Nanoscience

Co-operative Education Option is available (see the Co-operative Education (http://www.carleton.ca/calendars/2012-13/undergrad/regulations/co-operativeeducation) section of this Calendar for details).

Graduation Requirements

In addition to the requirements listed below, students must satisfy:

1. the University regulations (see the Academic Regulations of the University (http://www.carleton.ca/calendars/2012-13/undergrad/regulations/academicregulationsoftheuniversity) section of this Calendar),
2. the common regulations applying to all B.Sc. programs including those relating to Science Continuation and Breadth requirements (see the Academic Regulations for the Bachelor of Science Degree (http://www.carleton.ca/calendars/2012-13/undergrad/regulations/academicregulationsandrequirementsforthebachelorofsciencedegree)),

Students should consult with the Department when planning their program and selecting courses.

Program Requirements

Nanoscience
B.Sc. Honours (20.0 credits)

623

A. Credits Included in the Major CGPA (11.5 credits)		
1. 5.0 credits in:		5.0
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
CHEM 2103 [0.5]	Physical Chemistry I	
CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
CHEM 3100 [0.5]	Physical Chemistry II	
CHEM 3107 [0.5]	Experimental Methods in Nanoscience	
CHEM 3503 [0.5]	Inorganic Chemistry I	
CHEM 3600 [0.5]	Introduction to Nanotechnology	
CHEM 4908 [1.0]	Research Project and Seminar	
2. 1.0 credit from:		1.0
CHEM 2203 [0.5] & CHEM 2204 [0.5]	Organic Chemistry I and Organic Chemistry II	
CHEM 2302 [0.5] & CHEM 2303 [0.5]	Analytical Chemistry and Analytical Chemistry	
3. 1.0 credit from:		1.0
CHEM 4103 [0.5]	Surface Chemistry and Nanostructures	
CHEM 4104 [0.5]	Physical Methods of Nanotechnology	
CHEM 4201 [0.5]	Macromolecular Nanotechnology	
4. 4.5 credits in:		4.5
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
ELEC 3509 [0.5]	Electronics II	
ELEC 3908 [0.5]	Physical Electronics	
ELEC 3105 [0.5]	Basic EM and Power Engineering	
ELEC 3909 [0.5]	Electromagnetic Waves	
ELEC 4609 [0.5]	Integrated Circuit Design and Fabrication	
ELEC 4700 [0.5]	The Physics and Modeling of Advanced Devices and Technologies	
ELEC 4704 [0.5]	Nanoscale Technology and Devices	
B. Credits Not Included in the Major CGPA (8.5 credits)		
5. 2.5 credits in:		2.5
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
STAT 3502 [0.5]	Probability and Statistics	
6. 1.0 credits in:		1.0
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
7. 2.0 credits in Science Continuation (not CHEM)		2.0
8. 0.5 credit in:		0.5
NSCI 1000 [0.5]	Seminar in Science (or Approved Arts or Social Sciences)	
9. 1.5 credits in Approved Arts or Social Sciences		1.5
10. 1.0 credit in free electives		1.0
Total Credits		20.0

Chemistry (CHEM) Courses

Chemistry

Faculty of Science

CHEM 1001 [0.5 credit]
General Chemistry I
This maths-intensive course covers introduction to periodicity, gas laws, equilibrium, bonding, electrochemistry, and organic chemistry. This is a specialist course for students intending to take second year chemistry.
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1005, CHEM 1101.
Prerequisite(s): Ontario 4U/M in Chemistry or equivalent.
Lectures three hours a week, laboratory and tutorial three hours a week.

CHEM 1002 [0.5 credit]
General Chemistry II
This maths-intensive course covers an introduction to solution chemistry, acids and bases, thermodynamics, and kinetics. Specialist course for students intending to take second year chemistry.
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1006.
Prerequisite(s): CHEM 1005 with a minimum grade of B-, or CHEM 1001.
Lectures three hours a week, laboratory and tutorial three hours a week.

CHEM 1003 [0.5 credit]
The Chemistry of Food, Health and Drugs
Aspects of chemistry relating to food, food additives, drugs (both illicit and beneficial) and their relation to metabolism and health. Topics may include: proteins, carbohydrates, fats, vitamins and cofactors, enzymes, steroids, electrolyte and pH balance, trace elements.
Available only as a free option for Science students.
Prerequisite(s): a course in Chemistry (e.g. Ontario Grade 11).
Lectures three hours a week.

CHEM 1004 [0.5 credit]
Drugs and the Human Body
Intended for students with little or no background in Science. Topics include the pharmaceutical industry, the placebo effect, origin of drugs, laws, metabolism, drug dependence, over the counter medications, antibiotics, pain killers, stimulants, alcohol, caffeine and nicotine, marijuana, hallucinogens, birth control and steroids.
Available as a free elective only for Science students.
Lectures three hours a week.

CHEM 1005 [0.5 credit]
Elementary Chemistry I
Introduction to stoichiometry, periodicity, gas laws, equilibrium, bonding, and organic chemistry with emphasis on examples of relevance to the life sciences. For students who lack the prerequisite for CHEM 1001 or who are not intending to take upper year chemistry.
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1001, CHEM 1101.
Lectures four hours a week, laboratory and tutorial three hours a week.

CHEM 1006 [0.5 credit]
Elementary Chemistry II
Introduction to solution chemistry, acids and bases, thermodynamics, and kinetics, with emphasis on examples of relevance to the life sciences. For students who lack the prerequisite for CHEM 1002 or who are not intending to take upper year chemistry.
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1002.
Prerequisite(s): CHEM 1001 or CHEM 1005.
Lectures three hours a week, laboratory and tutorial three hours a week.

CHEM 1007 [0.5 credit]
Chemistry of Art and Artifacts
Aspects of chemistry relating to art history and archaeology. Topics include the properties of materials of historical and cultural importance, the nature of colour, the properties of such materials and the chemical and physical processes leading to their deterioration. The course requires only minimal previous chemistry, and gives descriptions which are aimed at students who do not have an extensive science background. Available only as a free elective for Science students.
Lectures three hours a week.

CHEM 1101 [0.5 credit]
Chemistry for Engineering Students
Topics include stoichiometry, atomic and molecular structure, thermodynamics and chemical equilibrium, acid-base chemistry, carbon dioxide in water, alkalinity, precipitation, electrochemistry, kinetics and basic organic chemistry. Laboratory component emphasizes techniques and methods of basic experimental chemistry.
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1001, and CHEM 1005.
Prerequisite(s): Ontario 4U/M in Chemistry or equivalent.
Lectures three hours a week, laboratory three hours a week.

CHEM 2103 [0.5 credit]
Physical Chemistry I
Basic principles of thermodynamics. Development of the laws of thermodynamics, enthalpy, entropy and free energy, and their applications to phase equilibria, electrochemistry, and kinetics. Brief introduction to quantum mechanics.
Precludes additonal credit for BIOC 2300, CHEM 2101 and CHEM 2102. Students presenting both CHEM 2103 and CHEM 2207 or CHEM 2203 will not receive additional credit for CHEM 2800. Students in the B.Sc. program with CHEM 2203 may use CHEM 2800 only as a free elective.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002, and MATH 1004 and MATH 1107, and Grade 12 Physics or PHYS 1007 and PHYS 1008.
Lectures three hours a week, problems one hour a week, laboratory three hours a week.

CHEM 2203 [0.5 credit]
Organic Chemistry I
Structure, organization, and scope of organic chemistry including molecular structures of well-known and important organic chemicals, types of chemical reactions, and spectroscopic methods used in identification. Training in the handling and purification of organic compounds, organic chemical reactions, and the use of infrared spectroscopy.
Precludes additional credit for CHEM 2207. Students presenting both CHEM 2203 and CHEM 2101 will not be able to receive additional credit for CHEM 2800. Students in the B.Sc. program with CHEM 2203 will only be able to use CHEM 2800 in the free elective category, except for students in the Environmental Science Program, who may include CHEM 2203 in the Approved Science Course category while maintaining CHEM 2800 as a mandatory course requirement.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002.
Lectures three hours a week, laboratory and tutorial three hours a week.

CHEM 2204 [0.5 credit]
Organic Chemistry II
Further discussion of chemical bonding in organic compounds, nomenclature, stereochemistry, and a systematic coverage of the chemical reactions of organic functional groups. Laboratory experience in organic chemical reactions, use of infrared spectroscopy and other techniques to determine the structure of unknown organic compounds. Precludes additional credit for CHEM 2208 and CHEM 2206.
Prerequisite(s): CHEM 2203.
Lectures three hours a week, laboratory and tutorial three hours a week.

CHEM 2206 [0.5 credit]
Organic Chemistry IV
Further discussion of the chemical bonding in organic compounds, nomenclature, stereochemistry, and a systematic coverage of the chemical reactions of the organic functional groups. The laboratory consists of computational experiments and calculations on organic structures and reactions.
Precludes additional credit for CHEM 2204 and CHEM 2208.
Prerequisite(s): CHEM 2203 or CHEM 2207.
Lectures three hours a week, laboratory and tutorial three hours a week.

CHEM 2207 [0.5 credit]
Introduction to Organic Chemistry I
Structure, organization, and scope of organic chemistry, including molecular structures of well-known and important organic chemicals, types of chemical reactions, and spectroscopic methods used in identification.
Precludes additional credit for CHEM 2203. Students presenting both CHEM 2207 and CHEM 2101 will not be able to receive additional credit for CHEM 2800. Students in the B.Sc. program with CHEM 2207 will only be able to use CHEM 2800 in the free elective category, except for students in the Environmental Science Program, who may include CHEM 2207 in the Approved Science Course category while maintaining CHEM 2800 as a mandatory course requirement.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002.
Lectures three hours, tutorial one hour a week.

CHEM 2208 [0.5 credit]
Introduction to Organic Chemistry II
Further discussion of the chemical bonding in organic compounds, nomenclature, stereochemistry, and a systematic coverage of chemical reactions of the organic functional groups.
Precludes additional credit for CHEM 2204 and CHEM 2206.
Prerequisite(s): CHEM 2207 or CHEM 2203.
Lectures three hours a week, tutorial one hour a week.

CHEM 2302 [0.5 credit]
Analytical Chemistry
An introduction to quality assurance measures, calibration strategies and the fundamentals of solution-based analytical measurement processes. Qualitative and quantitative analysis using potentiometric and electrolysis techniques including ion selective electrodes, coulometry, amperometry and voltammetry. Redox, acid/base and EDTA titrations in the context of various buffer systems.
Precludes additional credit for CHEM 2300.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002, or CHEM 1101, (MATH 1007 or MATH 1004) and MATH 1107. .
Lectures three hours a week, laboratory three hours a week.

CHEM 2303 [0.5 credit]
Analytical Chemistry
Spectrophotometric analysis using Uv-Vis, fluorescence and FTIR instrumentation. Modern separation methods including CE, GC and LC. Recent techniques and applications using mass spectrometry. Applications of all of the above to real-world analysis including the advancement of environmental, biochemistry and health-related research.
Precludes additional credit for CHEM 2300 and CHEM 2301.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002, or CHEM 1101, (MATH 1007 or MATH 1004) and MATH 1107.
Lectures three hours a week, laboratory three hours a week.

CHEM 2501 [0.5 credit]
Introduction to Inorganic and Bioinorganic Chemistry
The basic concepts of inorganic chemistry, including the origins of elemental properties, simple theories of bonding, intermolecular forces, main group and transition metal chemistry, coordination chemistry. Inorganic ions in biochemistry, including ion transport and storage, oxygen carriers and hydrolases, redox proteins.
Precludes additional credit for CHEM 3506.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002.
Lectures three hours a week, tutorial one hour a week.

CHEM 2800 [0.5 credit]
Foundations for Environmental Chemistry
A basis of chemistry needed to understand the environment: composition of the atmosphere and natural waters; equilibrium; surface properties; kinetics and spectroscopy; physical and chemical properties of chemicals in the environment. This is a limited enrolment course; therefore top priority will be given to students registered in the Environmental Science program. Students in the B.Sc. program with CHEM 2203 or CHEM 2207 will only be able to use CHEM 2800 in the free elective category, except for students in the Environmental Science program, who may include CHEM 2203 or CHEM 2207 in the Approved Science Course category while maintaining CHEM 2800 as a mandatory course requirement.
Prerequisite(s): CHEM 1006 with a minimum grade of B- or CHEM 1002, or CHEM 1101, (MATH 1007 or MATH 1004). .
Lectures three hours a week, laboratory three hours a week.

CHEM 3100 [0.5 credit]
Physical Chemistry II
Further development of thermodynamic equations and their applications to mass changes, chemical potential, chemical equilibria, transport properties and advanced phase equilibria. Use of partial differentials and development of Maxwell's relations will also be covered.
Precludes additional credit for CHEM 2102.
Prerequisite(s): CHEM 2103 or BIOC 2300, and MATH 1005 or MATH 2007.
Lectures three hours a week, problems one hour a week, laboratory three hours a week.

CHEM 3101 [0.5 credit]
Quantum Chemistry
Classical equations of motion, harmonic oscillator, diatomic and polyatomic molecules, molecular mechanics, quantum mechanics, Schrödinger equation and wave functions, vibrational spectra, hydrogen atom, quantum numbers, electronic spectra, bonding in small molecules.
Prerequisite(s): CHEM 2103, MATH 2007 and MATH 2008.
Lectures and problems three hours a week.

CHEM 3102 [0.5 credit]
Methods of Computational Chemistry
Molecular orbital theory of organic and inorganic chemistry. Applications of computational chemistry to chemical bonding, aromaticity, molecular spectra. Semi-empirical and ab initio electronic structure theory. Comparison of theoretical methods used to obtain molecular properties. Introduction to statistical thermodynamics.
Prerequisite(s): CHEM 3101.
Lectures and problems three hours a week.

CHEM 3106 [0.5 credit]
Computational Chemistry Methods Laboratory
Industry-standard quantum chemistry software is used for Hartree-Fock, density functional, and post Hartree-Fock correlation calculations. Results are applied to problems in molecular structure, thermodynamics, vibrational spectroscopy, and kinetics. The UNIX operating system, Bourse-shell programming, and Python scripting are also introduced.
Prerequisite(s): CHEM 3102 (may be taken concurrently).
Laboratory four hours a week.

CHEM 3107 [0.5 credit]
Experimental Methods in Nanoscience
Thin film production and characterization, scanning electron microscopy, synthesis of metal nanoparticles and particle size determination, computational modeling of nanostructures.
Prerequisite(s): CHEM 3100.
Laboratories and tutorials four hours a week.

CHEM 3201 [0.5 credit]
Advanced Organic Chemistry I
Instrumental methods for determining organic structures. Selected organic reactions with emphasis on mechanisms and reactive intermediates.
Prerequisite(s): CHEM 2204 or CHEM 2206 or CHEM 2208.
Lectures three hours a week.

CHEM 3202 [0.5 credit]
Advanced Organic Chemistry II
Continued mechanistic survey of additional organic reactions with emphasis on synthetic usefulness and stereochemistry. Interspersed with selected topics such as instrumental methods, photochemistry, literature of organic chemistry, natural and synthetic polymers, heterocycles, terpenes and alkaloids.
Prerequisite(s): CHEM 3201 or equivalent.
Lectures three hours a week.

CHEM 3205 [0.5 credit]
Experimental Organic Chemistry
A laboratory-based course including advanced concepts and techniques in organic synthesis, structure determination, and the rates and mechanisms of reactions. Students are responsible for literature surveys, acquisition of theoretical background, and design of experimental procedures.
Note: failure to complete CHEM 3201 by the end of the fall term will require deregistration from CHEM 3205.
Prerequisite(s): CHEM 2204 or CHEM 2206, CHEM 3201 or BIOC 3101 (may be taken concurrently).
Laboratory four hours a week.

CHEM 3305 [0.5 credit]
Advanced Analytical Chemistry Laboratory
Advanced instrumentally based techniques of analysis. Emphasis on identification and quantitation of low-level contaminants in environmental matrices using chromatographic and spectroscopic methods, including sampling, cleanup, measurement and reporting of results.
Prerequisite(s): CHEM 2302 and CHEM 2303.
Laboratory four hours a week.

CHEM 3401 [0.5 credit]
Physical Aspects of Biochemistry
Chemistry, structure and function of nucleic acids, proteins, carbohydrates, and lipids. Thermodynamics of biological systems, chemical mechanisms and organic transformations. Intended for Chemistry Majors.
Precludes additional credit for BIOC 2200, BIOL 2200, and BIOC 3101
Prerequisite(s): CHEM 2103 and CHEM 2204.
Lectures three hours a week.

CHEM 3503 [0.5 credit]
Inorganic Chemistry I
Symmetry, identification of Raman and infrared active vibrations, symmetry-adapted molecular orbital theory of polyatomic molecules, electron deficient bonding, bonding in coordination complexes, solid state bonding, ionic lattices. Laboratory will introduce the student to a range of synthetic techniques and physical methods of characterization.
Precludes additional credit for CHEM 3507.
Prerequisite(s): CHEM 2501.
Lectures three hours a week, laboratory and tutorial four hours a week.

CHEM 3504 [0.5 credit]
Inorganic Chemistry II
Physical properties of coordination complexes, ligand substitutions and electron transfer reaction mechanisms, organometallic chemistry: bonding, nomenclature and catalysis. Laboratory will introduce the student to a range of synthetic techniques and physical methods of characterization.
Precludes additional credit for CHEM 3508.
Prerequisite(s): CHEM 3503.
Lectures three hours a week, laboratory and tutorials four hours a week.

CHEM 3507 [0.5 credit]
General Inorganic Chemistry I
Symmetry, identification of Raman and infrared active vibrations, symmetry-adapted molecular orbital theory of polyatomic molecules, electron deficient bonding, bonding in coordination complexes, solid state bonding, ionic lattices.
Precludes additional credit for CHEM 3503.
Prerequisite(s): CHEM 2501.
Lectures three hours a week, tutorial one hour a week.

CHEM 3508 [0.5 credit]
General Inorganic Chemistry II
Physical properties of coordination complexes, ligand substitutions and electron transfer reaction mechanisms, organometallic chemistry: bonding, nomenclature and catalysis.
Precludes additional credit for CHEM 3504.
Prerequisite(s): CHEM 3503 or CHEM 3507.
Lectures three hours a week, tutorial one hour a week.

CHEM 3600 [0.5 credit]
Introduction to Nanotechnology
Nanoscale units, bulk vs. nanoproperties, electrons, atoms and ions, metals, band structure, electrical conduction, biosystems , molecular devices, quantum mechanics and optics, tools for measuring nanostructures. Production of nanostructures: self assembly, nanoscale crystal growth, polymerization. Applications to sensors, magnets, electronics, drug delivery. Toxicology of nanostructures.
Prerequisite(s): CHEM 3100.
Lectures three hours a week.

CHEM 3700 [0.5 credit]
Industrial Applications of Chemistry
Uses of chemistry in a number of industries: fertilizers, electrochemical, metallurgical, petrochemical, pulp and paper, plastics, pharmaceutical. Interaction of chemistry with economic, political, engineering, environmental, health, legal considerations. Guest lecturers.
Prerequisite(s): CHEM 2103 and one of CHEM 2207 or CHEM 2203.

CHEM 3800 [0.5 credit]
The Chemistry of Environmental Pollutants
Inorganic and organic environmental pollutants: their toxicology, production, use pattern and known effects on the environment. Aspects of risk and regulation. Chemistry involved in water and sewage treatment.
Prerequisite(s): CHEM 2207 or CHEM 2203 or CHEM 2800.
Lectures three hours a week.

CHEM 3999 [0.0 credit]
Co-operative Work Term

CHEM 4100 [0.5 credit]
Advanced Topics in Physical Chemistry I
Principles of Group Theory as applied to Chemistry. Point groups, character tables, symmetry orbitals, molecular orbitals, aromaticity, allowed and forbidden reactions, sandwich complexes. Selection rules in spectroscopy, molecular vibrations.
Prerequisite(s): CHEM 3102.
Lectures three hours a week.

CHEM 4102 [0.5 credit]
Advanced Topics in Physical Chemistry II
Statistical thermodynamics, energy states, equilibrium, partition functions for diatomic molecules. Chemical kinetics: rate laws, solution of differential equations, transition state theory, bimolecular reactions in gases and in solution, chain reactions, catalysis, atmospheric chemical reactions and photochemistry.
Prerequisite(s): CHEM 3102.
Lectures and seminars three hours a week.

CHEM 4103 [0.5 credit]
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.
Prerequisite(s): CHEM 3600 and CHEM 3107.
Lectures three hours a week.

CHEM 4104 [0.5 credit]
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.
Prerequisite(s): CHEM 3600 and CHEM 3107.
Lectures three hours a week.

CHEM 4201 [0.5 credit]
Macromolecular Nanotechnology
Biological and synthetic macromolecules related to nanoscale phenomena. Challenges and opportunities associated with natural and synthetic polymers on the nanoscale. Molecular recognition, self-assembled nanostructures, scaffolds and templates, functional nanomaterials, amphiphilic architectures, nanocomposites, and nanomachines. Applications to sensing, biomaterials, drug delivery, and polymer based devices.
Prerequisite(s): CHEM 3600 or permission of the department.

CHEM 4202 [0.5 credit]
Advanced Topics in Organic Chemistry I
Topics include 2-dimensional 1H and 13CNMR spectroscopy and structure determination of complex organic molecules.
Prerequisite(s): CHEM 3201.
Also offered at the graduate level, with different requirements, as CHEM 5407, for which additional credit is precluded.
Lectures and seminars three hours a week.

CHEM 4203 [0.5 credit]
Synthetic Organic Chemistry
The application of reactions to the synthesis or organic molecules. Emphasis on design of synthetic sequences, new reagents, and stereoselectivity. Topics include advanced methods for synthesis and reactions of alkenes, carbonyls, and enolates. Functional group interconversion, oxidation and reduction, protecting groups, rearrangements, and metal-catalyzed cross-coupling are also discussed.
Prerequisite(s): CHEM 3201 and CHEM 3202. Lectures and seminars three hours a week.

CHEM 4204 [0.5 credit]
Organic Polymer Chemistry
Introduction to basic principles of polymer chemistry, industrial and synthetic polymers, different types of polymerization and polymer characterization. Study of commodity plastics, engineering thermoplastics, and specialty polymers, with emphasis on their synthesis.
Prerequisite(s): CHEM 3201 or equivalent. Lectures three hours a week.
Also offered at the graduate level, with different requirements, as CHEM 5406, for which additional credit is precluded.

CHEM 4205 [0.5 credit]
Reactivity and Mechanism in Organic Chemistry
The application of frontier molecular orbital theory (HOMO-LUMO interactions) to organic reactions, including thermal and photochemical cycloadditions of pi-systems (including 1,3-dipoles) and rearrangements. Reactions of radicals and carbenes; conformational analysis, stereochemical effects, and methods for the determination of reaction mechanisms.
Prerequisite(s): CHEM 3202 and CHEM 3503 (may be taken concurrently).
Lectures and seminars three hours a week.

CHEM 4206 [0.5 credit]
Natural Products Chemistry
A survey of the major classes of natural products with respect to their structural elucidation, synthesis, biosynthesis and bioactivity, with emphasis on compounds that have medicinal importance.
Prerequisite(s): CHEM 3201 and CHEM 3202,.
Lectures and seminars three hours a week.

CHEM 4301 [0.5 credit]
Advanced Topics in Analytical Chemistry I
Trace and ultratrace analytical chemistry. Sampling and sample preservation. The problems of the blank. Trace and ultratrace analysis. Sampling and sample preparation. Atomic absorption, fluorescence and emission spectroscopy.
Prerequisite(s): CHEM 2103 and one of CHEM 2302 or CHEM 2303.
Lectures and seminars three hours a week.

CHEM 4302 [0.5 credit]
Advanced Topics in Analytical Chemistry II
Solutions and separations in analytical chemistry. Stability of aqueous solutions of standards and samples. Complex formation, multi-step and competing equilibria and their application to the design of selective methods of separation and determination. Electroanalytical techniques. Electroanalytical chemistry of aqueous solutions. Phase equilibria and solvent extraction.
Prerequisite(s): CHEM 2103 and one of CHEM 2302 or CHEM 2303.
Lectures and seminars three hours a week.

CHEM 4304 [0.5 credit]
Advanced Applications In Mass Spectrometry
Detailed breakdown of the physical, electrical and chemical operation of mass spectrometers. Examination of the different mass spectrometric geometries / configurations that are currently employed. Applications in mass spectrometry ranging from the analysis of small volatile organic molecules to large non-volatile biological macromolecules. Descriptions of the use of mass spectrometry in industry as well as commercial opportunities in the field.
Prerequisite(s): CHEM 2103 or BIOC 2300, and one of CHEM 2302 or CHEM 2303.
Lectures and seminars three hours a week.

CHEM 4406 [0.5 credit]
Pharmaceutical Drug Design
Important elements of rational drug design. Ligand-receptor interactions, structure-activity relationships, molecular modeling of pharmacophores, structure and mechanism-based approaches to drug design. Enzyme inhibition in chemotherapy and design of anti-viral drugs.
Prerequisite(s): CHEM 2103 and (CHEM 2203 or CHEM 2207), BIOC 3101 and (BIOC 3102 or BIOC 3008).
Lectures and laboratory five hours a week.

CHEM 4407 [0.5 credit]
Polymer Modeling
Polymer architectures; Flexible and rigid rod polymers; Rotational isomeric states (RIS); Molecular mechanics, Ramachandran Map, Helix parameters; internal and external parameters; regular and random coil structures; molecular dynamics; calculation of end-to-end distance, NMR chemical shifts; conformational entropy and properties.
Prerequisite(s): MATH 1107 and CHEM 2204 or permission of the department.
Lectures three hours per week.

CHEM 4502 [0.5 credit]
Radiochemistry
A study of nuclear stability and decay; chemical studies of nuclear phenomena. Applications of radioactivity.
Prerequisite(s): CHEM 2302, CHEM 2303, and CHEM 3100, or permission of the Department.
Lectures and seminars three hours a week.

CHEM 4503 [0.5 credit]
Advanced Topics in Inorganic Chemistry I
A quantitave basis for ligand field theory; unreal and real wavefunctions of d-orbitals; derivation of the energies of d-orbitals using variational principle, secular determinants, and ligned field operators; the effect of ligand field on free ion term symbols, wavefunction descriptions of terms symbols; applications.
Prerequisite(s): CHEM 3504 and CHEM 3101.
Lectures three hours a week.

CHEM 4504 [0.5 credit]
Advanced Topics in Inorganic Chemistry II
Reactivity of inorganic coordination compounds. Thermodynamic and kinetic factors affecting reactivity. Industrial and biochemical processes catalyzed by metal coordination compounds. Experimental methodologies, data analysis and rate law evaluation used to obtain reaction mechanisms leading to improved methods of catalysis.
Prerequisite(s): CHEM 3504 or equivalent.
Lectures three hours a week.

CHEM 4700 [0.5 credit]
Special Topics in Chemistry
A topic of current interest in any branch of chemistry. Only one special topics course may be presented for credit.
Prerequisite(s): permission of the Department.

CHEM 4800 [0.5 credit]
Atmospheric Chemistry
Properties of natural atmospheric constituents; biogeochemical cycles involving gases; chemical reactions in the atmosphere; anthropogenic atmospheric pollutants (e.g., chlorofluorocarbons, sulphur and nitrogen oxides, photochemical smog sources and effects on the biosphere. Relation between the structure of molecules and their spectral and reactive properties.
Prerequisite(s): CHEM 2103 or CHEM 2800.
Lectures three hours a week.

CHEM 4907 [1.0 credit]
Honours Essay and Research Proposal
An independent research study using library resources. The candidate will prepare a critical review of a topic approved by a faculty advisor.
Precludes additional credit for CHEM 4908 [1.0], FOOD 4907 [1.0] and FOOD 4908 [1.0].
Prerequisite(s): fourth year standing in an Honours Chemistry program and permission of the department.

CHEM 4908 [1.0 credit]
Research Project and Seminar
Senior students in Honours Chemistry carry out a research project under the direction of one of the members of the Department. A written report and an oral presentation of the work are required before a grade can be assigned.
Precludes additional credit for CHEM 4907, FOOD 4907 and FOOD 4908.
Prerequisite(s): any two of CHEM 3106, CHEM 3107, CHEM 3205, CHEM 3305 and CHEM 3504.
Laboratory and associated work equivalent to at least eight hours a week for two terms.

Summer session: some of the courses listed in this Calendar are offered during the summer. Hours and scheduling for summer session courses will differ significantly from those reported in the fall/winter Calendar. To determine the scheduling and hours for summer session classes, consult the class schedule at central.carleton.ca

Not all courses listed are offered in a given year. For an up-to-date statement of course offerings for the current session and to determine the term of offering, consult the class schedule at central.carleton.ca