BACHELOR OF SCIENCE IN CHEMISTRY

Program Learning Outcomes

a. Demonstrate an understanding of key concepts and an ability to solve problems in the five chemistry sub-disciplines: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry and physical chemistry.
b. Perform basic chemistry laboratory procedures, including the use of modern instrumentation, for the synthesis, separation, isolation, analysis and characterization of molecules.
c. Effectively communicate the results of scientific experiments in oral reports, technical graphics and written reports.
d. Demonstrate the retention and synthesis of prior learning in advanced classes.
e. Search the chemical literature for published work relevant to a project of interest, read and understand technical literature related to the discipline.
f. Draw on classroom knowledge to contribute to solutions of problems encountered in a laboratory.
g. Articulate an understanding of the relationship between chemistry and related disciplines such as biological science, materials science and environmental science.
h. Contribute to solving problems encountered in chemistry as part of a team.
i. Understand the key experiments that led to the development of chemical theories and models.

High school preparation for the chemistry and biochemistry degree programs should include two years of algebra, one year of geometry, one-half year of trigonometry, one year of chemistry, and one year of physics. Calculus is highly recommended.

Code	Title	Units
CHEM 115	General Chemistry I	5
CHEM 233	Organic Chemistry I	3
CHEM 300	Physical Chemistry for Life Sciences I	3
CHEM 321	Quantitative Chemical Analysis	3
CHEM 351	Physical Chemistry I: Thermodynamics and Kinetics	3

Chemistry (B.S.) — 70 units minimum

- All courses used in the major program must be completed with letter grades (CR/NC not allowed) and a minimum GPA of 2.0 (SFSU Major GPA).
- Grades of C or better are required in chemistry prerequisite courses.

Lower-Division Requirements (32 units)

Code	Title	Units
CHEM 115	General Chemistry I	4
CHEM 215	General Chemistry II	4
CHEM 233 & CHEM 234	Organic Chemistry I and Organic Chemistry I Laboratory	5
CHEM 251	Mathematics and Physics for Chemistry	3
MATH 226	Calculus I	4
MATH 227	Calculus II	4
Select One:		8
PHYS 111 & PHYS 112 & PHYS 121 & PHYS 122	General Physics I and General Physics I Laboratory and General Physics II and General Physics II Laboratory	
PHYS 220 & PHYS 222 & PHYS 230 & PHYS 232	General Physics with Calculus I and General Physics with Calculus I Laboratory and General Physics with Calculus II and General Physics with Calculus II Laboratory	

Upper-Division Requirements (29 units)

Code	Title	Units
CHEM 321	Quantitative Chemical Analysis	3
CHEM 322	Quantitative Chemical Analysis Laboratory	2
CHEM 325	Inorganic Chemistry	3
CHEM 335	Organic Chemistry II	3
CHEM 336	Organic Chemistry II Laboratory	2
CHEM 340	Biochemistry I	3
CHEM 351	Physical Chemistry I: Thermodynamics and Kinetics	3
CHEM 353	Physical Chemistry II: Quantum Chemistry and Spectroscopy	3
CHEM 390GW	Contemporary Chemistry and Biochemistry Research - GWAR	3
CHEM 426	Advanced Inorganic Chemistry Laboratory [1]	2
CHEM 451	Experimental Physical Chemistry Laboratory [1]	2

Upper-Division Electives (9 units minimum)

A minimum of 9 units of electives must be selected from the following list of courses. Courses from community colleges cannot be substituted for the courses on the list below. Graduate-level courses in chemistry or appropriate courses in biology, physics, geosciences, and computer science may be substituted upon prior approval of an advisor. Students should keep in mind that non-Chemistry courses may require additional prerequisites that are not met in the Chemistry degree or permission of the instructor.

Code	Title	Units
CHEM 341	Biochemistry II	3
CHEM 343	Biochemistry I Laboratory [1]	3
CHEM 370	Computer Applications in Chemistry and Biochemistry	3
CHEM 420	Environmental Analysis	3
CHEM 422	Instrumental Analysis	4
CHEM 433	Advanced Organic Chemistry	3
CHEM 443	Biophysical Chemistry Laboratory	4
CHEM 645GW	Research Trends in Chemistry and Biochemistry - GWAR	3
CHEM 667	Optical Engineering for the Biological Sciences	3
CHEM 680	Chemical Oceanography	3
CHEM 685	Projects in the Teaching of Chemistry and Biochemistry	1
CHEM 686	Experiences in Teaching Chemistry and Biochemistry [2]	1
CHEM 699	Independent Study [3]	2-3

Select One:		3
CSC 306	An Interdisciplinary Approach to Computer Programming	
CSC 408	Machine Learning and Data Science for Personalized Medicine	
CSC 509	Data Science and Machine Learning for Medical Image Analysis	

[1] Students may substitute CHEM 343 for CHEM 426 or CHEM 451 upon prior approval of advisor. If CHEM 343 is used as a substitute, it cannot also be used as an elective.
[2] May be repeated and up to 2 units used towards Elective requirement.
[3] By petition only. Units must be taken in the same semester to be used as an upper division elective.

General Education Requirements

Requirement	Course Level	Units	Area Designation
Oral Communication	LD	3	A1
Written English Communication	LD	3	A2
Critical Thinking	LD	3	A3
Physical Science	LD	3	B1
Life Science	LD	3	B2
Lab Science	LD	1	B3
Mathematics/ Quantitative Reasoning	LD	3	B4
Arts	LD	3	C1
Humanities	LD	3	C2
Arts or Humanities	LD	3	C1 or C2
Social Sciences	LD	3	D1
Social Sciences: US History	LD	3	D2
Lifelong Learning and Self-Development (LLD)	LD	3	E
Ethnic Studies	LD	3	F
Physical and/or Life Science	UD	3	UD-B
Arts and/or Humanities	UD	3	UD-C
Social Sciences	UD	3	UD-D
SF State Studies			
Courses certified as meeting the SF State Studies requirements may be upper or lower division in General Education (GE), a major or minor, or an elective.			
American Ethnic and Racial Minorities	LD or UD	3	AERM
Environmental Sustainability	LD or UD	3	ES
Global Perspectives	LD or UD	3	GP
Social Justice	LD or UD	3	SJ

Note: LD = Lower-Division; UD = Upper-Division.

First-Time Student Roadmap (4 Year)

The roadmaps presented in this Bulletin are intended as suggested plans of study and do not replace meeting with an advisor. For a more personalized roadmap, please use the Degree Planner (https://registrar.sfsu.edu/degreeplanner/) tool found in your Student Center.

First-Time Student Roadmap (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/bs-chemistry/roadmap-i-ii-eng/)

SF State Scholars

The San Francisco State Scholars program provides undergraduate students with an accelerated pathway to a graduate degree. Students in this program pursue a bachelor's and master's degree simultaneously. This program allows students to earn graduate credit while in their junior and/or senior year, reducing the number of semesters required for completion of a master's degree.

SF State Scholars Roadmap (http://bulletin.sfsu.edu/colleges/science-engineering/chemistry-biochemistry/bs-chemistry/scholars-roadmap/)

General Advising Information for Transfer Students

a. Before transfer, complete as many lower-division requirements or electives for this major as possible.
b. The following courses are not required for admission but are required for graduation. Students are strongly encouraged to complete these units before transfer; doing so will provide more flexibility in course selection after transfer.
   - a course in U.S. History
   - a course in U.S. & California Government

For information about satisfying the requirements described in (1) and (2) above at a California Community College (CCC), please visit http://www.assist.org (http://assist.org). Check any geographically accessible CCCs; sometimes options include more than one college. Use ASSIST to determine:

- Which courses at a CCC satisfy any lower-division major requirements for this major;
- Which courses at a CCC satisfy CSU GE, US History, and US & CA Government requirements.

Remedial courses are not transferable and do not apply to the minimum 60 semester units/90 quarter units required for admission.

Additional units for courses that are repeated do not apply to the minimum 60 units required for upper-division transfer (for example, if a course was not passed on the first attempt or was taken to earn a better grade).

Before leaving the last California Community College of attendance, obtain a summary of completion of lower-division General Education units (IGETC or CSU GE Breadth). This is often referred to as a GE certification worksheet. SF State does not require delivery of this

certification to Admissions, but students should retain this document for verifying degree progress after transfer.

Credit for Advanced Placement, International Baccalaureate, or College-Level Examination Program courses: AP/IB/CLEP credit is not automatically transferred from the previous institution. Units are transferred only when an official score report is delivered to SF State. Credit is based on the academic year during which exams were taken. Refer to the University Bulletin in effect during the year of AP/IB/CLEP examination(s) for details regarding the award of credit for AP/IB/CLEP.

Students pursuing majors in science, technology, engineering, and mathematics (STEM) disciplines often defer 6-9 units of lower-division General Education in Areas C and D until after transfer to focus on preparation courses for the major. This advice does not apply to students pursuing associate degree completion before transfer.

Transferring From Institutions Other Than CCCs or CSUs

Review SF State's lower-division General Education requirements. Note that, as described below, the four basic skills courses required for admission meet A1, A2, A3, and B4 in the SF State GE pattern. Courses that fulfill the remaining areas of SF State's lower-division GE pattern are available at most two-year and four-year colleges and universities.

Of the four required basic skills courses, a course in critical thinking (A3) may not be widely offered outside the CCC and CSU systems. Students should attempt to identify and take an appropriate course no later than the term of application to the CSU. To review more information about the A3 requirement, please visit bulletin.sfsu.edu/undergraduate-education/general-education/lower-division/#AAEL.

Waiting until after transfer to take a single course at SF State that meets both US and CA/local government requirements may be an appropriate option, particularly if transferring from outside of California.