CHEMISTRY CEM

College of Natural Science

Credit cannot be earned in more than one course of each of the following groups: 130 and 141, 131 and 141, 142 and 153, 132 and 241 or 351, 311 and 411, 383 and 461, 361 and 384, 394 and 472.

130. *Introductory Chemistry I*

Fall, Winter, Summer. 4(3-3) MTH 108 or 111 or concurrently.

General discussion of principles. Atomic and molecular structure and spectra; stoichiometry; gases, liquids, solids, solutions, and changes of state. Laboratory experiments via film, TV tape or live demonstration.

131. *Introductory Chemistry II*

Winter, Spring, Summer. 3(3-0) 130; 161 concurrently.

Continuation of 130. Chemical kinetics and equilibrium; ionic equilibrium; acids and bases.

132. *Introductory Chemistry: Carbon Compounds*

Fall, Spring, Summer. 3(3-2) 131 or 141; 161.

Chemistry of carbon compounds, introducing the alphabetic and aromatic hydrocarbon series. Some typical compounds are prepared and their behavior studied.

141. *Principles of Chemistry I*

Fall, Winter. 4(4-0) MTH 108 or 111 or concurrently; satisfactory grade on placement examination; 161 concurrently.

Atomic and molecular structure, chemical kinetics and equilibrium; acids and bases. The solid state.

142. *Introductory Chemistry III*

Fall, Spring. 3(3-0) 131 or 141.

Reactions and behavior of inorganic compounds.

152. *Principles of Chemistry II*

Winter, Spring. 3(3-0) 131 or 141; MTH 112 or concurrently. Grade of C or better in 131 or 141 recommended.

Thermochemistry and applications of thermochemical principles; equilibrium and electrochemistry.

153. *Introductory Inorganic Chemistry*

Fall, Spring. 3(3-0) 152.

Descriptive inorganic chemistry with further discussion of bonding; introduction to radiochemistry.

161. *Introductory Chemistry Laboratory*

Fall, Winter, Spring, Summer. 1(0-3) 131 or 141 concurrently.

Laboratory work in chemistry including quantitative physiochemical or analytical experiments and chemical synthesis.

162. *Quantitative Analysis*

Fall, Winter, Spring, Summer. 2(0-6) 131 or 141; 161.

Laboratory work in quantitative chemistry.

163. *Introductory Inorganic Laboratory*

Spring. 2(0-6) 162.

Qualitative analysis and inorganic preparations.

241. *Organic Chemistry*

Fall, Winter, Summer. 5(4-3) 131 or 141; 161.

Common classes of organic compounds with emphasis on nomenclature, structural principles, reactions and reaction mechanisms.

242. *Organic Chemistry*

Winter, Spring, Summer. 5(4-3) 241.

Continuation of 241 with emphasis on polyfunctional compounds, particularly groups of compounds having biological significance.

245. *Organic Chemistry*

Spring. 3(3-0) 242.

Special topics in organic chemistry. Reactions of technical and biological interest, stereochemistry, reaction mechanism, etc.

311. *Inorganic Chemistry*

Fall, Summer. 4(4-0) 384 or 461 or concurrently; or approval of department.

The chemistry of selected non-metals and metals. Elementary coordination chemistry and acid-base theory. Bonding in inorganic compounds. The periodic law and table.

333. *Instrumental Methods*

Spring. 4(2-6) 132 or 241 or 351; 162.

Principles and application of separations and of instrumental methods of analysis. Flame emission/absorption, UV, visible and IR spectrophotometry; thin-layer column, ion-exchange, and gas chromatography; electrochemistry.

351. *Organic Chemistry*

Fall. 3(4-0) 152.

A comprehensive introduction to the fundamentals of organic chemistry, designed for chemistry majors but open to others who desire a rigorous, modern treatment of the subject.

352. *Organic Chemistry*

Winter. 3(4-0) 351.

Continuation of 351.

353. *Organic Chemistry*

Spring. 3(4-0) 352.

Continuation of 352.

354. *Organic Chemistry Laboratory*

Winter. 2(0-6) 162, 351.

A laboratory course in modern techniques of organic chemistry, including qualitative organic analysis.

355. *Organic Chemistry Laboratory*

Spring. 2(0-6) 352, 354.

Continuation of 354.

356. *Organic Chemistry Laboratory*

Fall. 2(0-6) 355.

Continuation of 355.

361. *Chemical Thermodynamics*

Fall, Spring. 3(4-0) One year general chemistry; one year general physics; MTH 215. Interdepartmental and jointly administered with the Chemical Engineering Department.

Thermodynamics. Properties of gases. Laws of thermodynamics, properties of ideal and non-ideal solutions, thermodynamics of chemical reactions, activities in non-ionic systems.

362. *Analytical-Physical Chemistry I*

Winter, Spring. 3(4-0) 361.

Applications of thermodynamics. Activity coefficients, ionic solutions, cell potentials, ionic equilibria including acid-base, complexation, solubility and redox equilibria, phase equilibria, distillation, extraction, chromatography.

363. *Analytical-Physical Chemistry II*

Spring. 3(4-0) 362.

Chemical kinetics. Homogeneous kinetics, reaction mechanisms, temperature dependence of reaction rates, transport process, heterogeneous kinetics, electrode kinetics, X-ray diffraction, crystal structure.

372. *Analytical-Physical Chemistry Laboratory I*

Winter. 2(1-3) 162; 383 or 361.

Measurement techniques. Temperature measurement and control, pressure, caloimetry, pH, acid-base titrations, cell potentials, treatment of data.

373. *Analytical-Physical Chemistry Laboratory II*

Spring. 2(1-3) 372.

Instrumental measurements. Electrode potentials, chromatography, spectrophotometry, electrolytic conductance, solution kinetics.

383. *Physical Chemistry: Introductory*

Fall, Summer. 3(4-0) 132 or 241 or 351; MTH 113.

Classical and chemical thermodynamics. Introduction to the laws and their applications in treating chemical reactions, pure substances, ideal and non-ideal mixtures, and colligative properties.

384. *Physical Chemistry: Introductory*

Winter, Summer. 3(4-0) 132 or 241 or 351; MTH 113.

Atomic and molecular structure. Atomic and molecular orbitals and chemical bonding. Rotational, vibrational and electronic spectra, nuclear magnetic resonance and electron spin resonance.

385. *Physical Chemistry: Introductory*

Spring. 3(4-0) 383 and 384.

Electrochemistry and electromotive force. Chemical kinetics. Macromolecules and biochemical systems. Nuclear chemistry.

394. *Spectroscopy Laboratory*

Spring. 2(1-3) 384 or 461.

Laboratory work in electronic, vibrational, and rotational spectroscopy, mass spectrometry, nuclear and electron spin resonance, dipole moments and magnetic susceptibility.

400H. *Honors Work*

Fall, Winter, Spring, Summer. Variable credit. Seniors, approval of department.

Assigned reading and investigation in chemistry under the supervision of the staff. The program will include some creative work.

411. *Systematic Inorganic Chemistry*

Winter, Summer. 4(4-0) 461.

Systematic study of the chemistry of representative metallic and non-metallic elements. Coordination chemistry and an introduction to acid-base theory and non-aqueous solvent systems.

414. *Laboratory Work in Inorganic Chemistry*

Winter, Spring, Summer. 3(1-6) Seniors.

Use of synthetic and analytical techniques commonly employed in modern research to prepare and characterize inorganic compounds.

419. *Problems and Reports*

Fall, Winter, Spring, Summer. 2 to 8 credits.

430. *Introduction to Radioactivity and Radioisotope Techniques*

Fall, Summer. 3(2-3) One year each of general college chemistry and physics and 161. 162 recommended. Physics majors cannot apply course towards graduation requirements. Interdepartmental with and administered by the Physics Department.

Elementary nuclear properties and processes with emphasis on radioactivity, its measurement, and its interaction with matter. Special attention is given to experimental techniques and applications of radioisotopes to problems in chemistry, the life sciences and industry.

446. Polymerization

Fall. 3(3-0) One year organic chemistry, elementary physical chemistry. Interdepartmental with the Chemical Engineering Department.

Formation and characterization of polymers of high molecular weight will be emphasized.

461. Theoretical Chemistry I

Fall. 3(4-0) One year general chemistry; one year general physics; MTH 215.

Quantum chemistry. Wave properties, postulates of quantum mechanics, hydrogen atom, helium atom, orbital theories, ionic bonds, simple molecules, valence-bond and molecular-orbital theories, complex molecules, introduction to spectra.

462. Theoretical Chemistry II

Winter. 3(4-0) 361, 461.

Spectroscopy and molecular structure. Electronic, infrared, Raman, and microwave spectroscopy, magnetic susceptibility and magnetic resonance, statistical mechanics, statistical thermodynamics, kinetic theory of gases, absolute rate theory.

471. Analytical-Physical Chemistry Laboratory III

Fall. 2(0-6) 363, 373.

Kinetics, operational amplifiers, polarography, coulometry, electrochemical kinetics, stopped-flow kinetics, digital measurements, neutron activation.

472. Analytical-Physical Chemistry Laboratory IV

Winter. 2(0-6) 461, 471.

Molecular properties. Mass spectrometry, nuclear and electron spin resonance spectroscopy, infrared spectroscopy, dipole moments, magnetic susceptibility, gaseous decomposition kinetics.

473. Analytical-Physical Chemistry Laboratory V

Spring. 2(0-6) 472.

Individual problems using instrumentation and/or computational methods resulting in a comprehensive written report.

484. Modern Physical Chemistry

Spring. 3(3-0) May re-enroll for a maximum of 6 credits if a different topic is taken. 462.

Topics may be selected from the following: physical properties and structure, molecular structure, spectroscopy, theory of solutions.

492. Chemical Spectroscopy

Winter, Summer. 3(3-0) 384 or 461.

Spectroscopy applied to chemical problems. Especially to atomic and molecular structure.

499. Seminar on Chemical Physics

Fall, Winter, Spring. 1(1-0) May re-enroll for a maximum of 3 credits. One year of analytical-physical chemistry. MTH 215; PHY 428.

Literature of chemical physics through oral reports on selected journal articles in the area.

811. Symmetry, Group and MO Theory

Winter. 3(3-0) Approval of department.

Applications of group and molecular orbital theory to chemical bonding, structure and reactions.

812. Advanced Inorganic Chemistry—Non-Metals

Winter. 3(3-0) 811 or approval of department.

Continuation of 811 with emphasis in structure and chemistry of the non-metals.

813. Advanced Inorganic Chemistry—Metals

Spring. 3(3-0) 811.

Continuation of 811 with emphasis on the structure and chemistry of the metals.

830. Nuclear and Radiochemistry

Winter. 3(3-0) Approval of department.

Chemistry of production, isolation and identification of radionuclides and their uses in chemical research.

834. Advanced Analytical Chemistry

Winter. 3(3-0) Approval of department.

Consideration of principles and equilibria pertaining to aqueous and non-aqueous neutralization, redox and complexation reactions and the various separation techniques employed in analyses.

835. Instrumental Anaylsis—Spectroscopy

Fall. 3(2-3) Approval of department.

Theory and applications in chemical analysis of emission spectroscopy, flame photometry, UV, visible and IR spectrophotometry, fluorometery, and the various X-ray methods.

836. Separations

Winter. 3(3-0) Approval of department.

Physical and chemical methods of separation.

837. Instrumental Analysis—Electroanalysis

Spring. 3(2-3) Approval of department.

Theory and applications of potentiometry, polarography, amperometry, coulometry, mass spectrometry, and other analytical methods.

838. Scientific Instrumentation

Winter. 4(3-4) Approval of department.

Scientific measurements. Principles and applications of servo systems, operational amplifiers, linear and digital solid state devices, analog, digital and hybrid instrumentation systems, and minicomputers for scientific measurements.

844. Structural Elucidation by Instrumental Methods

Fall. 3(3-0) Approval of department.

A practical instrumental analysis course with the major emphasis on the interpretation of data rather than a detailed description of the instrumentation. The fundamental principles behind the various measurements will be discussed in a general way, and important instrumental limitations will be noted.

847. Physical Chemistry of Macromolecules

Winter of odd-numbered years. 3(3-0) 446 or approval of department. Interdepartmental with and administered by the Chemical Engineering Department.

Thermodynamics–phase equilibria of polymer solutions; configuration and conformation of chain molecules; characterization of polymer molecular weight and distribution; theoretical and experimental results for dilute solution viscosity and diffusivity; polyelectrolytes.

851. Organic Chemistry

Fall. 3(3-0) 353; 462 or approval of department.

Chemical principles will be illustrated through a coordinated presentation of examples from inorganic and organic chemistry. About half of the course will be devoted to bonding and stereochemistry, the remainder to reactive intermediates in chemical reactions and their reactivity patterns.

852. Organic Chemistry

Winter. 3(3-0) 851.

Continuation of 851.

853. Organic Chemistry

Spring. 3(3-0) 852.

Continuation of 852.

880. Atomic and Molecular Structure

(882.) Fall. 3(3-0) 462 or approval of department.

Basic concepts of non-relativistic quantum mechanics will be developed and employed in a description of atomic and molecular structure.

881. Thermodynamics

Winter. 3(3-0) Approval of department.

Laws of thermodynamics and their application to pure substances and solutions.

883. Chemical Kinetics

Spring. 3(3-0) 880.

Rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases, photochemistry.

890. Problems and Reports

Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 12 credits. Approval of department.

899. Research

Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 12 credits. Approval of department.

Research in inorganic, analytical, organic, and physical chemistry.

908. Seminar

Summer. 2 credits. Approval of department.

Topics are selected from current active research areas.

913. Selected Topics in Inorganic Chemistry

Fall, Spring. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken.

Rare earth elements, recent advances in the chemistry of metals or nonmetals, high-temperature chemistry. Coordination chemistry and nonaqueous solvents.

918. Seminar in Inorganic Chemistry

Fall, Winter, Spring. 0 or 1(1-0)

Discussions of recent advances and reports by graduate students on research problems.

924. Selected Topics in Analytical Chemistry

Fall, Winter, Spring. 2(2-0) May re-enroll for a maximum of 6 credits if different topic is taken.

One of the following topics will be discussed: advances in electroanalytical chemistry, redox reactions, non-aqueous solvents in analytical chemistry, theory of acid-base equilibria, complex compounds in chemical analysis.

938. Seminar in Analytical Chemistry

Fall, Winter, Spring. 0 or 1(1-0)

Discussions of recent advances and reports by graduate students on research problems.

956. Selected Topics in Organic Chemistry

Fall, Winter, Spring. 2(2-0) or 3(3-0) May re-enroll for a maximum of 12 credits if different topic is taken. Approval of department.

Topics may be selected from heterocyclic chemistry, natural products, free radicals, carbonium ions, organic sulfur or nitrogen compounds, acidity functions, isotope effects, photochemistry and others.

958. *Seminar in Organic Chemistry*
Fall, Winter, Spring. 0 or 1(1-0)

Discussions of recent advances and reports by graduate students on research problems.

985. *Statistical Thermodynamics*
Fall of odd-numbered years. Winter and Spring of even-numbered years. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.

Definition of partition function; translational, rotational, vibrational and electronic partition functions and their calculation and application to thermodynamic problems; application of spectroscopic measurements to thermodynamic calculations.

987. *Selected Topics in Physical Chemistry*
Fall. 3(3-0) May re-enroll for a maximum of 6 credits if different topic is taken. Approval of department.

Mathematical preparation for quantum chemistry. Selected topics as: kinetics and photochemistry, macromolecular and surface chemistry, molecular spectroscopy, electro and magnetic properties of matter, application of statistical mechanics to chemical problems.

988. *Selected Topics in Physical Chemistry*
Winter. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.

Topics may be chosen from analysis and interpretation of the spectra of molecules, advanced molecular structure, magnetic resonance, spectroscopy, X-rays and crystal structure, statistical mechanics.

991. *Quantum Chemistry*
Fall, Winter, Spring. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.

Principles of quantum chemistry and their application to chemical problems. Electronic structure of molecules and its correlation with the chemical and physical properties of substances. Emission and absorption of radiation.

998. *Seminar in Physical Chemistry*
Fall, Winter, Spring. 0 or 1(1-0)

Discussions of recent advances and reports by graduate students on research problems.

999. *Research*
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Research in analytical, inorganic, organic, and physical chemistry.

CHINESE

See Linguistics and Oriental and African Languages

CIVIL AND SANITARY ENGINEERING

College of Engineering

Civil Engineering — C E

251. *Elementary Surveying*
Fall, Spring. 4(3-3) Trigonometry, EGR 160 or 267 or L A 123. Not open to majors.

Use of the tape, compass, level, and transit with simple maps; traverse closure and area computations. Profile, cross section and stadia surveys, U. S. land system.

252. *Surveying I*
Fall, Spring. 5(4-3) Trigonometry.

Instruments, theory of measurements, error analysis, stadia, horizontal and vertical curves, U.S. Public Land System, observation for meridian.

305. *Structural Mechanics I*
Winter, Spring. 4(4-0) MMM 211.

Stability and determinacy of structures. Two and three dimensional determinate structures. Indeterminate structural analysis by displacement and force methods based upon equilibrium, compatibility and load-deformation relations.

308. *Engineering Materials I*
Winter, Spring. 4(3-3) MMM 211 or concurrently.

Structure; composition; physical, mechanical and rheological properties of non-metallic construction materials. Emphasis on aggregates, asphalt, inorganic cements, concrete, and wood.

311. *Urban Utilities*
Winter. 3(3-0) 251.

Utilities and improvements necessary for urban populations. Course primarily designed for students in urban planning.

312. *Soil Mechanics I*
Spring, Summer. 4(3-3) MMM 211.

Properties of soil and particulate materials, physics of clay water systems, effective stress and consolidation theory, soil strength theory, and introduction to problems of design and construction.

321. *Hydrodynamics*
Winter, Spring. 5(4-2) MMM 206.

Fundamentals of flow of real fluid, fluid properties, kinematics, continuity, laminar and turbulent flow, form drag, stream lines, potential flow pipe and open channel flow.

342. *Survey of Transportation Systems*
Fall. 4(4-0) Juniors; not open to majors.

Survey of engineering aspects of all forms of transportation with emphasis on highway transportation including highway systems, planning, economic and financial aspects, geometrics and traffic studies.

351. *Applied Surveying and Mapping*
Fall, Spring. 5(3-6) 251, not open to majors.

Horizontal and vertical curves; earthwork, contours, volumes; meridian determinations.

353. *Surveying II*
Fall, Spring. 4(3-3) 252 or approval of department.

Continuation of 252 including photogrammetric methods, astronomical observations for latitude, longitude and meridian. Introduction to geodetic methods.

370. *Cost and Optimization Engineering*
Fall. 3(3-0) MTH 214 or concurrently.

Formulation of engineering decisions governed by current and future costs and returns. Comparison and optimization of alternative engineering projects, products and processes.

372. *Engineering Estimating*
Winter. 4(4-0) Juniors.

Construction planning and estimating with particular attention to factors affecting cost of materials, labor, equipment and overhead on a project. Methods used in estimating engineering projects.

374. *Construction Administration*
Spring. 4(4-0) Juniors.

Emphasis on owner-engineering-contractor relationships, ethics and professional registration. Plans, specifications, contract proposals, bidding procedures, and contract performance. Introduction to methods for project planning and control including critical path method.

382. *Environmental Engineering I—Hydrology and Water Supply*
Spring, Summer. 4(3-2) 321; CEM 131 or 141.

Hydrology of ground and surface waters. Hydraulic networks. Water supply and distribution systems. Water quality, control and treatment.

390. *Civil Engineering Analysis*
Fall, Winter. 3(3-0) MTH 215.

Analysis of civil engineering problems by numerical and statistical methods. Approximate methods and error analysis. Application to computer use.

400. *Structural Mechanics II*
Spring, Summer. 4(4-0) 305.

Energy methods in static and dynamic structural analysis, including the principles of virtual displacements and virtual forces. Influence lines. Matrix analysis of structures, influence and stiffness coefficients. Computer facilities are used.

405. *Structural Design in Steel*
Fall, Winter. 4(4-0) 305.

Beams, columns, tension and compression members, connections. Elastic, plastic and ultimate strength concepts.

406. *Structural Design in Concrete*
Winter, Spring. 4(4-0) 305.

Reinforced concrete beams, columns, slabs, footings and retaining walls. Elastic theory and ultimate strength concepts. Prestressed theory and design.

410. *Structural Mechanics III*
Fall. 4(4-0) 400.

Beam-columns, elastic buckling, thin-walled members. Elementary theory with special reference to structures. Elements of plates and shells. Introduction to inelastic behavior of structures.

419. *Soil Mechanics II*
Fall. 4(4-0) 312.

Elastic and plastic equilibrium in soil and rock masses, concepts of stability and soil-structure interactions. Applications to earth structures, bearing capacity and earth pressure problems.

421. *Hydrology*
Fall. 3(3-0) MTH 112, Juniors or approval of department.

Meteorologic and hydrologic phenomena associated with the hydrologic cycle; precipitation, melting of snow and ice, streamflow, evaporation and evapotranspiration; observational and analytical methods; river forecasting, design applications.

422. *Hydraulics*
Spring. 4(3-2) 321.

Pipes and pipe networks, open channel flow, flow measurements, hydraulic machinery, surges and water hammer.