

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

Learning outcomes

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

- Demonstrate broad and core science proficiency
- Demonstrate competency in at least two sciences or in a non-science area
- Apply learning to selection and pursuit of professional or graduate career objective
- Demonstrate proficiency in communication of scientific or research findings
- Demonstrate ability to apply the scientific method/approach to professional problems
- Demonstrate appreciation of the interrelation of core sciences to interdisciplinary problems

Special requirements

The Bachelor of Science in Science requires a minimum of 120 credits.

Along with the general education requirements of the undergraduate programs and the College of Humanities and Sciences for a Bachelor of Science degree, this curriculum requires 29 to 33 credits in foundation science and mathematics courses and 33 to 34 credits in supplemental courses in the concentration. In preparation for the required mathematical sciences courses, all students must take the Mathematics Placement Test. Science majors are strongly encouraged to select a minor in an area different from their area of concentration that will complement their career interests and contribute additional upper-level credits to their curriculum.

Science majors declaring the chemistry concentration may not simultaneously declare a major or minor in chemistry.

Grade requirements

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

Course	Title	Hours
CHEM 100	Introductory Chemistry (if required through placement test)	3
CHEM 101	General Chemistry I	3
CHEM 102	General Chemistry II	3
CHEM 301	Organic Chemistry	3
CHEM 302	Organic Chemistry	3

A minimum grade of C is required in the following courses before enrollment in advanced BIOL courses:

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

Degree requirements for Science, Bachelor of Science (B.S.) with a concentration in chemistry

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

Major requirements

Course	Title	Hours
Foundational courses		
Select one of the following:		4
BIOL 101 & BIOZ 101	Biological Concepts and Biological Concepts Laboratory	
BIOL/ENVS 103	Environmental Science	
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	

BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	4
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
ENVS 301	Introduction to Meteorology (or upper- level natural or health science elective from list below)	3
ENVS 310	Introduction to Oceanography (or upper-level natural or health science elective from list below)	2-3
INSC 490	Capstone Research Experience in Interdisciplinary Science (or an approved capstone from another natural science major from list below)	1-3
MATH 151	Precalculus Mathematics (or placement)	4
MATH 200	Calculus with Analytic Geometry I	4
PHYS 201 or PHYS 207	General Physics I University Physics I	4-5
STAT 208 or STAT 210	Statistical Thinking Basic Practice of Statistics	3
Supplemental courses		
Select one of the following:		4
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	
BIOL 201 & BIOZ 201	Human Biology and Human Biology Laboratory	
Select one of the following:		3
BIOL 317	Ecology	
ENVS/PHYS 315	Energy and the Environment	
BIOL 332/ ENVS 330	Environmental Pollution	
Or upper-level natural science elective from list below		
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
Select one of the following:		4
ENVS 105 & URSZ 204	Physical Geology and Physical Geography Laboratory	
URSP 204 & URSZ 204	Physical Geography and Physical Geography Laboratory	
Or a 200-level or higher natural science elective and a 200- level or higher natural science laboratory elective from the list below		
PHYS 202 or PHYS 208	General Physics II University Physics II	4-5
Total Hours		63-68

Open electives

Course	Title	Hours
Select seven-26 open elective credits		7-26
Total Hours		7-26

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

Natural science electives

Course	Title	Hours
LFSC 301	Integrative Life Sciences Research	3
LFSC 401	Faith and Life Sciences	3
PHTX 400	Drugs and Their Actions	3
Any 200-level or higher BIOL, BNFO, CHEM, CLSE, EGRB, ENVS, FRSC, INSC or PHYS course, except:		
BIOL 392	Introduction to Research	
BIOL 475	Biology Capstone Seminar: ____	
BIOL 477	Biology Capstone Experience	
BIOL 489	Communicating Research	
BIOL 490	Presenting Research	
BIOL 492	Independent Study	
BIOL 493	Biology Internship	
BIOL 495	Research and Thesis	
BIOL 496	Biology Preceptorship: ____	
BNFO 292	Independent Study	
BNFO 492	Independent Study	
BNFO 496	Undergraduate Teaching Assistantship in Bioinformatics	
CHEM 392	Directed Study	
CHEM 492	Independent Study	
CHEM 493	Chemistry Internship	
ENGR 490	Engineering Seminar	
ENGR 492	Independent Study in Engineering	
ENVS 490	Research Seminar in Environmental Studies	
ENVS 492	Independent Study	
ENVS 493	Environmental Studies Internship	
FRSC 490	Professional Practices in Forensic Science	
FRSC 492	Forensic Science Independent Study	
FRSC 493	Forensic Science Internship	
INSC 490	Capstone Research Experience in Interdisciplinary Science	
PHYS 490	Seminar in Conceptual Physics	
PHYS 492	Independent Study	

Natural science laboratory electives

Course	Title	Hours
BIOL 205	Basic Human Anatomy ¹	4
BIOL 309	Entomology ¹	4
BIOL 320	Biology of the Seed Plant ¹	4
BIOL 402	Comparative Vertebrate Anatomy ¹	5
BIOL 417	Mammalogy ¹	4
BIOL 435	Herpetology ¹	3
BIOL 445	Neurobiology and Behavior ¹	4

BIOL 503	Fish Biology ¹	4
BIOZ: any 200-level or higher course		
BNFO 380	Introduction to Mathematical Biology ¹	4
BNFO 420	Applications in Bioinformatics ¹	3
BNFO 440	Computational Methods in Bioinformatics ¹	3
CHEZ: any 200-level or higher course		
EGRB 307	Biomedical Instrumentation ¹	4
EGRB 308	Biomedical Signal Processing ¹	4
EGRB 310	Biomechanics ¹	4
ENVZ 335	Environmental Geology Laboratory	1
FRSZ: any 200-level or higher course		
PHIZ 206	Human Physiology Laboratory	1
PHYS 202	General Physics II ¹	4
PHYS 208	University Physics II ¹	5
PHYZ 320	Modern Physics Laboratory	1

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Courses have a combined lecture and lab and will satisfy both natural science lecture and laboratory requirements.

Health science electives

Course	Title	Hours
AFAM/ANTH/INTL/ GSWS 309	Gender and Global Health	3
AFAM 310	Black Health Matters: Social Determinants of Health in the African American Community	3
AFAM 401	African-Americans and the U.S. Health Care System	3
GSWS 392	Women's Health Care Across the Life Span	3
HPEX 325	Pathology and Pharmacology in Athletic Training	3
HPEX 345	Nutrition for Health and Disease	3
HPEX 350	Nutrition	3
HPEX 353	Disease Trends, Prevention and Control	3
HPEX 373	Structural Kinesiology	3
HPEX 374	Musculoskeletal Structure and Movement	4
HPEX 375	Physiology of Exercise	3
HPEX 440	Chronic Disease and Exercise Management	3
PSYC 401	Physiological Psychology	3
PSYC 412	Health Psychology	3
PSYC/GSWS 414	Psychology of Women's Health	3
SCTS 300	Introduction to Science and Technology Studies	3
SCTS 301	Illness Narratives	3
SCTS 392	Revolutions in Science I	3
SCTS 393	Revolutions in Science II	3
SCTS 397	Genetics and Society: 1865 to the Present	3

SCTS 398	History of Medicine and Public Health:	3
SOCY 344	Medical Sociology	3

Natural science capstones (approved for chemistry concentration)

Course	Title	Hours
BNFO 420	Applications in Bioinformatics	3
CHEM 398	Professional Practices and Perspectives Seminar	1
CLSE 402 & CLSE 403	Senior Design Studio I (Laboratory/Project Time) and Senior Design Studio II (Laboratory/Project Time)	4
EGRB 402	Biomedical Engineering Senior Design Studio	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
MATH 151 Precalculus Mathematics (or placement)	4
CHEM 101 & CHEZ 101 General Chemistry I and General Chemistry Laboratory I (or placement)	4
UNIV 101 Introduction to the University	1
UNIV 111 Focused Inquiry I	3
Play course video for Focused Inquiry I	
Approved diverse and global communities	3
Term Hours:	15

Spring semester	Hours
CHEM 102 & CHEZ 102 General Chemistry II and General Chemistry Laboratory II	4
HUMS 202 Choices in a Consumer Society	1
MATH 200 Calculus with Analytic Geometry I	4
UNIV 112 Focused Inquiry II	3
Play course video for Focused Inquiry II	
Approved human, social and political behavior	3
Term Hours:	15

Sophomore year

Fall semester	Hours
Select one of the following:	4
BIOL 101 & BIOZ 101 Biological Concepts and Biological Concepts Laboratory	-
BIOL 103 or ENVS 103 Environmental Science or Environmental Science	-
BIOL 151 & BIOZ 151 Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	-

CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
UNIV 200	Inquiry and the Craft of Argument	3
Experiential fine arts		1-3
Term Hours:		13-15

Spring semester

Select one of the following:		4
BIOL 201 & BIOZ 201	Human Biology and Human Biology Laboratory	-
BIOL 152 & BIOZ 152	Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II	-
CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
STAT 208 or STAT 210	Statistical Thinking or Basic Practice of Statistics	3
Approved literature and civilization		3
Term Hours:		15

Junior year**Fall semester**

CHEM 309 & CHEZ 309	Quantitative Analysis and Quantitative Analysis Laboratory	5
PHYS 201 or PHYS 207	General Physics I or University Physics I	4-5
Approved general education elective		3
Foreign language (101), upper-level open elective or minor elective		3-4
Term Hours:		15-17

Spring semester

ENVS 301	Introduction to Meteorology (or upper-level science elective)	3
PHYS 202 or PHYS 208	General Physics II or University Physics II	4-5
Approved science and technology		3-4
Foreign language (102), upper-level open elective or minor elective		3-4
Upper-level open elective or minor elective		3
Term Hours:		16-19

Senior year**Fall semester**

BIOL 317 or ENVS 315 or PHYS 315 or BIOL 332 or ENVS 330	Ecology or Energy and the Environment or Energy and the Environment or Environmental Pollution or Environmental Pollution	3
ENVS 105 or URSP 204	Physical Geology or Physical Geography	3
URSZ 204	Physical Geography Laboratory	1

Approved general education elective	3
Upper-level open elective or minor electives	6
Term Hours:	16

Spring semester

ENVS 310	Introduction to Oceanography (or upper- level science elective)	3
Select one of the following:		1-3
INSC 490	Capstone Research Experience in Interdisciplinary Science	-
Or approved capstone from another science major (biology, chemistry or physics)		-
Upper-level open electives or minor electives		12
Term Hours:		16-18
Total Hours:		121-130

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

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 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 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.