

CHEMISTRY, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN PROFESSIONAL CHEMIST

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 professional chemist concentration requires a greater number of chemistry courses, and is designed for students whose future studies or career plans involve chemistry as a central theme. With the proper combination of courses, this degree can be certified as meeting the requirements of the American Chemical Society.

Learning outcomes

- **Structure:** Students will demonstrate understanding of the relationship between molecular structure and function.
- **Descriptive chemistry:** Students will be conversant with common chemical phenomena both symbolically and sensorially.
- **Measurement and numeracy:** Students will perform calculations needed to describe and model common chemical phenomena.
- **Communication:** Students will develop written and oral communication skills needed to explain chemical phenomena to novices and experts.
- **Literacy:** Students will search, read and assess scientific literature.
- **Laboratory skills:** Students will develop and practice laboratory bench and instrumentation skills.
- **Information processing:** Students will interpret tables, graphs, drawings and models.
- **Critical thinking:** Students will practice critical thinking and problem solving.

Special requirements

Students must complete 50 credits in chemistry and 22 credits of collateral requirements.

A minimum grade of C is required in each prerequisite course:

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

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 for Chemistry, Bachelor of Science (B.S.) with a concentration in professional chemist

General education requirements

Course	Title	Hours
University Core Education Curriculum (minimum 21 credits)		
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I	3
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II	3
UNIV 200	Inquiry and the Craft of Argument	3
Approved humanities/fine arts		3
Approved natural/physical sciences		3-4
Approved quantitative literacy		3-4
Approved social/behavioral sciences		3-4
Total Hours		21-24

Course	Title	Hours
Additional College of Humanities and Sciences requirements (11-23 credits)		
HUMS 202	Choices in a Consumer Society	1
Approved H&S diverse and global communities		3
Approved H&S human, social and political behavior (fulfills University Core social/behavioral sciences)		
Approved H&S literature and civilization (fulfills University Core humanities/fine arts)		
Approved H&S science and technology (fulfills University Core natural/physical sciences)		
Approved H&S general education electives		6-8
Experiential fine arts ¹		1-3
Foreign language through the 102 level (by course or placement)		0-8
Total Hours		11-23

1

Course offered by the School of the Arts

Collateral requirements

Course	Title	Hours
MATH 200 & MATH 201	Calculus with Analytic Geometry and Calculus with Analytic Geometry	8
MATH 307	Multivariate Calculus	4

PHYS 207 & PHYS 208	University Physics I and University Physics II	10
Total Hours		22

Major requirements

Course	Title	Hours
Chemistry core		
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
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 303 & CHEZ 303	Physical Chemistry and Physical Chemistry Laboratory I	5
CHEM 304 & CHEZ 304	Physical Chemistry and Physical Chemistry Laboratory II	5
CHEM 309 & CHEZ 309	Quantitative Analysis and Quantitative Analysis Laboratory	5
CHEM 320	Inorganic Chemistry I	3
CHEM 398	Professional Practices and Perspectives Seminar	1
Capstone		
CHEM 499	Chemistry Capstone Experience	0
To complete the capstone experience, choose 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
Chemistry electives		
Select from the approved chemistry electives below (8 credits minimum)		8
Total Hours		50

Open electives

Course	Title	Hours
Select one to 16 credits		1-16

Total minimum requirement 120 credits

Course	Title	Hours
CHEM/CLSE 306	Industrial Applications of Inorganic Chemistry	3
CHEM/MEDC 310	Medicinal Chemistry and Drug Design	3
CHEM 403	Biochemistry I ¹	3
CHEM 404	Biochemistry II	3
CHEM 406 & CHEZ 406	Inorganic Chemistry II and Inorganic Chemistry Laboratory ¹	5
CHEM 409 & CHEZ 409	Instrumental Analysis and Instrumental Analysis Laboratory ¹	5
CHEM 492	Independent Study	1-4
CHEM 493	Chemistry Internship	1-3
CHEM 504	Advanced Organic Chemistry I	3
CHEM 507	Introduction to Natural Products	3

CHEM 510	Atomic and Molecular Structure	3
CHEM 512	Applied Molecular Modeling	3
Total Hours		6

These five courses are required to satisfy the requirements for the American Chemical Society certification of the professional chemist concentration. MATH 307 also is required for the American Chemical Society certification. Chemistry majors in the professional chemist concentration meet their statistics general education requirements by taking the required chemistry classes.

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		Hours
Fall semester		
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
MATH 200	Calculus with Analytic Geometry	4
UNIV 111	Focused Inquiry I	3
Play course video for Focused Inquiry I		
Approved H&S human, social, and political behavior		3
Term Hours:		14
Spring semester		
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	4
UNIV 112	Focused Inquiry II	3
Play course video for Focused Inquiry II		
Approved H&S science and technology		3
Term Hours:		15

Sophomore year		Hours
Fall semester		
CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
MATH 307	Multivariate Calculus	4
PHYS 207	University Physics I	5
UNIV 200	Inquiry and the Craft of Argument	3
Term Hours:		17
Spring semester		
CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
CHEM 309 & CHEZ 309	Quantitative Analysis and Quantitative Analysis Laboratory	5
CHEM 398	Professional Practices and Perspectives Seminar	1
PHYS 208	University Physics II	5
Term Hours:		16

Junior year**Fall semester**

CHEM 303 & CHEZ 303	Physical Chemistry and Physical Chemistry Laboratory I	5
CHEM 320	Inorganic Chemistry I	3
Foreign language (101 level)		4
Open electives		3
Term Hours:		15

Spring semester

CHEM 304 & CHEZ 304	Physical Chemistry and Physical Chemistry Laboratory II	5
CHEM 403	Biochemistry I	3
Approved H&S general education elective		3
Foreign language (102 level)		4
Term Hours:		15

Senior year**Fall semester**

CHEM 409 & CHEZ 409	Instrumental Analysis and Instrumental Analysis Laboratory	5
CHEM 499	Chemistry Capstone Experience	0
Approved H&S diverse and global communities		3
Approved H&S literature and civilization		3
Experiential fine arts		1-3
Term Hours:		12-14

Spring semester

CHEM 406 & CHEZ 406	Inorganic Chemistry II and Inorganic Chemistry Laboratory	5
Approved H&S general education elective		3
Open electives		8
Term Hours:		16
Total Hours:		120-122

- Chemistry (CHEM) (p. 3)
- Chemistry labs (CHEZ) (p. 5)

A minimum grade of C is required in each prerequisite course:

Course	Title	Hours
CHEM 100	Introductory Chemistry (if required through placement qualifiers)	3
CHEM 101	General Chemistry	3
CHEM 102	General Chemistry II	3
CHEM 301	Organic Chemistry	3
CHEM 302	Organic Chemistry	3
CHEM 309	Quantitative Analysis	3

In chemistry laboratories each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory, upon withdrawal or for other reasons, will incur a charge, billed from the Student Accounting Department.

Chemistry**CHEM 100. Introductory Chemistry. 3 Hours.**

Semester course; 3 lecture and 1 problem session hour. 3 credits. Prerequisite: students must be eligible to take MATH 131 or higher. A course in the elementary principles of chemistry for individuals who do not meet the criteria for enrollment in CHEM 101; required for all students without a high school chemistry background who need to take CHEM 101-102. These credits may not be used to satisfy any chemistry course requirements in the College of Humanities and Sciences.

CHEM 101. General Chemistry. 3 Hours.

Continuous courses; 3 lecture and 1 recitation hour. 3-3 credits. Prerequisite: CHEM 100 with a grade of C or higher, or high school chemistry and a satisfactory combination of Math SAT score and high school GPA. Pre- or corequisite: MATH 151. Prerequisite for CHEM 102: CHEM 101 with a grade of C or higher. Fundamental principles and theories of chemistry, including qualitative analysis.

CHEM 102. General Chemistry II. 3 Hours.

Semester course; 3 lecture and 1 recitation hours. 3 credits. Prerequisites: MATH 151, MATH 200, MATH 201 or satisfactory score on the VCU Mathematics Placement Test within the one-year period immediately preceding the beginning of the course; and CHEM 101 with a minimum grade of C. Fundamental principles and theories of chemistry, including qualitative analysis.

CHEM 110. Chemistry and Society. 3 Hours.

Semester course; 3 lecture hours. 3 credits. The basic principles of chemistry are presented through the use of decision-making activities related to real-world societal issues. Not applicable for credit toward the B.S. in Chemistry.

CHEM 112. Chemistry in the News. 3 Hours.

Semester course; 3 lecture hours. 3 credits. The basic principles of chemistry are used to interpret newspaper and magazine articles of current interest relating to chemistry in manufacturing, the global environment and medicine. Not applicable for credit toward the B.S. in Chemistry.

CHEM 301. Organic Chemistry. 3 Hours.

Continuous courses; 3 lecture hours. 3-3 credits. Prerequisite: CHEM 102 with a minimum grade of C. Prerequisite for CHEM 302: CHEM 301 with a minimum grade of C. A comprehensive survey of aliphatic and aromatic compounds with emphasis on their structure, properties, reactions, reaction mechanisms and stereochemistry.

CHEM 302. Organic Chemistry. 3 Hours.

Continuous courses; 3 lecture hours. 3-3 credits. Prerequisite: CHEM 102 with a minimum grade of C. Prerequisite for CHEM 302: CHEM 301 with a minimum grade of C. A comprehensive survey of aliphatic and aromatic compounds with emphasis on their structure, properties, reactions, reaction mechanisms and stereochemistry.

CHEM 303. Physical Chemistry. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 309 or CLSE 201 with minimum grades of C, and PHYS 202 or PHYS 208, and MATH 201 or MATH 301 or MATH 307. Ideal and nonideal gases, thermodynamics, free energy and chemical equilibrium.

CHEM 304. Physical Chemistry. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 303 with a minimum grade of C. Kinetics, solution thermodynamics, heterogeneous equilibria, electrochemistry and introductory biophysical chemistry.

CHEM 305. Physical Chemistry for the Life Sciences. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 301-302 and CHEM 309 with minimum grades of C; and MATH 200. Concepts and principles of physical chemistry as related to the life sciences, forensic science and the B.S in science programs. Major topics include thermodynamics of proteins and nucleic acids, enzyme kinetics and spectroscopic techniques useful in biophysical research such as circular dichroism, nuclear magnetic resonance and magnetic resonance imaging.

CHEM 306. Industrial Applications of Inorganic Chemistry. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 302 and CHEZ 302. Chemical engineering students: EGRC 201 and EGRC 205. A study and analysis of the most important industrial applications of inorganic chemistry, with emphasis on structure/properties correlation, materials and energy balance, availability and logistics of starting materials, economic impact and environmental effects. Crosslisted as: CLSE 306.

CHEM 309. Quantitative Analysis. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 102 with a minimum grade of C, and MATH 151. Theory and practice of gravimetric, volumetric and instrumental analysis techniques and treatment of multiple equilibria in aqueous solutions.

CHEM 310. Medicinal Chemistry and Drug Design. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: CHEM 302. This course is designed to expose undergraduate chemistry, biology and pre-medicine majors to the history, theory and practice of medicinal chemistry. The course will emphasize a combination of fundamentals and applications of drug design. In particular, the molecular aspects of drug action will be discussed. Special emphasis will also be placed on the methods used by medicinal chemists to design new drugs. Crosslisted as: MEDC 310.

CHEM 320. Inorganic Chemistry I. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 101-102 with minimum grades of C. A systematic, unified study of the structures, properties, reactions and practical applications of inorganic compounds.

CHEM 350. Guided Inquiry in Chemistry. 1.5 Hour.

Semester course; 1.5 lecture hours. 1.5 credits. Prerequisites: CHEM 101-102 with minimum grades of B. Student facilitators lead recitation sections using guided inquiry, group-based activities. Introduces students to the principles of guided inquiry, active learning and collaborative learning in chemistry through practical, hands-on class work, discussions, readings and a final project.

CHEM 351. Chemistry Preceptorship. 1.5 Hour.

Semester course; 1.5 lecture hours. 1.5 credits. Course may be repeated once for a total of 3 credits. Prerequisites: completion of relevant course with minimum grade of C, completion of CHEM 350 with a grade of B and permission of course instructor and departmental chair. Student facilitators lead recitation sections or laboratories in chemistry courses. Responsibilities vary and may include, but are not limited to, attending all classes, holding weekly review sessions or office hours and/or routine grading. A weekly reflection journal and final project are required.

CHEM 391. Topics in Chemistry. 1-4 Hours.

Semester course; variable hours. Variable credit. Maximum of 4 credits per semester; maximum total of 6 credits for all chemistry topics courses may be applied to the major. Prerequisites: CHEM 101-102 and CHEZ 101, 102. A study of a selected topic in chemistry. See the Schedule of Classes for specific topics to be offered each semester.

CHEM 392. Directed Study. 1-4 Hours.

Semester course; variable hours. 1-4 credits. May be repeated for a maximum total of 8 credits; only 3 credits are applicable to the chemistry major. Prerequisites: CHEM 102 and CHEZ 101 and 102. The independent investigation of chemical problems through readings and experimentation under the supervision of a research adviser. Written interim and final reports are required.

CHEM 398. Professional Practices and Perspectives Seminar. 1 Hour.

Semester course; 1 lecture hour. 1 credit. Prerequisites: CHEM 102 and CHEZ 102, each with a minimum grade of C. Enrollment is restricted to chemistry majors with at least sophomore standing. Seminar course for students considering careers in chemistry-related fields, covering topics such as scientific professionalism and ethics and using chemical literature.

CHEM 401. Applications of Instrumental Techniques in Organic and Forensic Chemistry. 4 Hours.

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: CHEM 302 and CHEZ 302. Theory and laboratory practice of instrumental and chemical methods applied to the analysis of organic compounds with emphasis on applications in forensic chemistry.

CHEM 403. Biochemistry I. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 302 with a minimum grade of C. A presentation of structural biochemistry, enzymology, biophysical techniques, bioenergetics and an introduction to intermediary metabolism.

CHEM 404. Biochemistry II. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: CHEM 403 with a minimum grade of C. A presentation of metabolism and its regulation as integrated catabolism and anabolism of molecules that are essential to life.

CHEM 406. Inorganic Chemistry II. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 304 and 320. An advanced study of inorganic chemistry, including inorganic spectroscopy, organometallic compounds and catalysis, and bioinorganic systems.

CHEM 409. Instrumental Analysis. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 303 and 309, and CHEZ 309. Theory and practice of modern spectrophotometric, electroanalytical and chromatographic and nuclear magnetic resonance methods.

CHEM 491. Topics in Chemistry. 1-4 Hours.

Semester course; variable hours. Variable credit. Maximum of 4 credits per semester; maximum total of 6 credits for all chemistry topics courses may be applied to the major. Prerequisites: CHEM 102 and CHEZ 101 and 102. A study of a selected topic in chemistry. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

CHEM 492. Independent Study. 1-4 Hours.

Semester course; variable hours. 1-4 credits. May be repeated for a maximum total of 8 credits; only 3 credits are applicable to the chemistry major. Prerequisites: CHEM 102 and CHEZ 101 and 102. The independent investigation of chemical problems through readings and experimentation under the supervision of a research adviser. Written interim and final reports required.

CHEM 493. Chemistry Internship. 1-3 Hours.

Semester course; variable hours. Variable credit. Maximum of 3 credits; 1 credit will be given for each 150 hours (approximately one month) of part-time or full-time chemical work experience. Prerequisites: CHEM 102 and CHEZ 101 and 102. Acquisition of chemistry laboratory experience through involvement in a professional chemistry setting. Written progress and final reports will be required.

CHEM 498. Honors Thesis. 1 Hour.

Semester course; 1 credit. Prerequisites: completion of 29 credits in chemistry, including CHEM 398 and at least six credits of CHEM 492. Students submit to the Department of Chemistry a thesis based on their independent study research. Students also present their results to the department as a research seminar.

CHEM 499. Chemistry Capstone Experience. 0 Hours.

Semester course; 0 hours. 0 credits. Prerequisites: CHEZ 302, CHEM 303 and CHEZ 303, CHEZ 309, CHEM 320, and CHEM 398, each with a minimum grade of C. Enrollment is restricted to chemistry majors with 90 credit hours of undergraduate course work. Culminating course that requires two credits of advanced laboratory and three credits of advanced lecture. The following courses qualify as a capstone experience if taken concurrently with CHEM 499: any two-credit 400-level laboratory course or two credits of either CHEM 392 or CHEM 492; and any three-credit 400-level or 500-level chemistry lecture course. Graded as pass/fail.

Chemistry labs

CHEZ 101. General Chemistry Laboratory I. 1 Hour.

Semester course; 1 lecture and 2 laboratory hours. 1 credit. Pre- or corequisite: CHEM 101. Experimental work correlated with CHEM 101 with selected forensic science applications. Each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory upon withdrawal or for other reasons will incur a charge billed from the Student Accounting Department.

CHEZ 102. General Chemistry Laboratory II. 1 Hour.

Semester course; 1 lecture and 2 laboratory hours. 1 credit. Prerequisites: CHEM 101 and CHEZ 101 with minimum grades of C. Pre- or corequisite: CHEM 102. Experimental work includes qualitative analysis with selected forensic science applications. Each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory upon withdrawal or for other reasons will incur a charge billed from the Student Accounting Department.

CHEZ 110. Chemistry and Society Laboratory. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Pre- or corequisite: CHEM 110. Experimental work correlated with CHEM 110. Not applicable for credit toward the B.S. in Chemistry. Each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory upon withdrawal or for other reasons will incur a charge billed from the Student Accounting Department.

CHEZ 301. Organic Chemistry Laboratory I. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 102 and CHEZ 102 with minimum grades of C. Pre- or corequisite: CHEM 301. Experimental work correlated with CHEM 301. Each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory upon withdrawal or for other reasons will incur a charge billed from the Student Accounting Department.

CHEZ 302. Organic Chemistry Laboratory II. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 301 and CHEZ 301 with minimum grades of C. Pre- or corequisite: CHEM 302. Experimental work correlated with CHEM 302. Each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory upon withdrawal or for other reasons will incur a charge billed from the Student Accounting Department.

CHEZ 303. Physical Chemistry Laboratory I. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 102 and CHEZ 102. Pre- or corequisites: CHEM 303, 309 and CHEZ 309. This course covers experiments in calorimetry, molecular and thermodynamic properties of gases and liquids, surfaces, electrochemistry, equilibria, polymers, phase diagrams, and biophysical chemistry. Extensive report writing, laboratory notebook writing and statistical analysis of data are emphasized. A final project may be required.

CHEZ 304. Physical Chemistry Laboratory II. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 303, 309 and CHEZ 303, 309. Pre- or corequisite: CHEM 304. This course covers experiments in absorption and emission spectroscopy, infrared and Raman spectroscopy, NMR spectroscopy, kinetics, photochemistry, biophysical chemistry and modeling. Report writing, laboratory notebook writing and statistical analysis of data are emphasized. A final project may be required.

CHEZ 309. Quantitative Analysis Laboratory. 2 Hours.

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisites: CHEM 102 and CHEZ 102 with minimum grades of C. Pre- or corequisite: CHEM 309. Laboratory associated with quantitative analysis. Includes practice in volumetric and instrumental laboratory techniques as applied to measurement sciences.

CHEZ 406. Inorganic Chemistry Laboratory. 2 Hours.

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisites: CHEM 320 and CHEZ 102. Pre- or corequisite: CHEM 406. Examination of inorganic nonmetal, transition metal and organometallic compounds using modern inorganic methods of synthesis and characterization. Each student is charged for breakage incurred. Approved safety glasses are required. Failure to check out of laboratory upon withdrawal or for other reasons will incur a charge billed from the Student Accounting Department.

CHEZ 409. Instrumental Analysis Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 302, 304 and 309 with minimum grades of C; CHEZ 303 and 309 with minimum grades of C. Pre- or corequisite: CHEM 409. Practice of electrochemical, spectroscopic and chromatographic methods of analysis.