

# CHEMISTRY AND BIOCHEMISTRY

Office: F. W. Olin Hall, Room 202

Mail Code: 2190 E. Iliff Ave. Denver, CO 80208

Phone: 303-871-2435

Email: cheminfo@du.edu

Web Site: <https://science.du.edu/chemistry> (<https://science.du.edu/chemistry/>)

The Department of Chemistry and Biochemistry offers a program of study that combines a traditional classroom emphasis with an innovative laboratory experience. In addition to providing excellent training for graduate study in chemistry and biochemistry, the program also is a strong pre-professional degree. A degree in chemistry, biochemistry or environmental chemistry prepares students for a variety of careers in chemical and biochemical research, medicine, life sciences, environmental science, atmospheric sciences, materials science, oceanography and teaching in chemistry or science in general. It also prepares students for employment with chemical, pharmaceutical, biotechnology, medical products, natural resources and environmental companies.

Because most medical and dental schools require a minimum of two years of chemistry for admission, a major in chemistry or biochemistry provides an excellent background for premed or pre-dental majors. Students who complete the bachelor of science in chemistry curriculum are certified by the American Chemical Society.

## Chemistry

### Bachelor of Arts Major Requirements

(183 credits required for the degree (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofarts/>))

Minimum of 40 credits of chemistry. Requirements include the following:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2270	Quantitative Chemical Analysis	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 2453 & CHEM 2463	Organic Chemistry III and Organic Chemistry Lab III	4
CHEM 3610	Physical Chemistry I	3
CHEM 3210	Instrumental Analysis (or CHEM 3820 Biochemistry Lab)	4
CHEM at 3000 level or higher <sup>1</sup>		5
<b>Total Credits</b>		<b>40</b>

<sup>1</sup> A maximum of three credits of CHEM 3995 Independent Research can count toward the credits for electives.

### Additional Requirements

Code	Title	Credits
<b>Calculus</b>		
MATH 1951	Calculus I	4
MATH 1952 or MATH 1962	Calculus II Honors Calculus II	4
MATH 1953 or MATH 1963	Calculus III Honors Calculus III	4
<b>Physics</b>		
One year, preferably:		
PHYS 1211	University Physics I	5

PHYS 1212	University Physics II	5
PHYS 1213	University Physics III	5
<b>Total Credits</b>		<b>27</b>

### Bachelor of Arts Minor Requirements

20 credits of chemistry. Requirements include:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
<b>Total Credits</b>		<b>20</b>

### Bachelor of Science Major Requirements

(183 credits required for the degree (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscience/>))

Minimum of 47 credits in chemistry. Requirements include the following:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2270	Quantitative Chemical Analysis	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 2453 & CHEM 2463	Organic Chemistry III and Organic Chemistry Lab III	4
CHEM 3210	Instrumental Analysis	4
CHEM 3610	Physical Chemistry I	3
CHEM 3620	Physical Chemistry II	3
CHEM 3621	Physical Chemistry III	3
CHEM 3500	Chemistry Frontiers	3
CHEM at the 3000 level or higher		3
<b>Total Credits</b>		<b>47</b>

### Additional Requirements

Code	Title	Credits
Calculus		
MATH 1951	Calculus I	4
MATH 1952 or MATH 1962	Calculus II Honors Calculus II	4

MATH 1953 or MATH 1963	Calculus III Honors Calculus III	4
Physics		
One year, preferably:		
PHYS 1211	University Physics I	5
PHYS 1212	University Physics II	5
PHYS 1213	University Physics III	5
<b>Total Credits</b>		<b>27</b>

### Bachelor of Science Minor Requirements

20 credits of chemistry. Requirements include:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
<b>Total Credits</b>		<b>20</b>

### Bachelor of Science in Chemistry Major Requirements

(183 credits required for the degree (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscienceinchemistry/>))

Minimum of 62 credits in chemistry. Requirements include the following:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2270	Quantitative Chemical Analysis	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 2453 & CHEM 2463	Organic Chemistry III and Organic Chemistry Lab III	4
CHEM 3210	Instrumental Analysis	4
CHEM 3610	Physical Chemistry I	3
CHEM 3620	Physical Chemistry II	3
CHEM 3621	Physical Chemistry III	3
CHEM 3811	Biochemistry-Proteins	3
CHEM 3820	Biochemistry Lab	3
CHEM 3500	Chemistry Frontiers	3

CHEM 3995	Independent Research <sup>1</sup>	6
CHEM at the 3000 level		6
<b>Total Credits</b>		<b>62</b>

<sup>1</sup> Thesis required

### Additional Requirements

Code	Title	Credits
<b>Mathematics</b>		
MATH 1951	Calculus I	4
MATH 1952 or MATH 1962	Calculus II Honors Calculus II	4
MATH 1953 or MATH 1963	Calculus III Honors Calculus III	4
Math or Computer Science Electives		8
<b>Physics</b>		
One year, preferably:		
PHYS 1211	University Physics I	5
PHYS 1212	University Physics II	5
PHYS 1213	University Physics III	5
<b>Total Credits</b>		<b>35</b>

## Biochemistry

### Bachelor of Science Major Requirements

(183 credits required for the degree (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscience/>))

Minimum of 47 credits in chemistry. Requirements include the following:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2270	Quantitative Chemical Analysis	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 2453 & CHEM 2463	Organic Chemistry III and Organic Chemistry Lab III	4
CHEM 3210	Instrumental Analysis	4
CHEM 3610	Physical Chemistry I	3
CHEM 3811	Biochemistry-Proteins	3
CHEM 3812	Biochemistry-Membranes/Metabolism	3
CHEM 3813	Biochemistry-Nucleic Acids	3
CHEM 3820	Biochemistry Lab	3
<b>Total Credits</b>		<b>47</b>

### Additional Requirements

Code	Title	Credits
<b>Biology <sup>2</sup></b>		
BIOL 1010 & BIOL 1020	Physiological Systems and Physiological Systems Lab	5

BIOL 1011 & BIOL 1021	Evolution, Heredity and Biodiversity and Evolution, Heredity and Biodiversity Lab	5
BIOL 2120 & BIOL 2121	Cell Structure and Function and Cell Structure & Function Lab	5
BIOL 2510 & BIOL 2511	General Genetics and General Genetics Lab	5
Chemistry 3xxx OR Biology 2xxx/3xxx		3-4
<b>Mathematics</b>		
MATH 1951	Calculus I	4
MATH 1952 or MATH 1962	Calculus II Honors Calculus II	4
MATH 1953 or MATH 1963	Calculus III Honors Calculus III	4
<b>Physics</b>		
One year, preferably:		
PHYS 1211	University Physics I	5
PHYS 1212	University Physics II	5
PHYS 1213	University Physics III	5
<b>Total Credits</b>		<b>50-51</b>

<sup>2</sup> These courses satisfy a minor in biological sciences, provided the minor is declared by the student.

## Bachelor of Science in Chemistry with Biochemistry Concentration Requirements

(183 credits required for the degree (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscienceinchemistry/>))

Minimum of 62 credits in chemistry. Requirements include the following:

Code	Title	Credits
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141	Chemistry of the Elements and Chemistry of the Elements Lab	4
CHEM 2270	Quantitative Chemical Analysis	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 2453 & CHEM 2463	Organic Chemistry III and Organic Chemistry Lab III	4
CHEM 3210	Instrumental Analysis	4
CHEM 3610	Physical Chemistry I	3
CHEM 3620	Physical Chemistry II	3
CHEM 3621	Physical Chemistry III	3
CHEM 3811	Biochemistry-Proteins	3
CHEM 3812	Biochemistry-Membranes/Metabolism	3
CHEM 3820	Biochemistry Lab	3
CHEM 3813	Biochemistry-Nucleic Acids	3
CHEM 3500	Chemistry Frontiers	3
CHEM 3995	Independent Research <sup>1</sup>	6
<b>Total Credits</b>		<b>62</b>

<sup>1</sup> Thesis required

### Additional Requirements

Code	Title	Credits
<b>Biology</b>		
BIOL 1010 & BIOL 1020	Physiological Systems and Physiological Systems Lab	5
BIOL 1011 & BIOL 1021	Evolution, Heredity and Biodiversity and Evolution, Heredity and Biodiversity Lab	5
BIOL 2120 & BIOL 2121	Cell Structure and Function and Cell Structure & Function Lab	5
Biology Elective		5
<b>Calculus</b>		
MATH 1951	Calculus I	4
MATH 1952 or MATH 1962	Calculus II Honors Calculus II	4
MATH 1953 or MATH 1963	Calculus III Honors Calculus III	4
Math or Computer Science Electives		8
<b>Physics</b>		
One year, preferably:		
PHYS 1211	University Physics I	5
PHYS 1212	University Physics II	5
PHYS 1213	University Physics III	5
<b>Total Credits</b>		<b>55</b>

## Environmental Chemistry

### Bachelor of Science Major Requirements

(183 credits required for the degree (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscience/>))

Minimum of 47 credits in chemistry. Requirements include the following:

Code	Title	Credits
<b>Required CHEM coursework</b>		
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2131 & CHEM 2141 or CHEM 2240	Chemistry of the Elements and Chemistry of the Elements Lab Introduction to Environmental Chemistry	4
CHEM 2270	Quantitative Chemical Analysis	4
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	4
CHEM 2452 & CHEM 2462	Organic Chemistry II and Organic Chemistry Lab II	4
CHEM 2453 & CHEM 2463	Organic Chemistry III and Organic Chemistry Lab III	4
CHEM 3210	Instrumental Analysis	4
CHEM 3610	Physical Chemistry I	3
CHEM 3500	Chemistry Frontiers	3
<b>Choose 3 courses from the following 4 options:</b>		<b>9</b>
CHEM 3410	Atmospheric Chemistry	
CHEM 3411	Aquatic Chemistry	

CHEM 3412	Environmental Chemistry & Toxicology	
CHEM 3413	Aerosol Science	
<b>Total Credits</b>		<b>47</b>

**Additional Requirements <sup>1</sup>**

Code	Title	Credits
<b>Calculus</b>		
MATH 1951	Calculus I	4
MATH 1952	Calculus II	4
or MATH 1962	Honors Calculus II	
MATH 1953	Calculus III	4
or MATH 1963	Honors Calculus III	
<b>Physics</b>		
One year, preferably:		
PHYS 1211	University Physics I	5
PHYS 1212	University Physics II	5
PHYS 1213	University Physics III	5
<b>Total Credits</b>		<b>27</b>

<sup>1</sup> Of the two minors required for this BS degree, one must be in biology, environmental science, GIS or sustainability.

**Environmental Chemistry Minor Requirements**

21-22 credits of chemistry. May not be paired with any B.S. or B.A. majors offered through the Department of Chemistry and Biochemistry or with the Chemistry minor. Requirements include:

Code	Title	Credits
<b>One year of Chemistry with lab is required.</b>		
CHEM 1010 & CHEM 1240	General Chemistry I and General Chemistry I Laboratory	4
CHEM 1020 & CHEM 1250	General Chemistry II and General Chemistry II Laboratory	4
CHEM 2240 or CHEM 2131	Introduction to Environmental Chemistry Chemistry of the Elements	4
<b>Choose 3 courses from the following list.</b>		<b>9-10</b>
A minimum of two courses must chosen be from these three options:		
CHEM 3410	Atmospheric Chemistry	
CHEM 3411	Aquatic Chemistry	
CHEM 3413	Aerosol Science	
A maximum of one additional course with lab from the following list may be chosen.		
CHEM 2270	Quantitative Chemical Analysis	
CHEM 2451 & CHEM 2461	Organic Chemistry I and Organic Chemistry Lab I	
<b>Total Credits</b>		<b>21</b>

**Requirements for Distinction in the Major for the Bachelor of Arts or Bachelor of Science Degrees**

- Minimum 3.0 cumulative GPA
- Minimum 3.5 major GPA
- CHEM 3500 (Frontiers) or CHEM 3820 (Biochemistry Lab)
- Six credits of research
- Completion of a thesis
- Presentation of poster at Undergraduate Research Symposium

The recommended order of courses is listed below for each degree. Please consult your advisor each quarter.

## Chemistry

### Bachelor of Arts (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofarts/>)

Chemistry credit: 40; calculus credit: 12; physics credit: 15

First Year					
Fall	Credits	Winter	Credits	Spring	Credits
FSEM 1111		4 WRIT 1122		4 WRIT 1133	4
CHEM 1010	3	CHEM 1020		3 CHEM 2131	3
CHEM 1240	1	CHEM 1250		1 CHEM 2141	1
MATH 1951 <sup>1</sup>	4	MATH 1952 or 1962		4 MATH 1953 or 1963	4
Electives		4 Electives		4 Electives	4
		<b>16</b>		<b>16</b>	<b>16</b>
Second Year					
Fall	Credits	Winter	Credits	Spring	Credits
CHEM 2451	3	CHEM 2452		3 CHEM 2453	3
CHEM 2461	1	CHEM 2462		1 CHEM 2463	1
Physics and Lab <sup>1</sup>	5	Physics and Lab		5 Physics and Lab	5
Electives		6 Electives		6 Electives	6
		<b>15</b>		<b>15</b>	<b>15</b>
Third Year					
Fall	Credits	Winter	Credits	Spring	Credits
CHEM 3610		3 CHEM Elective <sup>2</sup>		3 CHEM 2270	4
Electives	12	Electives		12 Electives	12
		<b>15</b>		<b>15</b>	<b>16</b>
Fourth Year					
Fall	Credits	Winter	Credits	Spring	Credits
CHEM Elective <sup>2</sup>		3 CHEM 3820 <sup>3</sup>		3 CHEM 3210 <sup>3</sup>	4
Electives	12	Electives		12 Electives	10
		<b>15</b>		<b>15</b>	<b>14</b>
<b>Total Credits: 183</b>					

<sup>1</sup> One year of calculus is required. One year of University Physics (recommended) or General Physics is required. Physics is a prerequisite for Physical Chemistry. The third quarter of physics may be taken at the same time as Physical Chemistry I. Students are encouraged to take Physical Chemistry II and III.

<sup>2</sup> 3000-level CHEM course.

<sup>3</sup> Either CHEM 3820 (CHEM 3811 is a prerequisite) in winter or CHEM 3210 in spring of 4th year.

### Bachelor of Science (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscience/>)

Chemistry credit: 47; calculus credit 12; physics credit: 15

First Year					
Fall	Credits	Winter	Credits	Spring	Credits
FSEM 1111		4 WRIT 1122		4 WRIT 1133	4
CHEM 1010	3	CHEM 1020		3 CHEM 2131	3
CHEM 1240	1	CHEM 1250		1 CHEM 2141	1
MATH 1951 <sup>1</sup>	4	MATH 1952 or 1962		4 MATH 1953 or 1963	4
Electives		4 Electives		4 Electives	4
		<b>16</b>		<b>16</b>	<b>16</b>
Second Year					
Fall	Credits	Winter	Credits	Spring	Credits
CHEM 2451	3	CHEM 2452		3 CHEM 2270	4
CHEM 2461	1	CHEM 2462		1 CHEM 2453	3

Electives	12	Physics and lab <sup>1</sup>	5	CHEM 2463	1
		Electives	6	Physics and lab	5
				Electives	3
	<b>16</b>		<b>15</b>		<b>16</b>
<b>Third Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 3610	3	CHEM 3620	3	CHEM 3210	4
Physics and lab	5	Electives	12	CHEM 3621	3
Electives	6		Electives		9
	<b>14</b>		<b>15</b>		<b>16</b>
<b>Fourth Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM Elective <sup>2</sup>	3	CHEM 3500	3	Electives	13
Electives	12	Electives	12		
	<b>15</b>		<b>15</b>		<b>13</b>
<b>Total Credits: 183</b>					

<sup>1</sup> One year of calculus is required. One year of University Physics (recommended) or General Physics is required. Physics is a prerequisite for Physical Chemistry. The third quarter of physics may be taken at the same time as Physical Chemistry I.

<sup>2</sup> 3000-level CHEM course.

## Bachelor of Science in Chemistry (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscienceinchemistry/>)

Chemistry credit: 62; math and computer science credit: 20; physics credit: 15

<b>First Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
FSEM 1111	4	WRIT 1122	4	WRIT 1133	4
CHEM 1010	3	CHEM 1020	3	CHEM 2131	3
CHEM 1240	1	CHEM 1250	1	CHEM 2141	1
MATH 1951 <sup>1</sup>	4	MATH 1952 or 1962	4	MATH 1953 or 1963	4
Electives	4	Electives	4	Electives	4
	<b>16</b>		<b>16</b>		<b>16</b>
<b>Second Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 2451	3	CHEM 2452	3	CHEM 2270	4
CHEM 2461	1	CHEM 2462	1	CHEM 2453	3
Math or computer science	4	Physics and lab	5	CHEM 2463	1
Electives	6	Math or computer science	4	Physics and Lab	5
		Electives	3	Math or Computer Science	3
	<b>14</b>		<b>16</b>		<b>16</b>
<b>Third Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 3610	3	CHEM 3620	3	CHEM 3621	3
CHEM 3811	3	CHEM 3820	3	CHEM 3210	4
Physics and lab	5	Electives	9	Electives	9
Electives	5				
	<b>16</b>		<b>15</b>		<b>16</b>
<b>Fourth Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 3995	2	CHEM 3500	3	CHEM 3995	2
CHEM Elective <sup>2</sup>	3	CHEM 3995	2	Electives	
Electives	9	Electives		CHEM Elective	3
		Electives	10	Electives	9
	<b>14</b>		<b>15</b>		<b>14</b>
<b>Total Credits: 183</b>					

<sup>1</sup> 20 credits of math and computer science is required, including one year of calculus. One year of University Physics (recommended) or General Physics is required. Physics is a prerequisite for Physical Chemistry. The third quarter of physics may be taken at the same time as Physical Chemistry I.

<sup>2</sup> Minimum of six credits of CHEM 3995 with written thesis.

## Biochemistry

### Bachelor of Science (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscience/>)

Chemistry credit: 47-50; biological sciences credit: 20-24; calculus credit: 12; physics credit: 15

First Year					
Fall	Credits	Winter	Credits	Spring	Credits
FSEM 1111		4 WRIT 1122		4 WRIT 1133	4
CHEM 1010	3	CHEM 1020	3	CHEM 2131	3
CHEM 1240	1	CHEM 1250	1	CHEM 2141	1
MATH 1951 <sup>1</sup>	4	BIOL 1011	4	BIOL 1010	4
Electives	3	BIOL 1021	1	BIOL 1020	1
		MATH 1952 or 1962	4	MATH 1953 or 1963	4
	15		17		17
Second Year					
Fall	Credits	Winter	Credits	Spring	Credits
CHEM 2451	3	CHEM 2452	3	CHEM 2270	4
CHEM 2461	1	CHEM 2462	1	CHEM 2453	3
BIOL 2120	4	BIOL 2510 & BIOL 2511	5	CHEM 2463	1
BIOL 2121	1	Physics and lab	5	Physics and lab	5
Physics and lab <sup>1</sup>	5			Electives	3
	14		14		16
Third Year					
Fall	Credits	Winter	Credits	Spring	Credits
CHEM 3811	3	CHEM 3812	3	CHEM 3813	3
CHEM 3610	3	CHEM 3820	3	CHEM 3210	4
Electives	9	Electives	9	Chemistry OR Biology elective <sup>2</sup>	3-4
				Electives	6
	15		15		16-17
Fourth Year					
Fall	Credits	Winter	Credits	Spring	Credits
Electives	15	Electives	15	Electives	12
	15		15		12
<b>Total Credits: 183</b>					

<sup>1</sup> One year of calculus is required. One year of University Physics (recommended) or General Physics is required. Physics is a prerequisite for Physical Chemistry. The third quarter of physics may be taken at the same time as Physical Chemistry I. Students are encouraged to take Physical Chemistry II and III. Biochemistry majors are encouraged to take research even if this brings their total chemistry credits over 47.

<sup>2</sup> Chemistry 3xxx OR Biology 2xxx/3xxx (3-4 credits). Elective may be completed at any time.

### Bachelor of Science in Chemistry with Biochemistry Concentration (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscienceinchemistry/>)

Chemistry credit: 62; biological sciences credit: 20; math and computer science credit: 20; physics credit: 15

First Year					
Fall	Credits	Winter	Credits	Spring	Credits
FSEM 1111		4 WRIT 1122		4 WRIT 1133	4
CHEM 1010	3	CHEM 1020	3	CHEM 2131	3
CHEM 1240	1	CHEM 1250	1	CHEM 2141	1

MATH 1951 <sup>1</sup>	4	BIOL 1021	1	BIOL 1010	4
Electives	3	BIOL 1011	4	BIOL 1020	1
		MATH 1952 or 1962	4	MATH 1953 or 1963	4
	<b>15</b>		<b>17</b>		<b>17</b>
<b>Second Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 2451	3	CHEM 2452	3	CHEM 2270	4
CHEM 2461	1	CHEM 2462	1	CHEM 2453	3
Math or computer science	4	Physics and lab <sup>1</sup>	5	CHEM 2463	1
BIOL 2120	4	Biology elective <sup>2</sup>	5	Physics and lab	5
BIOL 2121	1			Math or computer science	4
Electives	3				
	<b>16</b>		<b>14</b>		<b>17</b>
<b>Third Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 3610	3	CHEM 3620	3	CHEM 3621	3
CHEM 3811	3	CHEM 3820	3	CHEM 3813	3
Physics and Lab	5	CHEM 3812	3	CHEM 3210	4
Electives	3	Electives	6	Electives	6
	<b>14</b>		<b>15</b>		<b>16</b>
<b>Fourth Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 3995	2	CHEM 3500	3	CHEM 3995	2
Electives	12	CHEM 3995	2	Electives	12
		Electives	9		
	<b>14</b>		<b>14</b>		<b>14</b>

Total Credits: 183

<sup>1</sup> 20 credits of math or computer science is required, including one year of calculus. One year of University Physics (recommended) or General Physics is required. Physics is a prerequisite for Physical Chemistry. The third quarter of physics may be taken at the same time as Physical Chemistry I.

<sup>2</sup> Take a 2000- or 3000-level biology course.

<sup>3</sup> Minimum of six credits of CHEM 3995 with written thesis.

## Environmental Chemistry

### Bachelor of Science (<http://bulletin.du.edu/undergraduate/undergraduateprograms/traditionalbachelorsprogram/bachelorofscience/>)

Chemistry credit: 47; calculus credit: 12; physics credit: 15; one minor must be in biology, environmental science, GIS, or sustainability.

<b>First Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
FSEM 1111	4	WRIT 1122	4	WRIT 1133	4
CHEM 1010	3	CHEM 1020	3	MATH 1953 or 1963	4
CHEM 1240	1	CHEM 1250	1	CHEM 2240	4
MATH 1951 <sup>1</sup>	4	MATH 1952 or 1962	4	Electives	3
Electives	3	Electives	3		
	<b>15</b>		<b>15</b>		<b>15</b>
<b>Second Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 2451	3	CHEM 2452	3	CHEM 2270	4
CHEM 2461	1	CHEM 2462	1	CHEM 2453	3
Physics and lab <sup>1</sup>	5	Physics and lab	5	CHEM 2463	1
Electives	7	Electives	6	Physics and lab	5
				Electives	3
	<b>16</b>		<b>15</b>		<b>16</b>
<b>Third Year</b>					
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>	<b>Spring</b>	<b>Credits</b>
CHEM 3610	3	CHEM 3412	3	CHEM 3210	4

CHEM 3410	3 Electives	12 CHEM 3411	3
Physics and Lab	5	Electives	8
Electives	3		
	14	15	15
<b>Fourth Year</b>			
<b>Fall</b>	<b>Credits</b>	<b>Winter</b>	<b>Credits</b>
Electives	16	CHEM 3500	3
		Electives	12
	16	15	16

Total Credits: 183

<sup>1</sup> One year of calculus is required. One year of University Physics (recommended) or General Physics is required. Physics is a prerequisite for Physical Chemistry. The third quarter of physics may be taken at the same time as Physical Chemistry I. Students are encouraged to take Physical Chemistry II and III.

#### **CHEM 1001 Science of Contemporary Issues I (4 Credits)**

CHEM 1001 is the first class in a three-quarter sequence focused on real-world applications of chemistry. The first quarter focuses on sustainability, pollution, and climate change. To understand these topics, we will explore the behavior of gases, properties of solutions, chemical reactions in the atmosphere, and acid-base chemistry. This course cannot be taken for credit for a chemistry major or minor. A lab fee is associated with this course. The course counts toward the Scientific Inquiry: The Natural and Physical World requirement.

#### **CHEM 1002 Science of Contemporary Issues II (4 Credits)**

CHEM 1002 is the second class in a three-quarter sequence focused on real-world applications of chemistry. This course focuses on fossil fuels, renewable resources, nuclear energy, batteries, and fuel cells. To understand these topics, we will examine combustion reactions, radioactive elements, nuclear waste, and electrochemistry. This course cannot be taken for credit for a chemistry major or minor. A lab fee is associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Prerequisite: CHEM 1001.

#### **CHEM 1003 Science of Contemporary Issues III (4 Credits)**

CHEM 1003 is the final class in a three-quarter sequence focused on real-world applications of chemistry. This course focuses on plastics, nutrition, drugs, and genetic engineering. To understand these topics, we will learn about polymerization, macromolecules, and the chemistry behind foods such as fats, proteins, and carbohydrates. This course cannot be taken for credit for a chemistry major or minor. A lab fee is associated with this course. The course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Prerequisite: CHEM 1002.

#### **CHEM 1010 General Chemistry I (3 Credits)**

The first course in the introductory chemistry sequence for natural science and engineering majors. Topics covered include atomic and molecular structure, reactions in solution, and thermochemistry. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Co-requisite: CHEM 1240.

#### **CHEM 1020 General Chemistry II (3 Credits)**

The second course in the introductory chemistry sequence for science and engineering majors. Topics covered include thermodynamics, equilibria including acids and bases, and kinetics. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Pre-requisites: CHEM 1010 and CHEM 1240; Co-requisite: CHEM 1250.

#### **CHEM 1240 General Chemistry I Laboratory (1 Credit)**

Laboratory to accompany CHEM 1010. Experiments illustrate aspects of atomic structure, chemical bonding and thermochemistry. Lab fee associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Co-requisite: CHEM 1010.

#### **CHEM 1250 General Chemistry II Laboratory (1 Credit)**

Laboratory to accompany CHEM 1020. Experiments illustrate chemical principles applied to equilibrium of acids/bases, kinetics, and thermodynamics. Lab fee associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Pre-requisites: CHEM 1010 and CHEM 1240; Co-requisite: CHEM 1020.

#### **CHEM 2131 Chemistry of the Elements (3 Credits)**

Descriptive chemistry of main group and transition elements including redox and coordination chemistry. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Prerequisites: CHEM 1020 and CHEM 1250. Corequisite: CHEM 2141.

#### **CHEM 2141 Chemistry of the Elements Lab (1 Credit)**

Laboratory to accompany CHEM 2131. Study of reactions of main group and transition elements including redox and coordination chemistry. Lab fee associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement.

#### **CHEM 2240 Introduction to Environmental Chemistry (4 Credits)**

An introduction to the chemistry of the environment. Topics cover the chemistry of air, water, and soil with a special focus on the influence that humankind has on the natural environment. Course provides tools to understand environmental science from a chemical perspective. The course is a combined lecture and laboratory. Primarily for environmental science majors. Lab fee associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Prerequisites: CHEM 1010, CHEM 1020, CHEM 1040, and CHEM 1250.

**CHEM 2270 Quantitative Chemical Analysis (4 Credits)**

This combined lecture-laboratory course is primarily focused on understanding and applying the principles and techniques associated with making quantitative chemical measurements. Topics covered include statistics, applications of acid-base, complexation, precipitation, and redox titrations in chemical measurements, activity, electroanalytical techniques, and gravimetric analysis. Lab Fee associate with this course. Prerequisites: CHEM 2131 and CHEM 2141 or CHEM 2240.

**CHEM 2451 Organic Chemistry I (3 Credits)**

Structure and reactions of covalent compounds of carbon. Satisfies organic chemistry requirement in chemistry, biology and related fields. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Prerequisites: CHEM 2131 and CHEM 2141.

**CHEM 2452 Organic Chemistry II (3 Credits)**

Structure and reactions of covalent compounds of carbon. Satisfies organic chemistry requirement in chemistry, biology and related fields. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Prerequisite: CHEM 2451 and CHEM 2461.

**CHEM 2453 Organic Chemistry III (3 Credits)**

Structure and reactions of covalent compounds of carbon. Satisfies organic chemistry requirement in chemistry, biology and related fields. Prerequisite: CHEM 2451, CHEM 2452, CHEM 2461, and CHEM 2462.

**CHEM 2461 Organic Chemistry Lab I (1 Credit)**

Laboratory course in theory and practice of preparative and analytical organic chemistry, including introduction to IR and NMR spectroscopy. Lab fee associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Co-requisite: CHEM 2451.

**CHEM 2462 Organic Chemistry Lab II (1 Credit)**

Laboratory course in theory and practice of preparative and analytical organic chemistry, including introduction to IR and NMR spectroscopy. Lab fee associated with this course. This course counts toward the Scientific Inquiry: The Natural and Physical World requirement. Co-requisite: CHEM 2452.

**CHEM 2463 Organic Chemistry Lab III (1 Credit)**

Laboratory course in theory and practice of preparative and analytical organic chemistry, including introduction to IR and NMR spectroscopy. Lab fee associated with this course. Co-requisite: CHEM 2453.

**CHEM 3110 Chemical Systems I (3 Credits)**

Advanced discussion of modern concepts of organic chemistry; bonding, stereochemistry, reaction mechanisms. Prerequisites: CHEM 2453 and equivalent of one year of physical chemistry.

**CHEM 3120 Chemical Systems II (3 Credits)**

Interpretation of trends in the chemistry of the elements in terms of orbital interactions. Most examples will be taken from the third row transition metals and the boron and carbon groups. Prerequisites: CHEM 2131, CHEM 3310 and CHEM 3110.

**CHEM 3130 Chemical Systems III (3 Credits)**

Advanced-level physical biochemistry course intended for advanced-level undergraduates and graduate students. Focuses on kinetic, thermodynamic and dynamic aspects of biopolymers; delineates the relationship of these properties to the mechanism and function of biological macromolecules. Prerequisites: CHEM 3811, CHEM 3812, CHEM 3813, CHEM 3610 or the equivalent.

**CHEM 3210 Instrumental Analysis (4 Credits)**

Course focus is toward students' understanding of instrumental components and the theory behind both component's and instrument's operation. Emphasis is on techniques such as spectroscopy and chromatography. Students will experience extensive hands-on use of a number of instruments. Course provides a strong background for Chemistry Frontiers (CHEM 3500) and emphasizes techniques and skills sought by chemical and biotechnology industries. Lab fee associated with this course. Prerequisites: CHEM 2011 or CHEM 2270.

**CHEM 3220 Advanced Analytical Chemistry (3 Credits)**

Principles of chemical instrumentation applied to analytical measurements; principles, instrumentation and applications of spectrometric and chromatographic measurements. Prerequisites: CHEM 3210 and CHEM 3621, or the equivalent.

**CHEM 3310 Structure and Energetics I (3 Credits)**

Fundamentals of quantum chemistry, and introduction to symmetry and molecular structure of small and large systems. Prerequisite: one year of physical chemistry.

**CHEM 3320 Structure and Energetics II (3 Credits)**

Computational methods in chemistry. Prerequisites: CHEM 3310, one year of physical chemistry.

**CHEM 3410 Atmospheric Chemistry (3 Credits)**

The concepts of equilibrium thermodynamics, kinetics, and photochemistry will be applied to understanding atmospheric processes. Covers urban air pollution in detail with focus on primary pollutants. Also covers stratospheric chemistry with focus on ozone chemistry and the chemistry of climate change. Prerequisites: (CHEM 2270 and CHEM 2453) OR CHEM 2240.

**CHEM 3411 Aquatic Chemistry (3 Credits)**

The circulation of the oceans and their chemical make-up. 'Classical water pollution problems' like biological oxygen demand and turbidity are discussed. Also presented: aquifer structure and flow, ground water chemistry, pollutant partitioning between stationary and mobile phases, heterogeneous surface chemistry, and the detection of trace contaminants. Prerequisites: (CHEM 2270 and CHEM 2453) or CHEM 2240.

**CHEM 3412 Environmental Chemistry & Toxicology (3 Credits)**

A survey of environmental toxicology concepts: animal testing, dose-response data, epidemiology, risk assessment. The course includes ecotoxicology, focusing on the alteration of biological and chemical systems beyond the simple response of an individual to an environmental chemical. Prerequisites: CHEM 2270 and CHEM 2453.

**CHEM 3413 Aerosol Science (3 Credits)**

CHEM 3413 is an introductory course that presents fundamental concepts associated with atmospheric aerosols in both natural and human environments. The course will focus on the sources, behavior, and effects of atmospheric aerosols, or particulate matter (PM) within the contexts of the natural environment and climate, human health, and industrial applications. The course will provide an overview of the chemical and physical characteristics of particulate matter and measurement methods, including chemical reactions that lead to aerosol formation and transformation. Examples and demonstrations will discuss applications to medical science, public health, clouds and climate, air pollution, colors in the sky, the built environment, mechanical engineering, chemical industry, and many other topics that stimulate curiosity. Aerosols affect almost every aspect of the environment and human health and are an important part of countless industrial processes or commercial products. The course is designed to provide a background to students interested in further study or careers broadly in (a) the environmental sciences, (b) medical or health sciences, or (c) many chemical or other scientific or engineering fields where aerosol processes are involved. CHEM 3413 will be taught at an upper-division (3000) level, but with enough flexibility to expect all environmental science, chemistry, biochemistry, biology, ecology, or engineering majors with the prerequisite year of chemistry to have fun and be able to learn effectively and succeed. The course is lecture-only; no lab is required, although demonstrations and hands on activities will be involved. The course fulfills requirements for the Environmental Chemistry B.S. major or minor, elective credit toward the Environmental Science B.S. or B.A. majors, and elective credit toward graduate programs in Chemistry. Prerequisite: CHEM 2240 or CHEM 2131.

**CHEM 3500 Chemistry Frontiers (3 Credits)**

Advanced-level laboratory course required for all undergraduates majoring in chemistry or environmental chemistry. Emphasis on the development of oral, written, computer and presentation skills necessary for success as a scientist. Skills will be honed through state-of-the-art laboratory experiences from diverse areas of chemistry. Lab fee associated with this course. Prerequisites: CHEM 3210 and CHEM 3610.

**CHEM 3610 Physical Chemistry I (3 Credits)**

Fundamentals of thermodynamics, including phase and reaction equilibria, properties of solutions, and electrochemistry needed for advanced study in life sciences and for Physical Chemistry II and III. May be taken for graduate credit by nonchemistry majors. Prerequisites: CHEM 2453, calculus and physics.

**CHEM 3620 Physical Chemistry II (3 Credits)**

Fundamentals of quantum chemistry, including theories of atomic and molecular structure and spectroscopy. May be taken for graduate credit by nonchemistry majors. Prerequisite: CHEM 3610.

**CHEM 3621 Physical Chemistry III (3 Credits)**

Fundamentals of kinetic theory and statistical mechanics. May be taken for graduate credit by nonchemistry majors. Prerequisite: CHEM 3620.

**CHEM 3703 Topics in Organic Chemistry (3 Credits)**

May include organic photochemistry, organic synthesis, organic electrochemistry or natural products. May be repeated for credit. Prerequisites: CHEM 3110 or equivalent and others depending on topic.

**CHEM 3705 Topics in Biochemistry (3,4 Credits)**

May include physical techniques for exploring biological structure, biological catalysis, and selected fields within biochemistry taught from original literature. May be repeated for credit. Prerequisites: CHEM 3831 and 3813.

**CHEM 3811 Biochemistry-Proteins (3 Credits)**

Protein structure and function, starting with the building blocks and forces that drive the formation of protein structure and the basic concepts of protein structure, and continuing with enzyme catalysis, kinetics, and regulation. Prerequisites: CHEM 2453 or instructor permission.

**CHEM 3812 Biochemistry-Membranes/Metabolism (3 Credits)**

Membranes and membrane mediated cellular processes, energy and signal transduction, and metabolic/biosynthetic pathways. Prerequisite: CHEM 3811 or CHEM 3831.

**CHEM 3813 Biochemistry-Nucleic Acids (3 Credits)**

Molecular processes underlying heredity, gene expression and gene regulation in prokaryotes and eukaryotes. Prerequisites: CHEM 2453 and CHEM 3811.

**CHEM 3820 Biochemistry Lab (3 Credits)**

Purification and properties of biological molecules and structures. Lab fee associated with this course. Prerequisites: CHEM 3811 AND (CHEM 2011 OR CHEM 2270).

**CHEM 3831 Advanced Protein Biochemistry (3 Credits)**

This course provides fundamental insights into the chemistry and physics of proteins. It investigates how amino acids form proteins with highly complex three-dimensional structures and how these structures mediate function. We examine key research articles and their contribution to our current understanding of proteins. Topics range from protein folding to enzyme kinetics and emphasize basic principles. Prerequisites: CHEM 2453 and instructor permission.

**CHEM 3980 Internship-Undergraduate (0 Credits)**

Practical work experience.

**CHEM 3991 Independent Study (1-10 Credits)**

May be repeated for credit.

**CHEM 3995 Independent Research (1-10 Credits)**

Research project conducted under guidance of a faculty member. Credit hours and projects arranged on an individual basis. May be repeated for credit.