

# 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 |
|---|-------|-------|
| General education ( <a href="http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/">http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/</a> ) |       |       |
| Select 12-13 credits from general education foundations and 17-18 credits from areas of inquiry.  |       | 30    |

### Major requirements

#### • 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 |
|--|---|

### Ancillary requirements

|   |   |       |
|---|---|-------|
| 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<br>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 |
| Total Hours   |   | 120   |

1

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.

2

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 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 413 | Advanced Physical Chemistry Laboratory                 | 2   |
| CHEZ 451 | Developing Instructional Experiments in Chemistry      | 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   | Focused Inquiry I (satisfies general education UNIV foundations)  | 3     |
| Play course  | video for Focused Inquiry I   |       |
| General education course (select AOI for global perspectives)  |   | 3     |
| General education course (select BOK to complete breadth of knowledge requirement and AOI for diversities in the human experience) |   | 3     |
| Term Hours:  |   | 17    |

### 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 II                                | 4  |
| STAT 210            | Basic Practice of Statistics                                      | 3  |
| UNIV 112            | Focused Inquiry II (satisfies general education UNIV foundations) | 3  |
| Play course         | video for Focused Inquiry II                                      |    |
| Term Hours:         |   | 15 |

### Sophomore year

| Fall semester       |  | Hours |
|---------------------|--|-------|
| 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<br>or<br>PHYS 207  | General Physics I (either satisfies AOI for scientific and logical reasoning) or University Physics I | 4-5     |
| UNIV 200  | Inquiry and the Craft of Argument (satisfies general education UNIV foundations)                      | 3       |
| Term Hours:   |   | 17-18   |
| <b>Spring semester</b>  |   |         |
| CHEM 302<br>& 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<br>or<br>PHYS 208  | General Physics II or University Physics II   | 4-5     |
| Term Hours:   |   | 13-14   |
| <b>Junior year</b>  |   |         |
| <b>Fall semester</b>  |   |         |
| CHEM 313<br>or<br>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 (select BOK to complete breadth of knowledge requirement and AOI for creativity, innovation and aesthetic inquiry) |   | 3       |
| Open elective   |   | 3       |
| Term Hours:   |   | 14-15   |
| <b>Spring semester</b>  |   |         |
| CHEM 315  | Physical Chemistry II   | 3       |
| Foreign language 102  |   | 3       |
| Open electives  |   | 9       |
| Term Hours:   |   | 15      |
| <b>Senior year</b>  |   |         |
| <b>Fall semester</b>  |   |         |
| CHEM 499  | Chemistry Capstone Experience <sup>1</sup>  | 0       |
| Major electives (for capstone) <sup>1</sup>   |   | 5       |
| Open electives  |   | 9       |
| Term Hours:   |   | 14      |
| <b>Spring semester</b>  |   |         |
| Experiential fine arts  |   | 1-3     |
| Open electives  |   | 14      |
| Term Hours:   |   | 15-17   |
| Total Hours:  |   | 120-125 |

1

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 |

- Chemistry (CHEM) (p. 4)
- Chemistry labs (CHEZ) (p. 6)

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 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; 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 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 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, CHEZ 309, CHEM 320, CHEM 398, CHEM 313 or CHEM 314, and CHEZ 313 or CHEZ 315, 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 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.

**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.