CHEMISTRY CEM

Department of Chemistry
College of Natural Science

121 Explorations in Chemistry
Fall, Spring. 3(4-0) P: MTH 103 or concurrently R: Approval of department.
Introduction to core ideas in chemistry (structure and properties of matter, energy, and electrical forces) blended with science practices (use of models, argumentation, construction of scientific explanations, mathematical thinking) to understand and explain chemical phenomena.

141 General Chemistry
Fall, Spring, Summer. 4(4-0) P: ((MTH 103 or concurrently) or (MTH 110 or concurrently) or (MTH 116 or concurrently) or (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently)) or designated score on Mathematics Placement test
Elements and compounds; reactions; stoichiometry; thermochemistry; atomic structure; chemical bonding; states of matter; solutions; acids and bases; aqueous equilibria.

142 General and Inorganic Chemistry
Fall, Spring, Summer. 3(4-0) P: CEM 141 or CEM 151 or CEM 181H or LB 171
Kinetics; gaseous equilibria; acids and bases; pH; buffers; hydrolysis; titrations; heterogeneous equilibria; thermodynamics; redox and electrochemistry; transition metal chemistry; nuclear chemistry; main group chemistry.

143 Survey of Organic Chemistry
Fall, Spring, Summer. 4(3-3) P: CEM 141 or CEM 151 or CEM 181H or LB 171 Not open to students with credit in CEM 351.
Chemistry of carbon compounds. Chemistry of the main organic functional groups with applications to everyday life, industry, and biology.

151 General and Descriptive Chemistry
Fall. 4(4-0) P: ((MTH 116 or concurrently) or (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently)) or designated score on Mathematics Placement test
Stoichiometry; solutions; reactions and thermochemistry; quantum mechanics and atomic structure; periodic properties; chemical bonding; molecular structure; coordination chemistry; organic molecules and functional groups.

152 Principles of Chemistry
Spring. 3(4-0) P: CEM 151 or CEM 181H or LB 171
Gases, liquids, and solids; thermodynamics; changes of state; solutions and colligative properties; chemical equilibria; acids, bases, and aqueous equilibria; kinetics; redox reactions and electrochemistry; nuclear chemistry.

161 Chemistry Laboratory I
Fall, Spring, Summer. 1(0-3) P: (CEM 141 or concurrently) or (CEM 151 or concurrently) or (CEM 181H or concurrently) or (LB 171 or concurrently)
Experiments in general chemistry; stoichiometry, calorimetry, electrochemistry, molecular geometry, gas laws, kinetics, acids and bases, and inorganic chemistry.

162 Chemistry Laboratory II
Fall, Spring, Summer. 1(0-3) P: CEM 161 or CEM 185H or LB 171L RB: (CEM 142 or concurrently) or (CEM 152 or concurrently) or (CEM 182H or concurrently)
Analytical and inorganic chemistry; redox and acid base titrations; spectrophotometric and gravimetric analysis; preparation and analysis of coordination complexes of nickel, iron, and cobalt.

181H Honors Chemistry I
Fall. 4(4-0) P: (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently) R: Approval of department.
Atomic structure and quantum mechanics; chemical bonding and molecular structure; spectroscopy; coordination chemistry; materials or biological macromolecules.

182H Honors Chemistry II
Spring. 4(4-0) P: (CEM 151 or CEM 181H or LB 171) and ((MTH 126 or concurrently) or (MTH 133 or concurrently) or (MTH 153H or concurrently) or (LB 119 or concurrently)) R: Approval of department.
Gases, solids, liquids, solutions, and phase transitions; thermodynamics; spontaneity and the second law of thermodynamics; chemical equilibrium; acid-base equilibria; redox reactions and electrochemistry; kinetics.

185H Honors Chemistry Laboratory I
Fall. 2(1-3) P: CEM 181H or concurrently R: Approval of department.
Spectroscopic methods used to determine the structure of molecules and materials. Experiments applying principles of physical, organic, inorganic, analytical, biological, and materials chemistry, while introducing analytical (qualitative and quantitative) and synthetic techniques.

251 Organic Chemistry I
Fall, Spring, Summer. 3(4-0) P: CEM 141 or CEM 151 or CEM 181H or LB 171 Not open to students with credit in CEM 351.
Common classes of organic compounds including their nomenclature, structure, bonding, reactivity, and spectroscopic characterization.

252 Organic Chemistry II
Fall, Spring, Summer. 3(4-0) P: CEM 251 Not open to students with credit in CEM 352.
Continuation of CEM 251 with emphasis on polyfunctional compounds, particularly those of biological interest.

255 Organic Chemistry Laboratory
Fall, Spring, Summer. 2(1-3) P: (CEM 252 or concurrently) and (CEM 161 or LB 171L or CEM 185H) Not open to students with credit in CEM 355.
Preparation and qualitative analysis of organic compounds.

262 Quantitative Analysis
Fall, Spring, Summer. 3(3-3) P: (CEM 142 or CEM 152 or CEM 182H or LB 172) and (CEM 162 or CEM 185H or LB 172L)
Introduction to analytical chemistry and quantitative methods; aqueous solution equilibria and statistics related to quantitative chemical analysis; titrimetric, gravimetric, and spectrophotometric measurements.

311 Inorganic Chemistry
Fall. 3(3-0) P: CEM 142 or CEM 152 or CEM 182H or LB 172 RB: CEM 384
Basic symmetry, molecular orbital theory, and valence bond theory applications to inorganic systems. Physical properties and reactivity of transition metal systems.

333 Instrumental Methods and Applications
Spring. 3(2-3) P: {CEM 262 or (CEM 162 and BLD 213 and BLD 417)} and ((CEM 143 or CEM 251 or CEM 351) and completion of Tier I writing requirement)
Principles and applications of instrumental analysis of separation techniques.

351 Organic Chemistry I
Fall. 3(4-0) P: CEM 152 or CEM 182H or CEM 142 or LB 172 Not open to students with credit in CEM 251.
Structure, bonding, and reactivity of organic molecules.

352 Organic Chemistry II
Spring. 3(4-0) P: CEM 351 Not open to students with credit in CEM 252.
Carboxylate derivatives. Conjugation. Aromaticity. Amino acids. Proteins. Carbohydrates. Nucleic acids.

355 Organic Laboratory I
Spring. 2(0-6) P: (CEM 162 or CEM 185H or LB 172L) and (((CEM 352 or concurrently) or (CEM 252 or concurrently)) and completion of Tier I writing requirement)
Organic laboratory techniques. Distillation. Spectroscopy. Melting points. Recrystallization. Chromatography. Measuring physical properties.

356 Organic Laboratory II
Fall. 2(0-6) P: CEM 355
Multi-step organic synthesis. Qualitative organic analysis. Separation, identification, and characterization of unknowns.

383 Introductory Physical Chemistry I
Fall. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H or LB 172) and (MTH 133 or MTH 153H or MTH 126 or LB 119) RB: PHY 184 or PHY 232 or PHY 232C or PHY 294H or LB 274 SA: CEM 391
Physical chemistry of macroscopic systems: thermodynamics, kinetics, electrochemistry.

384 Introductory Physical Chemistry II
Spring. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H or LB 172) and (MTH 133 or MTH 153H or MTH 126 or LB 119) and (PHY 184 or PHY 232 or PHY 232C or PHY 294H or LB 274) RB: CEM 383
Physical chemistry of microscopic systems: quantum mechanics, spectroscopy.

395 Analytical/Physical Laboratory
Spring. 2(1-4) P: (CEM 483 and (CEM 484 or concurrently) and CEM 262) and completion of Tier I writing requirement SA: CEM 372, CEM 472
Chemical kinetics, thermodynamics, and computer-based data analysis methods.

400H Honors Work
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course. P: Completion of Tier I writing requirement. R: Approval of department.
Readings and investigations in chemistry.

411 Advanced Inorganic Chemistry
Spring. 4(4-0) P: CEM 311 or CEM 384 or CEM 483
Principles of structure and bonding. Symmetry. Solid state chemistry. Acid-base and redox reactions. Main group chemistry: transition metal bonding, spectra, and reaction mechanisms.

415 Advanced Synthesis Laboratory
Spring. 3(0-8) P: (CEM 411 and CEM 356) and completion of Tier I writing requirement RB: CEM 495 R: Open to juniors or seniors in the Bachelor of Science in Chemistry or in the Lyman Briggs Chemistry Coordinate Major or approval of department.
Methods of synthesizing inorganic and organometallic compounds.

419 Independent Study
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course. P: Completion of Tier I Writing Requirement R: Approval of department.
Faculty supervised readings in chemistry.

420 Independent Research
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course. RB: Completion of Tier I Writing requirement R: Approval of department.
Faculty supervised independent investigations in chemistry.

425 Chemistry Communication and Professional Development (W)
Fall. 3(3-0) P: ((CEM 262) and completion of Tier I writing requirement) and (CEM 255 or CEM 355) R: Open to students in the Chemistry Major or approval of department.
Written and oral communication skills for entering and participating in the chemistry profession and post-undergraduate programs. Includes discussion of academic honesty and research integrity.

434 Advanced Analytical Chemistry
Fall. 3(3-1) P: CEM 395 and CEM 352 and CEM 484 SA: CEM 361, CEM 362
Instrumental methods of analysis, including spectroscopy, chromatography, and electrochemistry.

435 Analytical Chemistry Laboratory
Spring. 3(1-4) P: (CEM 434) and completion of Tier I writing requirement SA: CEM 372, CEM 472
Application of instrumental spectroscopic, electrochemical, and chromatographic methods to solve quantitative chemical problems in the laboratory.

444 Chemical Safety
Fall. 1(1-0) P: (CEM 142 or CEM 152 or CEM 182H or LB 172) and (CEM 252 or CEM 352)
Prudent laboratory practices. Regulatory agencies' expectations of chemical industries and academia.

481 Seminar in Computational Chemistry
Fall of odd years. 3(2-3) P: (CEM 384 or CEM 483 or PHY 471) and MTH 235 RB: MTH 309 or MTH 314 or MTH 317H
Potential energy surfaces; matrix representation of quantum mechanics; linear combination of atomic orbitals; Hartree-Fock approximation; electron correlation; configuration interaction; coupled cluster theory; Moller Plesset perturbation theory; density functional theory

482 Science and Technology of Wine Production
Fall. 3(2-3) Interdepartmental with Chemical Engineering and Food Science. Administered by Chemistry. P: CEM 143 or CEM 251 or CEM 351 RB: Must be at least 21 years of age. R: Open to seniors or graduate students in the Department of Biosystems and Agricultural Engineering or in the Department of Chemical Engineering and Materials Science or in the Department of Chemistry or in the Department of Food Science and Human Nutrition or in the Department of Horticulture or in the Department of Microbiology and Molecular Genetics or in the Lyman Briggs Chemistry Coordinate Major. Approval of department.
Origin and history of wine and wine production. Determination and timing of harvest, methods of postharvest handling, storage, and processing of grapes into juice and wine. Physical and chemical changes in wine and processes. Analysis of must and its adjustment, fermentation, fining, and aging. Physiology of yeasts and bacteria involved in winemaking and spoilage. Cellar practices, problems, and operations.

483 Quantum Chemistry
Fall. 3(4-0) P: (MTH 235 or MTH 255H or MTH 347H or MTH 340) and (PHY 184 or PHY 294H or LB 274 or PHY 184B) and (CEM 142 or CEM 152 or CEM 181H or LB 172) SA: CEM 362, CEM 461
Postulates of quantum mechanics and the application to model systems, atoms and molecules. Introduction to molecular spectroscopy.

484 Molecular Thermodynamics
Spring. 3(4-0) P: (MTH 235 or MTH 255H or MTH 340 or MTH 347H) and (CEM 142 or CEM 152 or CEM 182H or LB 172) RB: CEM 483 SA: CEM 361, CEM 391
Microscopic properties of atoms and molecules revealed by spectroscopic measurements; connection between thermodynamic properties of macroscopic chemical systems and microscopic properties established using statistical thermodynamics.

485 Modern Nuclear Chemistry
Spring of even years. 3(3-0) P: (CEM 142 or CEM 152 or CEM 182H or LB 172) and (PHY 184 or PHY 232 or PHY 294H or LB 274) RB: CEM 483 or CEM 384 or PHY 471 SA: CEM 430
Elementary nuclear processes and properties; radioactivity, its measurement and its interaction with matter.

495 Molecular Spectroscopy
Fall. 2(1-4) P: (CEM 483 or CEM 484) and (CEM 395 or CEM 499) and ((CEM 262 or CEM 186H) and completion of Tier I writing requirement) SA: CEM 472
Experiments in magnetic resonance, optical, and vibrational spectroscopies.

499 Chemical Physics Seminar
Spring. 1(1-0) A student may earn a maximum of 2 credits in all enrollments for this course. P: ((PHY 215) and completion of Tier I writing requirement) and (MTH 235 or MTH 255H or MTH 340 or MTH 347H)
Written and oral reports on selected journal articles in chemical physics.

811 Advanced Inorganic Chemistry I
Fall. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles of chemical bonding, electronic structure, and reaction mechanisms of main group and transition metal compounds. Concepts of group theory.

812 Advanced Inorganic Chemistry II
Spring. 3(3-0) RB: CEM 811 R: Open only to graduate students in College of Natural Science or College of Engineering.
Descriptive chemistry of inorganic compounds. Emphasis on synthesis, structure, and reactivity patterns of coordination, organometallic, and solid state compounds of transition metals and main group elements.

820 Organometallic Chemistry
Fall. 3(3-0)
Organometallic functional groups. Principles of electronic structure, and bonding in organometallic species will be related to reactivity patterns in common systems. Preparation of complexes with applications to catalytic and stoichiometric organic syntheses.

832 Mass Spectrometry
Fall, Spring. 3(3-0) R: Open only to graduate students in the College of Natural Science or College of Engineering.
Instrumentation of mass spectrometry. Interpreting mass spectra of organic and inorganic molecules. Applications to analysis of large molecules and chromatography.

834 Advanced Analytical Chemistry I
Fall. 3(3-0) R: Open to graduate students in the College of Engineering or in the College of Natural Science.
Basic electronics and data acquisition and anaylsis, electrochemistry, and statistics for chemists.

835 Advanced Analytical Chemistry II
Fall. 3(3-0) R: Open to graduate students in the College of Engineering or in the College of Natural Science or in the School of Criminal Justice.
Separations, molecular spectroscopy and mass spectrometry

836 Separation Science
Spring of odd years. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Physical and chemical principles of separations, column technology, and instrumentation for gas, liquid, and supercritical fluid chromatography.

837 Electroanalytical Chemistry
Fall of even years. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Modern electroanalytical chemistry. Theory and applications to chemical and biological problems. Coulometry, voltammetry, ion-selective potentiometry, and other electrochemical techniques.

845 Structure and Spectroscopy of Organic Compounds
Fall. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Structural and stereochemical principles in organic chemistry. Applications of spectroscopic methods, especially nuclear magnetic resonance, static and dynamic aspects of stereochemistry. Spectroscopy in structure determination.

850 Intermediate Organic Chemistry
Fall. 3(3-0)
Traditional and modern basic reaction mechanisms and principles and their synthetic applications.

851 Advanced Organic Chemistry
Fall. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Structure, reactivity, and methods. Acid-base reactions, substitution, addition, elimination, and pericyclic processes. Major organic intermediates related to simple bonding theory, kinetics, and thermodynamics.

852 Methods of Organic Synthesis
Spring. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Principal reactions leading to carbon-carbon bond formation and functional group transformations. Strategies and methods of organic synthesis.

881 Atomic and Molecular Structure
Fall. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Postulates of quantum mechanics, analytical solutions of the Schroedinger equation, theoretical descriptions of chemical bonding, spectroscopy, statistical mechanics, and statistical thermodynamics.

882 Kinetics and Spectroscopic Methods
Spring. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Rate equations and mechanisms of chemical reactions: reaction rate theory, kinetic theory of gases, photochemistry. Spectroscopic methods, and applications of spectroscopy in reaction kinetics.

883 Computational Quantum Chemistry
Fall. 3(2-3) RB: CEM 461 or CEM 881
Computational methods in determining electronic energy levels, equilibrium nuclear configurations, and other molecular properties.

888 Computational Chemistry
Spring. 3(2-3)
Computational approaches to molecular problems. Use of ab initio and semi-empirical electronic structure, molecular mechanics and molecular dynamics software.

890 Chemical Problems and Reports
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
Investigation and report of a nonthesis problem in chemistry.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 20 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to graduate students in the Department of Chemistry.
Master's thesis research.

913 Selected Topics in Inorganic Chemistry
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open to graduate students in the Department of Chemistry or approval of department.
Current research topics in inorganic chemistry.

918 Inorganic Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 3 credits in all enrollments for this course. R: Open to graduate students in the Department of Chemistry.
Advances in inorganic chemistry reported by graduate students.

924 Selected Topics in Analytical Chemistry
Fall, Spring. 2 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to graduate students in College of Natural Science or College of Engineering.
Advanced computer techniques, surface chemistry, analytical chemistry of polymers, or statistics for chemists.

938 Analytical Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 3 credits in all enrollments for this course. R: Open to graduate students in the College of Engineering or in the College of Natural Science.
Advances in analytical chemistry reported by graduate students, faculty, and guest lecturers.

956 Selected Topics in Organic Chemistry
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Open only to graduate students in College of Natural Science or College of Engineering.
Heterocyclic and organometallic chemistry, natural products, photochemistry, free radicals, or reaction mechanisms.

958 Organic Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 2 credits in all enrollments for this course. R: Open to graduate students in the College of Engineering or in the College of Natural Science.
Advances in organic chemistry reported by graduate students.

971 Emerging Topics in Chemistry
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to doctoral students in the Chemistry or Chemical Physics major.
Discussion of a research topic of emerging interest in chemistry. Preparation of a proposal for funding of research.

985 Selected Topics in Nuclear Chemistry
Fall. 1 to 3 credits. A student may earn a maximum of 12 credits in all enrollments for this course. RB: Thermodynamics, Statistical Mechanics, Quantum Mechanics, Electricity and Magnetism, Differential and Integral Calculus, Differential Equations R: Open to doctoral students in the College of Engineering or in the College of Natural Science or in the Department of Chemistry.
Nuclear instruments, detectors and electronics, vacuum technology, electric and magnetic properties of nuclei, nuclear simulation tools, or nuclear spectroscopy and reactions.

987 Selected Topics in Physical Chemistry I
Fall. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to doctoral students or approval of department.
Topics such as kinetics and photochemistry, macromolecular and surface chemistry, molecular spectroscopy, electric and magnetic properties of matter, or applications of statistical mechanics to chemical problems.

988 Selected Topics in Physical Chemistry II
Spring. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to doctoral students or approval of department.
Topics such as analysis and interpretation of molecular spectra, advanced molecular structure theory, magnetic resonance, X-rays and crystal structure, scientific analysis of vacuum systems, or problems in statistical mechanics.

991 Quantum Chemistry and Statistical Thermodynamics I
Fall. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles and applications of quantum chemistry. Partition functions, spectroscopic measurements, and thermodynamic applications.

992 Quantum Chemistry and Statistical Thermodynamics II
Spring. 3(3-0) RB: CEM 991
Analytical and numerical methods for solving quantum chemical problems. Statistical mechanics of solids and liquids.

993 Advanced Topics in Quantum Chemistry
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. R: Open to graduate students in the College of Engineering or in the College of Natural Science.
Spectroscopic theory, properties of atoms and molecules in electric and magnetic fields, intermolecular forces. Many-body theory, molecular electronic structure, solid state chemistry, or molecular reaction dynamics.

994 Advanced Topics in Statistical Mechanics
Fall. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. R: Open to graduate students in the College of Engineering or in the College of Natural Science.
Nonequilibrium statistical mechanics and thermodynamics. Correlation functions and spectroscopy, light scattering, magnetic relaxation, transport properties of fluids and gases, or statistical mechanics of chemical reactions.

995 Nuclear Chemistry Seminar
Fall, Spring. 1 credit. A student may earn a maximum of 2 credits in all enrollments for this course. RB: One year of graduate work in nuclear chemistry or related experience R: Open to graduate students in the Department of Chemistry or in the Department of Physics and Astronomy.
Advances in nuclear chemistry reported by graduate students, faculty, and guest lecturers.

998 Physical Chemistry Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 3 credits in all enrollments for this course. R: Open to graduate students in the Department of Chemistry.
Advances in physical chemistry reported by graduate students.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Open to doctoral students in the Department of Chemistry.
Doctoral dissertation research.