

# Chemistry and Biochemistry B.A.

## Degree Requirements

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University of Colorado, Boulder • Fall 2017 • Department of Chemistry and Biochemistry

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Web Page: [www.colorado.edu/chembio/](http://www.colorado.edu/chembio/)

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**Introduction.** There are two ways for a student to earn a **B.A.** degree through the Department of Chemistry and Biochemistry: (1) as a chemistry major, or (2) as a biochemistry major. An honors program is available to chemistry and biochemistry students and there is a program for American Chemical Society certification of graduating chemistry majors. The following information describes these degrees and special programs.

### **Advising:**

Dr. Lynn Geiger, Ekeley M299C, 303-492-8504

All students are expected to schedule regular appointments with their academic advisor. To schedule appointments go MyCUHub <http://www.colorado.edu/mycuhub/>. The frequency of appointments is dependent upon each student's individual progress and needs. Freshmen and sophomores typically meet with their academic advisor at least once each semester, whereas juniors and seniors typically need to schedule yearly appointments. Students on academic probation or other special circumstances are expected to meet with the academic advisor to formulate an academic plan for successful completion of the biochemistry or chemistry degree. **All seniors are encouraged to schedule an appointment with their assigned academic advisor one semester prior to the intended graduation semester.**

Students interested in obtaining information about or declaring a chemistry or biochemistry major or minor should sign up for a new major meeting using the MyCUHub. For administrative questions, please see Anne McWilliams in the Undergraduate Chemistry Office, Ekeley M199, (303)492-8950.

**The following courses or their equivalents are required for the degree programs.**

### **I. Chemistry Major Requirements:**

#### **Chemistry Courses**

**General Chemistry:** CHEM 1400/1401 Foundations of General Chemistry and 2100/2101 Chemical Energetics and Dynamics, or non-majors general chemistry, CHEM 1113/1114 and CHEM 1133/1134. NOTE: CHEM 2100/2101 are taken after the second semester or organic chemistry. Students who transfer to Arts & Sciences after having taken General Chemistry for Engineers, CHEN 1211 and CHEM 1221 are required to take CHEM 1133/1134 to complete their general chemistry requirement. CHEN 1211 and CHEM 1221 are equivalent to CHEM 1113/1114 only.

**Organic Chemistry:** Lecture: CHEM 3451 and CHEM 3471, or CHEM 3311 and CHEM 3331. Lab: CHEM 3361 and CHEM 3381. Organic lecture and lab must be taken together. Chemistry majors who need to take organic chemistry in the off semester or during the summer will have to take the nonmajors labs (CHEM 3321 and 3341). Chemistry majors who take the nonmajors labs normally take CHEM 3381, to complete the organic lab requirement. Possible alternatives are independent study or CHEM 4021, inorganic lab. Students who have not yet decided whether to major in chemistry or in biochemistry should take CHEM 3361 and 3381 rather than CHEM 3321 and 3341. Students who are double majors with biochemistry can also take CHEM 3491 to satisfy their second semester organic lecture requirement.

**Physical Chemistry:** Lecture: CHEM 4511 and 4531. Lab: CHEM 4581 and CHEM 4591. Physical chemistry lecture and lab are usually taken together. PHYS 1120 is a corequisite and MATH 2400 (or APPM 2350) a prerequisite for CHEM 4511. If in doubt about the selection of alternates, consult an advisor for course perspectives. CHEM 4521 cannot be used to satisfy the major's physical chemistry requirement.

**Analytical/Instrumental Chemistry:** CHEM 4171 and CHEM 4181. CHEM 3331 or 3471 or 3491, and CHEM 3341 or 3381, and PHYS 1140 or CHEM 4400 are prerequisites for CHEM 4171. CHEM 4171 is taught in the fall semester and CHEM 4181 is taught in the spring semester. CHEM 4171 is a prerequisite for CHEM 4181.

**Inorganic Chemistry:** CHEM 4011. CHEM 3331, 3471 or 3491 is a prerequisite. CHEM 4011 is taught in the fall and spring semesters.

### Ancillary Courses

**Calculus:** MATH 1300, 2300 and 2400, or APPM 1350, 1360 and 2350 (or a combination of these sequences). Students need MATH 1150, or the required math placement score to start either of these sequences.

**Physics:** PHYS 1110, 1120 and 1140. A student who has taken PHYS 2010 and 2020, courses not requiring calculus, must make up the deficiency by completing PHYS 2130. Chemistry majors should consider Calculus I (MATH 1300) as a prerequisite and Calculus II (MATH 2300) as a corequisite for PHYS 1110.

### Recommended Electives

CHEM 3151 Air - Chemistry and Pollution, CHEM 3251 - Sustainable Energy from a Chemistry Perspective, CHEM 4021 - Inorganic Synthesis Lab, CHEM 4141- Environmental Water and Soil Chemistry, CHEM 4251 - Materials Chemistry, CHEM 4261 - Organic Materials, CHEM 4271 - Chemistry of Solar Energy, CHEM 4555 – Theoretical and Computational Chemistry, CHEM 4611 - Survey of Biochemistry, CHEM 4700 - Foundations of Biochemistry, CHEM 4720 - Metabolic Pathways and Human Disease, CHEM 4740 - Biochemistry of Gene Transmission, Expression and Regulation CHEM 4901 - Independent Study, Graduate CHEM courses

**NOTE:** All students intending to enter graduate school in chemistry are advised to take additional advanced classes. Independent study (CHEM 4901) is especially recommended.

## II. Biochemistry Major Requirements:

### Chemistry courses

**General Chemistry:** CHEM 1400/1401 Foundations of General Chemistry, or non-majors general chemistry CHEM 1113/1114 and CHEM 1133/1134. Students who transfer to Arts & Sciences after having taken General Chemistry for Engineers, CHEM 1211 and CHEM 1221 are required to take CHEM 1133/1134 to complete their general chemistry requirement. CHEM 1211 and CHEM 1221 are equivalent to CHEM 1113/1114 only.

**Organic Chemistry:** Lecture: CHEM 3451 and CHEM 3491, or CHEM 3311 and CHEM 3331. Lab: CHEM 3321 and CHEM 3341, or CHEM 3361 and CHEM 3381. Organic lecture and lab must be taken together. CHEM 3361 and 3381 provide more lab hours and a better laboratory experience. Students who have not yet decided whether to major in chemistry or in biochemistry should take CHEM 3361 and 3381 rather than CHEM 3321 and 3341. Students who are double majors with chemistry can also take CHEM 3471 to satisfy their second semester organic lecture requirement.

**Physical Chemistry:** Lecture: CHEM 4400, or CHEM 4511 and CHEM 4531. PHYS 1120 is a co-requisite and MATH 2300 (or APPM 1360) is a prerequisite for CHEM 4400. PHYS 1120 is a co-requisite and MATH 2400 (or APPM 2350)

is a prerequisite for CHEM 4511. If in doubt about the selection of alternates, consult an advisor for course perspectives. CHEN 4521 cannot be used to satisfy the major's physical chemistry requirement.

**Biochemistry:** Lecture: CHEM 4700, CHEM 4720 and CHEM 4740. Lab: CHEM 4761. Survey of Biochemistry, CHEM 4611, cannot be used to satisfy this requirement. Physical Chemistry is a recommended prerequisite for CHEM 4700.

### Ancillary Courses

**Calculus:** MATH 1300 and 2300, or APPM 1350 and 1360 (or a combination of these sequences). Students need MATH 1150, or the required math placement score to start either of these sequences.

**Physics:** PHYS 1110, 1120 and 1140. A student who has taken PHYS 2010 and 2020, courses not requiring calculus, must make up the deficiency by completing calculus three or an additional advanced elective from the list below. Biochemistry majors should consider Calculus I (MATH 1300) as a prerequisite and Calculus II (MATH 2300) as a co-requisite for PHYS 1110.

**Introductory Biology (8 credit hours):** A two-semester introductory biology sequence with laboratory. This may be MCDB 1150 and MCDB 2150, or MCDB 111 and MCDB 2222, and one two credit lab from the following list: MCDB 1161 or 1171 or 2171, or EBIO 1210/1230 and 1220/1240.

### Advanced Electives

**Chosen from the following list to total 9 credit hours:** CHEM 4621 - Genome Databases, CHEM 4751 - Current Topics in Biochemical Research, CHEM 4791 - Bioorganic Chemistry in Biotechnology, CHEM 4011 - Inorganic Chemistry, CHEM 4131 - Chemistry of Global Health, CHEM 4171 - Instrumental Analysis 1, CHEM 4181 - Instrumental Analysis 2, CHEM 5341 - Chemical Biology and Drug Design, MCDB 2150 or 2222 (if not take as part of the intro biology sequence; cannot also count EBIO 2070 as a required ancillary course), MCDB 3145 - Molecular Cell Biology 2, MCDB 3150 - Biology of the Cancer Cell, MCDB 3280 - Molecular Cell Physiology, MCDB 3501 - Structural Methods for Biological Macromolecules, MCDB 3650 - The Brain - From Molecules to Behavior, MCDB 3990 - Introduction to Systems Biology for Biologists, MCDB 4300 - Immunology, MCDB 4310 - Microbial Genetics and Physiology, MCDB 4410 - Human Molecular Genetics, MCDB 4471 - Mechanism of Gene Regulation in Eukaryotes, MCDB 4520 - Bioinformatics and Genomics, MCDB 4650 - Developmental Biology, MCDB 4777 - Molecular Neurobiology, EBIO 2070 - Genetics (cannot also count MCDB 2150/2151 as a required ancillary course), EBIO 3400 - Microbiology, EBIO 4530 - Functional Plant Biology, IPHY 3430 - Human Physiology, IPHY 3470 - Human Physiology 1 (restricted to IPHY majors), IPHY 3480 - Human Physiology 2 (restricted to IPHY majors)

**Note:** All students intending to enter graduate school biochemistry are advised to take additional advanced classes. Independent study (CHEM 4901) is especially recommended.

### **III. Minimum standards:**

**Grades:** The Department of Chemistry and Biochemistry will not accept any grades below C- among the required CHEM courses. At most one D or D+ among all the required ancillary courses, i.e. in required math, physics, and biology courses, may be considered for acceptance. Students should however be warned that a C- is many times the required prerequisite for enrollment. Grades of D- or F are not acceptable under any circumstances to fulfill major or ancillary requirements. In addition, the College of Arts & Sciences requires at least 30 hours of C- or better in the major and requires an average GPA of 2.00 or higher in all classes attempted in the major department. Any student who gets below a C- in a required course is encouraged to repeat the course to learn the material better, even if the grade could be counted.

**Credit Hours:** Students who do all their major courses at CU Boulder will more than meet the College requirements for the minimum total (30 credits) and upper division (18 credits) hours in the major.

**IV. Minors in Chemistry or Biochemistry.** Biochemistry majors can earn a chemistry minor by taking calculus 3 and the physical chemistry sequence (CHEM 4511 and 4531). Chemistry majors can earn a minor in biochemistry by taking the biochemistry sequence (CHEM 4700, and CHEM 4720 or 4740), or survey of biochemistry (CHEM 4611) as electives. Further details about minor requirements in chemistry and biochemistry are given in a separate handout available from Dr. Geiger or Dr. Kelly.

**V. Special Note to Freshmen Considering Chemistry or Biochemistry as a Major.** A decision regarding whether you will be a chemistry major or biochemistry major need not be made upon entry into the University. These majors require very similar courses through organic chemistry.

**VI. Undergraduate Chemistry and Biochemistry Club.** Chemistry and Biochemistry majors are encouraged to participate in the activities of the departmental Chemistry and Biochemistry Club. The organization's goal is to foster early professional development and interaction among the departmental majors. The club sponsors special lectures, career planning sessions, research lab tours, outreach programs, and social events of interest to the undergraduate majors. Students may also become Student Affiliate members of the American Chemical Society. Interested students should sign up on the department website to receive announcement from the club.

**VII. American Chemical Society Certification.** Chemistry majors receiving the B.A. degree and completing a more intensive program than the minimum required for graduation are certified to the Society. Chemistry and Biochemistry double majors automatically earn an ACS certified degree. Certified graduates are eligible to become regular members of the ACS after graduation; other chemistry graduates may become associate members after graduation and regular members after three years of professional experience in chemistry.

For certification a student majoring in chemistry only must complete, in addition to the requirements for the chemistry major, the following: CHEM 4021, one semester of biochemistry (either CHEM 4611, or CHEM 4700 plus one additional advanced course. Students majoring in both Chemistry and Biochemistry are not required to complete any additional coursework past the requirements for these majors to earn certification.

The advanced course must be a 4000 or 5000 level course in chemistry or related fields: molecular biology, chemical engineering, computer science, geochemistry, mathematics, or physics. Independent Study (CHEM 4901) will count as an advanced course for this purpose if (a) it is preceded by at least one semester of physical chemistry, and (b) if the student prepares a well-written summary describing his or her work. The student should submit a copy of the summary to their undergraduate advisor (Dr. Geiger or Dr. Kelly).

The formality of ACS certification is of most value to students intending to find jobs in chemical industry. This certification has less significance for students entering graduate studies in chemistry and the biological, biochemical, or health science fields. To meet the certification criteria, the ACS requires a more thorough background in undergraduate chemistry than that provided by the minimum requirements for the B.A. Chemistry degree at CU. Students should recognize that a thorough preparation in chemistry is of value to all students, whatever their future plans. Students at CU Boulder, have many options for advanced study beyond the minimum requirements.

**VIII. Chemistry and Biochemistry Honors Program.** Departmental Honors in chemistry or biochemistry (graduation *cum laude*, *magna cum laude*, *summa cum laude*) are awarded to qualified majors, in recognition of scholarly achievement. Interested students should contact Anne McWilliams (Ekeley M199, 492-8950) for referral to the departmental honors advisor, preferably prior to the senior year. To be eligible, a student must:

1. be chemistry or biochemistry major with a cumulative grade point average of at least 3.3, or obtain permission from the departmental honors advisor.
2. Complete advanced work, including a research project in chemistry or biochemistry. Taking 6 (or more) credit hours of independent study (CHEM 4901) normally satisfies this requirement, see a departmental honors advisor for a discussion of other options.

3. Submit a written report based on research completed and make a formal presentation based on this research to a committee of three faculty members during the final semester of undergraduate study. The committee normally includes the student's research advisor, the departmental honors advisor, and one faculty member from outside the department.

Chemistry/Biochemistry students may be interested in **General Honors**, which may be pursued in addition to or instead of **Departmental Honors**. For more information, students should contact the departmental honors advisor or the Honors Department.

**IX. Study Abroad.** Students in Chemistry and Biochemistry can take advantage of various opportunities to study abroad for one or two semesters during their college careers. Many students who have done this consider it one of the great experiences of their lives. Science is international, and it may be studied effectively in many places in the world. Many companies that employ chemists and biochemists are also international, and it may be an employment advantage to have international experience, especially combined with skills in other languages.

It is possible to study abroad by individual arrangements or in formal study-abroad programs conducted by CU. If you are interested in studying abroad, you should speak with Dr. Geiger or Dr. Kelly and also with a Study Abroad advisor. It is best if this is done about a year before you would like to start your year abroad. Students interested in studying abroad should note that it is not usually possible to complete chemistry or biochemistry major requirements while on study abroad.

**X. Arts & Sciences College Requirements.** To graduate, students must satisfy general requirements of the College of Arts & Sciences. These regulations are subject to change, and students have the option of choosing either the rules in force when they entered the College or current rules. All students are encouraged to consult their degree audit for information about their progress towards completion of degree requirements.

**XI. Teaching Certification.** Chemistry or biochemistry majors can also earn certification as teachers through the School of Education. The program for a secondary school science-teaching certificate is challenging requiring a broad, strong background in science, as well as course work in education and practice teaching. It usually requires at least five years of study. Students interested in secondary school teaching certification should contact the School of Education.

## **XII. AP, IB and Transfer Coursework**

1. **AP, ADVANCED PLACEMENT IN CHEMISTRY.** The following will be allowed for advanced placement in chemistry. Score of 5: credit for general chemistry 1 with lab (CHEM 1113 and 1114); students may register for general chemistry 2 (CHEM 1133/1134). It is strongly recommended that students consult a departmental advisor before registering for a second semester general chemistry course.

2. **IB, INTERNATIONAL BACCALAUREATE IN CHEMISTRY.** The following will be allowed for IB-higher in chemistry. Score of 7: credit for general chemistry 1 and 2; students may register for organic chemistry 1 lecture and lab. Score of 6: credit for general chemistry 1; students may register for general chemistry 2. It is strongly recommended that students consult a departmental advisor before registering for an organic chemistry or second semester general chemistry course.

3. Students may **transfer** courses in chemistry that are equivalent to courses given at CU Boulder but carry fewer credit hours. They must take sufficient courses in chemistry so that the total credits for graduation is at least 30. An advisor should be consulted regarding this type of deficiency.

4. **Transfer students** should note that the College of Arts & Sciences requires at least 18 hours of upper-division credits in the major. Lower division courses at other institutions will transfer as lower division credit, even if the corresponding CU Boulder courses are upper division. For example, organic chemistry taken at a community college or as lower division at a four-year college will only carry lower division credit if it is accepted by the

department to satisfy CHEM 3311, 3321, 3331, and 3341. A chemistry or biochemistry major with such transfer credit may need to take additional upper division chemistry courses to complete the required 18 hours in the major and 45 upper division hours.

5. **Transfer students** who plan to complete a B.A. degree in the Chemistry and Biochemistry Department must complete at the Boulder campus a minimum of 12 credit hours of upper-division courses in chemistry covering at least two (2) of the sub-disciplines in their major. The sub-disciplines for a chemistry major are organic, physical, inorganic, and analytical/instrumental. The sub-disciplines for a biochemistry major are organic, physical, and biochemistry. Course work to satisfy this minimum requirement may **NOT** include CHEM 4901 and must be completed after matriculation into the College of Arts and Sciences.

### **XIII. Course Schedule:** Suggestions for Undergraduate Majors in Chemistry or Biochemistry.

Undergraduate majors in the Chemistry and Biochemistry Department must plan their courses carefully since there are specific prerequisites for advanced courses that must be completed in an orderly sequence during the freshman through the junior years. In addition, the College of Arts & Science Core curriculum must be worked into the schedule. Suggestions for majors include:

1. Math should be started the first year and continued without a break.
2. Math courses can be a serious hurdle for many chemistry and biochemistry majors. It is much better to start Pre-Calculus Math 1150, doing a fair bit of review work, and earn A's or B's than to try Calculus I, (MATH 1300 or APPM 1350) and receive a D or F. Even students who have some calculus in high school may have difficulty with MATH 1300 if their algebra, geometry, and trig backgrounds are weak. When chemistry or biochemistry students fail to achieve good grades their first year at CU Boulder, it is most commonly due to a weak math background.
3. Chemistry should be taken the first year, and should take precedence over general biology if biology is also required in the student's course work.
4. Students are very strongly advised against taking General Physics 1 until they have completed Calculus 1, and preferably both Calculus 1 and Calculus 2.
5. Most first year students should take no more than 16 hours per semester and preferably less. Students who are working may want to consider taking even fewer hours per semester. Taking 16 hrs/sem while working more than 20 hrs/week is likely to hurt academic performance.
6. Quality is better than quantity. Thus, undergraduates who complete a degree with a grade point average greater than 3.4 will have many job and graduate school opportunities even though they may have taken only 12-14 hours each semester. Whereas students who take 18-22 hours each semester, with a GPA less than 3.0, will find few or no graduate school openings. Students, who must work outside of school, should consider taking a lighter course load.
7. University study requires an intensive effort on a student's part for at least nine months a year. Students should therefore use their summers wisely. Summer may be a good time to catch up on coursework or credits; many required and elective courses are taught during summer school. On the other hand, many students find it advantageous to have a change of pace during the summer, and many need to earn some money. A chemistry-related job can be a great experience. Some large and small chemical or health-related companies hire undergraduates during summers. Career Services can be helpful in locating a suitable position. Some schools around the country have undergraduate research participation programs open to outside students. CU Boulder offers the Undergraduate Research Opportunity Program (UROP) and the Biosciences Undergraduate Research Skills and Training (BURST) program to a limited number of students.

8. When planning curriculum, students should choose the best goal and pursue it aggressively, **even though** it may not be what is eventually pursued. When a better goal is found, change, and enthusiastically pursue the new goal. **Do not do a halfway job** of pursuing a goal because it may not be the correct one in the long run. Students should **always** keep their minds open for new/better goals and courses.

9. Inorganic Chemistry (CHEM 4011), Instrumental Analysis 1 (CHEM 4171) and Instrumental Analysis 2 (CHEM 4181) are required courses for chemistry majors. They are each taught **only once a year**. CHEM 4011 and 4171 are taught in the fall and CHEM 4181 is taught in the spring semester. The major's organic chemistry courses (CHEM 3451, 3471, 3491, 3361, 3381) are also only taught once a year. Plan ahead for these courses. The elective course CHEM 4021 (Inorganic Synthesis Lab) is also taught only in the spring semester. Most graduate courses are taught once a year, with a few taught every other year.

10. Students taking biology should realize that EBIO 1210/1230 is taught only in the fall semester, and the second-semester biology course, EBIO 1220/1240, is taught only in the spring. The EBIO sequence is also taught during the summer. The MCDB sequence is not taught in the summer.