# Chemistry Courses (CHEM)

## CHEM Courses

This is a list of courses with the subject code CHEM. For more information, see Chemistry (College of Liberal Arts and Sciences) in the catalog.

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<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
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<td>CHEM:0500</td>
<td>Review of Chemistry Fundamentals</td>
<td>0 s.h.</td>
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<tr>
<td>CHEM:1000</td>
<td>First-Year Seminar</td>
<td>1-2 s.h.</td>
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<tr>
<td>CHEM:1050</td>
<td>Chemistry of Our World</td>
<td>3 s.h.</td>
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<tr>
<td>CHEM:1060</td>
<td>Technology and Society Laboratory</td>
<td>1 s.h.</td>
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<td>CHEM:1070</td>
<td>General Chemistry I</td>
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<td>CHEM:1080</td>
<td>General Chemistry II</td>
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<td>CHEM:1090</td>
<td>Supplemental Chemistry Lab</td>
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<td>CHEM:1100</td>
<td>Chemistry in Industry and the Economy</td>
<td>3 s.h.</td>
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<tr>
<td>CHEM:1110</td>
<td>Principles of Chemistry I</td>
<td>4 s.h.</td>
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<td>CHEM:1120</td>
<td>Principles of Chemistry II</td>
<td>4 s.h.</td>
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<tr>
<td>CHEM:1160</td>
<td>Principles of Chemistry Lab</td>
<td>2 s.h.</td>
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<tr>
<td>CHEM:2021</td>
<td>Fundamentals of Chemical Measurements</td>
<td>3 s.h.</td>
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<tr>
<td>CHEM:2210</td>
<td>Organic Chemistry I</td>
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<td>CHEM:2220</td>
<td>Organic Chemistry II</td>
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<td>CHEM:2230</td>
<td>Organic Chemistry I for Majors</td>
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<tr>
<td>CHEM:2240</td>
<td>Organic Chemistry I for Majors</td>
<td>3 s.h.</td>
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<tr>
<td>CHEM:2420</td>
<td>Organic Chemistry Laboratory</td>
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<tr>
<td>CHEM:2440</td>
<td>Organic Chemistry Laboratory for Majors</td>
<td>3 s.h.</td>
</tr>
<tr>
<td>CHEM:2410</td>
<td>Organic Chemistry Laboratory</td>
<td>3 s.h.</td>
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</table>

Prerequisites, corequisites, and recommendations are provided as necessary.
CHEM:3110 Equilibria and Electrochemistry 3 s.h. Modern theory and practice; emphasis on chemical equilibria (acid-base chemistry, solubility, complexation) and electroanalytical chemistry (potentiometry, voltammetry, coulometry). Prerequisites: CHEM:1120 with a minimum grade of C-

CHEM:3120 Spectroscopy and Separations 3 s.h. Modern theory and practice; emphasis on atomic and molecular spectroscopy, mass spectrometry, chemical separations. Prerequisites: CHEM:1120 with a minimum grade of C-

CHEM:3250 Inorganic Chemistry 3 s.h. Modern principles; emphasis on descriptive chemistry of the main group and transition elements, ionic and covalent chemical bonding theories, symmetry, inorganic stereochemistry. Prerequisites: CHEM:2210 with a minimum grade of C- or CHEM:2230 with a minimum grade of C-

CHEM:3430 Analytical Measurements 3 s.h. Modern theory and practice of laboratory methods; emphasis on experimental techniques and data analysis in spectroscopy, chromatography, electrochemistry. Prerequisites: CHEM:2021 with a minimum grade of C- and CHEM:3110 with a minimum grade of C- or CHEM:3120 with a minimum grade of C-.

CHEM:3440 Physical Measurements 3 s.h. Laboratory experience using advanced instrumental and computational methods to generate and analyze data relevant to modern physical chemistry. Prerequisites: CHEM:2021 with a minimum grade of C- and CHEM:4431 with a minimum grade of C- or CHEM:4432 with a minimum grade of C-.

CHEM:3530 Inorganic Chemistry Laboratory 3 s.h. Preparation and characterization of a variety of inorganic, organometallic, and coordination compounds of the main group and transition elements; emphasis on synthetic techniques, methods for characterization of inorganic species. Prerequisites: CHEM:3250 with a minimum grade of C- and CHEM:2410 with a minimum grade of C- or CHEM:2420 with a minimum grade of C- and CHEM:2021 with a minimum grade of C-

CHEM:3994 Undergraduate Research 1-4 s.h.

CHEM:4000 Scientists and Writers 1 s.h. Science communication and collaborative skills that are highly sought after by employers in STEM firms including pharmaceutical firms, biotech start-ups, and many others; these same skills essential for reporting on, writing about, or translating science in any area; studio-style format. Same as JMC:4000, WRIT:4002.

CHEM:4270 Advanced Inorganic Chemistry 3 s.h. Modern principles, including crystal field/ligand field/molecular orbital theory, inorganic reaction mechanisms, coordination chemistry, bioinorganic chemistry, main group and transition metal organometallic chemistry, solid-state inorganic chemistry. Prerequisites: CHEM:3250 with a minimum grade of C-

CHEM:4372 Advanced Organic Chemistry 3 s.h. Basic concepts from perspectives of structure, mechanism, synthesis, stereochemistry. Prerequisites: CHEM:2220 with a minimum grade of C- or CHEM:2240 with a minimum grade of C-

CHEM:4430 Principles of Physical Chemistry 3 s.h. Kinetics, transport properties, elementary thermodynamics, and selected topics in quantum mechanics and spectroscopy; emphasis on application of chemistry to areas of science including health and biosciences, environmental sciences, and related areas. Prerequisites: CHEM:1120 with a minimum grade of C- and MATH:1460 with a minimum grade of C- or MATH:1550 with a minimum grade of C- or MATH:1850 with a minimum grade of C-.

CHEM:4431 Chemical Thermodynamics 3 s.h. Chemical thermodynamics and its application to chemical equilibrium, phase changes and chemical equilibria; ideal and real gases; kinetic theory; surface absorption and electrochemistry; thermodynamics. Prerequisites: CHEM:1120 with a minimum grade of C- and MATH:1560 with a minimum grade of C- or MATH:1860 with a minimum grade of C-

CHEM:4432 Quantum Mechanics and Chemical Kinetics 3 s.h. Quantum mechanics and its application to atomic and molecular structure; determination of structure and bonding by various spectroscopic methods; chemical kinetics. Prerequisites: CHEM:1120 with a minimum grade of C- and MATH:1560 with a minimum grade of C- or MATH:1860 with a minimum grade of C-.

CHEM:4450 Synthesis and Measurement 3 s.h. Laboratory investigations integrating synthesis and measurement techniques from inorganic, analytical, and physical chemistry; emphasis on modern applications of chemistry in biology, medicine, environmental science, catalysis, and materials science. Prerequisites: CHEM:4432 with a minimum grade of C- or CHEM:4430 with a minimum grade of C- or CHEM:4431 with a minimum grade of C- and CHEM:2420 with a minimum grade of C- or CHEM:2410 with a minimum grade of C- and CHEM:3120 with a minimum grade of C- and CHEM:3250 with a minimum grade of C- or CHEM:2021 with a minimum grade of C-

CHEM:4480 Introduction to Molecular Modeling 3 s.h. Theory and application of ab initio quantum mechanics, semiemipirical molecular orbital theory, and molecular mechanics force fields to chemical research problems; underlying theory of these methods (with emphasis on ab initio theory) and their practical application to chemical problems; computational chemistry projects using modeling software. Prerequisites: CHEM:2220 with a minimum grade of C- or CHEM:2240 with a minimum grade of C-

CHEM:4760 Radiochemistry: Energy, Medicine, and the Environment 3 s.h. Fundamental theoretical concepts of radiochemistry and their application in energy, medicine, and environmental sectors. Prerequisites: CHEM:2210 with a minimum grade of C- or CHEM:2230 with a minimum grade of C-

CHEM:4850 Upstream Biotechnology Processes 2 s.h. Introduction to fermentation, fermenter preparation, cell growth and medium requirements, inoculation, sampling, process termination, separation of cells, fermentation case study, enzyme activity, and biocatalysis. Same as PHAR:4850.
Recommendations: knowledge of basic chemistry.

undergraduate standing in engineering and science.
in the field. Requirements: graduate standing or advanced
properties, characterization, applications of materials at
nanotechnology; fabrication and synthesis, size dependent
Basic principles associated with nanoscience and

CHEM:5118 Nanomaterials
Basic principles associated with nanoscience and
nanotechnology; fabrication and synthesis, size dependent
properties, characterization, applications of materials at
nanometer length scales, recent technological breakthroughs
in the field. Requirements: graduate standing or advanced
undergraduate standing in engineering and science.
Recommendations: knowledge of basic chemistry.

Chemistry Courses (CHEM)

CHEM:4873 Atmospheric and Environmental Chemistry
Fundamental chemical processes of importance in the
atmosphere, soil, and water, with emphasis on kinetics
and photochemistry of homogeneous and heterogeneous
reactions, atmospheric structure and dynamics, global
geochemical cycling, chemistry-climate relationships,
environmental remediation strategies; experimental methods
in field and laboratory studies.

CHEM:5013 Science Writing in Chemistry
How to providing clear, simple, and direct scientific
documents; formulating good scientific questions; developing
scientific context; process of writing, critiquing, and rewriting
scientific documents; accepting constructive criticism;
creating constructive criticism for others; student-created
independent scientific proposal suitable as a funding
application. Prerequisites: CHEM:5091 and CHEM:7270.
Corequisites: CHEM:7999. Requirements: all comprehensive
exams completed and passed.

CHEM:5091 Graduate Chemistry Orientation
Pedagogy, safety, and research issues relevant to advanced
chemistry careers.

CHEM:5107 Electrochemistry
Fundamental aspects, including mass transport and electron
transfer, electrochemical methodology (e.g., voltammetry
and potentiometry), determination of homogeneous and
heterogeneous reaction mechanisms. Recommendations:
CHEM:3110 and CHEM:3120.

CHEM:5108 Spectroscopy
Principles of atomic and molecular absorption and emission
spectroscopy in ultraviolet, visible, and infrared regions of
the spectrum, including fluorescence, phosphorescence,
Raman spectroscopy; applications to analytical problems,
with emphasis on modern instrumentation and methodology.
Recommendations: CHEM:3110 and CHEM:3120.

CHEM:5109 Separations
Analytical separations; basic theory, practical applications,
instrumentation, modern techniques (extractions, gas
and liquid chromatography, capillary electrophoresis),
and detection (mass spectrometry). Recommendations:
CHEM:3110 and CHEM:3120.

CHEM:5114 Chemical Systems Modeling
Basic processes and techniques; these methods
applied to systems relevant to students' own research.
Recommendations: CHEM:3110 or CHEM:3120.

CHEM:5115 Biophotonics
Structure, dynamics of biomolecules and their optical
spectroscopy; ultrasensitive fluorescence spectroscopy,
vibrational spectroscopy, optical activity and circular
dichroism, time-resolved spectroscopy. Recommendations:
CHEM:3110 and CHEM:3120.

CHEM:5116 Nuclear Physics Concepts
Introduction to fundamental concepts describing the
behavior of unstable nuclei, including radioactive emissions,
radionuclide generation, and interaction with the physical
world; the production and modes of decay of radionuclides,
the concepts of radioactive decay and equilibrium, and
radiation's interactions with matter; and the occurrence
and importance of natural and anthropogenic radionuclides
relative to their use and importance to the environment and
human health.

CHEM:5122 Radiochemistry Separation Concepts I
Chemical and physical manipulation samples that enable
the identification and measurement of radionuclides. These
concepts focus strongly on practical inorganic and analytical
chemistry techniques, including sample handling, sample
dissolution/destruction, oxidation state manipulation,
equilibrium reactions, and analyte preconcentration.
Addresses the analytical implications of various sample types,
including matrix and radionuclides interferences, and various
techniques for addressing these issues.

CHEM:5123 Radiochemistry Separation Concepts II
Chemical and physical manipulation samples that enable
the identification and measurement of radionuclides. These
concepts focus strongly on practical inorganic and analytical
chemistry techniques, including sample handling, sample
dissolution/destruction, oxidation state manipulation,
equilibrium reactions, and analyte preconcentration.
Addresses the analytical implications of various sample types,
including matrix and radionuclides interferences, and various
techniques for addressing these issues.

CHEM:5124 Radiochemistry Instrumental Analysis I
Theory, operation, calibration, and maintenance of
instrumentation used for the identification and measurement
of radiation. Instrumentation covered includes gas-flow
proportional counters, Geiger-Müller counters, ionization
chambers, liquid scintillation counters, semiconductor
detectors, and solid scintillation detectors. For each
technology introduced, students learn the fundamental
concepts of detection, operation, calibration, troubleshooting,
maintenance, and sample measurement.

CHEM:5125 Radiochemistry Instrumental Analysis II
Theory, operation, calibration, and maintenance of
instrumentation used for the identification and measurement
of radiation. Instrumentation includes gas-flow proportional
counters, Geiger-Müller counters, ionization chambers, liquid
scintillation counters, semiconductor detectors, and solid
scintillation detectors. For each technology introduced,
students learn the fundamental concepts of detection,
operation, calibration, troubleshooting, maintenance, and
sample measurement.

CHEM:5126 Radiochemistry Data Analysis and
Statistics
Introduction to mathematical concepts and calculations used
in radiochemistry to calculate analytical results and assess
data, including radioactivity calculations, counting statistics,
detection limit decisions, and uncertainty estimations used
in the generation of analytical results, and the optimization
and evaluation of analytical systems to meet data and
measurement quality objectives using the previously listed
concepts.
CHEM:5127 Radiochemistry Quality Assurance 1 s.h.
Various components of quality assurance that govern radiochemical analysis, including the traceability of measurements, the standardization of measurement systems, the process of obtaining and maintaining laboratory accreditation, the various quality control procedures used to ensure defensible data, and the regulatory standards impacting radiochemical measurements; best practices for method validation and instrument validation, and the statistical concepts and tests for evaluating radiochemical data.

CHEM:5128 Radiation Safety and Health Physics 1 s.h.
Radiation safety and health physics concepts used to both minimize human exposure to radiation and evaluate its potential effect, including processes for minimizing and evaluating exposure, radioactive materials handling and exposure, licensure considerations, and dosimetry. Discussion of the biological effects of radiation, including both acute and chronic exposure outcomes, and the regulatory limits meant to minimize these effects.

CHEM:5129 Radiochemistry Separation Laboratory 2 s.h.
Introduces students to the radiochemistry laboratory environment and covers commonly used radiochemical separation techniques; fundamental laboratory safety and techniques including exposure and contamination control, waste disposal, sample preparation and preservation, and standard preparation and verification; perform radiochemical separation methods for gross alpha radium, tritium, and uranium using a variety of techniques including co-precipitation, distillation, extraction chromatography, and ion exchange.

CHEM:5130 Radiochemistry Instrumental Analysis Laboratory 2 s.h.
Introduces students to radiation measurement instruments and data analysis software; set-up, calibration, maintenance, and use of alpha scintillation counters, gamma spectrophotometers, gas-flow proportional counters, and liquid scintillation counters; perform setup, calibration, and analysis with each of the listed instruments and their associated software packages.

CHEM:5150 Chemometrics 3 s.h.
Mathematical, statistical, and signal processing methods for analytical chemistry; hypothesis testing, experimental design, model building, optimization, digital filtering.

CHEM:5190 Seminar: Analytical Chemistry 0-1 s.h.
Content varies.

CHEM:5199 Special Topics in Analytical Chemistry arr.
Content varies.

CHEM:5203 Organometallic Chemistry 3 s.h.

CHEM:5204 Physical Methods in Inorganic Chemistry 3 s.h.
Application of physical methods to problems; recent developments; emphasis on magnetic resonance spectroscopy. Recommendations: CHEM:4270.

CHEM:5205 Bioinorganic Chemistry 2-3 s.h.
The role of metal ions in biology from an inorganic chemical perspective; emphasis on structure and mechanism for transition metal-containing metallo-enzymes.

CHEM:5206 Solid-State and Materials Chemistry 3 s.h.
Introduction to the chemical concepts of solid-state chemistry; focus on synthesis and characterization of various inorganic materials; structure/property relationships, real-world examples. Recommendations: CHEM:4270.

CHEM:5212 Mass Spectrometry 3 s.h.
Examination of mass spectrometry in terms of basic theory, instrumentation, qualitative and quantitative analysis, and its application to the environmental and biological sciences. Recommendations: CHEM:3110 or CHEM:3120.

CHEM:5290 Seminar: Inorganic and Chemical Education Research 0-1 s.h.

CHEM:5299 Special Topics in Inorganic Chemistry 1-3 s.h.
Recommendations: CHEM:4270.

CHEM:5321 Spectroscopic Methods in Organic Chemistry 3-4 s.h.
Methods and techniques of structure determination for organic compounds.

CHEM:5326 Organic Reactions 3 s.h.
Survey of organic reactions used in contemporary organic synthesis; emphasis on C-C bond forming reactions, functional group interconversions, oxidations and reductions; mechanistic details of reaction types; innovations in catalytic and asymmetric organic reactions. Recommendations: CHEM:4372.

CHEM:5328 Mechanisms of Organic Reactions 3 s.h.
Application of basic mechanistic concepts.

CHEM:5329 Advanced Organic Synthesis 1-3 s.h.

CHEM:5390 Seminar: Organic Chemistry 0-1 s.h.

CHEM:5399 Organic Chemistry Special Topics 1,3 s.h.
Recommendations: CHEM:4372.

CHEM:5431 Statistical Thermodynamics I 3 s.h.
Fundamentals of classical thermodynamics and equilibria; ensembles; noninteracting systems; theory of phase transitions; Monte-Carlo methods; classical fluids; nonequilibrium systems. Recommendations: CHEM:4431.

CHEM:5433 Quantum and Computational Chemistry 3 s.h.
Fundamental principles of quantum chemistry; angular momentum; approximation methods; theory of atomic and molecular electronic structure; applications of computational quantum mechanics to chemical systems. Corequisites: CHEM:4432, if not taken as a prerequisite.

CHEM:5434 Molecular Spectroscopy 3 s.h.
Quantum mechanical models of atoms, molecules, and chemical oscillators; electrostatics and magnetism; electromagnetic waves; refractive index and polarization; matter waves; symmetry and orbitals; vibronic and spin-orbit coupling; electron correlation and exchange; selection rules. Recommendations: CHEM:5433.

CHEM:5435 Chemical Kinetics 3 s.h.
Potential energy surfaces, transition state theory, diffusion limited rates, linear free energy relationships, isotope effects, solvent effects, RRKM theory; connection between experiment and various theories in the gas and solution phases; emphasis on assignment of experimental error to derived quantities. Recommendations: CHEM:4432.
CHEM:5438 Surface Chemistry and Heterogeneous Processes 3 s.h.
Fundamental and applied aspects of surface chemical processes; theories of molecular adsorption/desorption and surface complexation; kinetics; surface analysis and instrumentation; applications of surface chemistry in heterogeneous catalysis, heterogeneous environmental/atmospheric processes, and materials chemistry. Recommendations: CHEM:4431.

CHEM:5490 Seminar: Physical and Environmental Chemistry 0-1 s.h.

CHEM:5499 Physical Chemistry Topics 1-3 s.h.
Advanced topics relevant to modern physical chemistry. Recommendations: CHEM:4432 and MATH:1860.

CHEM:5599 Special Topics in Chemistry Education 3 s.h.
Special topics related to chemistry education; topics vary.

CHEM:5875 Perspectives in Biotechnology 1 s.h.
Topics related to careers in biotechnology with an emphasis on preparing graduate students for careers outside of academia; discussions led by a series of guest speakers from leading biotech industries; understanding the societal impact of basic research; participation in round-table discussions; and presentation of student research findings. Requirements: graduate standing and good academic standing in a participating department supported by the Predoctoral Training Program in Biotechnology. Same as BMB:5875, CBE:5875, CEE:5875, MICR:5875, PHAR:5875.

CHEM:5990 Chemistry Colloquium 0-1 s.h.
Presentation and discussion of research by invited presenters.

CHEM:6990 Research Seminar 0-1 s.h.
Presentation and discussion of thesis research for advanced degrees.

CHEM:7270 Ethics in Chemical Sciences 1 s.h.
Scholarly integrity for being a responsible chemist on graduate-level research; introduction to infrastructure of scientific scholarship with emphasis on interacting with peers, funding agencies, industrial entities; responsible conduct in research in the context of creation of knowledge, dissemination of scientific findings, intellectual property, and conflict of interest; workshops to study cases in chemical research to illustrate the principles of scholarly integrity.

CHEM:7604 Ethics in Chemical Sciences for Postdocs 0 s.h.
Introduction to infrastructure of scientific scholarship; emphasis on interacting with peers, funding agencies, industrial entities; scholarly integrity for being a responsible chemist on graduate-level research; responsible conduct in research in context of creation of knowledge, dissemination of scientific findings, intellectual property, conflict of interest; workshop cases in chemical research that illustrate principles of scholarly integrity.

CHEM:7999 Research in Chemistry arr.
Thesis work for advanced degrees.