

# MAJOR IN CHEMISTRY, SUSTAINABLE CHEMISTRY CONCENTRATION

Chemistry, the central science, engages biochemistry, biology, engineering, and environmental and materials sciences. Chemists synthesize compounds from life-enhancing medicines to the materials of modern society with the understanding that there can be unintended consequences. Chemists collect and analyze data used in policy decisions including those involving the air, food, soil, and water. Chemists develop materials and processes that are safer, and are more energy and material efficient. Chemists develop processes for the recovery and conversion of waste to raw material. Chemistry majors develop a solid foundation in general chemistry and mathematics followed by coursework in organic chemistry, analytical chemistry, physical chemistry, inorganic chemistry, chemical biology, and physics. The curriculum is rounded out by courses in the liberal and communications arts.

Chemistry majors in the sustainability track are encouraged to participate in undergraduate research. Ample opportunities exist for undergraduate students to become involved in ground-breaking research in the laboratories of individual faculty members. Students have access to state-of-the-art equipment in faculty laboratories and the Central Instrument Facility including NMR, FTIR, UV/Vis, fluorescence, and

mass spectrometers, vacuum lines, x-ray diffractometers and many more. Undergraduate research is strongly encouraged for any student considering a career in chemistry and many students complete supervised research for academic credit. Development of skills in all of the aforementioned analytical techniques will allow graduates to pursue a consultant, educator, or researcher career.

## Learning Outcomes

- Describe the unintended consequences associated with the synthesis of compounds ranging from life-enhancing medicines to the materials of modern society.
- Articulate the thought process used to develop safer, more energy and material efficient processes, including the recovery and conversion of waste to raw material—the principles of Green chemistry.
- Effectively communicate the results of the collection and analysis of data used in policy decisions for questions involving the air, food, soil, and water.

## Requirements

### Effective Fall 2022

Chemistry majors must achieve a minimum grade of C (2.000) in all the listed courses required for the major in chemistry.

#### Freshman

		AUCC	Credits
CHEM 120 <sup>1</sup>	Foundations of Modern Chemistry (GT-SC2)	3A	4
CHEM 121 <sup>1</sup>	Foundations of Modern Chemistry Laboratory (GT-SC1)	3A	1
CHEM 192	Introductory Seminar in Chemistry		2
CHEM 241 <sup>2</sup>	Foundations of Organic Chemistry		4
CHEM 242 <sup>2</sup>	Foundations of Organic Chemistry Laboratory		1
CHEM 263	Foundations of Inorganic Chemistry		4
CHEM 264	Foundations of Inorganic Chemistry Laboratory		1
CO 150	College Composition (GT-CO2)	1A	3
Select one course from the following:			3
AREC 202	Agricultural and Resource Economics (GT-SS1)	3C	
ECON 202	Principles of Microeconomics (GT-SS1)	3C	
Select one course from the following:			4
MATH 155	Calculus for Biological Scientists I (GT-MA1)	1B	
MATH 160	Calculus for Physical Scientists I (GT-MA1)	1B	
Diversity, Equity, and Inclusion ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion</a> )			3
<b>Total Credits</b>			<b>30</b>

#### Sophomore

CHEM 231	Foundations of Analytical Chemistry		3
CHEM 232	Foundations of Analytical Chemistry Lab		2
CHEM 322	Foundations of Chemical Biology Laboratory		1
GES 101	Foundations of Environmental Sustainability		3
PH 121 or 141	General Physics I (GT-SC1) Physics for Scientists and Engineers I (GT-SC1)	3A	5
PH 122 or 142	General Physics II (GT-SC1) Physics for Scientists and Engineers II (GT-SC1)	3A	5

Select one course from the following:			4
BC 351	Principles of Biochemistry		
CHEM 321	Foundations of Chemical Biology		
Select one group from the following:			8
Group A			
MATH 271	Applied Mathematics for Chemists I		
MATH 272	Applied Mathematics for Chemists II		
Group B			
MATH 161	Calculus for Physical Scientists II (GT-MA1)	1B	
MATH 261	Calculus for Physical Scientists III		
<b>Total Credits</b>			<b>31</b>
<b>Junior</b>			
CHEM 338	Environmental Chemistry	4B	3
CHEM 371	Fundamentals of Physical Chemistry		4
CHEM 372	Fundamentals of Physical Chemistry Lab	4A	1
Select one course from the following:			3
ANTH 200	Cultures and the Global System (GT-SS3)	1C	
HORT 171/SOCR 171	Environmental Issues in Agriculture (GT-SS3)	1C	
SOC 220	Environment, Food, and Social Justice (GT-SS3)	1C	
Advanced Electives (see list below)			6
In-depth Chemistry Courses (see list below)			5
Advanced Writing ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing</a> ) <sup>3</sup>		2	3
Arts and Humanities ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities</a> )		3B	3
Historical Perspectives ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives</a> )		3D	3
<b>Total Credits</b>			<b>31</b>
<b>Senior</b>			
CHEM 431	Instrumental Analysis		4
Select one course from the following:			2
CHEM 493	Senior Seminar	4C	
CHEM 499 <sup>4</sup>	Senior Thesis	4C	
Select six credits from the following courses:			6
CHEM 555	Chemistry of Sustainability		
ERHS 410	Environmental Health-Air and Waste Management		
GES 465/MSE 465	Sustainable Strategies for E-Waste Management		
GES 542	Biobased Fuels, Energy, and Chemicals		
Advanced Electives (see list below)			3
Arts and Humanities ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-and-humanities">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-and-humanities</a> )		3B	3
Electives <sup>5</sup>			10
<b>Total Credits</b>			<b>28</b>
<b>Program Total Credits:</b>			<b>120</b>

### In-depth Chemistry Courses

At least 1 credit must come from AUCC 4B designated courses.

Code	Title	AUCC	Credits
CHEM 311	Introduction to Nanoscale Science		3
CHEM 315	Foundations of Polymer Chemistry		3
CHEM 320	Chemistry of Addictions		3
CHEM 333	Forensic Chemistry		3
CHEM 433	Clinical Chemistry		3
CHEM 440	Advanced Organic Chemistry Laboratory	4B	2
CHEM 445	Synthetic Organic Chemistry	4B	3
CHEM 448	Medicinal Chemistry		3
CHEM 461	Inorganic Chemistry	4B	3
CHEM 462	Inorganic Chemistry Laboratory		2
CHEM 476	Physical Chemistry II	4B	3
CHEM 477	Physical Chemistry Laboratory II		1
CHEM 498	Research		1-3

## Advanced Electives

Code	Title	Credits
ATS 350	Introduction to Weather and Climate	2
ATS 351	Introduction to Weather and Climate Lab	1
ERHS 320	Environmental Health–Water Quality	3
ERHS 332	Principles of Epidemiology	3
ERHS 400	Radiation Safety	3
ERHS 410	Environmental Health–Air and Waste Management	3
ERHS 430	Human Disease and the Environment	3
ERHS 446	Environmental Toxicology	3
ERHS 448	Environmental Contaminants	3
ERHS 450	Introduction to Radiation Biology	3

Upper-Division regular courses (300-379; 400-479) from the following subject codes:

AA
AB
ANEQ
BC
BIOM
BMS
BSPM
BZ
CBE
CHEM
CS
CT
ESS
FTEC
FW
HES
HORT
LIFE
MATH
MIP

NR
NSCI
PH
PSY
SOCR
STAT

<sup>1</sup> Students who complete General Chemistry Freshman year (CHEM 111 or CHEM 107, CHEM 112 or CHEM 108, CHEM 113, CHEM 114) do not have to take CHEM 120 and CHEM 121.

<sup>2</sup> Students may complete the organic chemistry requirement by taking CHEM 341, CHEM 343, and CHEM 344. Students who take CHEM 245/CHEM 246 may complete the organic chemistry requirement by taking CHEM 343/CHEM 344. For both sets of these students, CHEM 343/CHEM 344 together count as an in-depth chemistry course.

<sup>3</sup> CHEM 301 is recommended.

<sup>4</sup> CHEM 499 by department approval. Students fulfilling the AUCC 4C requirement with CHEM 499 must write a thesis and present it to the department.

<sup>5</sup> Select enough elective credits to bring the program total to a minimum of 120 credits, of which at least 42 must be upper-division (300- to 400-level).

## Major Completion Map

### Distinctive Requirements for Degree Program:

TO PREPARE FOR FIRST SEMESTER: The curriculum for the new American Chemical Society Certified Chemistry major assumes students enter college prepared to take calculus. Entering students who are not prepared to take calculus will need to fulfill pre-calculus requirements in the first semester. CHEM 111 and CHEM 120 require Algebra II as a prerequisite (this prerequisite is met by having Algebra II by test credit, transfer credit, or placement out of MATH 117 and MATH 118 on Math Placement Exam). Earned grades of C (2.000) or better are required in all listed courses for the major in chemistry. Students with credit for CHEM 111, CHEM 112, CHEM 113, CHEM 114 do not need to take CHEM 120, CHEM 121. Students with credit for CHEM 341, CHEM 343, CHEM 344 do not need to take CHEM 241, CHEM 242.

**Freshman**

<b>Semester 1</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 120	Foundations of Modern Chemistry (GT-SC2)	X		3A	4
CHEM 121	Foundations of Modern Chemistry Laboratory (GT-SC1)	X		3A	1
CHEM 192	Introductory Seminar in Chemistry	X			2
CO 150	College Composition (GT-CO2)	X		1A	3
Select one course from the following:		X			3
AREC 202	Agricultural and Resource Economics (GT-SS1)			3C	
ECON 202	Principles of Microeconomics (GT-SS1)			3C	
Diversity, Equity, and Inclusion ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion</a> )		X		1C	3

**Total Credits****16**

<b>Semester 2</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 241	Foundations of Organic Chemistry	X			4
CHEM 242	Foundations of Organic Chemistry Laboratory	X			1
CHEM 263	Foundations of Inorganic Chemistry	X			4
CHEM 264	Foundations of Inorganic Chemistry Laboratory	X			1
MATH 155 or 160	Calculus for Biological Scientists I (GT-MA1) Calculus for Physical Scientists I (GT-MA1)	X		1B	4

**Total Credits****14****Sophomore**

<b>Semester 3</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 231	Foundations of Analytical Chemistry	X			3
CHEM 232	Foundations of Analytical Chemistry Lab	X			2
GES 101	Foundations of Environmental Sustainability				3
PH 121 or 141	General Physics I (GT-SC1) Physics for Scientists and Engineers I (GT-SC1)	X		3A	5
Select one course from the following:		X			4
Group A:					
MATH 271	Applied Mathematics for Chemists I				
Group B:					
MATH 161	Calculus for Physical Scientists II (GT-MA1)			1B	

**Total Credits****17**

<b>Semester 4</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 321 or BC 351	Foundations of Chemical Biology Principles of Biochemistry				4
CHEM 322	Foundations of Chemical Biology Laboratory				1
PH 122 or 142	General Physics II (GT-SC1) Physics for Scientists and Engineers II (GT-SC1)	X		3A	5
Select one course from the following:		X			4
Group A:					
MATH 272	Applied Mathematics for Chemists II				
Group B:					
MATH 261	Calculus for Physical Scientists III				

**Total Credits****14****Junior**

<b>Semester 5</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 371	Fundamentals of Physical Chemistry	X			4
CHEM 372	Fundamentals of Physical Chemistry Lab	X		4A	1
Select one course from the following:		X			3
ANTH 200	Cultures and the Global System (GT-SS3)			1C	

HORT 171/ SOCR 171	Environmental Issues in Agriculture (GT-SS3)			1C	
SOC 220	Environment, Food, and Social Justice (GT-SS3)			1C	
In-depth Chemistry Courses (see list on Program Requirements tab)		X			5
Advanced Writing ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing</a> )				2	3
<b>Total Credits</b>					<b>16</b>
<b>Semester 6</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 338	Environmental Chemistry	X			3
Advanced Electives (see list on Program Requirements tab)		X			6
Arts and Humanities ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities</a> )				3B	3
Historical Perspectives ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives</a> )			X	3D	3
<b>Total Credits</b>					<b>15</b>
<b>Senior</b>					
<b>Semester 7</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
Select six credits from the following courses:		X			6
CHEM 555	Chemistry of Sustainability				
ERHS 410	Environmental Health-Air and Waste Management				
GES 465/ MSE 465	Sustainable Strategies for E-Waste Management				
GES 542	Biobased Fuels, Energy, and Chemicals				
Arts and Humanities ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-and-humanities">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-and-humanities</a> )			X	3B	3
Advanced Electives (See list on Program Requirements tab.)		X			3
Elective			X		3
<b>Total Credits</b>					<b>15</b>
<b>Semester 8</b>		<b>Critical</b>	<b>Recommended</b>	<b>AUCC</b>	<b>Credits</b>
CHEM 431	Instrumental Analysis				4
Select one course from the following:		X			2
CHEM 493	Senior Seminar			4C	
CHEM 499	Senior Thesis			4C	
Electives		X			7
The benchmark courses for the 8th semester are the remaining courses in the entire program of study.		X			
<b>Total Credits</b>					<b>13</b>
<b>Program Total Credits:</b>					<b>120</b>