# CHEMISTRY CEM

## Department of Chemistry
## College of Natural Science

**141 General Chemistry**
Fall, Spring. 4(4-0) P:M: ((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 (LBS 117 or concurrently) or (LBS 118 or concurrently)) or designated score on Mathematics Placement test Not open to students with credit in CEM 151 or CEM 181H or LBS 171.
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. 3(4-0) P:M: CEM 141 or CEM 151 or CEM 181H or LBS 171 Not open to students with credit in CEM 152 or CEM 182H or LBS 172.
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. 4(3-3) P:M: CEM 141 or CEM 151 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:M: ((MTH 116 or concurrently) or (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LBS 117 or concurrently) or (LBS 118 or concurrently)) or designated score on Mathematics Placement test Not open to students with credit in CEM 141 or CEM 181H or LBS 171.
Atomic structure, chemical bonding and molecular structure; solid state; main group chemistry; acids and bases; transition metal chemistry; coordination chemistry and theories of bonding.

**152 Principles of Chemistry**
Spring. 3(4-0) P:M: CEM 151 or CEM 181H or LBS 171 Not open to students with credit in CEM 142 or CEM 182H or LBS 172.
The mole concept and stoichiometry; solution stoichiometry; thermochemistry; gases, liquids, and solids; kinetics; chemical equilibria; acid-based equilibria; aqueous equilibria; thermodynamics; redox and electrochemistry.

**161 Chemistry Laboratory I**
Fall, Spring. 1(0-3) P:M: (CEM 141 or concurrently) or (CEM 151 or concurrently) Not open to students with credit in LBS 171L or CEM 185H.
Experiments in general chemistry; stoichiometry, calorimetry, electrochemistry, molecular geometry, gas laws, kinetics, acids and bases, and inorganic chemistry.

**162 Chemistry Laboratory II**
Fall, Spring. 1(0-3) RB: (CEM 161 or LBS 171L or CEM 185H) and ((CEM 142 or concurrently) and (CEM 152 or concurrently)) Not open to students with credit in LBS 172L or CEM 186H.
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:M: (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LBS 118 or concurrently) R: Approval of department.
Elements and compounds; stoichiometry; reactions; atomic structure and quantum mechanics, chemical bonding and molecular structure; spectroscopy; coordination chemistry and theories of bonding; structure of biochemical molecules.

**182H Honors Chemistry II**
Spring. 4(4-0) P:M: (CEM 151 or CEM 181H or LBS 171) and ((MTH 126 or concurrently) or (MTH 133 or concurrently) or (MTH 153H or concurrently)) R: Approval of department.
Thermodynamics and chemical equilibria; acids and bases; redox chemistry; main group elements; solid state; group theory and symmetry; molecular orbital theory; transition metal chemistry and spectroscopy.

**185H Honors Chemistry Laboratory I**
Fall. 2(0-6) P:M: CEM 181H or concurrently R: Approval of department.
Spectroscopy and diffraction methods for the study of electronic structure and molecular geometry; synthesis and separation methods for the preparation and characterization of molecules; application to inorganic, organic, and biochemical molecules and materials.

**186H Honors Chemistry Laboratory II**
Spring. 2(0-6) P:M: CEM 182H or concurrently R: Approval of department.
Laboratory research.

**251 Organic Chemistry I**
Fall, Spring. 3(4-0) P:M: CEM 141 or CEM 151 or CEM 181H or LBS 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. 3(4-0) P:M: 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. 2(1-3) P:M: (CEM 252 or concurrently) and (CEM 161 or LBS 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:M: CEM 162 or LBS 172L Not open to students with credit in CEM 186H.
Preparation and quantitative analysis of chemical compounds.

**332 Instrumental Methods**
Spring. 2(2-0) P:M: (CEM 143 or CEM 251 or CEM 351) and (CEM 162 and MT 213 and MT 417) Not open to students with credit in CEM 333 or CEM 434.
Principles of instrumental analysis and separation techniques.

**333 Instrumental Methods and Applications**
Spring. 3(2-3) P:M: {((CEM 143 or CEM 251 or CEM 351) or completion of Tier I writing requirement) and (CEM 262 or CEM 186H)} or (CEM 162 and MT 213 and MT 417) Not open to students with credit in CEM 332.
Principles and applications of instrumental analysis of separation techniques.

**351 Organic Chemistry I**
Fall. 3(4-0) P:M: CEM 152 or CEM 182H or CEM 142 or LBS 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:M: 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:M: (CEM 162 or CEM 186H or LBS 172L or (CEM 352 or concurrently)) or completion of Tier I writing requirement Not open to students with credit in CEM 255.
Organic laboratory techniques. Distillation. Spectroscopy. Melting points. Recrystallization. Chromatography. Measuring physical properties.

**356 Organic Laboratory II**
Fall. 2(0-6) P:M: 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:M: (CEM 142 or CEM 152 or CEM 182H or LBS 172) and (MTH 133 or MTH 153H or MTH 126 or LBS 119) Not open to students with credit in CEM 391.
Physical chemistry of macroscopic systems: thermodynamics, kinetics, electrochemistry.

**384 Introductory Physical Chemistry II**
Spring. 3(4-0) P:M: CEM 383 Not open to students with credit in CEM 461.
Physical chemistry of microscopic systems: quantum mechanics, spectroscopy.

**391 Molecular Thermodynamics**
Fall. 3(4-0) P:M: (CEM 142 or CEM 152 or CEM 182H) and (MTH 234 or MTH 254H or LBS 220) and (PHY 184 or PHY 232) RB: One year of general chemistry, calculus, and general physics. SA: CEM 361 Not open to students with credit in CEM 383.
Statistical mechanics and its use in classical chemical thermodynamics. Applications of thermodynamics to chemical systems at equilibrium. Introduction to chemical kinetics.

**392 Quantum Chemistry**
Fall, Spring. 3(4-0) P:M: CEM 391 and (MTH 234 or LBS 220 or MTH 254H) RB: One year of general chemistry, calculus through differential equations, and general physics. SA: CEM 362, CEM 461 Not open to students with credit in CEM 384.
Postulates of quantum mechanics and their application to model systems, atoms and molecules. Introduction to molecular spectroscopy.

**395 Analytical/Physical Laboratory**
Spring. 2(1-4) P:M: (CEM 391 or CEM 383) and (CEM 262 and completion of Tier I writing requirement) RB: One year of general chemistry, calculus, and general physics. 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:M: Completion of Tier I writing requirement. R: Approval of department.
Readings and investigations in chemistry.

**410 Literature and Writing in Chemistry**
Spring. 3 credits. P:M: (CEM 252 and CEM 384) and ((CEM 333 or concurrently) and completion of Tier I writing requirement) R: Open only to juniors or seniors in the Chemistry major.
Library research related to a topic in contemporary chemistry; thesis required.

**411 Inorganic Chemistry**
Spring. 4(4-0) P:M: CEM 383 or CEM 391
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**
Fall. 3(0-8) P:M: (CEM 411) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the Bachelor of Science degree program in Chemistry.
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. 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. R: Approval of department.
Faculty supervised independent investigations in chemistry.

**434 Advanced Analytical Chemistry**
Fall. 3(3-0) P:M: CEM 392 and CEM 395 and CEM 352 SA: CEM 361, CEM 362
Instrumental methods of analysis, including spectroscopy, chromatography and electrochemistry.

**435 Analytical Chemistry Laboratory**
Spring. 2(1-3) P:M: (CEM 434 or concurrently) and completion of Tier I writing requirement. SA: CEM 372, CEM 472
Electronic and optical components of chemical instrumentation. Spectroscopic and chromatographic methods.

**444 Chemical Safety**
Fall. 1(1-0) P:M: CEM 142 and CEM 252
Prudent laboratory practices. Regulatory agencies' expectations of chemical industries and academia.

**481 Seminar in Computational Chemistry**
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 6 credits in all enrollments for this course. P:M: (MTH 133 and CSE 231) and ((CEM 152 or concurrently) or (CEM 182H or concurrently)) RB: CPS 260 and CEM 351
Written and oral reports on selected journal articles in computational chemistry.

**485 Modern Nuclear Chemistry**
Spring of even years. 3(3-0) P:M: (CEM 141 or CEM 152 or CEM 182H) and (PHY 232 or PHY 184) RB: CEM 392 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:M: CEM 392 and CEM 395 RB: One year of physical chemistry. SA: CEM 472
Experiments in magnetic resonance, optical, and vibrational spectroscopies.

**499 Chemical Physics Seminar**
Fall, Spring, Summer. 1(1-0) A student may earn a maximum of 2 credits in all enrollments for this course. P:M: ((PHY 321) and completion of Tier I writing requirement) and (MTH 235 or LBS 220 or MTH 255H)
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**
Fall. 3(3-0) R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles of equilibria and applications in analytical methodology. Acid-base, complexation, redox reactions. Potentiometry and conductometry. Solute partitioning in extraction and chromatography. Kinetic methods of analysis.

**835 Spectrochemical Methods of Analysis**
Spring of even years. 3(2-3) R: Open only to graduate students in College of Natural Science or College of Engineering.
Principles and applications of atomic absorption, emission, fluorescence. Plasma emission spectroscopy. UV, visible, IR spectrophotometry. Reaction-rate methods. Molecular fluorescence and phosphorescence. Principles and applications of lasers.

**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.

**838 Computer-Based Scientific Instrumentation**
Fall. 3(1-6) A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to graduate students in College of Natural Science or College of Agriculture and Natural Resources.
Electronic and computer-aided measurement and control in scientific instrumentation and experimentation. Principles and applications of digital computers, operational amplifiers, digital logic devices, analog-to-digital converters, and other electronic instruments.

**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 only to graduate students in College of Natural Science or College of Engineering.
Chemistry of metal-metal bonds and clusters, organometallic chemistry, layered oxides, and complex layered oxides. Photochemistry. Solid state chemistry and applications of quantum mechanics.

**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 only 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 only to graduate students in College of Natural Science or College of Engineering.
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 only to graduate students in College of Natural Science or College of Engineering.
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.

**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 of odd years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to graduate students in the College of Natural Science or the College of Engineering.
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**
Spring of even years. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to graduate students in the College of Natural Science or the College of Engineering.
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.

**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 only 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 120 credits in all enrollments for this course. R: Open only to doctoral students in the Department of Chemistry.
Doctoral dissertation research.