447. Hotel Law

Winter, Spring. 4(4-0) 440.

Negotiable instruments, warranties, property, torts, civil rights, agency, partnerships, corporations as applied to hotel and restaurant management.

468. Field Studies

Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 8 credits. Business majors and approval of department.

Planned program of observation and work in selected business firms. Analysis and reports.

848. The Legal Environment of Business

Winter, Summer. 4(4-0)

Critical examination of the environment in which business operates. Analysis of the component elements of the legal environment of business and the structural framework in which law functions.

849. Legal Environment of International Business

Spring, Summer. 4(4-0)

Commercial and financial transactions in international business, foreign agencies, branches, subsidiaries. Aspects of labor relations, antitrust, taxation, and transportation as related to foreign operations. Litigation and arbitration in the international business community.

871. Seminar: Office Management

Winter, Summer. 3 credits. May re-enroll for a maximum of 6 credits. Approval of department.

Problems, practices, and policies involved in office administration. Methods of establishing, analyzing, standardizing, and controlling administrative systems and procedures in the office.

878. Seminar in Business Law

Fall, Spring. 4(4-0) May re-enroll for a maximum of 8 credits. 848 or approval of department.

Public policy with regard to contracts, antitrust, security transactions, labor relations of the firm, viewed from the legislative, judicial, and executive vantage points.

890. Special Problems

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

CHEMICAL ENGINEERING CHE

College of Engineering

201. Chemical Engineering Calculations

Fall, Winter. 3(3-0) CEM 153; MTH 214; PHY 287 or concurrently.

Chemical engineering calculations. Organization of calculations. Material balances, energy balances, behavior of gases, equilibrium relations and reaction rates.

202. Thermodynamics for Chemical Engineering

Winter, Spring. 3(3-0) 201, MTH 215 or concurrently.

First and second laws. Internal energy, enthalpy, entropy, free energy, and work functions. Application to batch and flow processes, open and closed systems, reacting and nonreacting systems. Interrelationships of thermodynamic properties for perfect gases and for real substances.

301. Transfer Processes and Separations

Fall, Winter. 4(4-0) 201; 361 or concurrently; MTH 215.

Thermodynamics of fluid flow. Application to flow equipment. Frictional effects for laminar and turbulent motion of compressible and incompressible fluids. Dimensional analysis and similitude. Continuity and flow equations in tensor notation. Treatment of fluid flow as a momentum transfer process. Analogous treatment of heat flow. Heat transfer in solids and flowing fluids.

302. Transfer Processes and Separations

Winter, Spring. 4(4-0) 301.

Heat transfer in condensing and boiling systems. Application to engineering equipment. Condensers, interchangers, and multiple effect evaporators. Radiation. Mass transfer. Analogies with momentum and heat. Continuous and stagewise contactors.

303. Transfer Processes and Separations

Fall, Spring. 4(4-0) 302.

Simultaneous heat and mass transfer. Humidification. Gas absorption. Distillation, ideal, non-ideal, binary and multicomponent. Extraction. Azeotropic and extractive distillation. Mass transfer with chemical reaction.

361. Chemical Thermodynamics

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

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

404. Chemical Engineering Operations

Spring. 3(3-0) 303 or concurrently.

Mechanical separation of heterogeneous mixtures. Gravitational and centrifugal methods. Cake filtration and filter-medium filtration. Crystallization from solution. Phase equilibria and separation by crystallization. Adsorption and chromatography.

422. Chemical Engineering Laboratory

Fall, Winter. 4(0-12) 303.

Assigned projects requiring laboratory investigation. Experimental work involving transport phenomena, momentum, heat, and mass transfer; separation processes such as distillation, filtration, and drying; thermodynamics and reactor kinetics.

428. Chemical Reaction Engineering

Fall. 3(3-0) 303; CEM 362, 461.

Quantitative treatment of mechanisms and rates of chemical reactions. Catalysis. Design and analysis of flow and non-flow reactors. Interpretation of laboratory kinetic data.

443. Chemical Engineering of the Solid State

Spring. 4(4-0) CEM 461.

Polymeric, crystalline, organic, and inorganic solids. Relation of bond type and steric configuration to mechanical, electrical, thermal, and optical properties. Influence of macroscopic structure on physical properties. Surface phenomena. Applications.

446. Polymerization

Fall. 3(3-0) One year organic chemistry, elementary physical chemistry. Interdepartmental with and administered by the Chemistry Department.

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

451. Dynamics and Control of Chemical Engineering Systems

Winter. 5(5-0) 303, MTH 215.

Transient behavior of chemical engineering processes. Elements and dynamic response of control loops. Composition measurement and control. Analysis of system stability. Optimizing control.

460. Problems and Reports

Fall, Winter, Spring. 1 to 9 credits. Seniors, approval of department.

Library and laboratory investigations of problems relating to departmental research.

461. Process Selection and Optimization

Winter. 3(3-0) 303.

Application of chemical engineering principles in design calculations. Selection of the optimum design for equipment, functional units, and for the overall process. Influence of design on capital investment, operating cost, product loss, and product quality.

462. Process Design

Spring. 3(1-6) 461.

Integrated design of the complete chemical engineering process. Process engineering, project engineering, instrumentation, and layout.

465. Process Optimization Methods

Spring. 3(3-0) MTH 215, knowledge of linear algebra. Interdepartmental with Systems Science.

Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods.

481. Transport Phenomena

Fall. 3(3-0) 303, 361.

Solution of engineering problems using the general equations of change for transport of momentum, heat, and mass in an arbitrary continuum. Interphase transport.

801. Advanced Chemical Engineering Calculations I

Fall. 3(3-0) 303.

Chemical engineering applications of advanced mathematical methods. Formulation and solution of mathematical equations which describe physical problems. Computer solutions.

802. Advanced Chemical Engineering Calculations II

Winter. 3(3-0) 801.

Continuation of 801.

811. Advanced Chemical Engineering Thermodynamics I

Fall. 3(3-0) 203, 361; CEM 461.

Advanced treatment of the laws of thermodynamics. Cryogenic processes. Corresponding state and higher parameters in computing properties of chemical compounds and solutions.

817. Advanced Chemical Reaction Engineering I

Winter. 3(3-0) 428.

Treatment of absorption and catalysis and their application to catalytic reactors. Heat, momentum, and mass-transfer in fixed-bed and fluidized-bed reactors. Non-catalytic heterogeneous reactions. Homogenous chain reactions and free radical mechanisms. Computer applications to solution of complex kinetic problems.

821. Theory of Nuclear Reactors

Fall of even-numbered years. 3(3-0) PHY 289; MTH 341; or approval of department.

Theory and design of nuclear research and power reactors. Nuclear transformation, fission, and energy conversion. Derivation of chain

reaction design criteria, and calculation of flux-power distribution. Analysis of reactor safety, reliability, and economics.

825. *Theory, Applicability and Engineering of Radioisotopes*

Winter of even-numbered years. 3(3-0) PHY 498 or CEM 461 or approval of department.

Principles of utilization of radioisotopes in research and production problems for engineering and science majors. Fundamentals and preparation techniques of radioisotopes. Selection, specification, measurement and disposal for typical technical problems.

826. *Flow of Heat I*

Spring. 3(3-0) 303.

Steady and unsteady state heat transfer. Conduction and convection in flow and non-flow systems.

831. *Distillation, Absorption, and Extraction I*

Spring. 3(3-0) 303.

Stagewise calculations in distillation, absorption, and extraction processes. Computer techniques. Liquid-gas and liquid-liquid equilibria. Batch, continuous, binary and multi-component calculations.

832. *Distillation, Absorption and Extraction II*

Fall. 3(3-0) 303.

Mass transfer in distillation, absorption, and extraction processes. Continuous and stagewise phase contactors. Column hydrodynamics and plate efficiency.

841. *Advanced Transport Phenomena*

Winter. 3(3-0) MTH 215, B.S. in engineering or physical science.

Use of equations of change in solving engineering problems. Boundary layer and penetration theories of interphase transport. Potential flow. Theories of turbulence from statistical standpoint.

881. *Seminar*

Fall, Winter, Spring, Summer. 1(0-2) May re-enroll for a maximum of 3 credits allowed toward M.S. degree and 6 credits toward Ph.D. degree.

Detailed library investigation of one or more specialized aspects of chemical engineering, such as recent theoretical developments in one of the unit operations; presentations of these studies to a seminar group. Participation generally required each term of residence.

886. *Selected Topics in Chemical Engineering*

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

A newly developing area of chemical engineering selected by the department for offering each term. Information on the specific topic to be covered should be obtained from the department office before registration.

888. *Research Survey*

Fall, Winter, Spring, Summer. 3 credits.

Literature search, problem analysis, and layout of a complete research program.

893. *Special Problems*

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

899. *Research*

(EGR 899.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

912. *Advanced Chemical Engineering Thermodynamics II*

Winter of even-numbered years. 3(3-0) Approval of department.

Relation of thermodynamics to quantum theory and statistical mechanics. Computation of chemical engineering thermodynamic data from spectral measurements. Irreversible thermodynamics.

918. *Advanced Chemical Reaction Engineering II*

Spring of even-numbered years. 3(3-0) Approval of department.

Quantitative treatment of current literature in chemical kinetics and reaction engineering.

927. *Flow of Heat II*

Fall of even-numbered years. 3(3-0) Approval of department.

Fundamentals of radiant heat transfer. Computer techniques in the design of radiant and convective heat transfer equipment.

942. *Transport Properties*

Spring of odd-numbered years. 3(3-0) Approval of department.

Use of molecular theories to calculate transport properties of gases and liquids. Empirical methods of estimating transport coefficients. Rheology of polymer systems.

943. *Chemical Engineering of Solid Materials*

Winter of odd-numbered years. 3(3-0) Approval of department.

Mechanical, chemical, electrical, magnetic, optical and surface properties of solids. Effect upon these properties of electronic and molecular structure, of microscopic and macroscopic physical structure, and of physical and chemical methods of manufacture.

965. *Optimal Process Theory*

Fall of odd-numbered years. 3(3-0) Approval of department.

Current developments in the determination of optimal designs and operating policies for complex process systems. Numerical and analytic methods.

999. *Research*

(EGR 999.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

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*

(103.) 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) 383 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; 384 or 362 or concurrently.

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

373. Analytical-Physical Chemistry Laboratory II
Spring. 2(1-3) 372; 384 or 362.

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.

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

384. Physical Chemistry: Introductory
Winter, Summer. 3(4-0) 383.

Gas laws and kinetic-molecular theory. Thermodynamics and thermochemistry, solids, liquids, solutions and equilibria.

385. Physical Chemistry: Introductory
Spring. 3(4-0) 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. Chemistry Radioisotope Techniques
Summer. 3(2-4) Nine credits organic chemistry, 6 credits analytical chemistry.

Radioactivity, interactions of radiation with matter, isotope production, separations; applications to chemistry including tracer chemistry, activation analysis, isotope dilution, instrumentation.

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. Advanced Inorganic Chemistry
Winter. 3(3-0) 411 or approval of department; 880 concurrently.

Bonding and structure of inorganic materials; applications of group theory and quantum mechanics.

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. Radiochemistry
Winter. 3(2-3) 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. *Instrumental Analysis—Instrumentation*

Winter. 3(2-4) Approval of department.

Practice in design, construction and testing of typical apparatus employed in instrumental chemical analysis.

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.

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) 462 or 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. 984 or 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*

Winter. 2(2-0) or 3(3-0) May re-enroll for a maximum of 6 credits if different topic is taken. Approval of department.

Discussion on such topics as: kinetics and photochemistry, macromolecular and surface chemistry, application of statistical mechanics to chemical problems, molecular spectroscopy, electric and magnetic properties of matter.

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.

Theory of measurements, calculations, error analysis and instruments. Methods and calculations of engineering work.

253. *Surveying II*

Fall, Spring. 4(3-3) 252.

Land surveys, U.S. land systems, astronomical observations, triangulation and photogrammetry.

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 and rheological properties of non-metallic construction; materials. Applications to agglomerated, cementitious, polymeric and pavement materials.

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 flow in porous media and consolidation theory. Effective stress theory, pore water pressure and soil strength theories.

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.