

# Chemistry (CHEM)

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## Chemistry (CHEM) Courses

### **CHEM 5001 [0.25 credit] (CHM 8301)**

#### **Analytical Mass Spectrometry**

The principles of ion sources and mass spectrometers and their applications to problems in chemistry and biochemistry. Introduction to the chemistry of gaseous ions. Ion optics. Special emphasis on interpreting mass spectra.

### **CHEM 5002 [0.25 credit] (CHM 8301)**

#### **Multinuclear Magnetic Resonance Spectroscopy**

Principles of Nuclear Magnetic Resonance (NMR). NMR parameters studied: chemical shift, spin-spin coupling, electric quadrupole coupling, spin-spin, spin-lattice relaxation rates. NMR and the periodic table. Dynamic NMR. Applications in chemistry and biochemistry. The Fourier Transform technique. Pulse sequences. Basic principles/applications of two-dimensional NMR.

### **CHEM 5003 [0.25 credit] (CHM 8325)**

#### **Solid State NMR Spectroscopy**

Brief introduction to solid state NMR spectroscopy. Topics include dipolar coupling interactions, chemical shielding anisotropy, the quadrupolar interaction and averaging techniques such as magic angle spinning.

### **CHEM 5004 [0.25 credit] (CHM 8326)**

#### **NMR Spectroscopy**

Advanced NMR techniques for both proton and carbon spectra, various decoupling and related experiments. Interpretation of NOST, COSY and related data.

### **CHEM 5005 [0.25 credit] (CHM 8327)**

#### **Physical Organic Chemistry**

Hammett functions, transition state energies, stereochemistry of organic compounds, and mechanisms of organic reactions and their determination.

### **CHEM 5007 [0.25 credit] (CHM 8310)**

#### **Introduction to Photochemistry**

Basic principles of photochemistry including selection rules, energy transfer processes and the properties of excited state reactions. Lasers and their applications to measurements of the dynamics of elementary reactions.

### **CHEM 5010 [0.5 credit]**

#### **Bio-Organic Chemistry**

Chemical and biosynthetic methods applied to the major classes of biomolecules and their derivatives, including: carbohydrates, amino acids, peptides, proteins, nucleic acids, lipids, terpenes, heterocycles and natural products. Reactions and mechanisms that contribute to their biological activities.

Also offered at the undergraduate level, with different requirements, as CHEM 4207, for which additional credit is precluded.

### **CHEM 5102 [0.25 credit] (CHM 8346)**

#### **Supercritical Fluids**

Fundamental and practical aspects of the uses of supercritical fluids in the chemistry laboratory. Thermodynamic treatment of high pressure multicomponent phase equilibria, transport properties, solubilities, supercritical fluid extraction and chromatography for analytical purposes, reactions in supercritical fluids, equipment considerations, new developments.

Includes: Experiential Learning Activity

### **CHEM 5108 [0.5 credit] (CHM 8302)**

#### **Surface Chemistry and Nanostructures**

Surface structure, thermodynamics and kinetics, specifically regarding adsorption/desorption and high vacuum models. Nanoscale structures and their formation, reactivity and characterization. Thin films, carbon nanotubes, self-assembled monolayers and supramolecular aggregates.

Also offered at the undergraduate level, with different requirements, as CHEM 4103, for which additional credit is precluded.

### **CHEM 5109 [0.5 credit] (CHM 8302)**

#### **Advanced Applications in Mass Spectrometry**

Detailed breakdown of the physical, electrical and chemical operation of mass spectrometers. Applications in MS ranging from the analysis of small molecules to large biological macromolecules. Descriptions of the use of mass spectrometry in industry as well as commercial opportunities in the field.

Also offered at the undergraduate level, with different requirements, as CHEM 4304, for which additional credit is precluded.

**CHEM 5110 [0.25 credit] (CHM 8176)**  
**Chemistry Education and Chemistry Education Research**

Chemistry education including theories of learning, aligning intended outcomes with course activities and assessment, and troublesome areas of learning and teaching in chemistry. Key educational research areas are addressed, including types evidence, research methods, and central publications.

**CHEM 5111 [0.25 credit] (CHM 8358)**  
**Advanced Topics in Biomolecular Sciences**

Topics of current interest in biomolecular sciences and biological chemistry. Variable content from year to year.

**CHEM 5112 [0.25 credit] (CHM 8359)**  
**Advanced Topics in Materials Chemistry**

Topics of current interest in materials chemistry. Variable content from year to year.

**CHEM 5113 [0.25 credit] (CHM 8165)**  
**Stereoselective Synthesis**

Fundamentals of stereoselective synthesis and catalysis, including conformational analysis, substrate and catalyst control. Includes the use of allylic, chiral auxiliaries, directed reactions and chiral catalysts.

**CHEM 5114 [0.25 credit] (CHM 8173)**  
**Introduction to Molecular Simulation and Statistical Mechanics (Part A)**

Modern molecular simulation techniques including classical molecular dynamics and Monte Carlo simulations with the necessary statistical mechanics required to understand and interpret the results. Introduction to modern scientific computing environments via the Linux operating system.

**CHEM 5115 [0.25 credit] (CHM 8175)**  
**Introduction to Molecular Simulation and Statistical Mechanics (Part B)**

Modern molecular simulation techniques including classical molecular dynamics and Monte Carlo simulations with the necessary statistical mechanics required to understand and interpret the results. Introduction to modern scientific computing environments via the Linux operating system.  
Prerequisite(s): CHEM 5114.

**CHEM 5116 [0.25 credit] (CHM 8360)**  
**Characterization Methods and Applications of Advanced Materials**

Physico-chemical techniques including thermal analysis, optical spectroscopy, electrochemistry, X-ray and electron diffraction, electron microscopy, electron spectroscopies, magnetic resonance, and general instrumental methods. Applications may include: field effect transistors, photovoltaics, light emitting devices, batteries and fuel cells.

**CHEM 5117 [0.25 credit] (CHM 8361)**  
**Chemical Biology (Part A)**

Chemical Biology of modern molecular science with applications to understanding biological mechanisms. Chemical and genetically encoded probes for genomics, proteomics, metabolomics as well as biorthogonal chemistry, chemical genetics and expanded genetic codes and alphabets in the context of understanding and engineering living systems.

**CHEM 5118 [0.25 credit] (CHM 8363)**  
**Chemical Biology (Part B)**

Chemical Biology of modern molecular science with applications to understanding biological mechanisms. Chemical and genetically encoded probes for genomics, proteomics, metabolomics as well as biorthogonal chemistry, chemical genetics and expanded genetic codes and alphabets in the context of understanding and engineering living systems.  
Prerequisite(s): CHEM 5117.

**CHEM 5119 [0.25 credit] (CHM 8362)**  
**Molecular Magnetism I**

Introduction to the principals (Molecular Magnetism I) and advanced characterization of paramagnetic molecules (Molecular Magnetism II). Emphasis will be made on structure-property relationship. This course will contain variable content from year to year by discussing recent progress on molecular magnetism.

**CHEM 5120 [0.25 credit] (CHM 8330)**  
**Heterocyclic Chemistry**

Properties of heterocycles. Synthesis and reactivity of heterocyclic systems, with examples relevant to the synthesis of pharmaceuticals and natural products. Includes metal-catalyzed reactions.

**CHEM 5121 [0.25 credit] (CHM 8364)**  
**Molecular Magnetism II**

Introduction to the principals (Molecular Magnetism I) and advanced characterization of paramagnetic molecules (Molecular Magnetism II). Emphasis will be made on structure-property relationship. This course will contain variable content from year to year by discussing recent progress on molecular magnetism.

**CHEM 5122 [0.5 credit]****Advanced Topics in Computational Chemistry**

Computer simulation of materials, liquids, and biomolecules in the framework of intermolecular forces and statistical thermodynamics. Introduction to chemoinformatics and machine learning methods in chemistry.

Includes: Experiential Learning Activity

Also offered at the undergraduate level, with different requirements, as CHEM 4101, for which additional credit is precluded.

**CHEM 5202 [0.25 credit] (CHM 8323)****Chemistry of the Main Group Elements**

Fundamental and applied aspects of main group element chemistry. Topics may include non-metal chemistry, main group organometallic chemistry, application of main group element compounds to solid state synthesis (e.g. CVD and/or sol gel processes), uses of main group element compounds in synthesis.

**CHEM 5206 [0.5 credit] (CHM 8302)****Physical Methods of Nanotechnology**

An overview of methods used in nanotechnology. Principles of scanning probe techniques ranging from surface physics to biology. State of the art methods to create nanostructures for future applications in areas such as nanolithography, nanoelectronics, nano-optics, data storage and bio-analytical nanosystems.

**CHEM 5207 [0.25 credit] (CHM 8302)****Macromolecular Nanotechnology**

Fundamentals of synthetic macromolecules related to nanoscale phenomena. Challenges and opportunities associated with polymers on the nanoscale. Topics include molecular recognition, self-assembled nanostructures, functional nanomaterials, amphiphilic architectures, nanocomposites, and nanomachines. Applications to sensing, drug delivery, and polymer based devices. Also offered at the undergraduate level, with different requirements, as CHEM 4201, for which additional credit is precluded.

**CHEM 5208 [0.25 credit] (CHM 8302)****Bio Macromolecular Nanotechnology**

Fundamentals of biological macromolecules related to nanoscale phenomena. Challenges and opportunities associated with natural polymers on the nanoscale. Topics include molecular recognition, self-assembled nanostructures, scaffolds and templates, functional nanomaterials, amphiphilic architectures, nanocomposites, and nanomachines. Applications to sensing, biomaterials, drug delivery, and devices.

Also offered at the undergraduate level, with different requirements, as CHEM 4201, for which additional credit is precluded.

**CHEM 5300 [0.25 credit] (CHM 8331)****Physical Chemistry of Biological Macromolecules**

How the application of physical techniques, normally applied to small molecules, can be used to study macromolecular structure and function of DNA and proteins. Examples of applications to include kinetics, electrochemistry, equilibria phenomena (thermodynamics).

**CHEM 5304 [0.25 credit] (CHM 8349)****Free Radicals in Chemistry and Biology**

Oxidative stress induced by free radicals plays a significant role in fatal and chronic diseases. The chemistry of bio-radicals will be described and related to pathobiological processes such as lipid peroxidation and atherosclerosis, protein nitration and cross linking, and DNA scission.

**CHEM 5306 [0.25 credit] (CHM 8338)****Unimolecular Reaction Dynamics: Experiment and Theory**

Theoretical models that have been developed for the understanding of unimolecular reactions; statistical theories such as RRKM theory. Experimental techniques for exploring the kinetics and mechanism of unimolecular reactions, including mass spectrometry, coincidence spectroscopy and ZEKE spectroscopy.

**CHEM 5406 [0.5 credit] (CHM 8164)****Organic Polymer Chemistry**

Basic principles of industrial and synthetic polymers. Polymerization and polymer characterization. Topics to cover some important polymers with emphasis on synthesis, commodity plastics, engineering thermoplastics and specialty polymers.

Prerequisite(s): CHEM 3201 and CHEM 3202 and/or CHEM 4203 or the equivalent. Students should have a basic knowledge of organic reaction mechanisms and stereochemistry.

Also offered at the undergraduate level, with different requirements, as CHEM 4204, for which additional credit is precluded.

**CHEM 5407 [0.5 credit] (CHM 8134)****Spectroscopy for Organic Chemists**

Use of NMR spectroscopy in the elucidation of organic structures, interpretation of  $^1\text{H}$ ,  $^{13}\text{C}$  and  $^{19}\text{F}$  NMR. Use of NMR in determining relative and absolute stereochemistry. Two-dimensional NMR.

Also offered at the undergraduate level, with different requirements, as CHEM 4202, for which additional credit is precluded.

**CHEM 5500 [0.25 credit] (CHM 8348)****Analytical Instrumentation**

Principles of modern electronics, devices and instruments. Measurement of photonic and electrochemical signals. Conditioning of signals for feedback control and microcomputer interfacing. Computational data analysis techniques such as simplex optimization. Applications in chemical analysis include amperometric detector for capillary electrophoresis, and surface plasmon resonance immunosensor.

**CHEM 5501 [0.25 credit] (CHM 8352)****Analytical Approach to Chemical Problems**

Case study of analytical approach to various chemical problems in agricultural, biochemical, environmental, food processing, industrial, pharmaceutical and material sciences. Analytical methods include capillary electrophoresis, chemiluminescence, Fourier transform infrared spectroscopy, inductively coupled plasma emission spectroscopy, mass spectrometry, biochemical sensors, and fibre optics for remote sensing. Includes: Experiential Learning Activity

**CHEM 5600 [0.25 credit] (CHM 8323)****Quantum Mechanical Methods - Theory**

A course dealing with the theory behind quantum mechanical methods (HF, MP2, CI, DFT).

**CHEM 5606 [0.5 credit] (CHM 5606)****Environmental Chemistry and Toxicology**

Overview of environmental chemistry and toxicology principles including chemical sources, fate, and effects in the environment. Examining organic reactions occurring in abiotic environments and biological systems, study aspects of toxicant disposition and biotransformation. Emphasis on contemporary problems in human health and the environment. Also offered at the undergraduate level, with different requirements, as CHEM 4305, for which additional credit is precluded.

**CHEM 5607 [0.5 credit]****Advanced Topics in Analytical Chemistry I**

Analytical chemistry of trace and ultratrace elements/compounds. Special requirements for quantitative determination by various instrumental methods. Control of contamination and blanks. Analytical method development to improve selectivity, sensitivity and detection limit. Strength and limitations of each instrument in regard to optimization of all operating parameters. Also offered at the undergraduate level, with different requirements, as CHEM 4301, for which additional credit is precluded.

**CHEM 5705 [0.5 credit] (CHM 9109)****Ecotoxicology**

Selected topics and advances in ecotoxicology with emphasis on the biological effects of contaminants. The potential for biotic perturbation resulting from chronic and acute exposure of ecosystems to selected toxicants will be covered along with methods of pesticide, herbicide and pollutant residue analysis. Also listed as BIOL 6403.

**CHEM 5708 [0.5 credit] (CHM 8156)****Principles of Toxicology**

Basic theorems of toxicology with examples of current research problems. Toxic risk is defined as the product of intensive hazard and research problems. Each factor is assessed in scientific and social contexts and illustrated with many types of experimental material. Also listed as BIOL 6402 [BIO 9101].

**CHEM 5709 [0.5 credit] (CHM 8157)****Chemical Toxicology**

Introduction to modeling chemical hazards and exposures at the cellular level. The properties of toxic substances are compared to the responses of enzymatic systems. These interactions are defined as Quantitative Structure-Activity Relationships and used to interpret hazardous materials under regulations such as WHMIS. Also listed as BIOL 5709 [BIO 8113]. Prerequisite(s): BIOL 6402/CHEM 5708 (BIO 9101/CHM 8156).

**CHEM 5800 [0.5 credit]****Seminar in Biochemistry**

A graduate seminar on current topics in the field of Biochemistry. This course introduces the seminar format and involves student, faculty and invited seminar speakers. The student will present a seminar and submit a report on a current topic in Biochemistry. Includes: Experiential Learning Activity. Also listed as BIOL 5002.

**CHEM 5802 [0.0 credit] (CHM 8257S)****Seminar II**

Students are required to present a seminar on their Ph.D. research topic in their research program. In addition, students are required to attend the seminars of their fellow classmates and actively participate in the discussion following the seminar. Includes: Experiential Learning Activity. Also listed as FOOD 5802.

**CHEM 5804 [0.5 credit]****Modern Scientific Communication**

Communication and other skills useful for chemistry graduates. Effective manuscript writing, creating graphics, CV development, networking, science communication, use of social media, outreach, EDI considerations.

Also listed as FOOD 5804.

Precludes additional credit for CHEM 5801 (no longer offered), FOOD 5801 (no longer offered).

**CHEM 5805 [0.5 credit] (CHM 8167)****Seminar in Toxicology**

This course introduces the seminar format and involves student, faculty and invited seminar speakers. The student will present a seminar and submit a report on a current topic in toxicology.

Includes: Experiential Learning Activity

Also listed as BIOL 6405.

**CHEM 5806 [0.5 credit]****Advances in Applied Biochemistry**

A practical hands-on course in the field of Biochemistry. This course is run in a laboratory and will train students in highly specialized technique(s) in Biochemistry. The students will run experiments, gather data, assess and analyze the results and present the findings as a seminar.

Includes: Experiential Learning Activity

Also listed as BIOL 5004.

**CHEM 5810 [0.5 credit]****Seminar**

Principles and practice of oral scientific communication for scientific and non-scientific audiences. Students are required to present short seminars geared towards a general audience (in the style of Three-minute thesis (3MT) and/or TedTalk) as well as a research seminar geared towards a scientific audience.

Also listed as FOOD 5810.

Precludes additional credit for CHEM 5801 (no longer offered), FOOD 5801 (no longer offered).

**CHEM 5900 [0.5 credit] (CHM 8158)****Directed Special Studies**

Under the direction of an approved member of Faculty, the student will undertake advanced study of a field of chemistry unrelated to their thesis topic. Approval of the Associate Chair, Graduate and Postdoctoral Affairs Chemistry is required and will only be granted under unusual conditions.

**CHEM 5901 [0.25 credit] (CHM 8304)****Advanced Topics in Organic Chemistry**

Topics of current interest in organic chemistry. The content of this course may vary from year to year.

**CHEM 5902 [0.25 credit] (CHM 8302)****Advanced Topics in Inorganic Chemistry**

Topics of current interest in inorganic chemistry. The content of this course may vary from year to year.

**CHEM 5903 [0.25 credit] (CHM 8309)****Advanced Topics in Physical/Theoretical Chemistry**

Topics of current interest in physical/theoretical chemistry. The content of this course may vary from year to year.

**CHEM 5904 [0.5 credit] (CHM 8104)****Scientific Data Processing and Evaluation**

Optimization of scientific measurements, calibration, uni-variate and multi-variate analysis of scientific data, "intelligent" spreadsheets for scientific data processing and presentation, noise reduction using spreadsheets, correction for signal drifts; examples from chemistry, spectroscopy and other scientific disciplines.

Prerequisite(s): CHEM 4301, or permission from the Department.

Also offered at the undergraduate level, with different requirements, as CHEM 4303, for which additional credit is precluded.

**CHEM 5905 [0.5 credit] (CHM 5105)****Radiochemistry**

A study of nuclear stability and decay; chemical studies of nuclear phenomena. Applications of radioactivity.

Prerequisite(s): permission of the Department.

Also offered at the undergraduate level, with different requirements, as CHEM 4502, for which additional credit is precluded.

**CHEM 5909 [3.0 credits]****M.Sc. Thesis**

Includes: Experiential Learning Activity

**CHEM 6909 [0.0 credit]****Ph.D. Thesis**

Includes: Experiential Learning Activity