



Chemistry

College of Natural Sciences and Mathematics

Bachelor of Arts • Bachelor of Science • Minor
Subject Matter Program (Pre-Credential Preparation) • Master of Science

PROGRAM DESCRIPTION

Chemistry is the area of science in which the composition, structure, properties, and reactions of substances are studied. The Chemistry Department at Sacramento State offers a BS, BA (including concentrations in Biochemistry or Forensic Chemistry), and MS degree in Chemistry (including a concentration in Biochemistry).

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

The graduate program in Chemistry leads to a Master of Science (MS) degree. It provides students an opportunity to receive advanced training in chemistry and biochemistry and to pursue independent research. The MS program enhances a student's overall knowledge in chemistry and experimental skills.

Career Possibilities

Forensic Chemist • 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 • Teaching Art Restoration • Biotechnologist • Pharmaceutical Sales

Faculty

Brad Baker, Susan Crawford, Roy Dixon, Rodney Feazell, Benjamin Gherman, James Hill, Cynthia Kellen-Yuen, Jeff Mack, Mary McCarthy-Hintz, Kathie McReynolds, James Miranda, Jeffrey Paradis, James Ritchey, Linda Roberts, Tom Savage, John Spence

Contact Information

Susan Crawford, Department Chair
Evelyn Bradley-Owens, Administrative Support Coordinator
Sequoia Hall 506
(916) 278-6684
www.chem.csus.edu

Concentrations

BA: Biochemistry - The BA degree with a concentration in Biochemistry provides increased training in 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 and medicine.

BA: Forensic Chemistry - The BA degree with a concentration in Forensic Chemistry provides a strong background in chemistry and an opportunity to take appropriate courses in the Criminal Justice Division.

Special Features

- The Department of Chemistry is accredited by the American Chemical Society, and students graduating with the BS degree will receive a certificate from the Society.
- Extensive available instrumentation includes a Hewlett-Packard 5890 Series II GC-Mass spectrometer; a Bruker Avance-300 NMR; a Bruker MSL 300MHz wide bore NMR; a Perkin-Elmer 2000 FTIR; a Shimadzu UV-2401 PC spectrometer; an HP 8452A UV-VIS diode array spectrometer; a Shimadzu, RF-5301PC spectrofluorophotometer; Ocean Optics UV spectrometers; a Beckman L2-50 ultracentrifuge; Agilent/HPLC systems; an EPR spectrometer; a Beckman HPLC and system; a Perkin-Elmer atomic absorption spectrometer; Powder XRD; thermoanalyzer; a QuantumCube computational system; several gas chromatographs; and many PC workstations.
- Several science computing labs are available to students.
- 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 and Bachelor of Arts majors are strongly encouraged to complete an independent research project. All graduate students must enroll in a graduate research course.
- All faculty serve as advisors to students and 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.

UNDERGRADUATE PROGRAMS

Three BA programs are available: One without a concentration (general) and two with concentrations (Biochemistry or Forensic Chemistry). The common requirements of the three programs are shown below under "Core Requirements."

Advising: The Department believes advising of students is an important function. Members of the Chemistry Department who 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, coordinated to the area of each student's expressed interest.

Minimum Grade Requirements: In all courses required for the Chemistry major and minor, a minimum grade of "C-" must be earned with the exception of Chemistry 1A which requires a grade of C or better. A minimum grade of "C-" is required in all prerequisite courses with the exception of Chemistry 1A which requires a grade of C or better to meet the prerequisite requirement for CHEM 1B 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.

Prerequisites: When enrolling in a course, it is required that the student will have met the specific prerequisites listed. A course listed as a prerequisite may have its own set of prerequisites. All must be met prior to enrolling in a chemistry course. Students not meeting the prerequisite requirements for a course will be administratively removed from the 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.

Requirements • Bachelor of Arts Degree

Units required for Major: 64-71

Minimum total units required for the BA: 120

A minimum grade of "C-" is required in all courses applied to the Chemistry major. Grades below "C-" in prerequisite courses do not satisfy prerequisite requirements.

Courses in parentheses are prerequisites.

Core Requirements (39-43 units)

- (5) CHEM 1A* General Chemistry I (High school algebra [two years] and high school chemistry; or equivalent)
- (5) CHEM 1B General Chemistry II (CHEM 1A with a passing grade of "C" or better)
- (3) CHEM 24 Organic Chemistry Lecture I (CHEM 1B)
- (3) CHEM 25 Organic Chemistry Lab (CHEM 24, CHEM 124, may be taken concurrently)
- (4) CHEM 31 Quantitative Analysis (CHEM 1B)
- (3) CHEM 124 Organic Chemistry Lecture II (CHEM 24, or instructor permission; concurrent enrollment in CHEM 25 recommended)

- (4) MATH 30 Calculus I (MATH 29 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus diagnostic test)
- (4) MATH 31 Calculus II (MATH 30 or appropriate high school based AP credit)
- (8-12) PHYS 5A General Physics: Mechanics, Heat, Sound (Recently completed three years of high school algebra and geometry; and a college course in algebra and trigonometry) **AND**
- PHYS 5B General Physics: Light, Electricity, and Magnetism, Modern Physics (PHYS 5A or instructor permission) **OR**
- PHYS 11A General Physics: Mechanics (MATH 30, MATH 31; or equivalent certificated high school courses. MATH 31 may be taken concurrently) **AND**
- PHYS 11B General Physics: Heat, Light, Sound (MATH 31, PHYS 11A) **AND**
- PHYS 11C General Physics: Electricity and Magnetism, Modern Physics (MATH 31, PHYS 11A)

*Passing a placement exam or obtaining a passing grade of "C" or better in CHEM 4 is required to enroll in CHEM 1A.

Additional Requirements for Concentration

Units required: 25-28

Students should choose one of the three following focuses with advice from their Department advisor. Units are in addition to the core requirements above.

No Concentration - General (25 units)

- (3) CHEM 140A Physical Chemistry Lecture I (CHEM 1B, CHEM 24, CHEM 31, MATH 32; PHYS 5A, PHYS 5B or PHYS 11A, PHYS 11B, PHYS 11C; PHYS 11C may be taken concurrently)
- (3) CHEM 140B Physical Chemistry Lecture II (CHEM 140A)
- (3) CHEM 141 Physical Chemistry Laboratory (CHEM 140A, CHEM 140B, or CHEM 142, instructor permission ENGL 20 or an equivalent second semester composition course; CHEM 140B may be taken concurrently)
- (4) MATH 32 Calculus III (MATH 31)
- (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.

Biochemistry Concentration (25-27 units)

- (3) BIO 10 Basic Biological Concepts
- (4-6) CHEM 142 Introduction to Physical Chemistry (CHEM 1B, CHEM 24, PHYS 5A, PHYS 5B, MATH 31 **OR**
- CHEM 140A Physical Chemistry Lecture I (CHEM 1B, CHEM 24, CHEM 31, MATH 32; PHYS 5A, PHYS 5B or PHYS 11A, PHYS 11B, PHYS 11C; PHYS 11C may be taken concurrently) **AND**
- CHEM 140B Physical Chemistry Lecture II (CHEM 140A)

- (3) CHEM 160A Structure and Function of Biological Molecules (CHEM 124; MATH 26A or MATH 30 is recommended.)
- (3) CHEM 160B Metabolism and Regulation of Biological Systems (CHEM 160A)
- (3) CHEM 162 General Biochemistry Laboratory (CHEM 31; CHEM 160A or CHEM 161 either may be taken concurrently, ENGL 20 or an equivalent second semester composition course)
- (3) CHEM 164 Advanced Biochemistry Laboratory (CHEM 162 or equivalent, ENGL 20 or an equivalent second semester composition course)
- (6) Electives in Biological Sciences (must be from the approved list and may be taken with only BIO 10 as a prerequisite): includes BIO 121, BIO 131, BIO 139, BIO 180 and BIO 184. The Biological Sciences Department has agreed to the waiver of prerequisites for electives.

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, CHEM 160B, CHEM 162, CHEM 164, BIO 10, and 6 units of upper division Biology courses from the approved list.

Forensic Chemistry Concentration (25-28 units)

- (3) CHEM 125 Advanced Organic Chemistry Laboratory (CHEM 25, CHEM 124, ENGL 20 or an equivalent second semester composition course)
- (4) CHEM 142 Introduction to Physical Chemistry (CHEM 1B, CHEM 24, PHYS 5A, PHYS 5B, MATH 31)
- (3) CHEM 161 General Biochemistry (CHEM 20 or CHEM 124)
- (3) CHEM 162 General Biochemistry Laboratory (CHEM 31; CHEM 160A or CHEM 161 either may be taken concurrently, ENGL 20 or an equivalent second semester composition course)
- (3) CRJ 1 Introduction to Criminal Justice and Society
- (3) CRJ 146 Introduction to Physical Evidence (CRJ 4)
- (6-9) A minimum of six units from the following:
 - CHEM 110 Inorganic Chemistry Lecture (CHEM 125, CHEM 140B or CHEM 142 or instructor permission; CHEM 140B may be taken concurrently, however, students are encouraged to complete CHEM 140B and CHEM 141 first; Corequisite: CHEM 110L) **AND**
 - CHEM 110L Advanced Inorganic Chemistry Laboratory (CHEM 125, ENGL 20 or an equivalent second semester composition course; Corequisite: CHEM 110)
 - CHEM 133 Chemical Instrumentation (CHEM 31, CHEM 140B or CHEM 142, ENGL 20 or an equivalent second semester composition course)
 - CHEM 141 Physical Chemistry Laboratory (CHEM 140A and CHEM 140B or CHEM 142, ENGL 20 or an equivalent second semester composition course; CHEM 140B may be taken concurrently)

- CHEM 164 Advanced Biochemistry Laboratory (CHEM 162 or equivalent, ENGL 20 or an equivalent second semester composition course)

Requirements • Bachelor of Science Degree

Units required for the Major: 77

Minimum total units required for the BS: 122

A minimum grade of "C-" is required in all courses applied to the Chemistry major. Grades below "C-" in prerequisite courses do not satisfy prerequisite requirements.

Note: Additional units may be required to meet the Sacramento State foreign language requirement.

Courses in parentheses are prerequisites.

A. Required Lower Division Courses (44 units)

- (5) CHEM 1A* General Chemistry I (High school algebra [two years] and high school chemistry; or equivalent)
- (5) CHEM 1B General Chemistry II (CHEM 1A with a passing grade of "C" or better)
- (3) CHEM 24 Organic Chemistry Lecture I (CHEM 1B)
- (3) CHEM 25 Organic Chemistry Lab (CHEM 24, CHEM 124, may be taken concurrently)
- (4) CHEM 31 Quantitative Analysis (CHEM 1B)
- (4) MATH 30 Calculus I (MATH 29 or four years of high school mathematics which includes two years of algebra, one year of geometry, and one year of mathematical analysis; completion of ELM requirement and Pre-Calculus diagnostic test)
- (4) MATH 31 Calculus II (MATH 30 or appropriate high school based AP credit)
- (4) MATH 32 Calculus III (MATH 31)
- (4) PHYS 11A General Physics: Mechanics (MATH 30, MATH 31; or equivalent certificated high school courses. MATH 31 may be taken concurrently)
- (4) PHYS 11B General Physics: Heat, Light, Sound (MATH 31, PHYS 11A)
- (4) PHYS 11C General Physics: Electricity and Magnetism, Modern Physics (MATH 31, PHYS 11A)

*Passing a placement exam or obtaining a passing grade of "C" or better in CHEM 4 is required to enroll in CHEM 1A.

B. Required Upper Division Courses (33 units)

- (3) CHEM 110 Inorganic Chemistry Lecture (CHEM 125, CHEM 140B or CHEM 142 or instructor permission; CHEM 140B may be taken concurrently, however, students are encouraged to complete CHEM 140B and CHEM 141 first. Corequisite: CHEM 110L)
- (2) CHEM 110L Advanced Inorganic Chemistry Laboratory (CHEM 125, ENGL 20 or an equivalent second semester composition course; Corequisite: CHEM 110)
- (3) CHEM 124 Organic Chemistry Lecture II (CHEM 24, or instructor permission; concurrent enrollment in CHEM 25 recommended.)
- (3) CHEM 125 Advanced Organic Chemistry Laboratory (CHEM 25, CHEM 124, ENGL 20 or

- an equivalent second semester composition course)
- (4) CHEM 133 Chemical Instrumentation (CHEM 31, CHEM 140B or CHEM 142, ENGL 20 or an equivalent second semester composition course)
- (3) CHEM 140A Physical Chemistry Lecture I (CHEM 1B, CHEM 24, CHEM 31, MATH 32; PHYS 5A, PHYS 5B or PHYS 11A, PHYS 11B, PHYS 11C; PHYS 11C may be taken concurrently)
- (3) CHEM 140B Physical Chemistry Lecture II (CHEM 140A)
- (3) CHEM 141 Physical Chemistry Laboratory (CHEM 140A, CHEM 140B, CHEM 142, ENGL 20 or an equivalent second semester composition course; CHEM 140B may be taken concurrently)
- (3) CHEM 160A Structure and Function of Biological Molecules (CHEM 124; MATH 26A or MATH 30 is recommended.)
- (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 Lecture (CHEM 124 and CHEM 140B; CHEM 140B may be taken concurrently)
- CHEM 128 Organic Synthesis (CHEM 124)
- CHEM 198 Senior Research (One upper division chemistry laboratory class, ENGL 20 or an equivalent second semester composition course, instructor permission)
- An appropriate upper division mathematics or physics course approved by advisor and department chair.

Requirements • Minor

Units Required: 24 of chemistry, 6 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 applied to the Chemistry minor.

Requirements • Subject Matter Program (Pre-Credential Preparation)

Due to policy changes from the California Commission on Teacher Credentialing and the federal No Child Left Behind Mandate, the Science Subject Matter Program was under review at the time of this 2008-2010 catalog printing and is subject to revision. As a result, it is important to consult a credential advisor for current details.

Currently there is a need in K-12 education for chemistry majors. Chemistry majors who have an interest in teaching should contact the credential advisor in the department (Dr. Jeffrey Paradis, Sequoia Hall 444C, 278-6987, paradis@csus.edu) or the Department Chair (Sequoia Hall 506) to plan an academic program and to explore ways to become involved in teaching.

GRADUATE PROGRAM

The graduate program in Chemistry focuses on three related areas: development of general analytical techniques, synthesis and chemical separations of organic and biochemical materials, and applications of analytical techniques to fields such as biotechnology, biochemistry, analytical chemistry, organic chemistry, environmental chemistry, materials chemistry, and inorganic chemistry. A student's ability to work in a laboratory environment requiring analytical or biochemical skills will be enhanced and his/her overall knowledge in chemistry will be strengthened. A culminating research project in collaboration with a chemistry faculty member is required. This experience will further develop the laboratory and creative thinking skills of a student.

Course Requirements: The program centers on a core of four courses designed to increase a student's knowledge and skills in applications of analytical techniques, general instrumentation techniques, chemical separation techniques, and analysis of spectra with applications in the field of biochemistry and organic chemistry primarily. Electives are offered to permit students to expand further their knowledge and skills in chemistry. In addition, students must regularly attend seminars offered approximately once a week each semester. Each student will give one seminar during his/her tenure as a graduate student that is on a literature topic not related to his/her thesis topic and another on his/her thesis results. Participation in seminar expands a student's knowledge of current research in chemistry and also assists in developing his/her oral presentation skills.

Thesis/Research: All students are required to complete a thesis involving research in a laboratory environment. This work may be done on campus with a chemistry faculty member or at an employer's work site providing the work involves producing a new contribution to the field of chemistry. A chemistry faculty member must be identified as an advisor for a project at an employer's work site.

Advising: Following admission to the program, students are advised by the graduate coordinator or by a faculty member who has agreed to supervise the student in a thesis project. Normally students are expected to consult with several faculty members before deciding on a thesis project. Students who are fully qualified to enter the graduate program can normally finish their degree in two years.

Financial Aid/Employment: Financial aid is available from several sources. The Financial Aid Office at California State University, Sacramento is available to assist students who need help meeting the cost of attending the university. You must complete a free application for federal aid in order to apply. Please refer to the section in the university catalog that discusses financial aid. Qualified graduate students may be assigned as teaching associates. Teaching associates teach undergraduate chemistry laboratories and are responsible for both leading a discussion and supervising a laboratory. Good communication skills are needed for these positions. To be eligible for a teaching associate position a student must be a classified graduate student in good standing, possess a minimum GPA of 3.0, have good English communication skills and pass a general chemistry examination. Only a limited number of positions

are available. Please contact the Department Chair for current information. Employment in the university as a student assistant or in other positions is another way of earning income.

Foreign Language: Other than satisfying the Sacramento State foreign language requirement, 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 and online using computers on the fourth and fifth floors of Sequoia Hall.

Contact Lenses: Chemistry Department policy states 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.

Noncompliance 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".

Laboratory Fees: Students enrolling in chemistry laboratory courses or supervisory courses involving laboratory research are required to pay a laboratory fee for each course. In addition, if a student breaks an item in a laboratory, s/he is required to replace it or pay a breakage cost. An administrative hold is placed on a student's academic record if either is not paid. Details are given at the first class meeting.

Repeating a Chemistry Course: Students repeating a Chemistry course must repeat an equivalent course in both units and content.

Admission Requirements

Admission as a classified graduate student in Chemistry requires:

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

Students who do not meet the admission requirements because they are missing several courses required for a BA degree may be admitted with conditionally classified graduate status. The missing undergraduate courses must be completed before a student can become a classified graduate student.

Admission Procedures

Students desiring to apply to the chemistry graduate program should first contact the Chemistry Department Graduate Coordinator or Department Chair. Information about the graduate program will be discussed with you.

Applications are accepted as long as room for new students exists. However, students are strongly urged to apply by April 1 for the following fall or October 1 for the following spring in order to allow time for admission before registration. All prospective graduate students, including Sacramento State graduates, must file the following with the Office of Graduate Studies, River Front Center 206, (916) 278-6470:

- an online application for admission; and
- two sets of official transcripts from all colleges and universities attended, *other than Sacramento State*.

Approximately six weeks after receipt of all items listed, an admission decision will be mailed to the applicant.

Placement Examinations:

- All new graduate students must take two placement exams administered at the beginning of each semester by the Chemistry Department. Students are expected to take an exam in organic and physical chemistry. These exams cover topics commonly found in undergraduate courses.
- Exam results are used to determine undergraduate deficiencies in these areas of chemistry. All deficiencies must be removed by either taking and passing with a grade of "B" an appropriate undergraduate course or by taking again and passing the placement exam.
- A placement exam can be taken only twice; if the exam is not passed after the second attempt, the appropriate undergraduate course must be completed.

Advancement to Candidacy

After completing at least 40 percent of the graduate degree course work with an overall GPA of 3.0 or higher, a student may submit an application for Advancement to Candidacy, which indicates the proposed program of graduate study is acceptable to the student, faculty advisor and graduate coordinator. This procedure may begin as soon as the classified graduate student has:

- removed any deficiencies in admission requirements;
- completed at least 12 units of 200-level courses with a minimum 3.0 GPA;
- passed the Writing Proficiency Examination (WPE), or secured approval of a WPE waiver, and by completion of one semester of CHEM 294; and
- obtained advisor's approval of thesis topic.

Requirements • Master of Science Degree

Units required: 30

Minimum GPA: 3.0

A. Required Core Courses (14 units)

- (3) CHEM 220 Spectrometric Identification of Compounds
- (3) CHEM 230 Separation Methods in Chemistry
- (3) CHEM 231 Chemical Separations Laboratory (CHEM 230)
- (3) CHEM 240 Advanced Instrumentation Laboratory (CHEM 24, CHEM 25, CHEM 124 or instructor permission)
- (2) CHEM 294 Seminar in Chemistry (four semesters required)

B. Electives (6 units)

- (6) Select two of the following:
- CHEM 221 Synthesis and Reactivity of Organic Compounds (Two semesters of organic chemistry lecture, CHEM 24 and CHEM 124)
- CHEM 245 Computational Chemistry (CHEM 140A and CHEM 140B or CHEM 142 or instructor permission)
- CHEM 250 Selected Topics in Chemistry (Enrollment in MS Chemistry graduate program or instructor permission)
- CHEM 260 Protein Biochemistry (One semester of biochemistry)
- Upper division course approved by graduate advisor and department chair (e.g. BIO 180, CHEM 110, CHEM 126, CHEM 128, CHEM 141)

C. Completion Requirements (10 units)

- (8) CHEM 299 Special Problems
- (2) CHEM 500 Culminating Experience (Advanced to candidacy and chair permission of his/her thesis committee)

Requirements • Master of Science Degree • Biochemistry Concentration

Units required: 30

Minimum GPA: 3.0

A. Required Courses (14 units)

- (3) CHEM 260 Protein Biochemistry (one semester of Biochemistry)
- (3) CHEM 261 Nucleic Acids Chemistry (one semester of Biochemistry)
- (6) Select two of the following:
- CHEM 220 Spectrometric Identification of Compounds
- CHEM 230 Separation Methods in Chemistry
- CHEM 231 Chemical Separations Laboratory (CHEM 230)
- CHEM 240 Advanced Instrumentation Laboratory (CHEM 24, CHEM 25, CHEM 124 or instructor permission)
- (2) CHEM 294 Seminar in Chemistry (four semesters required)

B. Electives (6 units)

Graduate and upper division Chemistry and Biology courses selected with approval of graduate advisor and department chair (e.g. CHEM 221, CHEM 245, CHEM 250, BIO 222, BIO 220, BIO 223, BIO 224, BIO 245).

C. Culminating Requirements (10 units)

- (8) CHEM 299 Special Problems
- (2) CHEM 500 Culminating Experience (Advanced to candidacy and chair permission of his/her thesis committee)

Lower Division Courses

CHEM 1A. General Chemistry I. Fundamental principles and concepts of chemistry, including stoichiometry; thermochemistry; atomic and molecular structure; solution chemistry, including acid-base chemistry; quantum theory; bonding and intermolecular forces; and chemical kinetics. Fairly mathematical, requiring the ability to perform arithmetic and algebraic computations. Lecture three hours, laboratory six hours. **Note:** Enrollment is predicated on students passing a standardized diagnostic qualifying exam given prior to each semester or passing CHEM 4 with a grade of "C" or better. **Prerequisite:** High school algebra (two years) and high school chemistry, or equivalent. **Units:** 5.0.

CHEM 1B. General Chemistry II. 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 with a passing grade of "C" or better. **Units:** 5.0.

CHEM 4. Chemical Calculations. Introductory chemistry for students who plan to major in a scientific field. Appropriate for students desiring to prepare themselves for Chemistry 1A. Emphasizes the techniques of problem solving and utilizes 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. **Units:** 3.0.

CHEM 6A. Introduction to General Chemistry. Structure of atoms, molecules and ions; their interactions including stoichiometry, equilibria, and oxidation-reduction. Does not fulfill the requirements for more advanced study in chemistry and cannot be counted toward a major or minor in chemistry. Lecture three hours, discussion one hour, laboratory three hours. **Prerequisite:** One year high school algebra; high school chemistry recommended. **Units:** 5.0.

CHEM 6B. Introduction to Organic and Biological Chemistry. Introduction to structure and properties of the major classes of organic compounds; introduction to nomenclature and to the fundamental concepts of reaction mechanisms and stereochemistry; the chemistry and metabolism of carbohydrates, lipids, proteins (including enzymes); the chemistry of nucleic acids. Does not fulfill the requirement for more advanced study in chemistry and cannot be counted toward a major or minor in chemistry. Lecture three hours; discussion one hour; laboratory three hours. **Prerequisite:** CHEM 1A or CHEM 6A, or a high school chemistry course and passing a qualifying exam given in the first laboratory period. **Units:** 5.0.

CHEM 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. **Units:** 3.0.

CHEM 20L. Introductory Organic Chemistry Laboratory. Basic organic experimental techniques. Experimental topics include: melting points, purification of solids, distillation, chromatography, extraction, and functional group qualitative analysis. 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 may be taken concurrently. **Units:** 1.0.

CHEM 24. Organic Chemistry Lecture I. Introduction to the basic principals of organic chemistry, including nomenclature, properties and reactions of various classes of organic compounds. Reaction mechanisms will be emphasized. **Note:** Required for chemistry majors and recommended for preprofessional students. **Prerequisite:** CHEM 1B. **Units:** 3.0.

CHEM 25. Organic Chemistry Laboratory. Basic organic experimental techniques including the preparation, separation, purification and identification of organic compounds. Discussion one hour, laboratory six hours. **Prerequisite:** CHEM 24, CHEM 124; CHEM 124 may be taken concurrently. **Units:** 3.0.

CHEM 31. Quantitative Analysis. Chemical measurements including associated statistics, chemical equilibrium in aqueous solutions, volumetric analysis, and an introduction to spectrophotometry and chromatography. Lecture two hours, laboratory six hours. **Prerequisite:** CHEM 1B. **Units:** 4.0.

Upper Division Courses

CHEM 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. Does not fulfill credit requirements for the major or minor in chemistry. **Prerequisite:** GEOL 8 or BIO 7 and ENGL 20 or an equivalent second semester composition course. **Units:** 3.0.

CHEM 110. Inorganic Chemistry Lecture. 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. **Prerequisite:** CHEM 125, CHEM 140B or CHEM 142 instructor permission; CHEM 140B may be taken concurrently, however, students are encouraged to complete CHEM 140B and CHEM 141 first. **Corequisite:** CHEM 110L. **Units:** 3.0.

CHEM 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, ENGL 20 or an equivalent second semester composition course. **Corequisite:** CHEM 110. **Units:** 2.0.

CHEM 124. Organic Chemistry Lecture II. Continued discussion of the principals of organic chemistry, including nomenclature, properties, and reactions of various classes of organic compounds and spectroscopic analysis. Reaction mechanisms will be emphasized. **Prerequisite:** CHEM 24 or instructor permission; concurrent enrollment in CHEM 25 recommended. **Units:** 3.0.

CHEM 125. Advanced Organic Chemistry Laboratory. Focuses on advanced organic laboratory techniques and instrumental methods of analysis. Not intended for pre-health professional majors. Discussion one hour, laboratory six hours. **Prerequisite:** CHEM 25, CHEM 124, ENGL 20 or an equivalent second semester composition course. **Units:** 3.0.

CHEM 126. Physical Organic Chemistry Lecture. Application of bonding and molecular structure in correlating structure-reactivity relationships to organic reaction mechanisms. **Prerequisite:** CHEM 124 and CHEM 140B; CHEM 140B may be taken concurrently. **Units:** 3.0.

CHEM 128. Organic Synthesis. Application of functional group reactions to multistep syntheses. Recently developed synthetic methods and literature searching will be emphasized. **Prerequisite:** CHEM 124. **Units:** 3.0.

CHEM 133. Chemical Instrumentation. Modern instrumentation and methods for chemical analysis. Function of electronics and computers in instruments. Theory and use of instruments in the areas of electrochemistry, spectroscopy, mass spectrometry and chromatography. Lecture two hours, laboratory six hours. **Prerequisite:** CHEM 31, CHEM 140B or CHEM 142 instructor permission; ENGL 20 or an equivalent second semester composition course. **Units:** 4.0.

CHEM 140A. Physical Chemistry Lecture I. Introduction to chemical thermodynamics and kinetics. **Prerequisite:** CHEM 1B, CHEM 24, CHEM 31, MATH 32, PHYS 5A, PHYS 5B, or PHYS 11A, PHYS 11B, PHYS 11C; PHYS 11C may be taken concurrently. **Units:** 3.0.

CHEM 140B. Physical Chemistry Lecture II. Introduction to molecular quantum chemistry, structure of matter, molecular spectroscopy, and statistical thermodynamics. **Prerequisite:** CHEM 140A. **Units:** 3.0.

CHEM 141. Physical Chemistry Laboratory. Selected exercises in the practice of physio-chemical laboratory methods. Lecture one hour, laboratory six hours. **Prerequisite:** ENGL 20 or an equivalent second semester composition course; CHEM 140A, CHEM 140B or CHEM 142, instructor permission; CHEM 140B either may be taken concurrently. **Units:** 3.0.

CHEM 142. Introduction to Physical Chemistry. 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:** Not acceptable for the BS or the BA without concentration. **Prerequisite:** CHEM 1B, CHEM 24, PHYS 5A, PHYS 5B, MATH 31. **Units:** 4.0.

CHEM 160A. Structure and Function of Biological Molecules. The chemistry and biochemistry of amino acids, proteins, nucleic acids, lipids and carbohydrates. Also includes enzyme kinetics, the structure and function of biological membranes and discussion of some common laboratory methods. Lecture three hours. **Prerequisite:** CHEM 124; MATH 26A or MATH 30 is recommended. Fall only. **Units:** 3.0.

CHEM 160B. Metabolism and Regulation of Biological Systems. The bioenergetics and regulation of anaerobic and aerobic metabolic pathways. Major topics include glycolysis, Krebs's cycle, fatty acid and amino acid oxidation, lipid biosynthesis and photosynthesis. Particular emphasis is given to pathway regulation and integration. Lecture three hours. **Prerequisite:** CHEM 160A or equivalent course; one year of organic chemistry. Spring only. **Units:** 3.0.

CHEM 161. General Biochemistry. Introduction to the structure and function of biological molecules (carbohydrates, lipids, proteins, nucleic acids, enzymes and hormones), enzyme kinetics, the structure and function of membranes, and the bioenergetics and regulation of major anaerobic and aerobic metabolic pathways. **Prerequisite:** CHEM 20 or CHEM 124; one year of biological science is recommended. **Units:** 3.0.

CHEM 162. General Biochemistry Laboratory. Introduction to fundamental laboratory techniques for the purification and analysis of biological molecules, including chromatographic separation of amino acids and proteins, electrophoretic separation of proteins and nucleic acids, enzyme kinetics, and basic bioinformatics. Discussion one hour, laboratory six hours. **Prerequisite:** CHEM 31; CHEM 160A or CHEM 161 (either CHEM 160A or CHEM 161 may be taken concurrently); ENGL 20 or an equivalent second semester composition course. **Units:** 3.0.

CHEM 164. Advanced Biochemistry Laboratory. Capstone course which emphasizes biochemical laboratory experimental design and trouble-shooting skills. Common biochemistry laboratory techniques are applied in semester-long individual student projects. Discussion one hour, laboratory six hours. **Prerequisite:** CHEM 162 or equivalent; ENGL 20 or an equivalent second semester composition course. **Units:** 3.0.

CHEM 189. Directed Research. Directed undergraduate research involving a project that requires inquiry and use of chemical literature. A well-written, comprehensive and well-documented final report must be submitted to receive a final grade. **Note:** May be repeated; however only three units may be applied toward the major requirement in chemistry for the BA or BS degrees. May be used for credit toward BS degree if an upper division laboratory course is completed prior to enrolling. Additionally, the final report must be based on experimental techniques or advanced computer modeling and demonstrate a significant ability to use chemical literature and information retrieval. **Prerequisite:** ENGL 20 or an equivalent second semester composition course and instructor and department chair permission. **Units:** 1.0-3.0.

CHEM 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. **Units:** 6.0-12.0.

CHEM 196. Experimental Offerings in Chemistry. To be offered in the various fields of chemistry in response to student demand. **Prerequisite:** Appropriate upper division course work or instructor permission. **Units:** 1.0-3.0.

CHEM 198. Senior Research. The student will conduct an independent study of a chemical research topic that is based on experimental techniques or advanced computer modeling. Significant use of chemical literature and information retrieval is required. A well-written, comprehensive, and well-documented final report must be submitted to receive a final grade. A weekly seminar is required. Seminar one hour, laboratory activities are a minimum of six hours per week. **Prerequisite:** One upper division chemistry laboratory class, ENGL 20 or an equivalent second semester composition course and instructor and department chair permission. **Units:** 3.0.

Graduate Courses

CHEM 220. Spectrometric Identification of Compounds. Interpretation of ultraviolet, infrared, nuclear magnetic resonance, and the mass spectra for the elucidation of chemical structures, with emphasis on problem solving. **Units:** 3.0.

CHEM 221. Synthesis and Reactivity of Organic Compounds. Covers the use of reactions of known mechanism for the synthesis of organic compounds. Course's goal is to give the student the ability to reasonably predict the products of many reactions. **Prerequisite:** Two semesters of organic chemistry lecture, CHEM 24 and CHEM 124. **Units:** 3.0.

CHEM 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. **Units:** 3.0.

CHEM 231. Chemical Separations Laboratory. Practical applications of chemical separations with an emphasis on performing separations for compound isolation, identification, and quantitation. Experimental techniques covering sample handling, extractions, and gas and liquid chromatography. One hour of lecture and two three hour laboratories. **Prerequisite:** CHEM 230. **Units:** 3.0.

CHEM 240. Advanced Instrumentation Laboratory. Synthesis of compounds and application of modern separation techniques to determine structure and reactivity will be emphasized. Organic, inorganic, and/or biological chemicals may be synthesized. Instrumental methods that may be used include: HPLC, FT-IR, nuclear magnetic resonance, UV-VIS, fluorescence, atomic absorption, and mass spectrometry and cyclic voltammetry. One hour of lecture and two three hour laboratories. **Prerequisite:** CHEM 24, CHEM 25, CHEM 124 or instructor permission. **Units:** 3.0.

CHEM 245. Computational Chemistry. Theory and application of computational methods used in the chemical sciences. Demonstration and instruction of widely used computational software. Covering techniques including molecular modeling, semi-empirical methods, and ab initio methods. Application of computational methods to thermodynamics, kinetics, spectra, electrochemistry, and molecular properties. Application of computational methods to various sub-disciplines of chemistry. Lecture three hours. **Prerequisite:** CHEM 140A and CHEM 140B or CHEM 142, or instructor permission. **Units:** 3.0.

CHEM 250. Selected Topics in Chemistry. Intensive coverage of one or more advanced topics in chemistry. A variety of learning/teaching methodologies may be employed including lecture, team projects, computer modeling, oral presentations and poster projects. May be team-taught. **Note:** May be team-taught. May be repeated once for credit if topics are different. **Prerequisite:** Enrollment in MS Chemistry graduate program or instructor permission. **Units:** 3.0.

CHEM 260. Protein Biochemistry. Provides a comprehensive review of proteins, with emphasis on protein structure and structure/function relationships. Topics include methods for structure determination, stability and folding, catalysis and denovo protein design. Topical examples from the literature, particularly those related to disease states, are used to illustrate fundamental principles of protein structure and function. **Prerequisite:** One semester of biochemistry. **Units:** 3.0.

CHEM 261. Nucleic Acid Chemistry. The recent biochemical literature will be used to study the structural, chemical, and physical properties of nucleic acids. Chemical mechanisms of mutation, protein-nucleic acid interactions, and DNA-drug interactions will be used to illustrate these properties. **Prerequisite:** Undergraduate course in biochemistry. **Units:** 3.0.

CHEM 294. Seminar in Chemistry. Student presentations of topics from the chemical literature and their thesis research. **Note:** Grade of C/NC will be based on attendance and successful presentation of a seminar. May be repeated for a total of 2 units **Graded:** Credit / No Credit. **Units:** 0.5.

CHEM 296. Experimental Offerings in Chemistry. Specialized topics in chemistry to be scheduled in response to student needs. **Units:** 1.0-3.0.

CHEM 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. **Units:** 1.0-6.0.

CHEM 500. Culminating Experience. Completion of a thesis or project approved for the Master's degree. 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. **Prerequisite:** Advanced to candidacy and chair permission of his/her thesis committee. **Graded:** Thesis in Progress. **Units:** 1.0-3.0.