972. Viscoelasticity and Flow of Polymeric Materials
Spring of odd years. 3(3-0)
Time dependent and steady flow properties of polymeric materials related to molecular and structural parameters. Examples of polymeric blends and composites with thermoplastic and thermoset components.

973. Advanced Polymer Reaction Engineering
Spring of even years. 3(3-0) R: Open only to graduate students in the Department of Chemical Engineering.
Principles of chain polymerization and network forming reactions. Emulsion and suspension polymerization versus graft reactions on bulk polymers. Reactor design. Morphology in polymer alloys, effects of mixing on polymer reactions.

999. Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 72 credits in all enrollments for this course. R: Open only to Chemical Engineering majors.

CHEMISTRY CEM

Department of Chemistry
College of Natural Science

141. General Chemistry
Fall, Spring. 4(4-0) P: (MTH 103 or concurrently or MTH 110 or concurrently or MTH 116 or concurrently or LBS 117 or concurrently) Not open to students with credit in CEM 152 or CEM 182H or LBS 165.
Atoms, molecules, ions; chemical calculations; reactions, energy changes; gases; periodic properties of elements; chemical bonds; states of matter, solutions; acids and bases; aqueous reactions and ionic equations.

142. General and Inorganic Chemistry
Fall, Spring. 3(4-0) P: (CEM 141) Not open to students with credit in CEM 151 or CEM 181H or LBS 266.
Kinetics; gaseous equilibria; acids and bases; pH; aqueous equilibria involving buffers, hydrolysis, and titrations; heterogeneous equilibria of weakly soluble salts; electrochemistry; coordination chemistry, stereochemistry, and bonding within the transition elements.

143. Survey of Organic Chemistry
Fall, Spring. 4(3-3) P: (CEM 141 or CEM 152) Not open to students with credit in CEM 251 or 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 LBS 117 or concurrently) Not open to students with credit in CEM 142 or CEM 181H or LBS 266.
Atomic and molecular structure; ionic and molecular bonding models; periodic trends; chemical reactivity by periodic group; nomenclature, structure, bonding and reactivity of coordination compounds; bioinorganic chemistry.

152. Principles of Chemistry
Spring. 3(3-0) P: (CEM 151) Not open to students with credit in CEM 141 or CEM 182H or LBS 165.
The mole concept; stoichiometry and chemical calculations; gas laws; phase changes; thermodynamics; enthalpy, entropy and free energy; crystal structures; properties of solutions; chemical kinetics; gaseous equilibria; theory and reactions of acids/bases; aqueous equilibria; electrochemistry.

161. Chemistry Laboratory I
Fall, Spring. 1(0-3) P: (CEM 141 or concurrently or CEM 151 or concurrently) Not open to students with credit in LBS 165L or CEM 185H.
Quantitative physiochemical or analytical experiments and chemical synthesis.

162. Chemistry Laboratory II
Spring. 1(0-3) P: (CEM 161 or LBS 165L) and (CEM 142 or concurrently or CEM 152 or concurrently) Not open to students with credit in LBS 266L.
Preparation and qualitative analysis of inorganic compounds.

181H. Honors Chemistry I
Fall. 4(4-0) P: (MTH 124 or concurrently or MTH 132 or concurrently or MTH 152H or concurrently or LBS 118 or concurrently) R: Approval of department.
States of matter. Descriptive inorganic chemistry by periodic groups of elements. Kinetic theory of gases. Thermodynamics, chemical equilibrium and electrochemistry. Properties of solutions. Macromolecular chemistry. Macroscopic kinetics.

182H. Honors Chemistry II
Spring. 4(4-0) P: (CEM 181H) and (MTH 126 or concurrently or MTH 133 or concurrently or MTH 153H or concurrently) R: Approval of department.
Subatomic, atomic and molecular structure. Quantum theory and bonding. Stereochemistry and nomenclature. Experimental methods of structure determination. Reactions of compounds of the main-group and transition elements. Reaction dynamics. Nuclear chemistry.

185H. Honors Chemistry Laboratory I
Fall. 2(0-6) P: (CEM 181H or concurrently) R: Approval of department.
Techniques of measurement: experiments related to gas behavior, thermodynamics, electrochemistry, chemical kinetics and properties of solutions.

186H. Honors Chemistry Laboratory II
Spring. 2(0-6) P: (CEM 182H or concurrently) R: Approval of department.
Independent laboratory work in chemistry.

251. Organic Chemistry I
Fall, Spring. 3(4-0) P: (CEM 141 or CEM 152 or CEM 182H or LBS 165) Not open to students with credit in CEM 143 or 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: (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: (CEM 252 or concurrently) and (CEM 161 or LBS 165L or CEM 185H) Not open to students with credit in CEM 355.
Preparation and qualitative analysis of organic compounds.

262. Quantitative Analysis
Fall, Spring. 2(2-3) P: (CEM 162 or LBS 266L) Not open to students with credit in CEM 186H.
Preparation and quantitative analysis of chemical compounds.

333. Instrumental Methods
Spring. 3(2-3) P: (CEM 143 or CEM 251 or CEM 351) and (CEM 262 or CEM 186H) and completion of Tier I writing requirement. Not open to students with credit in CEM 372.
Principles of instrumental analysis. Application of separation techniques and instrumental analysis.

351. Organic Chemistry I
Fall. 3(4-0) P: (CEM 152 or CEM 182H or CEM 142 or LBS 266) Not open to students with credit in CEM 143 or 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 186H or LBS 266L or CEM 352 or concurrently) and 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: (CEM 355) CEM 355.
Multi-step organic synthesis. Qualitative organic analysis. Separation, identification, and characterization of unknowns.

361. Analytical-Physical Chemistry I
Fall. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H or LBS 266) and (MTH 234 or MTH 254H or LBS 220) and (PHY 182B or PHY 184 or PHY 184B or PHY 232 or PHY 232B or PHY 294H) Not open to students with credit in CEM 383.
Thermodynamics and its application to simple systems: gases, liquids and solids.

362. Analytical-Physical Chemistry II
Spring. 3(4-0) P: (CEM 361) and (CEM 251 or concurrently or CEM 351 or concurrently)
Advanced treatment of equilibria, chemical kinetics and separations.

372. Analytical-Physical Chemistry Laboratory I
Spring. 3(1-6) P: (CEM 262) and (CEM 383 or CEM 361) and completion of Tier I writing requirement.
Electronic and optical components of chemical instrumentation. Spectroscopic and chromatographic methods.

383. Introductory Physical Chemistry I
Fall. 3(4-0) P: (CEM 142 or CEM 152 or CEM 182H or LBS 266) and (MTH 133 or MTH 153H or MTH 126 or LBS 119) Not open to students with credit in CEM 361.
Physical chemistry of macroscopic systems: thermodynamics, kinetics, electrochemistry.

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

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.

410. Literature and Writing in Chemistry
Spring. 3 credits. P: (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 B.A. degree program in Chemistry majors.
Library research related to a topic in contemporary chemistry; thesis required.

411. Inorganic Chemistry
Spring. 4(4-0) P: (CEM 361 or CEM 383)
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 472) and (CEM 411 or concurrently) and completion of Tier I writing requirement. R: Open only to juniors or seniors in the B.S. 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.

461. Theoretical Chemistry
Fall. 3(4-0) P: (CEM 361 or concurrently or CEM 383 or concurrently) and (MTH 234 or LBS 220 or MTH 254H)
Postulates of quantum mechanics. Model problems. Theories of chemical bonding. Interaction of radiation with matter. Foundation of spectroscopy, statistical mechanics.

472. Analytical-Physical Chemistry Laboratory II
Fall. 3(1-6) P: (CEM 372) and (CEM 461 or concurrently or CEM 384 or concurrently) and completion of Tier I writing requirement.
Kinetic measurements. Electrochemical, radiochemical and spectrophotometric measurements of reaction rates. Mass spectrometry. Electronic, vibrational and rotational spectroscopy.

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: (MTH 133 and CSE 230) and (CEM 152 or concurrently or CEM 182H or concurrently) RB: CSE 260 and CEM 351)
Written and oral reports on selected journal articles in computational chemistry.

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: (CEM 362) and (MTH 235 or LBS 220 or MTH 255H) and (PHY 321) and completion of Tier I writing requirement.
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) P: 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.

832. Mass Spectrometry
Fall of odd years. 3(3-0) R: Open only to graduate students in 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.

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) P: CEM 461 or CEM 881.
Computational methods in determining electronic energy levels, equilibrium nuclear configurations, and other molecular properties.

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 Chemistry.

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 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) P: CEM 991.
Analytical and numerical methods for solving quantum chemical problems. Statistical mechanics of solids and liquids.

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 Chemistry.
Advances in physical chemistry reported by graduate students.

999. Doctoral Dissertation 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 doctoral students in Chemistry and Chemical Physics.

CHINESE CHS

Department of Linguistics and Germanic, Slavic, Asian and African Languages
College of Arts and Letters

101. Elementary Chinese I
Fall. 5(5-0) Not open to students with credit in CHS 112.
Pronunciation, writing system, and basic vocabulary and sentence patterns, with emphasis on conversation.

102. Elementary Chinese II
Spring. 5(5-0) P: (CHS 101 or CHS 112)
Further work on conversation, character writing, and comprehension, with increasing emphasis on vocabulary building and grammar.

111. Introductory Chinese: Business Emphasis I
Summer. 3(3-0) Not open to students with credit in CHS 101.
Beginning-level speaking, listening comprehension, and reading for Chinese in business-related contexts. Economic conditions and business culture in China.

112. Introductory Chinese: Business Emphasis II
Summer. 3(3-0) P: (CHS 111) Not open to students with credit in CHS 101.
Further development of skills in speaking, listening comprehension, and reading for Chinese in business- related contexts. Economic conditions and business culture in China.

201. Second-Year Chinese I
Fall. 5(5-1) P: CHS 102 or approval of department.
Intermediate-level work on skills in conversation, comprehension, and grammar. Practice in composition.

202. Second-Year Chinese II
Spring. 5(5-0) P: CHS 201 or approval of department.
Further intermediate-level work on skills in conversation, comprehension, and grammar. Continued practice in composition.

301. Third-Year Chinese I
Fall. 4(4-0) P: CHS 202.
Advanced-level work on speaking, listening comprehension, reading, and writing skills, based on materials of cultural interest.

302. Third-Year Chinese II
Spring. 4(4-0) P: CHS 301.
Advanced-level work on speaking, listening comprehension, reading, and writing skills, based on materials of cultural interest.

350. Studies in the Chinese Language
Spring. 3(3-0) P: CHS 201 or approval of department.
Grammatical structures of modern Chinese. Grammar review, sound system, word formation, sentence and discourse structures, historical evolution of the Chinese language, dialects, sociolinguistics.

401. Fourth-Year Chinese I
Fall. 3(3-0) P: CHS 302.
Reading, discussion, and writing of advanced materials, including classical texts of broad cultural interest.

402. Fourth-Year Chinese II
Spring. 3(3-0) P: CHS 401.
Further reading, discussion and writing based on original materials, including classical texts of broad cultural interest.