

# CHEMISTRY AND BIOCHEMISTRY

College of Natural Sciences and Mathematics

**Department Chair:** Christopher R. Brazier

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## Faculty

Roger A. Acey (Emeritus), Dennis M. Anjo (Emeritus), Stuart R. Berryhill, Deepali Bhandari, Christopher R. Brazier, Xianhui Bu, Paul T. Buonora, Jeffrey A. Cohlberg (Emeritus), Andrew Chen, Shahab Derakhshan, Nancy Gandner, Thach Ho, Lijuan Li, Marco A. Lopez, Eric Marinez, Douglas D. McAbee, Margaret L. Merryfield, Stephen P. Mezyk, Kensaku Nakayama, Vasanthi Narayanaswami, Patrick Pierce, Michael Schramm, Jason Schwans, Gary Shankweiler, Young Shon, Katarzyna Slowinska, Krzysztof Slowinski, Eric Sorin, Enrico Tapavicza, Paul M. M. Weers

**Administrative Support Coordinator:** Irma Sanchez

## Advisors:

Undergraduate: Douglas D. McAbee  
Credential: James Kisiel, Tim Williamson  
Graduate: Biochemistry: Paul M. M. Weers; Chemistry: Lijuan Li

**Graduate Studies Committee:** Lijuan Li, Krzysztof Slowinski, Christopher R. Brazier, Young Shen, Paul M. M. Weers

**Honors in the Major:** Douglas D. McAbee

Students desiring information should contact the undergraduate advisor.

## Career Possibilities

Patent Agent • Chemist • Assayer • Water Purification Chemist • Chemical Lab Technician • Biochemist • Quality Control Coordinator • Pharmaceutical or Technical Sales Representative • Public Health Educator • Industrial Hygienist • Health Administrator • Teacher • Food / Drug Inspector • Materials Scientist • Medical Librarian • Environmental Scientist • Criminologist • Pharmacologist • Dentist • Physician • Geochemist • Chemical Oceanographer (Some of these, and other careers, require additional education or experience. For more information, see [www.careers.csulb.edu](http://www.careers.csulb.edu).)

## Introduction

The Department of Chemistry and Biochemistry offers three bachelor's degrees, the B.S. in Chemistry, the B.S. in Biochemistry, and the B.A. in Chemistry, and two master's degrees, the M.S. in Chemistry and the M.S. in Biochemistry. These programs combined serve over 700 majors. In addition, the Department offers a Minor in Chemistry.

## Degree Programs

The programs in chemistry and biochemistry at the bachelor's degree level are planned to develop background in a specific science, to serve as preparation for graduate work in chemistry or biochemistry, and to provide a foundation for those students seeking careers in the chemical sciences, teaching, law, medicine, dentistry, pharmacy and other health-related professions, and in industrial and governmental scientific occupations. The B.S. degree in Chemistry is certified by the American Chemical Society (American Chemical Society, Committee on

Professional Training, 1155 Sixteenth St., NW, Washington, DC 20036, phone: 202-872-4589).

The B.S. degree in Biochemistry is certified by the American Society for Biochemistry and Molecular Biology (ASBMB department/program accreditation sub-committee, 11200 Rockville Pike, Suite 302, Rockville MD 20852-3110, phone: 240-283-6600).

**Transfer Students:** A student who transfers to the University must take at least 16 units of upper division chemistry courses here. To receive credit towards the major for courses taken elsewhere in place of CHEM 371A,B and/or 377A,B, consent of the Department Chair is required. Satisfactory performance on appropriate proficiency examinations may also be required.

The Department of Chemistry and Biochemistry offers graduate study leading to research-based master of science degrees in chemistry and biochemistry.

Applicants for the master of science degree programs should apply online both to the university and to the department. Links to the online application forms can be found on the department's web site (<http://chemistry.csulb.edu> – click on "Graduate Programs").

A limited number of teaching associate and graduate and research assistantships are available. Usually, these involve half-time work in the instructional program at the freshman and sophomore level or work in the laboratory. An applicant may apply for a teaching associate or graduate assistant position in the course of completing the online departmental application.

## Academic Advising and Facilitated Enrollment into Classes

All entering students who declare a major in a degree program offered by this department need to contact the College of Natural Sciences and Mathematics' (CNSM) Academic Advising Center (HSCI 164) and participate in the College's Science Safari to Success (for first time freshmen) or EONS (Enrollment and Orientation in the Natural Sciences and Mathematics for transfer students) Program. These programs are held in June/July for those starting in the Fall Semester and in January for those starting in the Spring Semester. Department advisors will be available to provide an overview of the students' chosen baccalaureate degree program, to assist with academic advisement, to provide information on the many career opportunities available, and to aid students in enrolling in classes. Contact the CNSM Academic Advising Center, Jensen Student Access to Sciences and Mathematics Center (HSCI 164), or department office for additional information.

## Concurrent and/or Summer Enrollment in Another College

Students who wish to take course work in a community or other college to meet curricular requirements while enrolled as undergraduates in the College of Natural Sciences and Mathematics must petition the appropriate department for approval prior to enrolling in specific

courses. This policy applies to concurrent enrollment or summer enrollment. University policy must also be complied with; see "Concurrent Enrollment" and "Transfer of Undergraduate Credit" in this catalog. Courses not receiving prior approval will not be accepted for credit by the Department.

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## Undergraduate Programs

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### Bachelor of Science in Chemistry (120 units)

#### Degree Progress

BS Chemistry majors must complete the following requirements within the specified time of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete. Students required to enroll in pre-baccalaureate math may receive one additional semester to meet the requirements.

Freshmen: A grade "C" or better must be achieved in both MATH 122 and CHEM 111A within one calendar year. A grade of "C" or better must be achieved in CHEM 111B and CHEM 220A within two calendar years.

Transfer Students: A grade of "C" or better must be achieved in both CHEM 220A and PHYS 151 within 1 calendar year.

In addition, all BS Chemistry majors must earn a "C" or better in all courses counting toward the major and must maintain major and upper-division major GPAs of 2.0 or higher. A student whose GPA in the major or upper division GPA in the major falls below 2.0 will be advised that they are at risk of being dismissed from the major and granted one semester to raise their major GPA(s) to 2.0. Students who do not successfully raise their major GPA(s) must meet with an advisor to declare another major or submit an appeal to the Department of Chemistry and Biochemistry explaining why they need one additional semester. Students whose major GPAs remain below 2.0 after this additional semester must declare a new major.

#### Students Desiring Entrance into a Health Professions Program

Students desiring entrance into one of the various health-related professional schools should consult with the Health Professions Advising Office in the College of Natural Sciences and Mathematics, Jensen Student Access to Sciences and Mathematics Center (HSCI-164) for more information. Most of these schools do not require students to major in any particular discipline and many favor applicants who have earned a baccalaureate; rather, they want students who have done well in their major and who also took the prerequisite courses required by that particular school.

#### Requirements

Lower Division:

Either take all of the following:

BIOL 211 Introduction to Evolution and Diversity (4)  
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)  
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better. Prerequisite/Corequisite: CHEM 111B.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L are required if courses were taken prior to catalog year 2010-11.

Or one of the following:

BIOL 200 General Biology (4)  
Prerequisite: GE Foundation requirements.

BIOL 205 Human Biology (4)  
Prerequisites: GE Foundation requirements.

BIOL 207 Human Physiology (4)  
Prerequisites: GE Foundation requirements.

Take either:

CHEM 111A General Chemistry (5)  
Prerequisites: A passing score on the Chemistry Placement Examination.  
Corequisite: MATH 109 or higher.

and

CHEM 111B General Chemistry (5)  
Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

or

CHEM 112A Advanced General Chemistry (5)  
Prerequisite: Department consent.

and

CHEM 112B Advanced General Chemistry (5)  
Prerequisite: CHEM 112A with a grade of "C" or better

Take either:

CHEM 251 Quantitative Analysis (4)  
Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is advised that CHEM 251 be taken within one calendar year of CHEM 111B.

or

4 units of electives chosen in consultation with an advisor.

Take all of the following courses:

CHEM 220A Organic Chemistry I (3)  
Prerequisites: CHEM 111B with a grade of "C" or better.  
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)  
Prerequisites: CHEM 220A with a grade of C or better  
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L

MATH 122 Calculus I (4)  
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)  
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)  
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

PHYS 151 Mechanics and Heat (4)  
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)  
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following courses:

CHEM 320L Organic Chemistry Laboratory for Chemistry & Biochemistry Majors (2) F, S  
Prerequisites: CHEM 220A.

Corequisites: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 320B.

CHEM 331 Inorganic Chemistry (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

CHEM 332 Inorganic Chemistry Lab (2)

Prerequisite/Corequisite: CHEM 331.

CHEM 361 Chemical Communications (3)

Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GEAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GEAR Writing Intensive Capstone.  
Prerequisite/Corequisite: CHEM 220A.

CHEM 371A Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

CHEM 371B Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

CHEM 373. Physical Chemistry Laboratory (3)

Prerequisites: CHEM 361, CHEM 371A or 377A, and CHEM 371B or 377B, all with a grade of "C" or better.

CHEM 431 Advanced Inorganic Chemistry (3)

Prerequisite(s): CHEM 331, with a grade of "C" or better.

Prerequisite(s)/Corequisite(s): CHEM 371B.

CHEM 441A Biological Chemistry (3) or CHEM 448 (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

CHEM 451 Instrumental Methods of Analysis (5)

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

CHEM 461 Chemistry Capstone (1)

Prerequisite: Department consent.

Take one of the following:

CHEM 420 Advanced Organic Chemistry Lab (3)

Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466. (all with a grade of C or better).

CHEM 498 Senior Thesis (3)

Prerequisites: Major GPA 3.0 or higher, 3 units of CHEM 496 with a grade of "A", consent of instructor.

Take an additional 3 units of upper division chemistry electives including at least one unit of CHEM 496. CH E 330, CH E 430, or CH E 475 may be used as chemistry electives.

Students are also advised to take one or more additional courses in mathematics, such as MATH 247, MATH 364A, MATH 370A, MATH 380.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, CHEM 111A, CHEM 111B, CHEM 112A, CHEM 220A, CHEM 220B, CHEM 320L, CHEM 331, CHEM 361, CHEM 371A, CHEM 371B, MATH 122, MATH 123, PHYS 151, PHYS 152.

## Bachelor of Arts in Chemistry (120 units)

### Degree Progress

BA Chemistry majors must complete the following requirements within the specified time of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete. Students required to enroll in pre-baccalaureate math may receive one additional semester to meet the requirements.

Freshmen: A grade "C" or better must be achieved in both MATH 122 and CHEM 111A within one calendar year. A grade of "C" or better must be achieved in CHEM 111B and CHEM 220A within two calendar years.

Transfer Students: A grade "C" or better must be achieved in both CHEM 220A and PHYS 151 within one calendar year.

In addition, BA Chemistry majors must earn a "C" or better in all courses counting toward the major and must maintain major and upper-division major GPAs of 2.0 or higher. A student whose GPA in the major or upper division GPA in the major falls below 2.0 will be advised that they are at risk of being dismissed from the major and granted one semester to raise their major GPA(s) to 2.0. Students who do not successfully raise their major GPA(s) must meet with an advisor to declare another major or submit an appeal to the Department of Chemistry and Biochemistry explaining why they need one additional semester. Students whose major GPAs remain below 2.0 after this additional semester must declare a new major.

### Requirements

Lower Division:

Take either of the following pairs:

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

and

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

or

CHEM 112A Advanced General Chemistry (5)

Prerequisite: Department consent.

and

CHEM 112B Advanced General Chemistry (5)

Prerequisite: CHEM 112A with a grade of "C" or better

Take either:

CHEM 251 Quantitative Analysis (4)

Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is advised that CHEM 251 be taken within one calendar year of CHEM 111B.

or

4 units of electives chosen in consultation with an advisor

Take all of the following courses:

CHEM 220A Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better.  
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

**CHEM 220B Organic Chemistry II (3)**

Prerequisites: CHEM 220A with a grade of C or better.  
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

**MATH 122 Calculus I (4)**

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

**MATH 123 Calculus II (4)**

Prerequisite: A grade of "C" or better in MATH 122.

**PHYS 151 Mechanics and Heat (4)**

Prerequisite/Corequisite: MATH 122.

**PHYS 152 Electricity and Magnetism (4)**

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

**Upper Division:**

Take all of the following courses:

**CHEM 320L Organic Chemistry Laboratory for**

**Chemistry & Biochemistry Majors (2)**

Prerequisite: CHEM 220A

Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B

**CHEM 331 Inorganic Chemistry (3)**

Prerequisites: CHEM 111B with a grade of "C" or better.

**CHEM 361 Chemical Communications (3)**

Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GVAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GVAR Writing Intensive Capstone.

Prerequisite/Corequisite: CHEM 220A.

Take one of the following courses:

**CHEM 420 Advanced Organic Chemistry Lab (3)**

Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466, all with a grade of "C" or better.

**CHEM 498 Senior Thesis (3)**

Prerequisites: major GPA>3, 3 units of CHEM 496 with a grade of "A", consent of instructor

Take all of the following courses:

**CHEM 451 Instrumental Methods of Analysis (5)**

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

**CHEM 461 Chemistry Capstone (1)**

Prerequisite: Department consent.

Select one pair from the following:

**CHEM 371A Physical Chemistry (3)**

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

and

**CHEM 371B Physical Chemistry (3)**

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

or

**CHEM 377A Fundamentals of Physical Chemistry (3)**

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

and

**CHEM 377B Fundamentals of Physical Chemistry (3)**

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Take an additional 3 additional units chosen with

advisor consultation from the following:

CHEM 332, CHEM 373, CHEM 421, CHEM 431, CHEM 441A, 441B, CHEM 448, CHEM 480, CHEM 496. Only one biochemistry pathway may be used toward this degree program: either CHEM 448 or CHEM 441A and/or 441B.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: CHEM 111A, CHEM 111B, CHEM 112A, CHEM 220A, CHEM 220B, CHEM 320L, CHEM 361, CHEM 371B, CHEM 377B, MATH 122, MATH 123, PHYS 151, PHYS 152.

Students must consult an advisor to select additional courses to meet the student's individual goals and interests.

## **Bachelor of Science in Biochemistry (120 units)**

### **Degree Progress**

BS and Biochemistry majors must complete the following requirements within the specified time of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. Students who have not met the requirements by the required semester must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete. Students required to enroll in pre-baccalaureate math may receive one additional semester to meet the requirements.

**Freshmen:** A grade "C" or better must be achieved in both MATH 122 and CHEM 111A within one calendar year. A grade of "C" or better must be achieved in CHEM 111B and CHEM 220A within two calendar years.

**Transfer Students:** A grade of "C" or better must be achieved in both CHEM 220A and PHYS 151 within 1 calendar year.

In addition, BS and Biochemistry majors must earn a C or better in all courses counting towards the major and must maintain major and upper-division major GPAs of 2.0 or higher. A student whose GPA in the major or upper division GPA in the major falls below 2.0 will be advised that they are at risk of being dismissed from the major and granted one semester to raise their major GPA(s) to 2.0. Students who do not successfully raise their major GPA(s) must meet with an advisor to declare another major or submit an appeal to the Department of Chemistry and Biochemistry explaining why they need one additional semester. Students whose major GPAs remain below 2.0 after this additional semester must declare a new major.

### **Requirements**

**Lower Division:**

Take either:

**CHEM 111A General Chemistry (5)**

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

and

**CHEM 111B General Chemistry (5)**

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

or

**CHEM 112A Advanced General Chemistry (5)**

Prerequisite: Department consent.

and

CHEM 112B Advanced General Chemistry (5)  
Prerequisite: CHEM 112A with a grade of "C" or better

Take either:

CHEM 251 Quantitative Analysis (4)  
Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is advised that CHEM 251 be taken within one calendar year of CHEM 111B.

or

4 units of electives chosen in consultation with an advisor

Take all of the following courses:

BIOL 211 Introduction to Evolution and Diversity (4)  
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)  
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better.  
Prerequisite/Corequisite: CHEM 111B.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L are required if courses were taken prior to catalog year 2010-11.

CHEM 220A Organic Chemistry I (3)  
Prerequisites: CHEM 111B with a grade of "C" or better.  
Corequisites: CHEM 224 is required for students repeating course.  
CHEM 223A must be taken concurrently if required by a degree plan.

CHEM 220B Organic Chemistry II (3)  
Prerequisites: CHEM 220A with a grade of C or better  
Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L

MATH 122 Calculus I (4)  
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

MATH 123 Calculus II (4)  
Prerequisite: A grade of "C" or better in MATH 122.

PHYS 151 Mechanics and Heat (4)  
Prerequisite/Corequisite: MATH 122.

PHYS 152 Electricity and Magnetism (4)  
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Upper Division:

Take all of the following courses:

BIOL 340 Molecular Cell Biology (3)  
Prerequisites: BIOL 211, BIOL 212, all with a grade of "C" or better.

CHEM 320L Organic Chemistry Laboratory for Chemistry & Biochemistry Majors (2) F, S  
Prerequisite: CHEM 220A.  
Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 320B.

CHEM 361 Chemical Communications (3)  
Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GWAR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GWAR Writing Intensive Capstone.  
Prerequisite/Corequisite: CHEM 220A.

CHEM 441A Biological Chemistry (3)  
Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

CHEM 441B Biological Chemistry (3)  
Prerequisite: CHEM 441A with a grade of "C" or better.

CHEM 443 Biological Chemistry Laboratory (4)  
Prerequisites: CHEM 441A and either CHEM 361 or CHEM 466; all with a grade of "C" or better.

CHEM 461 Chemistry Capstone (1)  
Prerequisite: Department consent.

Select one of the following:

CHEM 371A Physical Chemistry (3)  
Prerequisites: 111B, MATH 123, PHYS 152 (all with a grade of "C"

or better).  
Prerequisite/Corequisite: MATH 224.

CHEM 377A Fundamentals of Physical Chemistry (3)  
Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).  
(CHEM 371A,B is recommended as preparation for graduate studies in biochemistry)

Select one of the following:

CHEM 371B Physical Chemistry (3)  
Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).  
Prerequisite/Corequisite: MATH 224.

CHEM 377B Fundamentals of Physical Chemistry (3)  
Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Select one course from the following:

CHEM 420 Advanced Organic Chemistry Lab (3)  
Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466. (all with a grade of C or better).

CHEM 451 Instrumental Methods of Analysis (5)  
Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

Take at least three units of elective chosen from: :

BIOL 342/342L, BIOL 370, BIOL 416, BIOL 430, BIOL 431, BIOL 432, BIOL 433, BIOL 443, BIOL 445, BIOL 473; CHEM 251, CHEM 331, CHEM 332, CHEM 373, CHEM 420, CHEM 421, CHEM 431, CHEM 451, CHEM 466, CHEM 480, CHEM 496, CHEM 498, CHEM 498H, CHEM 499.

To meet prerequisite standards for courses in this program's requirements, a "C" or better is necessary in the following: BIOL 211, BIOL 212, CHEM 111A, CHEM 111B, CHEM 112A, CHEM 220A, CHEM 220B, CHEM 320L, CHEM 361, CHEM 441A, CHEM 371B, CHEM 377B, MATH 122, MATH 123, PHYS 151, PHYS 152.

## Single Subject Chemistry Concentration

The Chemistry Concentration meets the subject matter competence requirement for the Single Subject Teaching Credential in Chemistry. Consult with an adviser in the Department of Science Education early to plan a program.

### Requirements

Lower Division:

Take all of the following courses:

ASTR 100 Astronomy (3)  
Corequisites: One course from General Education Category B.2 and ASTR 100L.

BIOL 211 Introduction to Evolution and Diversity (4)  
Prerequisite/Corequisite: CHEM 111A with a grade of "C" or better.

BIOL 212 Intro to Cell and Molecular Biology (4)  
Prerequisites: BIOL 211, CHEM 111A with grades of "C" or better. Prerequisite/Corequisite: CHEM 111B.

BIOL 213 Introduction to Ecology and Physiology (4)  
Prerequisites: BIOL 211, BIOL 212, CHEM 111B all with a grade of "C" or better.

NOTE: BIOL 111, BIOL 111L, BIOL 212, BIOL 212L, BIOL 213, BIOL 213L are required if courses were taken prior to catalog year 2010-11.

CHEM 251 Quantitative Analysis (4)  
Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is strongly recommended that CHEM 251 be taken within one calendar year of CHEM 111B.

### GEOL 102 General Geology (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

### GEOL 104 Geology Laboratory (1)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent. Prerequisite/Corequisite: GEOL 102.

### GEOL 160 Introduction to Oceanography (3)

Prerequisites/Corequisites: A course that fulfills the A.1 GE requirement and three years of high school mathematics including algebra, geometry, and intermediate algebra or the equivalent.

Select one pair from the following:

#### CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

#### CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Or

#### CHEM 112A Advanced General Chemistry (5)

Prerequisites: Department consent

#### CHEM 112B Advanced General Chemistry (5)

Prerequisite: CHEM 112A with a grade of "C" or better

Select one pair from the following:

#### PHYS 100A General Physics (4)

Prerequisite: MATH 109 or MATH 113 or MATH 119A or MATH 122.

#### PHYS 100B General Physics (4)

Prerequisite: PHYS 100A.

or

#### PHYS 151 Mechanics and Heat (4)

Prerequisite/Corequisite: MATH 122.

#### PHYS 152 Electricity and Magnetism (4)

Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

Select one pair from the following:

#### MATH 119A Survey of Calculus I (3)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 113.

#### MATH 119B Survey of Calculus II (3)

Prerequisite: A grade of "C" or better in MATH 119A or MATH 122.

or

#### MATH 122 Calculus I (4)

Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113.

#### MATH 123 Calculus II (4)

Prerequisite: A grade of "C" or better in MATH 122.

Upper Division:

Take all of the following:

#### CHEM 220A Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better. Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

#### CHEM 220B Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better. Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

#### CHEM 451 Instrumental Methods of Analysis (5)

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or

CHEM 377B; all with a grade of "C" or better.

#### CHEM 496 Special Problems in Chemistry (1-3)

Prerequisite: Consent of instructor.

#### SCED 403 Integrated Science (3)

Prerequisites: Completion of all credential breadth requirements for the Single Subject Teaching Credential Program in Science, three-fourths of the credential specializations courses, and consent of instructor.

Take one of the following:

#### CHEM 441A Biological Chemistry (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

Or

#### CHEM 448 Fundamentals of Biological Chemistry (3)

Prerequisites: CHEM 220B or 227 with a grade of "C" or better.

Take one of the following:

#### CHEM 431 Advanced Inorganic Chemistry (3)

Prerequisite(s): CHEM 331, with a grade of "C" or better. Prerequisite(s)/Corequisite(s): CHEM 371B.

#### CHEM 441B Biological Chemistry (3)

Prerequisite: CHEM 441A with a grade of "C" or better.

## Single Subject Teaching Credential in Chemistry

In addition, prospective Chemistry teachers are required to complete 45 units of professional preparation in the Single Subject Credential Program, including student teaching. Professional preparation courses may be taken as early as the junior year. With careful planning, it is possible to complete many of the credential program courses, except for student teaching, as an undergraduate. Courses may also be started as a post-baccalaureate student. Refer to the Single Subject Teacher Education section of this catalog or the Single Subject Credential Program website ([www.ced.csulb.edu/single-subject](http://www.ced.csulb.edu/single-subject)) for a description of the professional preparation requirements, courses, and application procedures.

The Chemistry Subject Matter Program is being revised to meet new state standards. When the revised program has been approved by the Commission on Teacher Credentialing, the new course requirements will be in effect and supersede current requirements.

## Honors in Biochemistry or Chemistry

Students majoring in the B.S. in Biochemistry, B.S. in Chemistry, or B.A. in Chemistry who would like an enriched academic program including an intensive research experience may be eligible to graduate with Honors in the Major through the University Honors Program. Students may complete General Honors through the University Honors Program as well; in such cases the General Honors thesis requirement is met through Honors in the Major (see University Honors in this catalog).

## Requirements for Admission to Honors in the Major

The requirements for Honors in the Major also satisfies the requirements of a college-wide program, Honors in Biological Sciences, created with the support of a grant from the Howard Hughes Medical Institute. While Honors in the Major requires junior or senior standing, the college-wide program offers an enriched curriculum. Interested students

should contact the Honors in the Major director or the Jensen Student Access to Sciences and Mathematics Center.

1. Junior or senior standing with at least one year remaining before graduation.
2. Declared major of B.S. in Biochemistry, B.S. in Chemistry, or B.A. in Chemistry.
3. Submission of an application detailing interest in the program and willingness to commit to a year-long research experience.
4. Letter of recommendation from a CSULB faculty member familiar with the student's work.
5. Completion of CHEM 220A,B and one upper division chemistry lecture course. Students may apply during the semester in which they expect to complete these courses.
6. GPA of at least 3.00 in all courses in the major and in all upper division courses in the major.

### Requirements for Graduation with Honors in the Major

1. GPA of at least 3.30 in all upper division courses in the major and in Honors courses.
2. Completion of all requirements for the B.S. in Biochemistry, B.S. in Chemistry, or B.A. in Chemistry.
3. Completion of one 500-level lecture course or 400/500 dual level course in chemistry (3 units).
4. Completion of 3 units CHEM 496, Undergraduate Directed Research.
5. Completion of 3 units of CHEM 498H, Senior Thesis - Honors.
6. Presentation of research results in a public forum. This requirement may be met by presentation at a scientific conference or at a local venue; consult the Honors in the Major advisor for additional information.

Substitutions to this program must be approved by the Honors in the Major Advisor.

## Minor in Chemistry

### Requirements

The Minor in Chemistry is available to any non-Chemistry or non-Biochemistry major. Students must earn a "C" or better in every course counted towards the minor.

A minimum of 19 units of chemistry coursework which must include a minimum of six units of upper division chemistry courses and the following:

CHEM 111A General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

CHEM 111B General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

If students choose to take Organic Chemistry, then they must use courses from only one of the two Organic Chemistry paths to meet the requirements of the minor:

CHEM 227 Fundamentals of Organic Chemistry (3)

Prerequisite: CHEM 111A with a grade of "C" or better; CHEM 111B is recommended.

or

CHEM 220A Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better.  
Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required

by a degree plan.

CHEM 220B Organic Chemistry II (3)

Prerequisites: CHEM 220A with a grade of C or better

Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L

If students choose to take Physical Chemistry, then they must use courses from only one of the three Physical Chemistry paths to meet the requirements of the minor:

CHEM 371A Physical Chemistry: Thermodynamics and Kinetics (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

CHEM 371B Physical Chemistry: Quantum Mechanics and Spectroscopy (3)

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

or

CHEM 375 Physical Chemistry for Engineers (3)

Prerequisites: MATH 123; PHYS 151 and either PHYS 152 or EE 210/EE 210L; CH E 220; CHEM 111A/B; and CHEM 220A or CHEM 227, all grades of "C" or better. CH E 310 is strongly recommended.

or

CHEM 377A Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

CHEM 377B Fundamentals of Physical Chemistry (3)

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

If students choose to take Biochemistry, then they must use courses from only one of the two Biochemistry paths to meet the requirements of the minor:

CHEM 441A Biological Chemistry (3)

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

CHEM 441B Biological Chemistry (3)

Prerequisites: CHEM 441A with a grade of "C" or better.

Or

CHEM 448 Fundamentals of Biological Chemistry (3)

Prerequisites: CHEM 220B or 227 either with a grade of "C" or better

In addition to the courses listed above the following courses may be used to complete the minor in chemistry: CHEM 223A, CHEM 223B, CHEM 251, CHEM 296, CHEM 320L, CHEM 331, CHEM 332, CHEM 373, CHEM 420, CHEM 421, CHEM 431, CHEM 443, CHEM 449, CHEM 451, CHEM 466, CHEM 480, CHEM 496.

The following courses are not acceptable toward the minor: CHEM 90, CHEM 100, CHEM 101, CHEM 140, CHEM 224, CHEM 302, CHEM 361

### Graduate Credit Earned as an Undergraduate Chemistry or Biochemistry Major

Graduate credit usually may not be earned in advance of the baccalaureate degree. However, based upon the recommendation of the Department Chairman and the Chairman of the Department Graduate Studies Committee, academic performance (a grade point average of 3.00 overall and 3.00 in the major), and promise of academic

achievement in postgraduate study, a student in his/her senior year may be granted approval to earn a maximum of 12 units of course work in the 400 and 500 level taken at this University toward his/her prospective graduate program, subject to the following conditions:

1. The course work must be in addition to that required by the Department for the B.A. or B.S. degree in Chemistry or the B.S. degree in Biochemistry.

2. The undergraduate student must have a "Petition to Earn Credit in the Senior Year" approved by the appropriate Department Graduate Advisor, the Associate Dean for Graduate Accountability in the College of Natural Sciences and Mathematics, and the Dean of Graduate Studies.

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## Graduate Programs

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### Master of Science in Chemistry

#### Prerequisites

1. Acceptance as a graduate student by the Department of Chemistry and Biochemistry;
2. A bachelor's degree with a major in chemistry; or a bachelor's degree with undergraduate preparation in chemistry, physics and mathematics equivalent to that required for the bachelor's degree with a major in chemistry at this University. A student deficient in any of these courses must complete the course(s) as a graduate student. The courses that must be taken to make up those deficiencies will be determined by the Graduate Adviser in consultation with the Graduate Studies Committee. Students with majors in other areas may be considered for admission at the discretion of the Graduate Adviser.
3. Entering graduate students are required to take a minimum of two placement examinations (more exams may be required by Graduate Committee) as follows:
  - at the beginning of the first semester of the M.S. program: student chooses to take one placement examination in analytical, inorganic, organic, physical or biochemistry.
  - at the beginning of the second semester of the M.S. program, student takes any additional placement examination(s) required by the Thesis Committee to a minimum of two.

Under some circumstances with the approval of the Graduate Adviser, students may take 2 or more placement examinations at the beginning of the first semester.

Any student failing to pass a placement examination is required to complete with a minimum grade of "B" or better an appropriate course recommended by the Graduate Studies Committee. Usually the recommended courses are:

CHEM 251 and/or CHEM 451

if the subject is analytical chemistry;

CHEM 331 and/or CHEM 431

if the subject is inorganic chemistry;

CHEM 220A and/or CHEM 220B

if the subject is organic chemistry;

CHEM 371A and/or CHEM 371B

if the subject is physical chemistry;

CHEM 441A and/or CHEM 441B

if the subject is biochemistry.

4. The placement examinations are usually given on the Monday of the week preceding the first day of instruction. The Graduate Studies Committee evaluates the examination results and recommends appropriate courses to correct any deficiencies in chemistry.
5. Entering students must select a research advisor by the ninth week of the first semester. The thesis advisor will select two additional faculty members to serve on the Thesis Committee by the 13th week of the first semester. The Thesis Committee will prepare a degree program including the following: (1) additional placement examination(s) the student will take at the beginning of the second semester, (2) a list of graduate courses to be completed in the course of the program. The degree program must be finalized and forwarded to Graduate Advisor by the end of the first semester in residence. Any change in the approved degree program must be preauthorized by Graduate Advisor.
6. Each student shall prepare a thesis proposal in collaboration with the research advisor, stating the specific topic of the research and its significance, the specific objectives of the research, and the methods to be used. The thesis proposal must be approved by the Thesis Committee. The student must make a public presentation of the proposal by the end of the second semester in the MS program. Any major change in direction during the course of the research shall be subject to the approval of the Thesis Committee.

#### Advancement to Candidacy

The Department Graduate Studies Committee recommends advancement to candidacy after the graduate student has:

1. Either passed all the required placement examinations including those recommended by the Thesis Committee or achieved a grade of "B" or better in each course recommended by the Graduate Studies Committee for correcting the deficiencies;
2. Completed at least 6 units of courses on the proposed Graduate Program;
3. While in residence as a graduate student at this University, earned at least a 3.0 ("B") average in all upper division and graduate work, a 3.0 gpa in all CHEM courses, and a 3.0 GPA in all courses on the graduate program.
4. Fulfilled the Graduation Writing Assessment Requirement (GWAR);
5. Obtained approval of a graduate degree program by the Thesis Committee, the Graduate Adviser, the Department Chair (in consultation with the Graduate Studies Committee), and the Associate Dean or designee responsible for graduate studies in the College of Natural Sciences and Mathematics.
6. Make a public presentation of their thesis proposal and made appropriate progress in their proposed research as determined by the Thesis committee.

The criteria above should be met by the beginning of the third semester of graduate study. Deficient students may continue at the discretion of the Department Graduate Studies



Committee. Students should be advanced to candidacy as soon as they are eligible.

## Requirements

1. Advancement to candidacy;
2. Complete a minimum of 30 units including:
  - A. Take a minimum of 12 units in chemistry lecture courses in the 500 series (excluding CHEM 595);
  - B. Take CHEM 595 Colloquium for a total of 2 or 3 units  
Prerequisite: Graduate standing or consent of instructor.
  - C. Take CHEM 660 Seminar in Chemistry (1-3)  
Prerequisite: None
  - D. Take CHEM 697 Directed Research (4-6)  
Prerequisite: Arrangement with instructor.
  - E. Take CHEM 698 Thesis (4-6)  
Prerequisites: Advancement to candidacy for M.S. in Chemistry or M.S. in Biochemistry and arrangement with instructor.
  - F. Additional courses (excluding CHEM 595 and required courses in the BS Chemistry degree program) as approved by Thesis Committee with concurrence of Graduate Advisor.Changes in the above pattern of course requirements may be made only by the Graduate Studies Committee and the Graduate Advisor subject to approval by the College's Associate Dean.
3. Completion of a written thesis, of publication quality, acceptable to the members of the thesis committee and a public presentation of the thesis research. The public presentation must be completed before the thesis is signed by the committee members.
4. A record of regular attendance at departmental seminars, poster sessions, thesis proposal presentations, and thesis defenses.
5. While not a requirement for the degree, students in the MS program normally gain experience teaching laboratory sections of Chemistry courses, as preparation for professionally related teaching activities in their future careers.

## Master of Science in Biochemistry

### Prerequisites

1. Acceptance as a graduate student by the Department of Chemistry and Biochemistry;
2. A bachelor's degree with a major in chemistry or biochemistry or one of the biological sciences. Students with majors in other areas may be considered for admission at the discretion of the Graduate Advisor. Prerequisite courses include CHEM 220A,B, CHEM 377A,B, CHEM 441A,CHEM 441B, CHEM 443; MATH 122, MATH 123; PHYS 100A,B or their equivalents and courses in general biology and cell/molecular biology. A student deficient in any of these courses must complete the course(s) as a graduate student.
3. Entering graduate students are required to take a placement examination in biochemistry at the beginning of the first semester of the MS program. A second placement examination in either organic chemistry or physical chemistry must be taken by the beginning of the second semester. Any student failing to pass a placement examination, is required to complete an appropriate course recommended by the

Graduate Studies Committee with a minimum grade of "B" or better. Usually the recommended courses are:

CHEM 220A and/or CHEM 220B

if the subject is organic chemistry.

(CHEM 371A or CHEM 377A) and/or (CHEM 371B or CHEM 377B)

if the subject is physical chemistry.

CHEM 441A and/or CHEM 441B

if the subject is biochemistry.

Under some circumstances, with the approval of the Graduate Advisor, students may take both placement examinations at the beginning of the first semester.

4. The placement examinations are usually given on the Monday of the week preceding the first day of instruction. The Graduate Studies Committee evaluates the examination results and recommends appropriate courses to correct any deficiencies in chemistry. 5. Entering students must select a research advisor by the ninth week of the first semester. The advisor will select two additional faculty members to serve on the Thesis Committee by the end of the 13th week of the first semester. The Thesis Committee will prepare a degree program including the following (1) the second placement examinations (in organic or physical chemistry) the student will take at the beginning of the second semester, (2) a list of graduate courses to be completed in the course of the program. The degree program must be finalized and forwarded to the Graduate Advisor by the end of the first semester in residence. Any changes in the approved degree program must be preauthorized by the Graduate Advisor.
5. Each student shall prepare a thesis proposal in collaboration with the thesis advisor, stating the specific topic of the research and its significance, the specific objectives of the research, and the methods to be used. The thesis proposal must be approved by the Thesis Committee. The student must make a public presentation of the proposal by the end of the second semester in the MS program. Any major change in direction during the course of the research shall be subject to the approval of the Thesis Committee.

### Advancement to Candidacy

The Department's Graduate Studies Committee recommends advancement to candidacy after the graduate student has:

1. Either passed all the required placement examinations including those recommended by the Thesis Committee or achieved a grade of B or better in courses recommended by the Graduate Studies Committee for correcting the deficiencies;
2. Completed at least 6 units of courses on the proposed Graduate Program;
3. While in residence as a graduate student at this University, earned at least a 3.0 ("B") average in all upper division and graduate work, a 3.0 gpa in all CHEM courses, and a 3.0 gpa in all courses on the graduate program.
4. Fulfilled the Graduation Writing Assessment Requirement (GWAR);

- Obtained approval of a graduate degree program by the Thesis Committee, the Graduate Adviser, the Department Chair (in consultation with the Graduate Studies Committee), and the Associate Dean responsible for graduate studies in the College of Natural Sciences and Mathematics.
- Made a public presentation of their thesis proposal and made appropriate progress in their proposed research as determined by the Thesis committee.

The criteria above should be met by the beginning of the third semester of graduate study. Deficient students may continue at the discretion of the Department Graduate Studies Committee. Students should be advanced to candidacy as soon as they are eligible.

## Requirements

- Advancement to candidacy;
- Complete a minimum of 30 units including:
  - Take a minimum of 12 units in chemistry lecture courses in the 500 series that must include CHEM 541 (excluding CHEM 595);
  - Take BIOL 540. In some circumstances, 3 units of another 500-level biology lecture course may be substituted with the approval of the Graduate Advisor.
  - Take CHEM 595 Colloquium for a total of 2 units  
Prerequisite: Graduate standing or consent of instructor.
  - Take CHEM 660 Seminar in Chemistry (1-3)  
Prerequisite: None
  - Take CHEM 697 Directed Research (3) and CHEM 697C Directed Research (1-3)  
Prerequisite: Arrangement with instructor.
  - Take CHEM 698 Thesis (4-6)  
Prerequisites: Advancement to candidacy for M.S. in Chemistry or M.S. in Biochemistry and arrangement with instructor.
  - Additional 400- and 500-level science courses (excluding CHEM 595 and required courses in the BS Biochemistry degree program) as recommended by the Thesis Committee and approved by the Graduate Advisor and the College's Associate Dean.  
Changes in the above pattern of course requirements may be made only at the discretion of the Graduate Studies Committee and the Graduate Advisor subject to approval by the College's Associate Dean or designee.
- Completion of a written thesis, of publication quality, acceptable to the members of the Thesis Committee and a public presentation of the thesis research. The public presentation must be completed before the thesis is signed by the committee members.
- A record of regular attendance at departmental seminars, poster sessions, thesis proposal presentations and thesis defenses.
- While not a requirement for the degree, students in the MS program normally gain experience teaching laboratory sections of Chemistry courses, as preparation for professionally related teaching activities in their future careers.

## Single Subject Teaching Credential in Chemistry

For information, refer to the undergraduate section in this department.

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## Chemistry and Biochemistry Courses (CHEM)

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### PREBACCALAUREATE

#### 90. Introduction to General Chemistry (4)

Prerequisite/Corequisite: MATH 109 or higher.

Preparatory course for CHEM 111A. Recommended for students who have not achieved a satisfactory score on the Chemistry Placement examination. Basic principles and concepts including atomic structure, nomenclature, and chemical calculations with emphasis on problem solving.

Credit/No Credit grading only. Cannot be taken for credit toward a university degree. Credit in CHEM 90 or CHEM 101 does not substitute for a passing score on the Chemistry Placement Test. Not open to students with credit in CHEM 101. (Lecture 3 hrs., activity 2 hrs.) May be offered in a hybrid format.

### LOWER DIVISION

#### 100. Chemistry and Today's World (4)

Prerequisite: One GE Foundation course (GE categories A1, A2, A3, or B2).

Introduction to basic principles of chemistry and a consideration of the benefits and problems arising from applications of chemistry. Discussions of foods and food additives, drugs, plastics, and other materials of everyday life, fuel sources, the atmosphere, and fresh water. Suitable for general education credit.

Not open for credit to chemistry or biochemistry majors or students with credit in CHEM 111A or CHEM 140. (Lecture 3 hrs., laboratory 3 hrs.) Course fee may be required.

#### 111A. General Chemistry (5)

Prerequisites: A passing score on the Chemistry Placement Examination.

Corequisite: MATH 109 or higher.

Students not planning to continue onto CHEM 111B may be concurrently enrolled in MATH 109.

Other students need to be concurrently enrolled in MATH 113 or MATH 115 or MATH 119A or MATH 122.

One year of high school chemistry is strongly recommended.

(This course is recommended for those intending to pursue careers in science or engineering.)

First semester of a two-semester sequence (CHEM 111A and CHEM 111B). Introduction to principles of chemistry including chemical reactions, stoichiometry, thermochemistry, electronic structure, bonding, and properties of solids, liquids, gases, and solutions.

Letter grade only (A-F). Credit in CHEM 90 or CHEM 101 does not substitute for a passing score on the Chemistry Placement Examination.

(Lecture 3 hrs., lab and problem solving session 6 hrs.) Course fee may be required.

#### 111B. General Chemistry (5)

Prerequisites: CHEM 111A and MATH 113 or MATH 115 or MATH 119A or MATH 122 all with a grade of "C" or better.

Second semester of a two-semester sequence (CHEM 111A and CHEM 111B). Continuation of chemical principles, chemical equilibrium, kinetics, thermodynamics, electrochemistry, elements of qualitative and quantitative inorganic analysis. Solving aqueous equilibrium problems are emphasized.

Letter grade only (A-F). (Lecture 3 hrs., lab and problem solving sessions 6 hrs.) Course fee may be required.

### 112A. Advanced General Chemistry (5)

Prerequisite: Department consent.

First semester of a two-semester advanced general chemistry sequence (CHEM 112A and CHEM 112B). Introduction to principles of chemistry including chemical reactions, stoichiometry, thermochemistry, electronic structure, bonding, and properties of solids, liquids, gases, and solutions, kinetics, and equilibrium.

Letter grade only (A-F). (Lecture 3 hrs., lab and problem session 6 hrs.)

### 112B. Advanced General Chemistry (5)

Prerequisite: CHEM 112A with a grade of "C" or better.

Second semester of a two-semester advanced general chemistry sequence (CHEM 112A and CHEM 112B). Continuation of chemical principles, electrochemistry, applications of bonding theories of inorganic molecules, trends and reactivities of elements and their compounds, elements of qualitative and quantitative inorganic analysis, introduction to coordination chemistry, solid-state chemistry, and reactions of transition metals. Solving aqueous equilibrium problems is emphasized.

Letter grade only (A-F). (Lecture 3 hrs., lab and problem session 6 hrs.).

### 140. General, Organic, and Biochemistry (5)

Prerequisites: Restricted to Pre-Nursing majors. A grade of "C" or better in MATH 109 or MATH 113 or MATH 117 or MATH 119A or MATH 122 or STAT 108; high school chemistry or equivalent.

This one-semester course encompasses general chemistry, organic chemistry, and biochemistry. Meets chemistry requirement for pre-nursing curriculum.

Letter grade only (A-F). (Lecture 3 hrs; problem solving session 1 hr., and laboratory 3 hrs.) Course fee may be required.

### 220A. Organic Chemistry I (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

Corequisites: CHEM 224 is required for students repeating course. CHEM 223A must be taken concurrently if required by a degree plan.

First semester of two-semester sequence (CHEM 220A, CHEM 220B; and CHEM 223A and CHEM 223B or CHEM 320L). Sequence meets requirements for medical and dental schools. Emphasis is upon application of modern principles of structure, reactivity, methods of synthesis, physical properties and spectroscopy. Not open to students with credit in CHEM 320A or CHEM 322A.

Letter grade only (A-F). (Lecture 3 hrs.)

### 220B. Organic Chemistry II (3)

Prerequisite: CHEM 220A with a grade of "C" or better.

Corequisite: CHEM 223B or CHEM 320L except for students who previously earned a "C" or better in CHEM 223B or CHEM 320L.

Second semester of two-semester sequence (CHEM 220A, CHEM 220B; CHEM 223A and CHEM 223B or CHEM 320L). Continuation of study of organic chemistry including chemistry or compounds containing more than one functional group, bioorganic molecules, and special topics. Not open to students with credit in CHEM 320B or CHEM 322B. Letter grade only (A-F). (Lecture 3 hrs.)

### 223A. Organic Chemistry Laboratory I (1)

Corequisite: CHEM 220A, except for students who have previously earned a "C" or better in CHEM 220A.

Introduction to organic laboratory techniques. First semester of a two-semester sequence (CHEM 223A, CHEM 223B). Not applicable to a degree in chemistry or biochemistry. Not open to students with credit in CHEM 320L or CHEM 323A.

Letter grade only (A-F). (Laboratory 3 hrs.)

### 223B. Organic Chemistry Laboratory II (1)

Prerequisites: CHEM 220A and CHEM 223A, both with a grade of "C" or better. Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Synthesis and characterization of organic and bioorganic compounds. Second semester of a two-semester sequence (CHEM 223A, CHEM 223B). Not applicable to a degree in chemistry or biochemistry. Not open to students with credit in CHEM 320B, or CHEM 320L, or CHEM 323B.

Letter grade only (A-F). (Laboratory 3 hrs)

### 224. Organic Chemistry Recitation (1)

Corequisite: CHEM 220A.

Problem solving session emphasizing principles learned in first semester organic chemistry.

Credit/No Credit grading only. May be repeated to a maximum of 3 units in different semesters. (Problem solving session 1 hr.) Does not count for General Education credit.

### 227. Fundamentals of Organic Chemistry (3)

Prerequisite: CHEM 111A with a grade of "C" or better; CHEM 111B is recommended.

Lecture course in chemistry of the carbon compounds.

Letter grade only (A-F). Not applicable to a degree in chemistry. (Lecture 3 hrs.) Not open for credit to students with credit in CHEM 327.

### 251. Quantitative Analysis (4)

Prerequisite: CHEM 111B with a grade of "C" or better. Strongly recommended for pre-pharmacy students and students planning careers in clinical or analytical laboratory sciences. It is strongly recommended that CHEM 251 be taken within one calendar year of CHEM 111B.

Introduction to techniques and theory of gravimetric and volumetric analysis, spectrophotometry, potentiometry, and chromatography.

Letter grade only (A-F). (Lecture 2 hrs., laboratory 6 hrs.) Course fee may be required.

### 296. Research Methods (1)

Prerequisites: CHEM 111A or CHEM 112A (grade of "B" or better) or consent of Instructor

Introduction to research methods in chemistry. Mixed course designed primarily to introduce lower division students to research before they take CHEM 496.

Letter grade only (A-F). (Lecture/seminar based course only)

## UPPER DIVISION

### 302. Survey of Biochemistry (3)

Prerequisites: A minimum of 3 units of university-level general and organic chemistry with grade of "C" or better.

Study of the chemistry, structures, metabolic reactions and functions of the major classes of biochemical compounds. Does not meet the requirements of medical or dental schools.

Letter grade only (A-F). Does not count for General Education credit. (Lecture 2 hrs., discussion 1 hr.)

### 320L. Organic Chemistry Laboratory (2)

Prerequisite: CHEM 220A.

Corequisite: CHEM 220B, except for students who have previously earned a "C" or better in CHEM 220B.

Introduction to organic laboratory techniques, synthesis and characterization of organic and bioorganic compounds.

Letter grade only (A-F). Not open for credit to students with credit in CHEM 320B. (Laboratory 6 hrs). Course fee may be required.

### 331. Inorganic Chemistry (3)

Prerequisites: CHEM 111B with a grade of "C" or better.

Introduction to coordination chemistry, solid-state chemistry, and reactions of transition metals.

Letter grade only (A-F). (Lecture 3 hrs.)

### **332. Inorganic Chemistry Laboratory (2)**

Prerequisite/Corequisite: CHEM 331.

Synthesis, characterization, and manipulation of inorganic compounds and materials.

Letter grade only (A-F). (Laboratory 3 hrs.)

### **361. Chemical Communications (3)**

Prerequisites: GE Foundation requirement. Students must have scored 11 or higher on the GWR Placement Examination or completed the necessary portfolio course that is a prerequisite for a GWR Writing Intensive Capstone.

Prerequisite/Corequisite: CHEM 220A.

Using the chemical literature. Writing technical reports for various purposes. Oral presentation of chemical information. Includes extensive writing. Fulfills the GE Writing Intensive Capstone requirement.

Letter grade only (A-F). (Seminar 3 hrs.)

### **371A. Physical Chemistry: Thermodynamics and Kinetics (3) F**

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

Half of the two semester physical chemistry package. The two courses, CHEM 371A,B, may be taken in either order. Principles and applications of classical thermodynamics; introduction to chemical kinetics.

Letter grade only (A-F). (Lecture 3 hrs.)

### **371B. Physical Chemistry: Quantum Mechanics and Spectroscopy (3)**

Prerequisites: CHEM 111B, MATH 123, PHYS 152 (all with a grade of "C" or better).

Prerequisite/Corequisite: MATH 224.

Half of the two semester physical chemistry package. The two courses CHEM 371A,B may be taken in either order. Principles and applications of quantum chemistry, spectroscopy, and statistical thermodynamics.

Letter grade only (A-F). (Lecture 3 hrs.)

### **373. Physical Chemistry Laboratory (3)**

Prerequisites: CHEM 361, CHEM 371A or 377A, and CHEM 371B or 377B, all with a grade of "C" or better.

Introduction to basic physico-chemical experimental techniques with applications to principles discussed in CHEM 371A,B and CHEM 377A,B.

Letter grade only (A-F). (Lecture 1 hr., laboratory 6 hrs.)

### **375. Physical Chemistry for Engineers (3)**

Prerequisites: MATH 123; PHYS 151 and either PHYS 152 or EE 210/EE 210L; CH E 220; CHEM 111A/B; and CHEM 220A or CHEM 227, all grades of "C" or better. CH E 310 is strongly recommended.

Principles and applications of real gases, liquids, and solutions; intra- and intermolecular interactions; kinetic theory and chemical kinetics; quantum chemistry, chemical bonding, and spectroscopy.

Letter grade only (A-F). (Lecture 3 hrs)

### **377A. Fundamentals of Physical Chemistry (3)**

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Half of the two semester physical chemistry package with a biochemical emphasis. The two courses CHEM 377A,B may be taken in either order. Principles of physical chemistry emphasizing thermodynamics and chemical kinetics. Biological and environmental science examples used to illustrate principles.

Letter grade only (A-F). (Lecture 3 hrs.)

### **377B. Fundamentals of Physical Chemistry (3)**

Prerequisites: CHEM 111B, MATH 123, and PHYS 152 (all with a grade of "C" or better).

Half of the two semester physical chemistry package with a biochemical emphasis. The two courses CHEM 377 A,B may be taken in either order. Principles of physical chemistry with emphasis on molecular structure and spectroscopy.

Letter grade only (A-F). (Lecture 3 hrs.)

### **385. Materials Science (3)**

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended.

Introduction to general principles of energy materials including catalytic, photovoltaic, and thermoelectric materials based on nanostructural and/or nanoporous systems. Students will be required to complete preparatory modules on Kinetics (reaction dynamics), Electrochemistry, Fermi statistics, and Diodes.

Letter grade only (A-F). Same course as PHYS 385. Not open for credit to students with credit in PHYS 385.

### **385C. Materials Science Colloquium (1)**

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended

Discussion of advances as reported in recent literature related to energy materials. Provides experience in library use, organization, presentation, and critical evaluation of the literature.

Letter grade only (A-F). Same course as PHYS 385C. Not open for credit to students with credit in PHYS 385C.

### **385L. Materials Science Laboratory (2)**

Prerequisite: CHEM 111A and PHYS 152 and (CHEM 111B or PHYS 320), completion of CHEM 111B is strongly recommended

Introduction to synthesis, characterization methods, and property measurement of advanced materials

Letter grade only (A-F). Course fee may be required. (Laboratory 6 hours). Same course as PHYS 385L. Not open for credit to students with credit in PHYS 385L.

### **420. Advanced Organic Chemistry Laboratory (3)**

Prerequisites: CHEM 220B or CHEM 320L and either CHEM 361 or CHEM 466, all with a grade of "C" or better.

Synthesis and characterization of organic compounds. Organic structures analyzed through interpretation of spectral data. Emphasis on use of high field NMR, mass spectrometry, IR, and UV. Applications of modern separation techniques.

In addition to regularly scheduled lectures, students are expected to attend three hours of lecture on use of chemical literature. Letter grade only (A-F). Course fee may be required. (Lecture 1 hr., laboratory 6 hrs.)

### **421./521. Physical Organic Chemistry (3) F**

Prerequisites: CHEM 220B with a grade of "C" or better.

Prerequisite/Corequisite: CHEM 371B or CHEM 377B.

Undergraduates enroll in CHEM 421; graduates in CHEM 521.

Theoretical interpretation of chemical and physical properties of organic compounds: mathematical derivations of rate equations from experimental results, quantitative comparison of organic compounds reactivities, mathematical correlations of structure and properties. Solving problems relating to reaction mechanisms to described factors.

Letter grade only (A-F). (Lecture 3 hrs.)

### **431. Advanced Inorganic Chemistry (3) F**

Prerequisite(s): CHEM 331, with a grade of "C" or better.

Prerequisite(s)/Corequisite(s): CHEM 371B.

Quantitative study of chemical bonding in inorganic molecules emphasizing on molecular orbital theory. Transition metal chemistry including coordination chemistry, ligand field theory, spectroscopy applications to structural analysis of inorganic molecules, and review of properties and reactivities of elements and their compounds.

Letter grade only (A-F). (Lecture 3 hrs.)

### **441A. Biological Chemistry (3)**

Prerequisites: CHEM 220B and either CHEM 320L or CHEM 223B all with a grade of "C" or better; a biology or microbiology course is recommended.

First semester of a two-semester sequence (CHEM 441A and 441B) in biochemistry. Chemical and mathematical treatment of energetics and kinetics of reactions in living systems, including chemistry and metabolism of carbohydrates and chemistry of proteins.

Letter grade only (A-F). (Lecture 3 hours)

### **441B. Biological Chemistry (3)**

Prerequisite: CHEM 441A with a grade of "C" or better.

Second semester of two-semester sequence (CHEM 441A and CHEM 441B) in biochemistry. Metabolism of lipids, proteins, and nucleic acids, and other advanced topics in metabolism.

Letter grade only (A-F). (Lecture 3 hours)

### **443. Biological Chemistry Laboratory (4)**

Prerequisites: Prerequisites: CHEM 441A and either CHEM 361 or CHEM 466; all with a grade of "C" or better.

Theory and practice of laboratory techniques used in biochemical research.

Letter grading only (A-F). (Lecture 1 hr., laboratory 9 hrs.) Course fee may be required.

### **448. Fundamentals of Biological Chemistry (3)**

Prerequisites: CHEM 220B or CHEM 227 either with a grade of "C" or better.

Major principles of biochemistry including metabolic processes, biological control and regulatory processes, nutrition and chemical energetics and kinetics of animals, plants and microorganisms. Emphasis on major concepts and problem solving.

Not open to chemistry majors. Not open for credit to students with credit in CHEM 441A,B. Letter grade only (A-F). (Lecture 3 hrs.)

### **449. Nutritional Biochemistry Laboratory (1)**

Prerequisite: CHEM 448 with a grade of "C" or better. May be taken concurrently with CHEM 448.

Analytical and biochemical analyses of foodstuffs and other compounds of biochemical interest.

Letter grade only (A-F). (Laboratory 3 hrs.) Course fee may be required.

### **451. Instrumental Methods of Analysis (5)**

Prerequisites: PHYS 152, CHEM 361; CHEM 371B or CHEM 377B; all with a grade of "C" or better.

Theory and application of instrumental methods to chemical problems. Includes measurement basics, atomic and molecular spectroscopy, electroanalytical chemistry, separation methods, surface analysis, and statistical evaluation of analytical data.

Letter grade only (A-F). (Lecture 3 hrs., laboratory 6 hrs.) Course fee may be required.

### **461. Chemistry Capstone (1) F,S**

Prerequisite/Corequisite: Department consent.

The capstone course for chemistry and biochemistry seniors integrating knowledge and skills from different disciplines of chemistry and biochemistry. Includes discussion of regulatory affairs, ethics in research, and seminars on research topics in chemistry and biochemistry.

Letter grade only (A-F). (Seminar 1 hr)

### **466. Research Design and Methods (3) S**

Prerequisites: BIOL 211, BIOL 212, BIOL 213, either BIOL 260 or CHEM 251, CHEM 220A,B and CHEM 223A,B all with a grade of "C" or better; GE Foundation requirement; a GPA of at least 3.0 in the major; and consent of the instructor. At least one unit of BIOL 496 or CHEM 496.

Corequisites: At least one unit of BIOL 496 or CHEM 496.

Introduction to hypothesis testing, experimental design, methodological and technical procedures for experimentation, grant writing, and techniques for written and oral presentation of research results. Research paper and oral presentation required.

Letter grade only (A-F). Same course as BIOL 466. (Lecture 3 hours). Not open for credit to students with credit in BIOL 466, BIOL 466H or CHEM 466H.

### **480./580. Biomolecular Modeling and Simulation (3)**

Prerequisites: CHEM 220A, MATH 123 (may be taken concurrently), and PHYS 100B or PHYS 152, all with a grade of "C" or better.

The study of biomolecular phenomena using computer-based modeling and simulation techniques with varying degrees of resolution, including development and validity of molecular models.

Letter grade only (A-F). (Lecture 3 hrs.)

### **485. Special Topics in Materials Chemistry (3)**

Prerequisite: CHEM 220B and CHEM 331 and CHEM 385 or consent of instructor

Areas of current interest in materials chemistry with introduction to principles of materials synthesis, characterization, and application.

Letter grade only (A-F)

### **496. Undergraduate Directed Research (1-3)**

Prerequisite: Consent of instructor.

Research in a specific topic in chemistry or biochemistry approved and directed by faculty. Written report required.

May be repeated to a maximum of 6 units. (Independent Study).

### **498H. Senior Thesis – Honors (1-3)**

Prerequisites: CHEM 466; at least one unit of CHEM 496 with a grade of "A"; admission into the Honors in Chemistry program, and consent of instructor.

Planning, preparation, and completion of thesis based on a research project in chemistry or biochemistry.

Letter grade only (A-F). Not available to graduate students.

### **498. Senior Thesis (3)**

Prerequisites: Major GPA 3.0 or higher, 3 units of CHEM 496 with a grade of "A", consent of instructor.

Continuation of research in chemistry and biochemistry, planning, preparation, and completion of thesis based on original research project. Submission of acceptable thesis meeting the guidelines for research reports issued by the Committee on Professional Training American Chemical Society is required.

Letter grade only (A-F). Not available for graduate students.

### **499. Directed Reading (1)**

Survey of chemical literature on some topic of current interest under supervision of a faculty member. Preparation of a written report based on readings.

Letter grade only (A-F). Not open for credit to graduate students.

## GRADUATE LEVEL

### 521./421. Physical Organic Chemistry (3) F

Prerequisites: CHEM 220B with a grade of "C" or better.  
Prerequisite/Corequisite: CHEM 371B or CHEM 377B.  
Undergraduates enroll in CHEM 421; graduates in CHEM 521.

Theoretical interpretation of chemical and physical properties of organic compounds: mathematical derivations of rate equations from experimental results, quantitative comparison of organics compounds reactivities, mathematical correlations of structure and properties. Solving problems relating to reaction mechanisms to described factors.

Letter grade only (A-F). (Lecture 3 hrs.)

### 522. Selected Topics in Organic Chemistry (3)

Prerequisite: CHEM 421 or CHEM 521 or consent of instructor.

Areas of current interest in organic chemistry.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

### 523. Synthetic Methods (3)

Prerequisites: CHEM 220B with a grade of "C" or better; CHEM 521 recommended

Introduction to current methods of synthetic transformations; topics may include, but not limited to the following: Retrosynthetic analysis, protecting groups, functional group transformations, enolate chemistry, organometallics, stereochemistry and conformational analysis, pericyclic reactions, alkene functionalization and reactions of carbon nucleophiles.

Letter grade only (A-F). (Lecture 3 hrs.)

### 524. Catalysis in Organic Chemistry (3)

A study of catalysis beginning with a general theory of catalysis. The course also covers catalysis in synthetic organic chemistry centered on metals and ligated metals and catalysis centered on organic molecules as the catalytic species.

Letter grade only (A-F). (Lecture 3 hrs.)

### 525. Introduction to Supramolecular Chemistry (3)

Prerequisites: Proficiency in any of the following as demonstrated by ACS placement exam: Organic, Biochemistry or Inorganic

Introduction to non-covalent interactions will be presented in the context of molecular recognition and self-assembly. Synthetic and biological examples will be used to understand these principles and how they can be applied to the preparation of new materials.

Letter grade only (A-F). (Lecture 3 hrs.)

### 531. Advances in Inorganic Chemistry (3)

Prerequisite: CHEM 431 or consent of instructor.

Current topics and advances in inorganic chemistry.

May be repeated to a maximum of 6 units with different topics.  
Letter grade only (A-F). (Lecture 3 hrs.)

### 532. Inorganic Materials Chemistry (3)

Prerequisite: CHEM 431 or consent of instructor.

Advanced studies in bonding in solids, crystal structure variations, band theory and electronic structure, crystal structure-electronic structure-physical properties relationship, electron transport properties, magnetic materials, materials by design for technological applications.

Letter grade only (A-F). (Lecture 3 hrs.)

### 533. Physical Techniques in Inorganic Chemistry (3)

Prerequisite: CHEM 431 or consent of instructor.

An introduction to physical techniques commonly used in inorganic chemistry with focus on the magnetic resonance spectroscopic techniques: EPR and multinuclear NMR.

Letter grade only (A-F). (Lecture 3 hrs.)

### 534. Crystal Structure Analysis (3)

Prerequisite: CHEM 431 or consent of instructor.

An introduction to structural methods commonly used in inorganic chemistry with focus on single crystal and powder X-ray diffraction.  
Letter grade only (A-F). (Lecture 3 hrs.)

### 541. Biochemistry Core for Graduate Study (3)

Prerequisites: CHEM 441A,B

The course is divided into three topics: (i) structure and evolution of proteins and their complexes with nucleic acids, lipids and carbohydrates, including structure determination methods; (ii) metabolic regulation from mechanistic and physiological viewpoints; (iii) applications of biochemical methodologies.

Letter grade only (A-F). (Lecture 3 hrs.)

### 542. Selected Topics in Biochemistry (3)

Prerequisites: CHEM 441B and CHEM 541 all with a grade of "C" or better; or consent of instructor.

Intensive discussion of a limited aspect of biochemistry with reference to current literature. Course content will vary from year to year.

May be repeated to a maximum of 6 units with different topics in different semesters. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.) Letter grade only (A-F).

### 544. Physical Biochemistry (3)

Prerequisites: Either CHEM 371A,B or CHEM 377A,B; CHEM 441B; CHEM 541 all with the grade of "C" or better; or consent of instructor.

Physical chemical aspects of protein and nucleic acid chemistry and related analytical methods.

Letter grade only (A-F). (Lecture 3 hrs.)

### 546. Protein Structure and Function (3)

Prerequisites: Either CHEM 371B or CHEM 377B; and both CHEM 441A and CHEM 541 with the grade of "C" or better; or consent of instructor.

Principles of protein structure, folding, and function. Includes techniques used for the production, isolation and characterization of proteins.

Letter grade only (A-F). (Lecture 3 hrs.)

### 547. Biochemistry of Nucleic Acids (3)

Prerequisites: CHEM 441B, CHEM 541 with the grade of "C" or better; or consent of instructor.

Gene expression with emphasis on regulatory mechanisms. Analytical techniques for isolation, purification, and characterization of nucleic acids.

Letter grade only (A-F). (Lecture 3 hrs.)

### 548. Cell Membranes (3)

Prerequisites: BIOL 340, BIOL 370, CHEM 441A, CHEM 541 with the grade of "C" or better; or consent of instructor.

Examination of modern membrane biochemistry. May include membrane structure and transport, phospholipids sorting, vesicular transport, membrane coat protein structure and function, and membrane-dependent signal transduction.

Letter grade only (A-F). (Lecture 3 hrs.)

### 549. Biochemistry of Lipids and Lipoproteins (3)

Prerequisites: BIOL 340, CHEM 441B, CHEM 541 all with the grade of "C" or better; or consent of instructor.

Current topics on the biochemistry of lipids and lipoproteins in health and disease. Lipid absorption, synthesis and transport; Cellular uptake of lipoproteins, lipid storage and mobilization; lipid signaling; cellular lipid efflux.

Letter grade only (A-F). (Lecture 3 hrs.)

### **552. Selected Topics in Analytical Chemistry (3)**

Prerequisite: CHEM 451 or consent of instructor.

Including electrochemical measurements, chromatographic techniques, spectroscopic techniques, radiochemical analysis and basic electronic components of instrumentation. Emphasizing the chemical principles involved, utility and limitations of each method. Includes trace analysis of water and air.

Letter grade only (A-F). May be repeated to a maximum of 6 units with different topics. Topics announced in the *Schedule of Classes*. (Lecture 3 hrs.)

### **553. Fundamentals of Electroanalytical Chemistry (3)**

In-depth description of electrochemical processes and research techniques. Voltammetric, potentiometric, and impedance methods. Scanning probe techniques. Analysis of current research literature related to electroanalytical chemistry and surface science.

Letter grade only (A-F). (Lecture 3 hrs.)

### **572. Advanced Physical Chemistry (3)**

Prerequisite: CHEM 371B or consent of instructor.

Special topics in physical chemistry.

May be repeated to a maximum of 6 units with different topics.

Letter grade only (A-F). (Lecture 3 hrs.)

### **573. Molecular Spectroscopy (3)**

Prerequisite: CHEM 371B or consent of instructor.

The interaction of electromagnetic radiation with atoms and molecules. Symmetry properties of molecules and the Hamiltonian. Angular momentum and the spectra of atoms and molecules. Pure rotational, vibrational, Raman, and electronic spectra of molecules. Understanding and predicting molecular spectra.

Letter grade only (A-F). (Lecture 3 hrs.)

### **574. Kinetics and Dynamics (3)**

Prerequisite: CHEM 371A or consent of instructor.

Reaction rates for chemical systems; dependence on concentration and temperature. Derivation of the mechanisms of chemical reactions. Kinetic theory and analysis of experimental results for different systems. Dynamics of chemical reactions; transition state theory, potential-energy surfaces, and reaction pathways.

Letter grade only (A-F). (Lecture 3 hrs.)

### **580./480. Biomolecular Modeling and Simulation (3)**

Prerequisites: CHEM 220A; MATH 123 (may be taken concurrently); PHYS 100B or PHYS 152, all with a grade of "C" or better.

The study of biomolecular phenomena using computer-based modeling and simulation techniques with varying degrees of resolution, including development and validity of molecular models.

Letter grade only (A-F). (Lecture 3 hrs.)

### **581. Biological Performance of Materials (3)**

Advance studies of the chemical and mechanical interactions between materials used in medical devices and implants and living organisms. The course content includes materials response to biological system and host response to biomaterials.

Letter grade only (A-F). (Lecture 3 hrs.)

### **595A. Colloquium in Biochemistry (1)**

### **595B. Colloquium in Organic Chemistry (1)**

### **595C. Colloquium in Analytical, Physical and Inorganic Chemistry (1)**

Prerequisite: Graduate standing or consent of instructor.

Discussion of advances as reported in recent literature. Provides experience in library use, organization, presentation, and critical evaluation of the chemical literature.

May be repeated to a maximum of 3 units (not more than a total of 3 units may be earned in any combination of CHEM 595 courses). Letter grade only (A-F). (Seminar 1 hr.)

### **660. Seminar in Chemistry (1)**

Weekly meetings for presentation and discussion of advanced work in special fields including original research by faculty and graduate students.

Credit/No Credit grading only. (Seminar 1 hr.) May be repeated to a maximum of 3 units.

### **695. Directed Reading (1)**

Survey of information in chemical literature on a current research topic, under direction of a faculty member. Written report prepared from these readings.

Letter grade only (A-F).

### **697. Directed Research (1-6)**

Prerequisite: Arrangement with instructor.

Laboratory work supervised on an individual basis. A written report will be required.

Letter grade only (A-F). May be repeated to a maximum of 3 units.

### **697C. Directed Research (1-3)**

Prerequisite: Arrangement with Instructor

Continuation of laboratory work supervised on an individual basis. A written report will be required.

Credit/No Credit grading only. May be repeated to a maximum of 3 units.

### **698. Thesis (1-6)**

Prerequisites: Advancement to candidacy for M.S. in Chemistry or M.S. in Biochemistry and arrangement with instructor.

Planning, preparation and completion of a thesis in chemistry or biochemistry.

Letter grade only (A-F).