

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

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 biochemistry concentration focuses on the biological aspects of chemistry, including molecular genetics and molecular biotechnology. This degree is another option for students planning to study medicine or dentistry.

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 46-47 credits in chemistry and related courses and 27-29 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
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 for Chemistry, Bachelor of Science (B.S.) with a concentration in biochemistry

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

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Course offered by the School of the Arts

Collateral requirements

Course	Title	Hours
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	4
BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	4
BIOL 300	Cellular and Molecular Biology	3
MATH 200 & MATH 201	Calculus with Analytic Geometry I and Calculus with Analytic Geometry II	8
Select one of the following:		8-10
PHYS 201 & PHYS 202	General Physics I and General Physics II	
PHYS 207 & PHYS 208	University Physics I and University Physics II	
STAT 210 or STAT 212	Basic Practice of Statistics (fulfills quantitative literacy) Concepts of Statistics	3
Total Hours		27-29

Major requirements

Course	Title	Hours
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 309 & CHEZ 309	Quantitative Analysis and Quantitative Analysis Laboratory	5
CHEM 313 or CHEM 314	Physical Chemistry I 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 403	Biochemistry I	3
CHEM 404	Biochemistry II	3
CHEZ 313 or CHEZ 315	Physical Chemistry Laboratory I ¹ Physical Chemistry Laboratory II	2
Capstone		
CHEM 499	Chemistry Capstone Experience	0
Choose at least one two-credit 400-level CHEZ course or two credits of CHEM 392 or CHEM 492 in addition to CHEM 404.		2
Chemistry elective		
Choose at least one three-credit elective from the list below		3
Total Hours		46-47

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Students may receive credit toward graduation for only one of CHEZ 313 or CHEZ 315.

Open electives

Course	Title	Hours
Select zero to 15 credits		0-15

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

Chemistry electives

Course	Title	Hours
BIOL 310	Genetics	3
CHEM 310	Medicinal Chemistry and Drug Design	3
CHEM 406	Inorganic Chemistry II	3
CHEZ 406	Inorganic Chemistry Laboratory	2
CHEM 409 & CHEZ 409	Instrumental Analysis and Instrumental Analysis Laboratory	5
CHEM 492 or CHEM 392	Independent Study Directed Study	3
CHEM 504	Advanced Organic Chemistry I	3
CHEM 507	Introduction to Natural Products	3
CHEM 512	Applied Molecular Modeling	3

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
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	4
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
MATH 200	Calculus with Analytic Geometry I	4
UNIV 111	Focused Inquiry I	3
Play course video for Focused Inquiry I		
Term Hours:		15

Spring semester

BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	4
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
UNIV 112	Focused Inquiry II	3
Play course video for Focused Inquiry II		
Term Hours:		16

Sophomore year

Fall semester		Hours
CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5

CHEM 398	Professional Practices and Perspectives Seminar	1
PHYS 201 or PHYS 207	General Physics I or University Physics I	4-5
STAT 210 or STAT 212	Basic Practice of Statistics or Concepts of Statistics	3
UNIV 200	Inquiry and the Craft of Argument	3
Term Hours:		16-17

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
PHYS 202 or PHYS 208	General Physics II or University Physics II	4-5
Term Hours:		14-15

Junior year**Fall semester**

BIOL 300	Cellular and Molecular Biology	3
CHEM 313 or CHEM 314	Physical Chemistry I or Physical Chemistry I with Math Modules	3-4
CHEZ 313	Physical Chemistry Laboratory I (if taken) ¹	0-2
Approved H&S science and technology		3
Foreign language (101 level)		4
Term Hours:		13-16

Spring semester

CHEM 315	Physical Chemistry II	3
CHEM 320	Inorganic Chemistry I	3
CHEZ 315	Physical Chemistry Laboratory II (if taken) ¹	0-2
Approved H&S human, social and political behavior		3
Foreign language (102 level)		4
Term Hours:		15

Senior year**Fall semester**

CHEM 403	Biochemistry I	3
Approved H&S diverse and global communities		3
Approved H&S general education elective		3
Chemistry electives		3
Open electives		4
Term Hours:		16

Spring semester

CHEM 404	Biochemistry II	3
CHEM 499	Chemistry Capstone Experience ²	0
Approved H&S general education elective		3
Approved H&S literature and civilization		3
Chemistry electives		2
Experiential fine arts		1-3

Open electives	3
Term Hours:	15-17
Total Hours:	120-127

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

1

Students may receive credit toward graduation for only one of CHEZ 313 or CHEZ 315.

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Choose at least one two-credit 400-level CHEZ course or two credits of CHEM 392 or CHEM 492 in addition to CHEM 404.

- 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 I	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 I. 3 Hours.

Semester course; 3 lecture and 1 recitation hours. 3 credits. Prerequisites: MATH 141, 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 100 with a minimum grade of B or satisfactory score on the chemistry placement exam/assessment within the one-year period immediately preceding the beginning of the course. Fundamental principles and theories of chemistry.

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 CHEM 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 313. Physical Chemistry I. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 201; MATH 307; PHYS 202 or PHYS 208; CHEM 302; and CHEM 309, all with a minimum grade of C. Quantum chemistry, atomic and molecular structure, spectroscopy. Students may receive credit toward graduation for only one of CHEM 313 or CHEM 314.

CHEM 314. Physical Chemistry I with Math Modules. 4 Hours.

Semester course; 3 lecture and 1 recitation hours. 4 credits. Prerequisites: MATH 201; PHYS 202 or PHYS 208; CHEM 302; and CHEM 309, all with a minimum grade of C. Quantum chemistry, atomic and molecular structure, spectroscopy. Presents multivariate calculus concepts necessary for physical chemistry. Students may receive credit toward graduation for only one of CHEM 313 or CHEM 314.

CHEM 315. Physical Chemistry II. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: CHEM 313 or CHEM 314 with a minimum grade of C. Kinetic theory of gases, statistical and classical thermodynamics, kinetics.

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 CHEM 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 313. Physical Chemistry Laboratory I. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEZ 309 and UNIV 200, each with a minimum grade of C. Corequisite: CHEM 313 or CHEM 314. Mathematical models of chemistry, including molecular structure, spectroscopy and kinetics. Report writing, laboratory notebook writing and statistical analysis of data are emphasized. A final project may be required. Students may receive credit toward graduation for only one of CHEZ 313 or CHEZ 315.

CHEZ 315. Physical Chemistry Laboratory II. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEZ 309 and UNIV 200, each with a minimum grade of C. Corequisite: CHEM 315. Mathematical models of chemistry, including thermodynamics, spectroscopy and kinetics. Report writing, laboratory notebook writing and statistical analysis of data are emphasized. A final project may be required. Students may receive credit toward graduation for only one of CHEZ 313 or CHEZ 315.

CHEZ 400. Exploring the Frontiers of Chemistry: Research Methods. 2 Hours.

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisites: CHEM 302 and CHEZ 302; CHEM 315 and CHEZ 315; CHEM 320; and CHEM 398, all with a minimum grade of C. Enrollment is restricted to students with 90 undergraduate credit hours. Introduction to the process of performing cutting-edge research in chemistry through the design, execution and presentation of a research project. A final presentation is required.

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 313 or CHEM 314; and CHEZ 313 or CHEZ 315, each with a minimum grade of C. Corequisite: CHEM 409. Practice of electrochemical, spectroscopic and chromatographic methods of analysis.

CHEZ 413. Advanced Physical Chemistry Laboratory. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 313 or CHEM 314; CHEM 315; and CHEZ 313 or CHEZ 315, all with a minimum grade of C. Atomic and molecular spectroscopy and structure. Report writing, laboratory notebook writing and statistical analysis of data are emphasized. A final project and presentation are required.

CHEZ 451. Developing Instructional Experiments in Chemistry. 2 Hours.

Semester course; 4 laboratory hours. 2 credits. Prerequisite: CHEM 351 with a minimum grade of C. Student preceptors help lead a general chemistry laboratory section and select an experiment to develop for a chemistry laboratory course. A final project and presentation focused on experiment development is required.