

# CHEMISTRY, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN CHEMICAL SCIENCE

The curriculum in chemistry prepares students for graduate study in chemistry and related fields and for admission to schools of medicine, dentistry, pharmacy and veterinary medicine. It prepares students to teach in secondary schools or to work in chemical and industrial laboratories and in related fields of business and industry. The department also offers required and elective courses in chemistry to students in other programs of study.

The Department of Chemistry offers five areas of concentration for completing the Bachelor of Science in Chemistry: chemical science, professional chemist, professional chemist with honors, biochemistry and chemical modeling. With proper selection of electives, the degree satisfies admission requirements to most schools of medicine, dentistry, pharmacy and veterinary medicine.

The chemical science concentration is tailored for the pre-professional study of the health sciences and other interdisciplinary areas where an emphasis on chemistry is sought. This concentration for the bachelor's degree in chemistry permits students to select more courses from other disciplines. With fewer requirements in mathematics, physics and chemistry, this concentration is one option for students planning to study medicine or dentistry.

## Student learning outcomes

Upon completing this program, students will know how to do the following:

### Chemistry core outcomes

- Demonstrate proficiency in the major concepts and theoretical principles of chemistry, critical thinking and problem-solving skills
- Demonstrate proficiency in laboratory skills, including wet chemistry and instrumental methods, and laboratory safety practices
- Demonstrate communication skills, both written and oral, needed to explain chemical phenomenon
- Demonstrate proficiency in scientific literacy skills including searching and reading scientific publications
- Demonstrate an understanding of the need for ethical practices in chemistry

### Chemical science concentration-specific outcomes

- Demonstrate the ability to apply basic laboratory skills to more advanced laboratory work, including data collection, data analysis and report writing

## Special requirements

Students must complete 36-37 credits in chemistry and 33-35 credits of ancillary requirements in addition to general education requirements.

A minimum grade of C is required in each prerequisite course except for CHEM 100, which requires a minimum grade of B.

Course	Title	Hours
CHEM 100	Introductory Chemistry (if required through placement qualifiers)	3
CHEM 101	General Chemistry I	3
CHEM 102	General Chemistry II	3
CHEM 301	Organic Chemistry	3
CHEM 302	Organic Chemistry	3
CHEM 309	Quantitative Analysis	3
CHEM 313	Physical Chemistry I	3-4
or CHEM 314	Physical Chemistry I with Math Modules	
CHEZ 101	General Chemistry Laboratory I	1
CHEZ 102	General Chemistry Laboratory II	1
CHEZ 301	Organic Chemistry Laboratory I	2
CHEZ 302	Organic Chemistry Laboratory II	2
CHEZ 309	Quantitative Analysis Laboratory	2

VCU students in other programs who wish to declare chemistry as their major must complete CHEM 101, CHEZ 101, CHEM 102 and CHEZ 102, each with a minimum grade of C and have a minimum GPA in their chemistry courses of 2.0.

## Degree requirements Chemistry, Bachelor of Science (B.S.) with a concentration in chemical science

Course	Title	Hours
<b>General education</b> ( <a href="http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/">http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/</a> )		
Select 30 credits of general education courses in consultation with an adviser.		30
<b>Major requirements</b>		
• Major core requirements		
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
CHEM 309 & CHEZ 309	Quantitative Analysis and Quantitative Analysis Laboratory	5
CHEZ 313	Physical Chemistry Laboratory I	2
CHEM 313 or CHEM 314	Physical Chemistry I or Physical Chemistry I with Math Modules	3-4
CHEM 315	Physical Chemistry II	3
CHEM 320	Inorganic Chemistry I	3
CHEM 398	Professional Practices and Perspectives Seminar	1
CHEM 499	Chemistry Capstone Experience <sup>1</sup>	0
• Additional major requirements		
Capstone requirements		
Select at least one two-credit 400-level CHEZ course or two credits of CHEM 392 or CHEM 492 and at least one three-credit 400- or 500-level CHEM course from the electives listed below.		5
<b>Ancillary requirements</b>		

CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural sciences and AOI for scientific logical reasoning)	4
HUMS 202	Choices in a Consumer Society	1
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
MATH 201	Calculus with Analytic Geometry II	4
STAT 210 or STAT 212	Basic Practice of Statistics Concepts of Statistics	3
Physics sequence (select one sequence)		8-10
PHYS 201 & PHYS 202	General Physics I and General Physics II (PHYS 201 satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	
PHYS 207 & PHYS 208	University Physics I and University Physics II (PHYS 207 satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	
Experiential fine arts <sup>2</sup>		1-3
Foreign language through the 102 level (by course or placement)		0-6
<b>Open electives</b>		
Select any course.		30-41
<b>Total Hours</b>		<b>120</b>

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Students in this concentration meet the capstone requirement by taking at least one two-credit 400-level CHEZ course or two credits of CHEM 392 (<http://bulletin.vcu.edu/search/?P=CHEM%20392>) or CHEM 492 (<http://bulletin.vcu.edu/search/?P=CHEM%20492>) and at least one three-credit 400- or 500-level CHEM course from the electives list.

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Course offered by the School of the Arts

**The minimum number of credit hours required for this degree is 120.**

### Major electives

Course	Title	Hours
CHEM 306	Industrial Applications of Inorganic Chemistry	3
CHEM 310	Medicinal Chemistry and Drug Design	3
CHEM 350	Guided Inquiry in Chemistry	1.5
CHEM 351	Chemistry Preceptorship	1.5
CHEM 391	Topics in Chemistry	1-4
CHEM 392	Directed Study	1-4
CHEM 403	Biochemistry I	3
CHEM 404	Biochemistry II	3
CHEM 406 & CHEZ 406	Inorganic Chemistry II and Inorganic Chemistry Laboratory	5
CHEM 409 & CHEZ 409	Instrumental Analysis and Instrumental Analysis Laboratory	5

CHEM 491	Topics in Chemistry	1-4
CHEM 492	Independent Study	1-4
CHEM 493	Chemistry Internship	1-3
CHEM 498	Honors Thesis	1
CHEM 504	Advanced Organic Chemistry I	3
CHEM 510	Atomic and Molecular Structure	3
CHEM 512	Applied Molecular Modeling	3
CHEM 511	Chemical Thermodynamics and Kinetics	3
CHEZ 400	Exploring the Frontiers of Chemistry: Research Methods	2
CHEZ 404	Biochemistry Laboratory	2
CHEZ 413	Advanced Physical Chemistry Laboratory	2

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

### Freshman year

Fall semester		Hours
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural sciences and AOI for scientific and logical reasoning)	4
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I (satisfies general education UNIV foundations)	3
General education course <sup>1</sup>		3
General education course <sup>1</sup>		3
<b>Term Hours:</b>		<b>17</b>
Spring semester		Hours
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
HUMS 202	Choices in a Consumer Society	1
MATH 201	Calculus with Analytic Geometry II	4
STAT 210	Basic Practice of Statistics	3
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II (satisfies general education UNIV foundations)	3
<b>Term Hours:</b>		<b>15</b>

Sophomore year		Hours
Fall semester		
CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
CHEM 309 & CHEZ 309	Quantitative Analysis and Quantitative Analysis Laboratory	5

PHYS 201 or PHYS 207	General Physics I (either satisfies AOI for scientific and logical reasoning) or University Physics I	4-5
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication (satisfies general education UNIV foundations)	3

**Term Hours:** 17-18

#### Spring semester

CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
CHEM 320	Inorganic Chemistry I	3
CHEM 398	Professional Practices and Perspectives Seminar	1
PHYS 202 or PHYS 208	General Physics II or University Physics II	4-5

**Term Hours:** 13-14

#### Junior year

##### Fall semester

CHEM 313 or CHEM 314	Physical Chemistry I or Physical Chemistry I with Math Modules	3-4
CHEZ 313	Physical Chemistry Laboratory I	2
Foreign language 101		3
General education course <sup>1</sup>		3
Open elective		3

**Term Hours:** 14-15

##### Spring semester

CHEM 315	Physical Chemistry II	3
Foreign language 102		3
Open electives		9

**Term Hours:** 15

#### Senior year

##### Fall semester

CHEM 499	Chemistry Capstone Experience <sup>2</sup>	0
Major electives (for capstone) <sup>2</sup>		5
Open electives		9

**Term Hours:** 14

##### Spring semester

Experiential fine arts		1-3
Open electives		14

**Term Hours:** 15-17

**Total Hours:** 120-125

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At least three additional general education courses (nine credits) are required. Three credits come from each of the following areas of inquiry: diversities in the human experience; creativity, innovation and aesthetic inquiry; and global perspectives. The latter two areas of inquiry courses should also fulfill the breadth of knowledge requirement from the areas of humanities/fine arts and social/behavioral sciences.

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Students in this concentration meet the capstone requirement by taking at least one two-credit 400-level CHEZ course or two credits of CHEM 392 (<http://bulletin.vcu.edu/search/?P=CHEM%20392>) or CHEM 492 (<http://bulletin.vcu.edu/search/?P=CHEM%20492>) and at least one three-credit 400- or 500-level CHEM course from the electives list.

**The minimum number of credit hours required for this degree is 120.**

## Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows qualified students to earn both the B.S. and M.S. in Chemistry in a minimum of five years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count nine hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 141 credits rather than the 150 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have had advanced training in chemistry through a combination of laboratory and classroom work and gained important professional development skills. Students may have the ability to design and incorporate graduate courses in another discipline as part of the accelerated program based on their career objectives. The goal of the accelerated program is to significantly enhance the student's qualifications to pursue a career in industry, teaching or the government. Alternatively, students who distinguish themselves may be able to pursue advanced study at the doctoral level in chemistry or chemical biology on an accelerated timetable.

## Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit (no later than two semesters prior to graduating with a baccalaureate degree, that is, before the end of the spring semester of their junior year) an Accelerated Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 90 undergraduate credit hours including CHEM 313 or CHEM 314, CHEZ 313, CHEM 315, CHEM 320, CHEM 302 and CHEM 309 and CHEZ 309; a minimum overall GPA of 3.0; and a minimum GPA of 3.25 in chemistry course work. Students who are interested in the accelerated program should consult with the graduate faculty adviser to the chemistry master's program before they have completed 60 credits. Successful applicants would enter the program in the fall semester of their senior year.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (<http://bulletin.vcu.edu/academic-regs/grad/satisfactory-academic-progress/>)" section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students admitted to the accelerated program is provided by both the undergraduate chemistry adviser and the faculty adviser to the chemistry graduate program.

## Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an

approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application. In order to continue pursuing the master's degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin. Three reference letters (at least one from a chemistry faculty member) must accompany the application.

## Degree requirements

The Bachelor of Science in Chemistry with a concentration in chemical science degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin. Students in the accelerated program will be required to take CHEM 409 and CHEZ 409 during the fall semester of senior year, as well as three credits of CHEM 392 or CHEM 492 each semester of the senior year in lieu of some elective course work.

A maximum of nine graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits will substitute as open elective credits for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

Undergraduate students admitted to the accelerated program may select nine credits from the four approved courses below.

Course	Title	Hours
CHEM 504	Advanced Organic Chemistry I	3
CHEM 510	Atomic and Molecular Structure	3
CHEM 511	Chemical Thermodynamics and Kinetics	3
CHEM 520	Advanced Inorganic Chemistry	3

## Recommended course sequence/plan of study

What follows is the recommended plan of study for students in the chemical science concentration in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

Course	Title	Hours
<b>Junior year</b>		
Fall semester		
CHEM 313	Physical Chemistry I	3-4
or CHEM 314	Physical Chemistry I with Math Modules	
CHEZ 313	Physical Chemistry Laboratory I (if taken)	2
General education course		3
General education courses or open electives		6
Term Hours:		14-15
Spring semester		
CHEM 315	Physical Chemistry II	3
Foreign language (101 level)		4
Open electives		9
Term Hours:		15
<b>Senior year</b>		
Fall semester		

CHEM 392	Directed Study	3
or CHEM 492	Independent Study	
CHEM 409 & CHEZ 409	Instrumental Analysis and Instrumental Analysis Laboratory	5
CHEM 499	Chemistry Capstone Experience <sup>1</sup>	0
Approved graduate chemistry course (from list above)		3
Foreign language (102 level)		4
Open elective		3
Term Hours:		17
Spring semester		
CHEM 392	Directed Study	3
or CHEM 492	Independent Study	
Approved graduate chemistry courses (from list above)		6
Experiential fine arts		3
Open elective		3
Term Hours:		15
<b>Fifth year</b>		
Fall semester		
CHEM 693	Chemistry Perspectives and Ethics	1
CHEM 696	Professional Skill Development	3
CHEM 698	Investigations in Current Chemistry Literature	1
Electives		6
Term Hours:		11
Spring semester		
CHEM 692	Chemistry Seminar Presentation	1
CHEM 696	Professional Skill Development	6
or CHEM 697	Directed Research	
Elective		3
Term Hours:		10

## Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows academically talented students to earn both the B.S. in Chemistry with a concentration in chemical science and the M.S. in Forensic Science with a concentration in forensic chemistry/drugs and toxicology in a minimum of five and a half years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count up to 12 hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 150 credits rather than the 162 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have both foundational work in chemistry and advanced training in forensic science through a combination of laboratory and classroom work and will have gained important professional development skills. The goal of the accelerated program is to significantly enhance the student's qualifications to pursue a career in the forensic science field. Alternatively, students who distinguish themselves may be able to pursue advanced study in doctoral or professional studies on an accelerated timetable.

## Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit an Accelerated

Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 90 undergraduate credit hours including CHEM 301 and CHEM 302 with laboratories (CHEZ 301 and CHEZ 302), CHEM 309 and laboratory (CHEZ 309); an overall GPA of 3.3; and a GPA of 3.0 in chemistry course work. Two reference letters (at least one from a chemistry or forensic science faculty member) must accompany the Accelerated Program Declaration Form.

Once enrolled in the accelerated program, students complete the course work for the B.S. in Chemistry with a concentration in chemical science with the exception of adding CHEM 409 and CHEZ 409, which are needed as prerequisites for several graduate forensic science courses and can fulfill open elective credits. Students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (<http://bulletin.vcu.edu/academic-regs/grad/satisfactory-academic-progress/>)" section of Bulletin, including maintaining a 3.0 GPA. Guidance to students in an accelerated program is provided by both the undergraduate chemistry adviser and the forensic science graduate program director.

## Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application. In order to continue pursuing the master's degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin.

## Degree requirements

The Bachelor of Science in Chemistry degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits substitute for required major electives and open electives for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

The graduate forensic science courses that may be taken as an undergraduate, once a student is admitted to the program, are:

Course	Title	Hours
FRSC 581	Forensic Analysis of Fire Debris and Explosive Evidence	3
FRSC 582	Forensic Analysis of Paint and Fiber Evidence	3
FRSC 644	Analytical Considerations in Forensic Toxicology	3
FRSC 671	Instrumentation in Forensic Chemistry	2
FRSC 672	Advanced Drug Analysis	3

FRSZ 671	Instrumentation in Forensic Chemistry Laboratory	1
STAT 543	Statistical Methods I	3

## Recommended course sequence/plan of study

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

Course	Title	Hours
<b>Junior year</b>		
Fall semester		
CHEM 313	Physical Chemistry I	3-4
or CHEM 314	Physical Chemistry I with Math Modules	
CHEZ 313	Physical Chemistry Laboratory I	2
Foreign language 101		3
General education course		3
Open elective		3
Term Hours:		14-15
Spring semester		
CHEM 315	Physical Chemistry II	3
CHEM 409 & CHEZ 409	Instrumental Analysis and Instrumental Analysis Laboratory	5
Foreign language 102		3
Open electives		4
Term Hours:		15
<b>Senior year</b>		
Fall semester		
CHEM 499	Chemistry Capstone Experience	0
FRSC 671 & FRSZ 671	Instrumentation in Forensic Chemistry and Instrumentation in Forensic Chemistry Laboratory	3
STAT 543	Statistical Methods I	3
Open electives		8
Term Hours:		14
Spring semester		
FRSC 644	Analytical Considerations in Forensic Toxicology	3
FRSC 672	Advanced Drug Analysis	3
Experiential fine arts		1-3
Open electives		8
Term Hours:		15-17
<b>Fifth year</b>		
Fall semester		
FRSC 570	Forensic Science Seminar	1
FRSC 660	Toolmark Examinations	3
or FRSC 661	Analysis of Pattern Evidence	
or FRSC 662	Firearm Identification	
FRSC 670	Forensic Evidence and Criminal Procedure	3
FRSC 673 & FRSZ 673	Forensic Microscopy and Forensic Microscopy Laboratory	3
Term Hours:		10
Spring semester		

FRSC 565	Scientific Crime Scene Investigation	3
FRSC 570	Forensic Science Seminar	1
FRSC 645	Applications in Forensic Toxicology	3
FRSC 677	Professional Practices and Expert Testimony	3
FRSC 793	Directed Research in Forensic Science	1
Term Hours:		11
<b>Sixth year</b>		
Fall semester		
FRSC 570	Forensic Science Seminar	1
FRSC 675	Forensic Serology and DNA Analysis	2
FRSC 793	Directed Research in Forensic Science	2
Concentration elective		4
Term Hours:		9