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.

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

Professional chemist concentration-specific outcome

- Demonstrate advanced laboratory skills

Special requirements

Students must complete 48-49 credits in chemistry and 28-36 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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 100</td>
<td>Introductory Chemistry (if required through placement qualifiers)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
</tbody>
</table>

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
or CHEM 314 Physical Chemistry I with Math Modules 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 professional chemist

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select 30 credits of general education courses in consultation with an adviser.</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

Major requirements

- Major core requirements
  - CHEM 102    General Chemistry II and General Chemistry Laboratory II 4
  - CHEM 301    Organic Chemistry and Organic Chemistry Laboratory I 5
  - CHEM 302    Organic Chemistry and Organic Chemistry Laboratory II 5
  - CHEM 309    Quantitative Analysis and Quantitative Analysis Laboratory 5
  - CHEM 313    Physical Chemistry I or CHEM 314 Physical Chemistry I with Math Modules 3-4
  - CHEZ 313    Physical Chemistry Laboratory I 2
  - CHEM 315    Physical Chemistry II 3
  - CHEM 320    Inorganic Chemistry I 3
  - CHEM 398    Professional Practices and Perspectives Seminar 1

- Concentration requirements
  - CHEZ 413    Advanced Physical Chemistry Laboratory 2

- 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
  - Major electives
    - Select from the list below. 10

Ancillary requirements

CHEM 499    Chemistry Capstone Experience 1 0
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 or CHEM 492 and at least one three-credit 400- or 500-level CHEM course from the electives listed below.

Course offered by the School of the Arts

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

### Major electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM/CLSE 306</td>
<td>Industrial Applications of Inorganic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM/MEDC 310</td>
<td>Medicinal Chemistry and Drug Design</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 391</td>
<td>Topics in Chemistry</td>
<td>1-4</td>
</tr>
<tr>
<td>CHEM 392</td>
<td>Directed Study</td>
<td>1-4</td>
</tr>
<tr>
<td>CHEM 403</td>
<td>Biochemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 404</td>
<td>Biochemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEZ 404</td>
<td>Biochemistry Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>CHEM 406</td>
<td>Inorganic Chemistry</td>
<td>5</td>
</tr>
<tr>
<td>&amp; CHEZ 406</td>
<td>Inorganic Chemistry Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 409</td>
<td>Instrumental Analysis</td>
<td>5</td>
</tr>
<tr>
<td>&amp; CHEZ 409</td>
<td>Instrumental Analysis Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 491</td>
<td>Topics in Chemistry</td>
<td>1-4</td>
</tr>
<tr>
<td>CHEM 492</td>
<td>Independent Study</td>
<td>1-4</td>
</tr>
<tr>
<td>CHEM 493</td>
<td>Chemistry Internship</td>
<td>1-3</td>
</tr>
<tr>
<td>CHEM 504</td>
<td>Advanced Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 507</td>
<td>Introduction to Natural Products</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 510</td>
<td>Atomic and Molecular Structure</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 511</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 512</td>
<td>Applied Molecular Modeling</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 520</td>
<td>Advanced Inorganic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEZ 400</td>
<td>Exploring the Frontiers of Chemistry</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Research Methods</td>
<td></td>
</tr>
<tr>
<td>CHEZ 404</td>
<td>Biochemistry Laboratory</td>
<td>2</td>
</tr>
</tbody>
</table>

These five courses are necessary 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.

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 101 &amp; CHEZ 101</td>
<td>General Chemistry I and General Chemistry Laboratory I</td>
<td>4</td>
</tr>
<tr>
<td>HUMS 202</td>
<td>Choices in a Consumer Society</td>
<td>1</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 307</td>
<td>Multivariate Calculus</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 207 &amp; PHYS 208</td>
<td>University Physics I and University Physics II</td>
<td>10</td>
</tr>
</tbody>
</table>

Experiential fine arts

Foreign language through the 102 level (by course or placement)

Open electives

Select any course.

**Total Hours:** 120

**Term Hours:** 15

### Sophomore year

#### Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 301 &amp; CHEZ 301</td>
<td>Organic Chemistry and Organic Chemistry Laboratory I</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 309 &amp; CHEZ 309</td>
<td>Quantitative Analysis and Quantitative Analysis Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>MATH 307</td>
<td>Multivariate Calculus</td>
<td>4</td>
</tr>
</tbody>
</table>

**Term Hours:** 16
### Total Hours: 120-123

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.

1. Required for American Chemical Society Certification.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 100</td>
<td>Introductory Chemistry (if required through placement qualifiers)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 102</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 301</td>
<td>Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 302</td>
<td>Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 309</td>
<td>Quantitative Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

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 139, 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 139, 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 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 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 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 308. Intensified Problem-solving in Quantitative Analysis. 2 Hours.
Semester course; 4 workshop hours. 2 credits. Prerequisites: CHEM 102 with a minimum grade of C; and MATH 151 or MATH 200. Corequisite: CHEM 309. Designed to improve student comprehension and success in CHEM 309 and CHEZ 309. Problem-solving sessions encompass the fundamental topics in chemical analysis that involve the theory and practice of gravimetric, volumetric and instrumental analysis techniques, including the treatment of multiple equilibria in aqueous solutions. Students form and work in small in-class study groups where they engage in cooperative learning activities as facilitated by the instructor. Each student participates in the discussion and presentation of problem solutions to the class. Students are given mock quizzes and exams and receive assistance on homework problems assigned in the quantitative chemistry lecture.

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 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; 1-4 independent study hours. 1-4 credits. Prerequisites: CHEM 102, CHEZ 101 and CHEZ 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 313 or CHEM 314; and CHEM 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 313, CHEM 314 or CHEM 315; and CHEM 309 and CHEZ 309. Theory and practice of modern spectrophotometric, electroanalytical and chromatographic and nuclear magnetic resonance methods.

**CHEM 411. 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 491. 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 492. Independent Study. 1-4 Hours.**
Semester course; variable hours. 1-4 credits. Prerequisites: CHEM 102 and CHEZ 102 with minimum grades of C. Pre- or corequisite: CHEM 493 or CHEM 492; 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 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 CHEM 101 and 102. 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 or HONR 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 309 and CHEZ 309; 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 404. Biochemistry Laboratory. 2 Hours.
Semester course; 4 laboratory hours. 2 credits. Prerequisites: CHEM 403; CHEZ 302; and CHEZ 313 or CHEZ 315; each with a minimum grade of C. Corequisite: CHEM 404. Fundamental biochemistry laboratory techniques. Report and laboratory notebook writing are emphasized. 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; and CHEZ 313; all with a minimum grade of C. Corequisite: CHEM 315. 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.