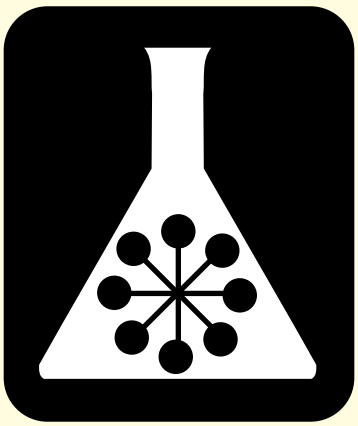
CHEMISTRY



BACHELOR OF ARTS
BACHELOR OF SCIENCE
SUBJECT MATTER PROGRAM
MINOR
MASTER OF SCIENCE

PROGRAM DESCRIPTION

Chemistry is the area of science in which the composition, structure, properties and reactions of substances are studied. Careers in chemistry can be found in such diverse fields as environmental protection, industrial research and development, health and safety, medicine, forensic chemistry, and electronics. The Chemistry Department at CSUS offers the BS, BA (including a concentration in Biochemistry), and MS degrees in chemistry.

The BS degree is recommended for students intending to pursue graduate work in chemistry or those desiring a strong technical background for work in the chemical industry or other highly technical areas. The BS degree is certified by the American Chemical Society.

The BA degree is more flexible in terms of upper division electives; and is recommended for students interested in the allied health areas or programs with a major component of chemistry. Students planning to teach chemistry, at the secondary level, may obtain a BA in chemistry.

The BA degree with a concentration in Biochemistry provides increased training in the growing field of biochemistry, an area that requires a balanced knowledge of chemistry and biology. The concentration will allow chemistry majors to specialize in the interdisciplinary area of biochemistry. It also provides an option for students who enjoy chemistry, but whose career interests are in the areas of medicine and biology. Students completing this degree will find job opportunities in biotechnology, biomedical instrumentation, diagnostics, immunochemistry, pharmaceuticals, and in basic research.

FACULTY

James Hill, *Department Chair*

Londa Borer; Daniel Decious; Joseph DiGiorgio; Richard Fish; David Forkey; Chung Sue Kim; Paul Noble; James Ritchey; Linda Roberts; John Russell; Jerry Wilson.

Evelyn Bradley-Owens, *Department Secretary*
Department Office, Science 506, 278-6684

FEATURES

Instrumentation in the Chemistry Department is extensive and includes: a Hewlett-Packard 5890 Series II GC-Mass spectrometer; Bruker AC-300 nmr; a Perkin-Elmer 1800 FTIR, a Perkin-Elmer diode array UV/Visible spectrometer and MPF-66 fluorescence spectrometer; a Perkin-Elmer Thermal Mechanical Analyzer; a Perkin-Elmer and a Waters HPLC; a Beckman L2-50 ultracentrifuge; a Varian E-4 epr spectrometer; Shimadzu CS-9000 dual wavelength spot scanner; Beckman HPLC and Capillary Electrophresis System, HP 715/80 computer workstation, many PC workstations/and three science computing labs; and several gas chromatographs.

Chemistry is an exciting intellectual challenge, both in theory and in experimental practice. The Chemistry faculty strongly believe that students majoring in chemistry should have an opportunity to participate in basic or applied research and to work closely with faculty in developing their chemical skills and knowledge. Bachelor of Science majors are required to complete an independent research project; and the Chemistry faculty recommend that Bachelor of Arts majors also do a research project. All graduate students must enroll in a graduate research course.

The Chemistry Department believes in effective academic advising, and faculty members from each area of specialization serve as advisors to students. Also, the faculty have a strong commitment to helping students find jobs or gain admission to graduate programs or professional schools. Many of our faculty have personal contacts with industry and government labs in the area, and with faculty in various graduate and professional schools.

CAREER POSSIBILITIES

Analytical Chemist • Biochemist • Inorganic Chemist • Organic Chemist • Physical Chemist • Polymer Chemist • Medicinal Chemist • Medicine • Dentistry • Pharmacy • Pharmacology • Patent Law • Food Technology • Agriculture • Technical Sales Representative • Environmental Quality Regulation

MAJOR REQUIREMENTS • BA

Total units required for BA: 124
Total units required for Major: 64-70
Courses in parentheses are prerequisites.

Note: A minimum grade ''C-'' is required in all courses required for the Chemistry major. Grades below "C-" in prerequisite courses do not satisfy prerequisite requirements.

Two BA programs are available: without a concentration (general) and with a concentration in Biochemistry. The common requirements of the two programs are shown below under "Core Requirements."

A. Core Requirements (39-43 units)

(5) CHEM 1A* General Chemistry (placement exam)
(5) CHEM 1B General Chemistry (CHEM 1A)
(3) CHEM 24 Organic Chemistry Lecture I (CHEM 1B)
(3) CHEM 25 Organic Chemistry Lab I (CHEM 20 or 24, and 124)
(4) CHEM 31 Inorganic Quantitative Analysis (CHEM 1B)
(3) CHEM 124 Organic Chemistry Lecture - II (CHEM 24)
(4) MATH 30 Calculus I (3 1/2 years high school math and MATH 29)
(4) MATH 31 Calculus II (MATH 30)
(8-12) PHYS 5A General Physics: Mechanics, Heat, Sound **AND**
PHYS 5B General Physics: Light, Electricity, & Magnetism, Modern Physics (PHYS 5A or permission of instructor) **OR**
PHYS 11A General Physics: Mechanics (MATH 30, 31) **AND**
PHYS 11B General Physics: Heat, Light, Sound (MATH 31, PHYS 11A) **AND**
PHYS 11C General Physics: Electricity & Magnetism, Modern Physics (MATH 31, PHYS 11A)

*A placement exam is required prior to enrolling in CHEM 1A.

B. Concentration Requirements

1. No Concentration - General (25 units)

(4) MATH 32 Calculus III (MATH 31)
(3) CHEM 140A Physical Chemistry Lecture (CHEM 31, MATH 32; PHYS 5A, 5B or PHYS 11A, 11B, 11C; PHYS 11C may be taken concurrently)
(3) CHEM 140B Physical Chemistry Lecture (CHEM 140A)
(3) CHEM 141 Physical Chemistry Laboratory (CHEM 140A, 140B)
(12) Additional Courses to a minimum of 24 upper division units in Chemistry, including two lecture courses and two laboratory courses. Elective courses should be selected in consultation with an adviser.

2. Biochemistry Concentration (25-27 units)

(3) BIO 10 Basic Biological Concepts
(4-6) CHEM 142 Physical Chemistry (PHYS 5A, 5B) **OR**
CHEM 140A Physical Chemistry Lecture (CHEM 31, MATH 32; PHYS 5A, 5B or PHYS 11A, 11B, 11C; PHYS 11C may be taken concurrently) **AND**
CHEM 140B Physical Chemistry Lecture (CHEM 140A)
(3) CHEM 160A Structure & Function of Biological Molecules (CHEM 124, PHYS 5A, 5B, MATH 31)
(3) CHEM 160B Metabolism & Regulation of Biological Systems (CHEM 160A)
(3) CHEM 162 General Biochemistry Laboratory (CHEM 31; 160A or 161)
(3) CHEM 164 Macromolecular Laboratory Techniques (CHEM 162)
(6) Electives in Biological Sciences (must be from approved list and may be taken with only BIO 10 as a prerequisite: includes BIO 121, 139, 180 and 184. The Biological Science Department has agreed to the waiver of prerequisites for elective courses other than BIO 10)

Note: Students may also complete a BA with concentration in Biochemistry by taking the general BA curriculum and completing the following additional courses: CHEM 160A, 160B, 162, 164, and six units of upper division Biology courses from the approved list

MAJOR REQUIREMENTS • BS

Total units required for BS: 124
Total units required for Major: 80
Courses in parentheses are prerequisites.

Note: A minimum grade ''C-'' is required in all courses required for the Chemistry major. Grades below "C-" in prerequisite courses do not satisfy prerequisite requirements.

A. Required Lower Division Courses (47 units)

Same as in *Core* for BA (general) in Chemistry, except PHYS 11A, B, C are required, and
(4) MATH 32 Calculus III (MATH 31)

B. Required Upper Division Courses (33 units)

(3) CHEM 110 Inorganic Chemistry Lecture (CHEM 140B; concurrent enrollment OK)
(2) CHEM 110L Advanced Inorganic Chemistry Lab (CHEM 125, Corequisite: CHEM 110)
(3) CHEM 124 Organic Chemistry Lecture - II (CHEM 24)
(3) CHEM 125 Organic Chemistry Laboratory - II (CHEM 25, 124)
(4) CHEM 133 Chemical Instrumentation (CHEM 31, 140B)
(3) CHEM 140A Physical Chemistry Lecture (CHEM 31, MATH 32; PHYS 5A, 5B or PHYS 11A, 11B, 11C; PHYS 11C may be taken concurrently)
(3) CHEM 140B Physical Chemistry Lecture (CHEM 140A)
(3) CHEM 141 Physical Chemistry Laboratory (CHEM 140B; may be taken concurrently)
(3) CHEM 198 Senior Research (CHEM 125, 141, permission of instructor)
(6) Additional courses from the following to a minimum total of 33 upper division units in Chemistry. Elective courses should be selected in consultation with an advisor.
CHEM 126 Physical Organic Chemistry (CHEM 125, 140B)
CHEM 128 Organic Synthesis (CHEM 124)
CHEM 160A Structure & Function of Biological Molecules (CHEM 124; MATH 26A or 30 is recommended)

An appropriate upper division mathematics or physics course approved by advisor and department chair

SUBJECT MATTER PROGRAM (Pre-Credential Preparation)

Chemistry majors who intend to pursue a teaching credential must complete the Science Subject Matter Program which is described in this catalog. Successful completion of this program fulfills the subject matter competence requirements and qualifies students to enter the teaching credential program in the School of Education. The Science teaching credential allows candidates to teach general science and chemistry at an advanced level in high school

Currently there is a need in K-12 education for chemistry science majors. Chemistry majors who have an interest in teaching should contact the credential advisor in the department (Dr. Linda Borer, SCI-514, 278-6712, borerl@csus.edu) or the department chair (SCI-506) to plan an academic program and to explore ways to become involved in teaching.

MINOR REQUIREMENTS

The Chemistry Minor requires 24 units of chemistry, six of which must be upper division chemistry. A course in quantitative analytical chemistry and a lower division organic laboratory course must be completed as part of the minor.

A minimum grade of "C-" is required in all courses required for the Chemistry minor.

ADDITIONAL INFORMATION

Accreditation

The Department of Chemistry is accredited by the American Chemical Society, and students graduating with the BS degree will receive the certificate of the Society.

Advising

The department believes advising of students is an important function. Five members of the Chemistry Department, all of whom have a strong interest in advising, have been selected to serve as advisors for students wishing to major in chemistry. Each represents a particular area of chemistry: analytical, inorganic, biochemistry, organic and physical. Each chemistry major will be assigned to one of these advisors when entering the Chemistry Department. If you have already developed a special interest in chemistry, express it at your initial Chemistry Department meeting or to the Department Chair, and the advisor in that area will be assigned to you.

Minimum Grade Requirements

In all courses required for the Chemistry major and minor a minimum grade of "C-" must be earned. A minimum grade of "C-" is required in all prerequisite courses specified in the University catalog for any Chemistry course. If a student has not achieved a "C-" in all prerequisite courses for a particular Chemistry course, the instructor of the course will administratively remove the student from class.

Transfer Majors and Minors

Transfer students majoring in chemistry must complete at least three of the required courses in chemistry while fulfilling the residence requirements of California State University, Sacramento. Transfer students seeking a minor in chemistry must complete at least one upper division chemistry course at the university.

GRADUATE PROGRAM

The graduate program in Chemistry offers coursework designed to increase the student's experimental skills for carrying out research in chemistry and to strengthen theoretical understanding of chemistry. Plan A provides extensive training in the experimental aspect of the discipline, requiring a thesis based on the student's own research. Students graduating under Plan A will be qualified to participate effectively in basic and applied research or continue further graduate studies leading to the doctorate in chemistry. Plan B requires a project – a research paper – instead of a thesis. After completing the research paper, the student will be given a comprehensive oral examination on the research paper and the coursework in the student's graduate program. Students graduating under Plan B will be qualified to work in job areas that require an in-depth knowledge of chemistry but not extensive laboratory experience. Each student should plan a program according to his/her background and objectives, in consultation with a faculty advisor. It is recommended that students consult with an advisor the semester prior to the one in which they will begin graduate study. For information on how to select an advisor, students should contact the chemistry graduate coordinator.

The Chemistry Department has a broad selection of modern instrumentation, which is used extensively in the graduate training program. See "Features" on the front page of this section for a representative list.

Instrumentation is used to support faculty and student research in all areas of chemistry, such as the following projects: magnetic properties and inorganic analogs of biochemical systems; molecular quantum mechanics; studies of reactivity and geometry in allylic systems; synthesis and reactions of aromatic, pseudoaromatic and organometallic compounds; synthesis and studies of heterocyclic systems; trace metal analysis; quantitative and qualitative studies of Lewis acid-base systems; polymer chemistry; enzyme studies; conformational analysis; characterization of proteins and plant biochemistry.

Financial aid for graduate students in the Chemistry Department comes from several sources. Student assistance funds are available for graduate students to work up to 20 hours per week in stockroom work or in grading. Teaching stipends are available to classified graduate students. Full-time students in good standing generally teach three laboratory sections per year. Contact the Department Chair for the latest stipend range.

Admission Requirements

Admission as a classified graduate student in Chemistry requires:

- a BA degree in Chemistry, or its equivalent **and**
- a minimum 2.5 GPA overall, in the last 60 units, and in chemistry, math, and physics courses **and**
- two or three letters of recommendation from persons qualified to judge the applicant's potential for successful graduate study

Students who have deficiencies in Admission Requirements that can be removed by specified additional preparation may be admitted with conditionally classified graduate status. Any such deficiencies will be noted on a written response to the admission application.

Admission Procedures

Students wishing to apply to this program should first see the Chemistry Department Graduate Coordinator.

Note: All new graduate students must take two placement exams administered at the beginning of each semester by the Chemistry Department. The two exams will cover physical and organic chemistry; the exam results will determine undergraduate deficiencies in these areas of chemistry. All deficiencies must be removed by taking appropriate undergraduate courses. Procedures for removal of deficiencies will be explained at the time of testing.

Advancement to Candidacy

Each student must file an application for Advancement to Candidacy, indicating a proposed program of graduate study. This procedure should begin as soon as the classified graduate student has:

- removed any deficiencies in Admission Requirements **and**
- completed the requirements for at least a Bachelor of Arts in Chemistry. This means the following CSUS courses, or their equivalents from other colleges, must be completed satisfactorily:

  General: CHEM 1A, 1B
  Organic: CHEM 24, 25, 124
  Analytical: CHEM 31
  Physical: CHEM 140A, 140B
  Physical: CHEM Laboratory 141
  PHYS 5A, 5B, or 11A, 11B, 11C
  MATH 30, 31, 32
- two additional courses to a minimum of 24 upper division units in chemistry, including two lecture and two laboratory courses **and**
- removed any undergraduate deficiencies in chemistry, as determined by the Chemistry Department placement exam results **and**
- completed at least 6 units in the master's degree program in graduate status, including at least one 200-level course, with a 3.0 minimum GPA **and**
- demonstrated English proficiency by passing the writing proficiency examination and by completion of one semester of CHEM 294 **and**
- obtained advisor's approval of thesis topic (Plan A) or project-research paper topic (Plan B)

Degree Requirements

The Master of Science in Chemistry requires completion of 30 units of coursework with a minimum 3.0 GPA. An outline of degree requirements follows:

A. Required Core Courses (18 units)

(4)	CHEM 215	Advanced Chemical Laboratory (CHEM 230 or permission of instructor)
(3)	CHEM 230	Separation Methods in Chemistry
(3)	CHEM 235	Organometallic Chemistry
(3)	CHEM 240	Kinetics & Mechanisms/Chem Reactions
(3)	CHEM 245	Chemical Thermodynamics
(2)	CHEM 294	Seminar in Chemistry

B. Plan Requirements (12 units)

Select one of the following plan requirements:

1. Plan A: Research and Thesis Requirements

a. Additional Requirements (6-9 units)

(3)	CHEM 225	Polymer Chemistry and Technology (CHEM 124, 140B) **AND/OR**
(3)	CHEM 220	Spectrometric Identification of Organic Compounds
(0-5)	upper division elective chemistry courses	
(6)	up to 6 units of upper division or graduate elective courses from other departments, subject to the graduate committee's approval	

b. Culminating Requirements (4-6 units)

(3-5)	CHEM 299	Graduate Research **and**
(1-3)	CHEM 500	Culminating Experience

Note: No more than 6 units total of CHEM 299 and 500 may be counted for the degree.

2. Plan B: Project Requirements

a. Additional Requirements (9 units)

(3)	CHEM 220	Spectrometric ID of Organic Compounds
(6)	Electives	

b. Culminating Requirements (3 units)

(1-2)	CHEM 297	Instrumental Technology **OR**
	CHEM 299	Special Problems
(1-3)	CHEM 500	Culminating Experience
	Oral exam	

ADDITIONAL INFORMATION

Foreign Language

A foreign language is not required for the degree. However, students planning additional graduate studies are encouraged to take courses in French, German, or Russian since proficiency in one of these is usually required in doctoral programs.

Chemical Safety

Safety in Chemical Laboratory Classes. Safety is an essential element of all Chemistry laboratory classes. Because hazardous chemicals are essential and their use is common and necessary, safety instruction is an integral part of chemistry laboratory classes. *Materials Safety Data Sheets* are available in the Chemistry Service Center.

Contact lenses in the chemical laboratory present a severe eye hazard. It is Chemistry Department Policy that contact lenses are prohibited in all chemistry laboratories; prescription glasses should be worn instead. In addition, safety goggles are required in all laboratories. Laboratory aprons are recommended.

Non-compliance with Safety Rules. Failure to comply with proper procedures and safety cautions may subject the student to disciplinary action. Any student showing persistent disregard for safety may have his/her grade lowered, and risk being withdrawn with a final grade of "F."

LOWER DIVISION COURSES

Note: All courses that have a laboratory component require students to purchase a laboratory breakage card before classes begin.

1A. General Chemistry. The fundamental principles and concepts of chemistry, including stoichiometry, thermochemistry, atomic and molecular structure, solution chemistry, acid-base chemistry, oxidation-reduction reactions, an introduction to chemical equilibrium and chemical kinetics. The course is fairly mathematical and requires an ability to do arithmetic and algebraic computations. Lecture three hours, laboratory six hours. **Note:** in order to enroll, all students must pass a qualifying exam given prior to each semester. **Prerequisites:** high school algebra (two years) and high school chemistry; **or** equivalent. 5 units. (CAN CHEM 2)

1B. General Chemistry. A continuation of the development of fundamental principles of chemistry and application of principles developed in CHEM 1A. The laboratory work emphasizes applications of equilibrium principles, including some qualitative analysis, coordination chemistry and bioinorganic chemistry. Lecture three hours, laboratory six hours. Knowledge of word processing and spreadsheet software is recommended. **Prerequisite:** CHEM 1A. 5 units. (CAN CHEM 4)

4. Chemical Calculations. An introductory chemistry course for students who plan to major in a scientific field. This is the appropriate course for students desiring to prepare themselves for Chemistry 1A. The emphasis of the course will be on the techniques of problem solving and will utilize such subjects as: unit cancellation; conversions between measuring systems; weight, moles and chemical equations; density; elementary gas laws; heat and temperature; elementary acid and base chemistry; oxidation and reduction; solutions. Three hours lecture. 3 units.

6A. Introduction to General Chemistry. The structure of atoms, molecules and ions; their interactions including stoichiometry, equilibria, and oxidation-reduction. This course will not fulfill the requirements for more advanced study in chemistry and cannot be counted toward a major or minor in chemistry. Lecture three hours, quiz one hour, laboratory three hours. **Prerequisite:** one year high school algebra; high school chemistry strongly recommended. 5 units. (CAN CHEM 6)

6B. Introduction to Organic and Biological Chemistry. Introduction to the structure and properties of the major classes of organic compounds; introduction to nomenclature of organic compounds and to the fundamental concepts of reaction mechanisms and stereochemistry; the chemistry and metabolism of carbohydrates, lipids, and proteins; the latter will include enzymes. This course will not fulfill the requirement for more advanced study in chemistry and cannot be counted toward a major or minor in chemistry. Lecture three hours; quiz one hour; laboratory three hours. **Prerequisite:** CHEM 1A or 6A. 5 units. (CAN CHEM 8)

20. Organic Chemistry Lecture—Brief Course. Basic principles of organic chemistry. Recommended for students majoring in life-sciences, but not recommended for preprofessional students. **Prerequisite:** CHEM 1B. 3 units.

20L. Introductory Organic Chemistry Laboratory. A brief laboratory course in basic organic experimental techniques. Experimental topics include: melting points, purification of solids, distillation, gas chromatography, extraction, and functional group qualitative analysis. Course is specifically designed for Biological Sciences majors and others who want to meet the Chemistry minor requirements for a lower division organic laboratory. Laboratory three hours. **Prerequisite:** CHEM 20 or 24. 1 unit.

24. Organic Chemistry Lecture—I. Principles of organic chemistry. (CHEM 24 and 124 together constitute the normal year long lecture course in organic chemistry.) **Note:** required for chemistry majors and recommended for preprofessional students. **Prerequisite:** CHEM 1B. 3 units.

25. Organic Chemistry Laboratory—I. Preparation, separation purification and identification of organic compounds. Discussion one hour, laboratory six hours. **Prerequisites:** CHEM 20 or 24, and 124; CHEM 124 may be taken concurrently. 3 units.

31. Inorganic Quantitative Analysis. Theory and practice of gravimetric and volumetric and analysis. Selected topics in photometry, electrogravimetry and chromatography. Lecture two hours, laboratory six hours. **Prerequisite:** CHEM 1B. 4 units. (CAN CHEM 12)

UPPER DIVISION COURSES

106. Chemical Concepts. Principles and concepts of chemistry with applications in the home and environment. Satisfies the upper division chemistry requirement for the multiple-subject teaching credential. Lecture one hour, discussion and activity four hours. This course does not fulfill credit requirements for the major or minor in chemistry. **Prerequisite:** PHYS 7. 3 units.

110. Inorganic Chemistry Lecture. The application of atomic structure, the periodic law, molecular structure and bonding principles, electrochemical principles and other selected models and concepts to theoretical and descriptive inorganic chemistry. Physical and chemical properties of selected elements and inorganic compounds are studied. **Prerequisites:** CHEM 125, 140B; CHEM 140B may be taken concurrently, however, students are encouraged to complete CHEM 140B and 141 first. **Corequisite:** CHEM 110L. Fall only. 3 units.

110L. Advanced Inorganic Chemistry Laboratory. Preparation, purification and instrumental studies of inorganic compounds. Instrumental and experimental techniques will include EPR, magnetic susceptibility, FTIR, UV-VIS spectroscopy and inert atmosphere techniques. **Prerequisite:** CHEM 125. **Corequisite:** CHEM 110. Fall only. 2 units.

124. Organic Chemistry Lecture II. Continuation of CHEM 24. **Prerequisite:** CHEM 24 or permission of the instructor; concurrent enrollment in CHEM 25 recommended. 3 units.

125. Organic Chemistry Laboratory II. Continuation of CHEM 25. Discussion one hour, laboratory six hours. **Prerequisites:** CHEM 25, 124. 3 units.

126. Physical Organic Chemistry Lecture. The application of bonding and molecular structure in correlating structure-reactivity relationships to organic reaction mechanisms. **Prerequisites:** CHEM 124, 140B; CHEM 140B may be taken concurrently. Fall only. 3 units.

128. Organic Synthesis. Application of functional group reactions to multistep syntheses. Recently developed synthetic methods and literature searching will be emphasized. **Prerequisite:** CHEM 124. Spring only. 3 units.

133. Chemical Instrumentation. Theory and application of analog and digital devices to the synthesis of chemical instrumentation systems. Analog and digital computers as laboratory tools. Selected electroanalytical spectrometric and chromatographic methods. Lecture two hours, laboratory six hours. **Prerequisite:** CHEM 31, 140B. 4 units.

140A. Physical Chemistry Lecture. Introduction to chemical thermodynamics, quantum chemistry, and the structure of matter. **Prerequisites:** CHEM 31; MATH 32; PHYS 5A, 5B, **or** PHYS 11A, 11B, 11C; PHYS 11C may be taken concurrently. 3 units.

140B. Physical Chemistry Lecture. Introduction to molecular quantum chemistry, molecular spectroscopy, statistical thermodynamics and chemical kinetics. **Prerequisite:** CHEM 140A. 3 units.

141. Physical Chemistry Laboratory. Selected exercises in the practice of physio-chemical laboratory methods. Lecture one hour, laboratory six hours. **Prerequisites:** CHEM 140A, 140B; CHEM 140B may be taken concurrently. 3 units.

142. Introduction to Physical Chemistry. An introductory presentation of the theoretical and practical aspects of thermodynamics, quantum chemistry, spectroscopy, and kinetics. As time permits, other topics will be: solution chemistry, hydrodynamics, electrochemistry, and crystallography. **Note:** course not acceptable for the BS or the BA without concentration. **Prerequisite:** PHYS 5A, 5B, MATH 31. Spring only. 4 units.

160A. Structure and Function of Biological Molecules. This course will describe the chemistry and biochemistry of amino acids, proteins, nucleic acids, lipids and carbohydrates. It will also include enzyme kinetics, centrifugation, chromatography, electrophoresis, and the structure and function of membranes. **Prerequisites:** CHEM 124; MATH 26A or 30 is recommended. Fall only. 3 units.

160B. Metabolism and Regulation of Biological Systems. This course will discuss anaerobic and aerobic metabolism and regulation. It will cover digestion, degradation, and biosynthesis of various metabolites, including proteins and nucleic acids. Special topics, such as photosynthesis and nerve chemistry, will be introduced. **Prerequisite:** CHEM 160A. Spring only. 3 units.

161. General Biochemistry. The chemistry and metabolism of carbohydrates, lipids, proteins, nucleic acids, enzymes and hormones. **Prerequisite:** CHEM 20 or 124; one year of biological science is desirable. 3 units.

162. General Biochemistry Laboratory. Qualitative and quantitative tests for and isolation of carbohydrates, lipids, proteins, nucleic acids and enzymes. Discussion one hour, laboratory six hours. **Prerequisites:** CHEM 31; 160A or 161. 3 units.

164. Macromolecular Laboratory Techniques. The course will teach spectroscopic techniques such as NMR and GC/MS in the study of membranes, proteins, and nucleic acids. Other techniques such as chromatography, electrophoresis, and analytical ultracentrifugation will be emphasized. **Prerequisite:** CHEM 162. Spring only. 3 units.

189. Directed Research. Admission to this course requires the approval of a research advisor, the Department Chair, and the completion of the first laboratory course in the area of the research project. A minimum GPA of 3.0 is recommended. **Note:** this course may be repeated; however only three units of this course may be applied toward the major requirement in chemistry for the BA degree. This course does not fulfill the minimum requirements of the BS degree. A written, final report is required. Petition is needed to add this course. Graded Credit/No Credit. 1-3 units.

194. Chemistry-Related Work Experience. Supervised employment in a Chemistry related company or agency. Placement is arranged through the Department and the Cooperative Education Program office. Requires completion of a 3-6 month work assignment and a written report. **Prerequisite:** Open only to upper division students and consent of Department Chair. Units may not be applied toward a major in Chemistry or Biochemistry. Graded Credit/No Credit. 6-12 units.

196. Experimental Offerings in Chemistry. To be offered in the various fields of chemistry in response to student demand. **Prerequisite:** appropriate upper division coursework or permission of instructor. 1-3 units.

197. Instrumental Technology. Supervised instruction on scientific instruments used in chemical research or industry. Students will choose two instruments from an approved list. The list will include the following: Hewlett-Packard 5890 GC-Mass spectrometer, Bruker AC-300 nmr, Perkin-Elmer 1800 FTIR, Perkin-Elmer diode array UV-VIS spectrometer, various HPLC equipment, graphite furnace AA and several gas chromatographs. Students should arrange for a chemistry faculty member to supervise instruction before adding this course. **Prerequisite:** Junior standing. Graded Credit/No Credit. 2 units.

198. Senior Research. The student will conduct an independent study of a chemical research topic. This study will be either a complete literature search with a review paper or a laboratory project with a thesis. A weekly seminar is required. Seminar one hour, laboratory a minimum of six hours per week. **Prerequisites:** CHEM 125, 141, permission of instructor. 3 units.

199. Special Problems. Individual projects or directed reading, open only to those students who appear competent to carry on individual work. Admission by consent of faculty member under whom work is to be conducted and approval of Department Chair. Graded Credit/No Credit. 1-3 units.

GRADUATE COURSES

The following graduate courses are offered by the Chemistry Department. Courses that are required in each of the core curricula are offered each year. The other graduate courses are generally offered in alternative years. The equivalent of a BA degree in chemistry or permission of the instructor is a prerequisite for all graduate courses.

215. Advanced Chemistry Laboratory. Preparation, separation, identification and structure-reactivity relationships will be studied using advanced chemical and instrumental methods as appropriate to graduate research. Students will do both core experiments and optional experiments designed to expand their laboratory skills and knowledge. Lecture one hour, laboratory nine hours. **Prerequisite:** CHEM 230 or permission of instructor. Spring only. 4 units.

220. Spectrometric Identification of Organic Compounds. Interpretation of ultraviolet, infrared, nuclear magnetic resonance, and the mass spectra for the elucidation of organic structures, with emphasis on problem solving. 3 units.

225. Polymer Chemistry and Technology I. Basic concepts in polymer chemistry involving configurational and conformational features influencing polymer properties: thermoplastics, thermosets, elastomers and thermoplastic elastomers. Principles of polymerization including chain polymerization and step polymerization: kinetics and mechanisms. Technology of commercially important polymers including important mechanical properties. **Prerequisites:** CHEM 124, 140B. Fall only. 3 units.

226. Polymer Chemistry and Technology II. Macromolecules in solution; physical dimensions of long-chain polymers; thermodynamics of polymer solutions; polymer solution at the interface. Characterization of polymers; molecular weight and polydispersity; end-group analyses; transition temperatures. Morphology and order in crystalline polymers. Macromolecular engineering; free radical methods; cationic methods; ring-opening polymerization techniques; block and graft polymerization techniques. **Prerequisite:** CHEM 225. Spring only. 3 units.

230. Separation Methods in Chemistry. Theoretical and practical aspects of separation sciences. Methods of separations that are included are liquid-liquid extraction and ion exchange, gas, and liquid chromatography. Lecture three hours. Fall only. 3 units.

235. Organometallic Chemistry. The synthesis, structure and reactions of organometallic compounds and their application to inorganic, organic and biochemical systems. Special emphasis on structure-reactivity relationships and catalysis by organometallic compounds. Lecture three hours. Spring only. 3 units.

240. Kinetics and Mechanisms of Chemical Reactions. Rates and mechanisms of chemical reactions, with emphasis on applying laboratory results to the study of reactions important to biochemical, inorganic, and organic systems. Lecture three hours. Spring only. 3 units.

245. Chemical Thermodynamics. Classical chemical thermodynamics, including thermochemistry, phase equilibria, chemical equilibria, and the thermodynamics of solutions. Lecture three hours. Fall only. 3 units.

294. Seminar in Chemistry. Student presentations of topics from the chemical literature and their thesis research. Grading is credit/no credit and will be based on attendance and successful presentation of a seminar. May be repeated for a total of 2 units. 0.5 unit.

296. Experimental Offerings in Chemistry. Specialized topics in chemistry to be scheduled in response to student needs. 1-3 units.

297. Instrumental Technology. The theory and application of instruments basic to graduate research. Demonstrations and supervised individual instruction on each instrument will be provided. Instruments included in the course are: Hewlett Packard 5890 GC-mass spectrometer, Perkin-Elmer 1800 FTIR, Perkin-Elmer diode array UV-VIS spectrometer, graphite AA furnace, Bruker AC-300 nmr, Varian model 700 autoprep gas-liquid chromotograph, Alpha Scientific magnetic susceptibility system and Beckman model L-2 preparative ultracentrifuge. **Prerequisite:** graduate standing. Graded Credit/No Credit. 1 unit.

299. Special Problems. Graduate research. Approval must be obtained from a departmental committee and the faculty member under whom the work is to be conducted. Written report must be submitted before a final grade is given. Graded Credit/No Credit. 1-6 units.

500. Culminating Experience. Credit given upon successful completion of a culminating thesis or project approved for the master's degree. Open only to the graduate student who has been advanced to candidacy for the master's degree and who secures the permission of the chair of his thesis committee. Should be taken in final semester prior to the completion of all requirements for the degree. Number of units of credit is determined by the candidate's master's degree advisory committee. Graded Credit/No Credit. For Master's Thesis, 1-3 units. For Master's Project, 1-2 units.