CHEMISTRY (CHEM)

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 catoblism and anoblism 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.

CHEM 504. Advanced Organic Chemistry I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. An integrated study of certain free radical and ionic reaction mechanisms with emphasis on electronic effects and stereochemical consequences of these reactions.

CHEM 506. Introduction to Spectroscopic Methods in Organic Chemistry. 1.5 Hour.
Half-semester course; 3 lecture hours. 1.5 credits. Introduction to mass spectrometry, infrared and 1D 1H and 13C NMR spectroscopy, theory and practice in the elucidation of organic structures.

CHEM 507. Introduction to Natural Products. 3 Hours.
Semester course; 3 lecture hours. 3 credits. A study of the biosynthetic origins, isolation, structure elucidation and uses of naturally occurring organic compounds. Emphasis is placed upon three major classes of compounds, carboaromatics, terpenes and alkaloids.

CHEM 510. Atomic and Molecular Structure. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301 and PHYS 208. Survey of the pertinent aspects of quantum mechanics. Line spectra, atomic structure and molecular bonding.

CHEM 511. Chemical Thermodynamics and Kinetics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The concepts and principles of thermodynamics and their application to chemical problems. The rates and mechanisms of chemical reactions including collision and transition state theories.

CHEM 512. Applied Molecular Modeling. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Atomistic and coarse-grained force fields. Principles behind molecular simulations. Molecular dynamics and Monte Carlo approaches to problems in chemistry, molecular physics, biophysics and nanoscience. Thermodynamic and transport properties. Free energy calculations and rare event dynamics. Hands-on introduction to basic programming and operating systems. Suggested background: physical chemistry (CHEM 303) or thermodynamics with elements of statistical mechanics (PHYS 340, CHEM 511 or CHEM 612).

CHEM 520. Advanced Inorganic Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The application of modern physical techniques for the determination of the symmetry, molecular structure, bonding and reaction mechanisms of inorganic compounds.

CHEM 532. Advanced Analytical Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Theories and principles of thermodynamics and kinetics relevant to analytical methods, including acid-base, redox, and metal complexation equilibria, nonaqueous systems, kinetics and an introduction to surface chemistry.

CHEM 550. Introduction to Polymer Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. A study of macromolecular compounds that includes classifications, methods of preparation, mechanisms, stereochemistry and applications. Physical characterizations, such as structure and property correlations, kinetics, thermodynamics, and molecular weight determinations are emphasized.

CHEM 580. Mechanical Properties of Plastics and Polymers. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course provides a link between the more practical aspects of plastics and the fundamental properties of the polymers from which they are made. Topics covered deal with the structure of polymers with emphasis on relationships with mechanical properties; rubber elasticity; the glass transition and other secondary transitions; time and temperature dependency; yield and fracture; crystallization and morphology; influence of polymer processing on mechanical properties.

CHEM 591. Topics in Chemistry. 1-6 Hours.
Semester course; variable hours. 1-6 credits per semester. Maximum total of 9 credits for all topics courses. An in-depth study of a selected topic in chemistry. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

CHEM 604. Advanced Organic Chemistry II. 3 Hours.
Semester course; 3 lecture hours. 3 credits. An integrated study of the mechanism and stereochemistry of organic reactions and their application to organic synthesis. Emphasis is placed on addition and condensation reactions, carbanions, carbines, and other reactive intermediates.

CHEM 605. Physical Organic Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The theory and application of physical methods in the study of the behavior of organic compounds. Topics covered include homogeneous kinetics, equilibria, acid-base catalysis, and the quantitative correlation of structure and reactivity as they apply to the understanding of the mechanisms of organic reactions.

CHEM 606. Advanced Spectroscopic Methods in Organic Chemistry. 1.5 Hour.
Half-semester course; 3 lecture hours. 1.5 credits. Prerequisite: CHEM 506 or permission of instructor. Advanced spectroscopic techniques including 2-D, multinuclear and solid state NMR; theory and practice in the education of organic structures.

CHEM 610. Applied Quantum Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Quantum mechanics applied to chemical problems in UV, IR and NMR spectroscopy and the electronic structures of atoms and molecules; development of the self-consistent field equations. Suggested background: CHEM 510.

CHEM 611. Molecular Spectroscopy. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course teaches the interaction of radiation and molecules; the rotation, vibration and electronic motion of molecules; molecular spectra and recent developments in laser spectroscopy. Suggested background: CHEM 510.

CHEM 612. Modern Statistical Mechanics: Fundamentals and Applications. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Fundamental topics in modern equilibrium and non-equilibrium statistical mechanics, with applications to selected chemical, physical and biological systems. Suggested background: CHEM 510 and 511.

CHEM 615. Chemical Thermodynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The study of the laws of thermodynamics and their application to pure phases, solutions and changes in state.

CHEM 616. Chemical Kinetics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. A study of the rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases and theories of catalysis.

CHEM 620. Advanced Inorganic Chemistry I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The application of modern physical techniques for the determination of the symmetry, molecular structure, bonding and reaction mechanisms of inorganic compounds.

CHEM 621. Advanced Inorganic Chemistry II. 3 Hours.
Semester course; 3 lecture hours. 3 credits. . A coordinated study of synthetic methods, stereochemistry and reaction mechanisms including catalysis of inorganic, organometallic and bioinorganic compounds. Suggested background: CHEM 620.

CHEM 622. Solid State and Materials Chemistry. 1.5 Hour.
Semester course; 1.5 lecture hours. 1.5 credits. Prerequisite: CHEM 320. This course will present amorphous and crystalline solids, crystal structures, unit cells and packing, Miller indices, crystallographic directions and planes, crystal defects and non-stoichiometric compounds, phase diagrams and solid solutions, band structure and theory, sol-gel chemistry, powder X-ray diffraction, and X-ray crystallography.

CHEM 630. Electroanalytical Chemistry. 1.5 Hour.
Modular course; 3 lecture hours. 1.5 credits per module. Presents the theory and application of electroanalytical techniques including cyclic voltammetry, potential step methods and microelectrode voltammetry. Suggested background: CHEM 409 or equivalent experience.

CHEM 631. Separation Science. 1.5 Hour.
Modular course; 3 lecture hours. 1.5 credits per module. Students discuss theories and principles of separation science as applied to chemical problems with emphasis on current techniques, instrumentation and applications. Suggested background: CHEM 409 or equivalent experience.

CHEM 632. Chemometrics. 1.5 Hour.
Modular course; 3 lecture hours. 1.5 credits per module. Computer methods for experimental design and data analysis of spectroscopic, electrochemical and chromatograph data. Topics include sampling theory, detection limits, curve resolution, Fourier transform-based instruments and factor analysis. Suggested background: CHEM 409 or equivalent experience.

CHEM 633. Mass Spectrometry. 1.5 Hour.
Modular course; 3 lecture hours. 1.5 credits per module. Topics include mass spectrometry ionization methods, mass analyzers, theory and applications for ion structure determination. Suggested background: CHEM 409 or equivalent experience.

CHEM 634. Surface Science. 1.5 Hour.
Modular course; 3 lecture hours. 1.5 credits per module. Topics include types of surfaces requiring surface analysis, electron-surface scattering (AES, UPS, XPS, HREELS, LEED, STM, SEM), photon-surface scattering (IR, NMR, EXAFS), molecule/ion-surface scattering (ISS, RMBS), chemisorption techniques and work function measurements. Suggested background: CHEM 409 or equivalent experience.

CHEM 635. Spectrochemical Analysis. 1.5 Hour.
Modular course; 3 lecture hours. 1.5 credits per module. Topics include instrumental components, such as lasers, photomultipliers, array detectors, monochromators, lock-in and boxcar detection, waveguides and optical fibers, atomic spectroscopic methods, fluorescence, Raman and circular dichroism spectroscopies. Suggested background: CHEM 409 or equivalent experience.

CHEM 636. Chemical Sensors and Biosensors. 1.5 Hour.
Semester course; 1.5 lecture hours. 1.5 credits. Prerequisite: CHEM 409. The goal of this course is to teach “structure-function” relationships responsible for the analytical response of sensors and biosensors based on chemical transduction. The material covered is intended to provide a connection between the chemical structure of sensors and the transduction mechanisms that produce a response signal, as well as the physicochemical factors that affect performance. The content provided will be from different textbooks but complemented with illustrative examples from the research literature. Note: This is a half-semester course.

CHEM 637. Electrochemistry Applications. 1.5 Hour.
Semester course; 1.5 lecture hours. 1.5 credits. The goal of this course is to teach applications of electrochemistry in science and technology, thus complementing the principles covered in CHEM 630. The course content is intended to enhance understanding of the practical aspects of electrochemistry, so students can appreciate the impact of this field in the real world. General topics include energy conversion and storage, electrocatalysis, corrosion, electroplating, and concepts for simulating electrode processes. Note: This is a half-semester course.

CHEM 638. Scanning Electrochemical Microscopy. 3 Hours.
Semester course; 1 lecture and 3 laboratory hours. 3 credits. Prerequisite: CHEM 409. Scanning electrochemical microscopy is a scanning probe technique that generates topographic images of surfaces immersed in liquids. Besides imaging, SECM allows quantitative characterization of chemical processes between tip and the scanned surface including nonconducting ones, thus expanding its applicability to biological substrates. The course is structured around experiments that exemplify applications of SECM and allows experiential learning on the principles and measuring capabilities of SECM. Each lecture focuses on a particular experiment that can be performed in one or two lab sessions. The goal of the course is to provide an ecosystem of experimental methods that graduate students can directly apply in their research. The list of experiments covers topics in chemistry, biology and materials science.

CHEM 690. Research Seminar in Chemistry. 1 Hour.
Semester course; 2 lecture hours. 1 credit. May be repeated for credit. In addition to reports presented by students, staff and visiting lecturers, current problems and developments in nanoscience and nanotechnology are discussed. Graded S/U/F.

CHEM 691. Topics in Chemistry. 1-6 Hours.
Semester course; variable hours. 1-6 credits per semester. Maximum total of 9 credits for all topics courses. An advanced study of selected topic(s) in chemistry. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

CHEM 692. Chemistry Seminar Presentation. 1 Hour.
Semester course; 2 lecture hours. 1 credit. May be repeated for credit. In addition to reports presented by students, staff and visiting lecturers, current problems and developments in chemistry are discussed.

CHEM 693. Chemistry Perspectives and Ethics. 1 Hour.
Semester course; 1 lecture hour. 1 credit. The objectives of this course are to prepare graduate students for a career in the physical sciences and develop graduate student competency in the responsible conduct of research from both ethical and safety standpoints. Graded as S/U/F.

CHEM 696. Professional Skill Development. 3 Hours.
Semester course; 1 lecture and 12 laboratory hours. 3 credits. May be repeated for a maximum of nine credits. Enrollment is restricted to students pursuing the M.S. in Chemistry. This course allows students to gain professional development skills through the process of identifying and securing an internship or an applied research program with a scientific professional in an industrial, government or academic laboratory. The research is completed under the guidance of a graduate faculty member in collaboration with another scientist in one of these settings. The course involves hands-on experience and skill development to enable students to connect with future employers and/or mentors in their chosen industry. A comprehensive written report and an oral presentation to the student's advisory committee is required. Students taking the course for the first time are required to participate in instructional sessions to clarify expectations, review roles and responsibilities and participate in activities related to professional skills development. Graded as satisfactory/unsatisfactory.

CHEM 697. Directed Research. 1-15 Hours.
Semester course; 1-15 credits. May be repeated for credit. Research leading to the M.S. and Ph.D. degree.

CHEM 698. Investigations in Current Chemistry Literature. 1 Hour.
Semester course; 1 lecture hour. 1 credit. May be repeated for credit; a maximum of two credit hours may be presented toward the didactic course graduation requirements to count as one course. Interactive course designed to engage graduate students in current research topics of chemistry while developing skills for critical analysis of primary chemistry literature through oral presentations, group discussions or other formats. Students are expected to enroll in this course at least once before their literature seminar presentation (CHEM 692).

CHEM 699. Scientific Writing in Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course focuses on building up competence to write research proposals commensurate to the oral candidacy exam requirement for the Ph.D., as well as writing research articles using standard templates of chemistry journals. Proposal topics and journal templates will be assigned by the instructor at the beginning of the course.