

# Chemistry (CHEM)

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**CHEM 117. Chemical Concepts and Applications. 3 Credits.**

Introduction to general and organic chemistry, with applications drawn from the health, environmental, and materials sciences. Prereq or Coreq: MATH 103 or MATH 107.

**CHEM 117L. Chem Concepts and Applications Lab. 1 Credit.**

Introduction to general and organic chemistry, with applications drawn from the health, environmental, and materials sciences. Prereq or Coreq: MATH 103 or MATH 107. (ND:LABSC) CCN.

**CHEM 121. General Chemistry I. 3 Credits.**

Matter, measurement, atoms, ions, molecules, reactions, chemical calculations, thermochemistry, bonding, molecular geometry, periodicity, and gases. Prereq or Coreq: MATH 103 or MATH 107.

**CHEM 121L. General Chemistry I Laboratory. 1 Credit.**

Matter, measurement, atoms, ions, molecules, reactions, chemical calculations, thermochemistry, bonding, molecular geometry, periodicity, and gases. Prereq or Coreq: MATH 103 or MATH 107.

**CHEM 122. General Chemistry II. 3 Credits.**

Intermolecular forces, liquids, solids, kinetics, equilibria, acids and bases, solution chemistry, precipitation, thermodynamics, and electrochemistry. Prereq: CHEM 121.

**CHEM 122L. General Chemistry II Laboratory. 1 Credit.**

Intermolecular forces, liquids, solids, kinetics, equilibria, acids and bases, solution chemistry, precipitation, thermodynamics, and electrochemistry. Prereq: CHEM 121L.

**CHEM 140. Organic Chemical Concepts and Applications. 1 Credit.**

Introduction to organic chemistry for pre-nursing and other students who need to meet the prerequisite for CHEM 260.

**CHEM 150. Principles of Chemistry I. 3 Credits.**

Chemistry for students with good high school preparation in mathematics and science. Electronic structure, stoichiometry, molecular geometry, ionic and covalent bonding, energetics of chemical reactions, gases, transition metal chemistry.

**CHEM 151. Principles of Chemistry II. 3 Credits.**

Liquids and solids, equilibrium, kinetics, thermodynamics, acids and bases, oxidation-reduction chemistry, electrochemistry. Coreq: CHEM 150.

**CHEM 160. Principles of Chemistry Laboratory I. 1 Credit.**

Chemistry for students with good high school preparation in mathematics and science. Electronic structure, stoichiometry, molecular geometry, ionic and covalent bonding, energetics of chemical reactions, gases, transition metal chemistry.

**CHEM 161. Principles of Chemistry Laboratory II. 1 Credit.**

Liquids and solids, equilibrium, kinetics, thermodynamics, acids and bases, oxidation-reduction chemistry, electrochemistry. Prereq: CHEM 160.

**CHEM 194. Individual Study. 1-3 Credits.****CHEM 196. Field Experience. 1-15 Credits.****CHEM 199. Special Topics. 1-5 Credits.****CHEM 240. Survey of Organic Chemistry. 3 Credits.**

Structure and bonding, nomenclature; hydrocarbons: alkanes, alkenes, alkynes, aromatics; substituted hydrocarbons: alkyl halides, stereochemistry, alcohols, phenols, ethers, amines; carbonyls: aldehydes, ketones; carboxylic acids, esters, amides. Prereq: CHEM 121.

**CHEM 260. Elements of Biochemistry. 4 Credits.**

Protein structure, function conformation, and dynamics; enzymes, DNA-RNA: structure and flow of genetic information; biological membranes; metabolism. 4 lectures. Prereq: CHEM 117 or CHEM 122, CHEM 140 or CHEM 240. Also listed under BIOC 260.

**CHEM 291. Seminar. 1-3 Credits.****CHEM 292. Study Abroad. 1-15 Credits.****CHEM 294. Individual Study. 1-5 Credits.****CHEM 299. Special Topics. 1-5 Credits.****CHEM 341. Organic Chemistry I. 3 Credits.**

First semester of a two-semester course in organic chemistry for students in sciences and pre-professional curricula. Prereq: CHEM 122 or CHEM 151.

**CHEM 341L. Organic Chemistry I Laboratory. 1 Credit.**

First semester of a two-semester course in organic chemistry for students in sciences and pre-professional curricula. Prereq: CHEM 122L or CHEM 161.

**CHEM 342. Organic Chemistry II. 3 Credits.**

Structure and reactivity, named reactions, carbon-carbon bond forming reactions, aromatic and heterocyclic chemistry, biomolecules and polymers, and multi-step synthesis. Prereq: CHEM 240 or CHEM 341.

**CHEM 342L. Organic Chemistry II Laboratory. 1 Credit.**

Structure and reactivity, named reactions, carbon-carbon bond forming reactions, aromatic and heterocyclic chemistry, biomolecules and polymers, and multi-step synthesis. Prereq: CHEM 341L.

**CHEM 353. Majors Organic Chemistry Laboratory I. 1 Credit.**

Organic functional group synthesis. Modern analytical tools for functional group analysis and structure determination. Coreq: CHEM 341.

**CHEM 354. Majors Organic Chemistry Laboratory II. 2 Credits.**

More advanced aspects of organic laboratory operations, synthesis, analysis, and structure determination using spectroscopic techniques. Coreq: CHEM 342.

**CHEM 364. Physical Chemistry I. 3 Credits.**

Mathematical and physical basis of chemical phenomena. Emphasis on quantum chemistry and spectroscopy. Prereq: CHEM 122 or CHEM 151, MATH 259 or MATH 265, PHYS 252.

**CHEM 365. Physical Chemistry II. 3 Credits.**

Mathematical and physical basis of chemical phenomena. Emphasis on chemical thermodynamics. Prereq: CHEM 122 or CHEM 151, MATH 259 or MATH 265 and PHYS 252.

**CHEM 379. Study Tour Abroad. 1-6 Credits.****CHEM 380. Chemistry Junior Seminar. 1 Credit.**

Includes discussion of chemistry topics, technical writing instruction and assignments; participation in senior seminar discussions.

**CHEM 391. Seminar. 1-3 Credits.****CHEM 392. Study Abroad. 1-15 Credits.****CHEM 394. Individual Study. 1-5 Credits.****CHEM 397. Fe/Coop Ed/Internship. 1-4 Credits.****CHEM 399. Special Topics. 1-5 Credits.****CHEM 425. Inorganic Chemistry I. 3 Credits.**

Electronic structure, ionic and covalent structure and bonding, point groups and symmetry, coordination chemistry, acid-base and redox chemistry. Prereq: CHEM 364. {Also offered for graduate credit - see CHEM 625.}

**CHEM 426. Crystallography/Crystal Chemistry. 2 Credits.**

Geometric and space group crystallography. Structure and bonding in common minerals and industrially important solids. Structure-property relationships. Half semester. {Also offered for graduate credit - see CHEM 626.}

**CHEM 427. X-Ray Diffraction. 2 Credits.**

Analytical X-ray powder diffraction for qualitative and quantitative analysis of crystalline solids. Crystal structure analysis using powder methods. Introduction to X-ray fluorescence spectrometry. Half semester. {Also offered for graduate credit - see CHEM 627.}

**CHEM 428. Geochemistry. 3 Credits.**

Introduction to geochemistry: chemistry of the Earth, groundwater, isotopes, global geochemical cycles, geochemical modeling, and environmental geochemistry. Recommended: CHEM 121 or CHEM 150. Cross-listed with GEOL 428. (alternate years) {Also offered for undergraduate credit - see CHEM 628.}

**CHEM 429. Inorganic Chemistry Laboratory. 2 Credits.**

Methods of synthesis and characterization of inorganic and organometallic compounds. Prereq: CHEM 354, CHEM 431L. Coreq: CHEM 425.

**CHEM 431. Analytical Chemistry I. 3 Credits.**

Chemical equilibrium and its analytical applications; introduction to chromatography and potentiometry. Prereq: CHEM 122 or CHEM 151, CHEM 122L or CHEM 161 and CHEM 342.

**CHEM 431L. Analytical Chemistry I Laboratory. 2 Credits.**

Chemical equilibrium and its analytical applications; introduction to chromatography and potentiometry. Prereq: CHEM 122L or CHEM 161.

**CHEM 432. Analytical Chemistry II. 3 Credits.**

Theory and application of modern instrumental techniques, including spectroscopy and electrochemistry. Prereq: CHEM 431. {Also offered for graduate credit - see CHEM 632.}

**CHEM 432L. Analytical Chemistry II Laboratory. 1 Credit.**

Theory and application of modern instrumental techniques, including spectroscopy and electrochemistry. Prereq: CHEM 431L. {Also offered for graduate credit - see CHEM 632L.}

**CHEM 435. Chemical History. 2 Credits.**

Survey of the history of the chemical sciences from the stone-age through the early 1900s. Prereq: CHEM 341. {Also offered for graduate credit - see CHEM 635.}

**CHEM 471. Physical Chemistry Laboratory. 2 Credits.**

Measurement of thermodynamic and spectroscopic properties of chemical substances, analysis of data. Prereq: CHEM 364.

**CHEM 472. Surface Chemistry. 2 Credits.**

The object of the course is to enhance the knowledge of experimental and computational techniques in a sub area of physical chemistry. {Also offered for graduate credit - see CHEM 672.}

**CHEM 476. Introduction to Computational Quantum Chemistry. 3 Credits.**

This is a mathematically non-rigorous introduction to procedures and capabilities of basic computational quantum chemistry with practical aspects on using common computational chemistry software. Recommended: CHEM 364, CHEM 365. {Also offered for graduate credit - see CHEM 676.}

**CHEM 491. Seminar. 1-5 Credits.****CHEM 492. Study Abroad. 1-15 Credits.****CHEM 494. Individual Study. 1-5 Credits.****CHEM 496. Field Experience. 1-15 Credits.****CHEM 499. Special Topics. 1-5 Credits.****CHEM 625. Inorganic Chemistry I. 3 Credits.**

Electronic structure, ionic and covalent structure and bonding, point groups and symmetry, coordination chemistry, acid-base and redox chemistry. {Also offered for undergraduate credit - see Chem 425.}

**CHEM 626. Crystallography/Crystal Chemistry. 2 Credits.**

Geometric and space group crystallography. Structure and bonding in common minerals and industrially important solids. Structure-property relationships. Half semester. {Also offered for undergraduate credit - see CHEM 426.}

**CHEM 627. X-Ray Diffraction. 2 Credits.**

Analytical X-ray powder diffraction for qualitative and quantitative analysis of crystalline solids. Crystal structure analysis using powder methods. Introduction to X-ray fluorescence spectrometry. Half semester. {Also offered for undergraduate credit - see CHEM 427.}

**CHEM 628. Geochemistry. 3 Credits.**

Introduction to geochemistry: chemistry of the Earth, groundwater, isotopes, global geochemical cycles, geochemical modeling, and environmental geochemistry. Cross-listed with GEOL 628. (alternate years) {Also offered for undergraduate credit - see CHEM 428.}

**CHEM 632. Analytical Chemistry II. 3 Credits.**

Theory and application of modern instrumental techniques, including spectroscopy and electrochemistry. {Also offered for undergraduate credit - see CHEM 432.}

**CHEM 632L. Analytical Chemistry II Laboratory. 1 Credit.**

Theory and application of modern instrumental techniques, including spectroscopy and electrochemistry. {Also offered for undergraduate credit - see CHEM 432L.}

**CHEM 635. Chemical History. 2 Credits.**

Survey of the history of the chemical sciences from the stone-age through the early 1900's. {Also offered for undergraduate credit - see CHEM 435.}

**CHEM 672. Surface Chemistry. 2 Credits.**

The object of the course is to enhance the knowledge of experimental and computational techniques in a sub area of physical chemistry. {Also offered for undergraduate credit - see CHEM 472.}

**CHEM 676. Introduction to Computational Quantum Chemistry. 3 Credits.**

This is a mathematically non-rigorous introduction to procedures and capabilities of basic computational quantum chemistry with practical aspects on using common computational chemistry software. {Also offered for undergraduate credit - see CHEM 476.}

**CHEM 690. Graduate Seminar. 1-3 Credits.****CHEM 696. Special Topics. 1-5 Credits.****CHEM 720. Introduction to Chemical Research. 2 Credits.**

This course will serve as an introduction to research in the molecular sciences, with the goal to prepare graduate students for a successful graduate research experience and for a future research career in the molecular sciences.

**CHEM 724. Chemical Applications of Group Theory. 1 Credit.**

Symmetry, point groups, basic theory of mathematical groups, application of group theory to chemical bonding and spectroscopy.

**CHEM 725. Inorganic Chemistry II. 3 Credits.**

Molecular orbital and valence bond theories, inorganic reactions and mechanisms. Prereq: CHEM 625.

**CHEM 726. Photochemistry and Photophysics. 4 Credits.**

Fundamental principles in photochemistry and photophysics, rules for electronic transitions, energy transfer, electron transfer, photochemical reactions of organic chromophores (carbonyls, alkenes, enones, aromatics), singlet oxygen, photochemistry in organized and constrained media, organic solid state photochemistry, instrumental methods in photophysics, application of photochemistry. Prereq: CHEM 625, CHEM 724.

**CHEM 727. Organometallic Chemistry. 3 Credits.**

Synthesis, reactivity, and bonding in organometallic compounds. Prereq: CHEM 425 or CHEM 625.

**CHEM 728. Physical Methods for Chemical and Biomolecular Research. 2 Credits.**

Fundamentals and applications of physical methodologies, with emphasis on spectroscopic methods, used to probe molecular structure and the structural basis of reactivity. Covers optical, chiroptical, vibrational, paramagnetic resonance, and nuclear spectroscopic methods along with their applications to the study of molecular and biomolecular systems. Prereq: CHEM 625 or BIOC 665.

**CHEM 729. X-Ray Structure Determination. 2 Credits.**

Use of single crystal X-ray diffraction data to determine molecular and crystal structures. Half semester.

**CHEM 730. Separations. 2 Credits.**

Theory of equilibrium chemistry in aqueous and nonaqueous systems; principles of chromatographic and other separation techniques. Prereq: CHEM 632.

**CHEM 732. Electrochemistry. 4 Credits.**

Theory and application of modern electrochemical methods, including potentiometry, voltammetry, electrochemical impedance spectroscopy, kinetics and mechanisms of electrode processes, corrosion, simulation techniques, and instrumentation. Prereq: CHEM 632.

**CHEM 734. Instrumentation Electronics. 5 Credits.**

Design and operation of digital and analog circuits used in chemical instrumentation, computer interfacing. Includes laboratory. Prereq: CHEM 632.

**CHEM 736. Mass Spectrometry. 2 Credits.**

Theory and application of mass spectrometry in analysis, tandem mass spectrometry, ionization techniques. Half semester. Prereq: CHEM 632.

**CHEM 741. Physical Organic Chemistry I. 4 Credits.**

Principles governing the reactivity of organic compounds and methods for determining reaction mechanisms.

**CHEM 742. Physical Organic Chemistry II. 2 Credits.**

Aromaticity, electrophilic substitution, Woodward-Hoffman rules. Half semester. Prereq: CHEM 741.

**CHEM 743. Reactive Intermediates. 2 Credits.**

Radicals, carbenes, nitrenes, arynes, carbenium ions, survey of other reactive intermediates. Half semester. Prereq: CHEM 741.

**CHEM 744. Organic Spectroscopy. 2 Credits.**

Structure elucidation by spectrometric methods, including infrared, mass spectrometry, UV, and nuclear magnetic resonance. Interpretation of 2-D NMR spectra. Half semester.

**CHEM 745. Organic Synthesis. 4 Credits.**

Functional group synthesis, synthetic design, stereochemical control. Prereq: CHEM 741.

**CHEM 746. Advanced NMR Spectrometry. 2 Credits.**

Theory of pulsed FT-NMR, instrumentation, pulse sequences (with emphasis on multipulse experiments), two-dimensional NMR and applications. Half semester. Prereq: CHEM 744.

**CHEM 747. Heterocycles. 2 Credits.**

Synthesis of heterocycles, aromaticity, organometallic chemistry, nucleosides, natural products. Prereq: CHEM 745.

**CHEM 748. Total Synthesis of Natural Products. 2 Credits.**

Retrosynthetic analysis, total synthesis, terpenes, alkaloids will be studied. Prereq: CHEM 745.

**CHEM 754. Organic Spectroscopy Laboratory. 1 Credit.**

Laboratory to accompany 744, with emphasis on NMR techniques. Half semester. Coreq: CHEM 744.

**CHEM 759. Intermediate Physical Chemistry. 3 Credits.**

Fundamental principles of physical chemistry including quantum chemistry, spectroscopy, molecular thermodynamics, and kinetics.

**CHEM 760. Statistical Thermodynamics. 4 Credits.**

Macroscopic and microscopic models for the study of equilibrium properties of pure phases and solutions.

**CHEM 761. Optical Spectroscopy. 2 Credits.**

Theory and practice of modern spectroscopic methods. Emphasis on visible and ultraviolet wavelength ranges. Half semester. Prereq: CHEM 632.

**CHEM 763. Kinetics. 2 Credits.**

Experimental methods to determine reaction rates, empirical rate laws, transition state theory. Half semester.

**CHEM 764. Dynamics. 2 Credits.**

Chemical physics of energy transfer and reactive collisions. Half semester. Prereq: CHEM 763.

**CHEM 766. Quantum Chemistry I. 4 Credits.**

Wave functions and their properties, quantum mechanical behavior of atoms and molecules.

**CHEM 767. Quantum Chemistry II. 2 Credits.**

Ab initio and semi-empirical methods for the calculation of energetic and structural properties of molecules; computational methods. Half semester. Prereq: CHEM 766.

**CHEM 790. Graduate Seminar. 1-3 Credits.****CHEM 791. Temporary/Trial Topics. 1-5 Credits.****CHEM 793. Individual Study/Tutorial. 1-5 Credits.****CHEM 794. Practicum. 1-10 Credits.****CHEM 795. Field Experience. 1-15 Credits.****CHEM 796. Special Topics. 1-5 Credits.****CHEM 797. Master's Paper. 1-3 Credits.****CHEM 798. Master's Thesis. 1-10 Credits.****CHEM 899. Doctoral Dissertation. 1-15 Credits.**