basic skills demonstrated in the lesson. Participants are presented with a basic model for clear chemistry lab teaching and are taught effective feedback techniques. (Credit/No Credit Only)

CHEM 502. Advanced Inorganic Chemistry (3)
Prerequisite: CHEM 401. Study of molecular structure of inorganic compounds; coordination chemistry; kinetics and mechanisms of inorganic reactions. Three hours lecture per week.

CHEM 522. Advanced Analytical Chemistry (3)
Prerequisite: CHEM 422/L or approval of the instructor. An advanced-level discussion of topics in analytical chemistry with particular emphasis on separation sciences and optical spectroscopy. Topics that will be discussed in detail are fluorescence, phosphorescence, phase and distribution equilibria, extraction techniques, electrophoresis and micro-fluid separation. Three hours lecture per week.

CHEM 531. Survey of Organic Reactions (3)
Prerequisite: CHEM 334. Detailed survey of the ranges of application and mechanisms of organic oxidations, reductions, additions, eliminations, condensations and degradations with specific reference to their applications to problems of synthesis and structure elucidation. Three hours lecture per week.

CHEM 534. Advanced Organic Chemistry (3)
Prerequisites: CHEM 334, 352 or 355. Physical and physiochemical consideration of organic chemistry. Kinetics, configuration. Three hours lecture per week.

CHEM 538. Natural Products (3)
Prerequisite: CHEM 334. Chemistry and biosynthesis of naturally-occurring compounds including alkaloids, steroids, terpenes, and mold metabolites, based on structure elucidation, synthesis, biosynthetic considerations, and physiological properties. Use of modern methods for structure determination and application of unique structural features in theoretical chemistry. Three hours lecture per week.

CHEM 541. Environmental Chemistry I (2)
Prerequisite: CHEM 422/L or instructor consent. Recommended Corequisite: CHEM 541L. Comprehensive survey of the earth's natural processes in atmosphere, water and soil, and the chemical aspects of the impact that human activities have produced in the natural environment. Also, topics such as energy resources, hazardous waste management/treatment, and risk assessment are discussed. Two hours lecture per week.

CHEM 541L. Environmental Chemistry I Lab (2)
Prerequisite: CHEM 422/L or instructor consent. Recommended Corequisite: CHEM 541. Application of chemical and instrumental methods for the identification and quantification of inorganic and organic contaminants present in water, soil, and air samples using E.P.A. approved methodologies and protocols. Six hours lab per week.

CHEM 542. Environmental Chemistry II (1)
Prerequisite: CHEM 541/L or instructor consent. Recommended Corequisite: CHEM 542L. Advanced-level discussion of topics in air, water and soil pollution. Includes the role of humic substances in natural waters, stratospheric ozone depletion, acid rain, photochemical smog, soil and treatment technologies. Case studies on soil and water pollution are also discussed. One hour lecture per week.

CHEM 542L. Environmental Chemistry II Lab (2)
Prerequisite: CHEM 541/L or instructor consent. Recommended Corequisite: CHEM 542. Advanced level experimental investigation on the identification and analysis of contaminated water, air, and soil samples are carried out. Experiments using latest treatment technologies are conducted to understand the application of chemical and biochemical concepts toward solving environmental problems. Also, experiments to characterize complex environmental systems are undertaken. Six hours lab per week.

CHEM 551. Chemical Thermodynamics (3)
Prerequisite: CHEM 352. Thermodynamic properties of pure systems, mixtures, electrochemical systems, surface phases and systems under the influence of external fields; equilibria and thermodynamics of chemical reactions. Three hours lecture per week.

CHEM 552. Quantum Chemistry (3)
Prerequisite: CHEM 352. Elements of wave mechanics and the application to chemical problems. Three hours lecture per week.

CHEM 553. Chemical Kinetics (3)
Prerequisite: CHEM 352. Critical consideration of the kinetics of reactions in gaseous and condensed phases, experimental methods, treatment of data, catalysis and chain reactions. Recent developments in the theory of reaction rates. Three hours lecture per week.

CHEM 554. Macromolecules (3)
Prerequisite: CHEM 352. Physical chemistry of high molecular weight compounds, ultracentrifuge, electro-phoresis, light scattering. Three hours lecture per week.

CHEM 564. Bio-Organic Chemistry (3)
Prerequisite: CHEM 334, CHEM 464 or approval of advisor and instructor. Application of physical organic methods to solution of structural and mechanistic problems in biochemistry.

CHEM 565. Receptor Biochemistry (3)
Prerequisite: CHEM 464 or CHEM 461. Study of the kinetics, structural requirements and signal-transduction mechanisms of receptor-ligand interactions. Three hours of lecture per week.

CHEM 566. DNA-Protein Interactions (3)
Prerequisites: CHEM 464 or CHEM 461 and 462. An advanced biochemistry course with an in-depth study of the biochemistry of DNA-Protein interactions. The course focuses on subfields of biochemistry that involve direct physical interaction between DNA and proteins, including DNA repair, mutagenesis, replication, transcription, translation, RNA interference, DNA packaging and chromosomal maintenance. Three hours of lecture per week.

CHEM 595A-Z. Experimental Topics Courses (1-3)
Prerequisites: Advisor and instructor consent. Specialized topics from a concentrated field of current interest presented at an advanced level. Since the topic chosen is different each semester, students may repeat this course with approval.

CHEM 599A-C. Independent Study (1-3)

CHEM 691. Literature Seminar (1)
Prerequisites: Graduate standing and instructor consent. Oral reports by graduate students on important topics from the current literature in chemistry.

CHEM 692. Thesis Seminar (1)
Prerequisites: Graduate standing and instructor consent. Oral reports by graduate students on results of their thesis research. Before presenting the report, students must submit a rough draft of their MS thesis to their graduate thesis committee and to the Department of Chemistry and Biochemistry as a whole.

CHEM 696A-C. Directed Graduate Research (1-7)
Prerequisites: Classified status and consent of a faculty member who will serve as thesis advisor. Program of research conducted under the direction of the thesis advisor in an area of interest to the student. May be repeated but no more than 7 units are allowed toward the M.S. degree.

CHEM 698A-C. THESIS (1-3)
Prerequisite: Classified standing and advisor's consent. For the M.S. degree: Thesis includes the preparation and writing of the master thesis. May be repeated once but not more than 3 units are allowed towards the M.S. degree.