Chemistry

- **M.Sc. Chemistry**
- **M.Sc. Chemistry with Specialization in Chemical and Environmental Toxicology**
- **Ph.D. Chemistry**
- **Ph.D. Chemistry with Specialization in Chemical and Environmental Toxicology**

M.Sc. Chemistry

Admission Requirements

Honours B.Sc. degree in Chemistry, with a B+ average in the last two years and a B average overall.

Applicants who do not meet this requirement, or whose undergraduate degree is in another, closely related field, may be accepted into the program, but may be assigned extra courses.

Qualifying Year

Applicants who do not qualify for direct admission to the Master's program may be admitted to a qualifying-year program (see 2.3 under General Regulations).

5.0 credits must be completed within two consecutive fall and winter terms, including a 1.0 credit Research Project and Seminar course (CHEM 4908 [1.0]), and 4.0 credits in 0.5- and 0.25-credit courses, as assigned by the Graduate Supervisor. An average grade of A- over these five credits, with a minimum grade of B in each course must be presented to be considered for admission to the M.Sc. program.

Program Requirements

- A research thesis defended at an oral examination (3.0 credits)
- One credit of graduate courses (made up of any combination of 0.5 credit and 0.25 credit courses)
- CHEM 5801 [1.0]
- Residence requirement - at least one year of full-time study

M.Sc. Chemistry (5.0 credits)

1. 3.0 credits in:		3.0
CHEM 5909 [3.0]	M.Sc. Thesis	
1. 1.0 credit in:		1.0
CHEM 5801 [1.0]	Seminar I	
1. 1.0 credit in graduate courses		1.0
Total Credits		5.0

M.Sc. Chemistry with Specialization in Chemical and Environmental Toxicology (5.0 credits)

1. 1.0 credit in:		1.0
BIOL 6402/ CHEM 5708 [0.5]	Principles of Toxicology	
or BIOL 6403 [0.5]	Ecotoxicology	
BIOL 6405 [1.0]	Seminar in Toxicology	
or CHEM 5805 [1.0]	Seminar in Toxicology	
1. 1.0 credit in:		1.0
CHEM 5801 [1.0]	Seminar I	
3. 3.0 credits in:		3.0
CHEM 5909 [3.0]	M.Sc. Thesis	
Total Credits		5.0

Guidelines for Completion of Master's Degree

Full-time students in the master's program will normally complete the degree requirements in two years. Part-time students will normally complete the degree requirements in four years.

Thesis Advisory Committee

Within four months of initial registration in the M.Sc. or Ph.D. program, a Thesis Advisory Committee (TAC) will be appointed for each student. Committee membership will be formally approved by the departmental chairs and OCCI directors at Carleton and the University of Ottawa. The committee will consist of a minimum of three members, including the thesis supervisor, and where practicable, at least one member will be from the other campus of OCCI. Committee membership may include adjunct faculty members of the Faculty of Graduate and Postdoctoral Studies (FGPS) at the University of Ottawa or the Faculty of Graduate Studies and Research at Carleton.

Once a year, the student will prepare a formal Thesis Progress Report. The report is not to exceed four pages and will outline the problem, methodology used, results achieved, and aims for future research. The TAC will evaluate the report and indicate whether the student has made satisfactory progress. No meeting with the student will be required if progress is deemed by the TAC to be satisfactory. A meeting to discuss the student's progress may be held at any time at the request of either the student or the committee.

Ph.D. Chemistry

About the Program

The Department of Chemistry offers a program of graduate studies and research leading to M. Sc. and Ph. D. degrees, in all areas of chemistry, including, analytical, inorganic, organic, physical and theoretical chemistry. Within these general areas, members of the faculty have active research programs in themes such as atomic layer deposition, bioinorganic sensors, functionally imprinted polymers, fungal toxicity, nanotechnology, polymers and nanocomposites, polymers for photonics, self assembly, thin films, microelectronics etc. Most of the instrument facilities relevant to these research activities exist in the department. We also leverage on the strength of the Ottawa Carleton Chemistry Institute for other instrumental needs. In addition to regular faculty members, several scientists from the government laboratories serve as adjunct professors with joint supervisory privileges. As needed, students are permitted to take courses from University of Ottawa towards the required credits. In addition to regular student funding, endowed scholarships are available to outstanding students.

Academic Regulations

See the General Regulations section of this Calendar.

Admission Requirements

The normal requirement for admission to the Ph.D. program is an M.Sc. degree in Chemistry. Direct entrance from a B.Sc. degree in Chemistry will be considered in exceptional cases.

Program Requirements

Ph.D. Chemistry (10.0 credits)		
1. 6.0 credits in:		6.0
CHEM 6909 [12.0]	Ph.D. Thesis	
2. A two-part comprehensive examination in Chemistry (see Note below)		0.0
3. 2.0 credits in graduate courses		2.0
4. 2.0 credits in:		2.0
CHEM 5801 [1.0]	Seminar I	
CHEM 5802 [1.0]	Seminar II	
5. At least three years of full-time study		
Total Credits		10.0

Ph.D. Chemistry with Specialization in Chemical and Environmental Toxicology (10.0 credits)		
1. 6.0 credits in:		6.0
CHEM 6909 [12.0]	Ph.D. Thesis	
2. A two-part comprehensive examination in Chemistry (see Note below)		
3. 1.5 credit in:		1.5
CHEM 5708/ BIOL 6402 [0.5]	Principles of Toxicology	
or CHEM 5705/ BIOL 6403 [0.5] [0.5	Ecotoxicology	
CHEM 5805 [1.0]	Seminar in Toxicology (not required for students who have already completed the Seminar in Toxicology for the Master's specialization)	
or BIOL 6405 [1.0]	Seminar in Toxicology	
4. 0.5 credit in additional graduate courses		0.5
5. 2.0 credits in:		2.0
CHEM 5801 [1.0]	Seminar I	
CHEM 5802 [1.0]	Seminar II	
6. At least three years of full-time study		
Total Credits		10.0

Chemical and Environmental Toxicology Courses

Other courses listed in the calendar under the primary academic units of psychology, biology, or chemistry may be taken, with the approval of the student's advisory committee, as options in addition to the basic requirements of the degree in chemical and environmental toxicology.

BIOL 6402/ CHEM 5708 [0.5] (BIO 9101)	Principles of Toxicology	0.5
BIOL 6403/ CHEM 5705 [0.5] (BIO 9104)	Ecotoxicology	0.5
BIOL 6405/ CHEM 5805 [1.0] (BIO 9105)	Seminar in Toxicology	0.5
BIOL 5709/ CHEM 5709 [0.5] (BIO 8113)	Chemical Toxicology	0.5

Notes

1. **Comprehensive examination**: The first part consists of a research proposal examination. The proposal topic can be in the same research area as that of the student's thesis supervisor, but should be significantly different from the student's thesis research project and any research being conducted by any faculty member of the Ottawa-Carleton Chemistry Institute. The second part of the examination will consist of either
   - a short presentation given by the student to an examining committee on a topic in his/her research area, or
   - a series of five two-hour examinations from a library of examinations. (No credit. Graded Pass or Fail.) Students admitted to the graduate program in Chemistry at Carleton University prior to May 1 2003 may follow the Comprehensive Examination requirement published in the 2002-2003 Graduate Calendar. Students who fail to complete the comprehensive examination by the end of the third year of the graduate chemistry program will be withdrawn from the program.
2. Full-time students who enter the doctoral program directly from the B.Sc. program normally will complete the degree requirements in four and one-half years. Part-time students normally will complete the degree requirements in nine years.

Program Requirements from M.Sc. Chemistry

- Same as above, except that only one seminar course will be required if a grade of at least A- has been obtained in Seminar I (CHEM 5801 [1.0] or equivalent). In addition, credit for up to 1.0 credit of graduate courses may be given to reduce the requirement for graduate course credit from two to one, if a grade of at least an A- has been obtained in each of the courses taken during M.Sc. Students must complete their comprehensive examination within two years or be withdrawn from the program
- Residence requirement: at least two years of full-time study.
- Full-time students who enter the doctoral program from the M.Sc. Chemistry program normally will complete the degree requirements in three years. Part-time students will normally complete the degree requirements in six years.

Orientation Examinations

Students coming from outside Canada or the United States must write orientation examinations at approximately the third-year university level. Each student will be informed of this requirement upon admission. The examinations will be given in the first week of the term in

September and January. Students can choose from any three examination modules in: organic, physical, inorganic/analytical and biochemistry.

In examination areas where the student shows unsatisfactory performance or deficiency, the Graduate Supervisor will assign undergraduate-level remedial courses. To be eligible to continue in the graduate program, the student must achieve a minimum grade of A- in each remedial course.

Thesis Advisory Committee

Within four months of initial registration in the M.Sc. or Ph.D. program, a Thesis Advisory Committee (TAC) will be appointed for each student. Committee membership will be formally approved by the departmental chairs and OCCI directors at Carleton and the University of Ottawa. The committee will consist of a minimum of three members, including the thesis supervisor, and where practicable, at least one member will be from the other campus of OCCI. Committee membership may include adjunct faculty members of the Faculty of Graduate and Postdoctoral Studies (FGPS) at the University of Ottawa or the Faculty of Graduate Studies and Research at Carleton.

Once a year, the student will prepare a formal Thesis Progress Report. The report is not to exceed four pages and will outline the problem, methodology used, results achieved, and aims for future research. The TAC will evaluate the report and indicate whether the student has made satisfactory progress. No meeting with the student will be required if progress is deemed by the TAC to be satisfactory. A meeting to discuss the student's progress may be held at any time at the request of either the student or the committee.

Chemistry (CHEM) Courses

CHEM 5002 [0.25 credit] (CHM 8301)
Multinuclear Magnetic Resonance Spectroscopy
Principles of Nuclear Magnetic Resonance (NMR). NMR parameters to be studied are: chemical shift, spin-spin coupling, electric quadrupole coupling, spin-spin and spin-lattice relaxation rates. NMR and the periodic table. Dynamic NMR. Applications in chemistry and biochemistry. The Fourier Transform technique. Pulse sequences. Basic principles and 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 NOSY, COSY and related data.

CHEM 5005 [0.25 credit] (CHM 8327)
Physical Organic Chemistry
Hammet 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 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.

CHEM 5103 [0.25 credit] (CHM 8318)
Free Radicals
Photochemical generation of free radical reaction intermediates in the condensed phase. Techniques to be explored include laser flash photolysis, pulse radiolysis, esr, CIDNP and matrix isolation.

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 4302, for which additional credit is precluded.

CHEM 5200 [0.25 credit] (CHM 8342)
Clay Minerals Chemistry
Occurrence, classification and mineralogy of clay minerals. Intercalation processes and chemical modifications. Characterization of natural and modified clays. Industrial applications.

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 4203, 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 4203, for which additional credit is precluded.

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 5305 [0.5 credit] (CHM 8356)
Physical Methods in Inorganic Chemistry
Characterization of inorganic materials and coordination complexes by electronic absorption and electron paramagnetic spectroscopies, temperature and field dependent magnetic susceptibilities, and crystallography.

CHEM 5309 [0.25 credit] (CHM 8347)
Electron Transfer: Theory and Experiment
The development of classical, semi-classical and quantum mechanical electron transfer models is described. In addition, the course will examine recent experimental results and the application of electron transfer theory to biological systems.

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
Analysis of proton NMR spectra. Fourier transform 13C NMR, strategies for structure elucidation, relaxation times, two-dimensional NMR. Aspects of mass spectrometry.
Also offered at the undergraduate level, with different requirements, as CHEM 4202, for which additional credit is precluded.

CHEM 5408 [0.25 credit] (CHM 8350)
Introduction to Polymer Structure and Morphology
Flexible and rigid rod polymers: effect of molecular constitution and conformation; examples of polymer architectures and function; the amorphous state and glass transition; the crystalline state: typical crystal structures of polymers; polymorphism; crystallinity and long spacing. Thermal and solvent-induced crystallization; Lamellar and Spherulitic morphology.

CHEM 5409 [0.25 credit] (CHM 8351)
Morphology of Polymers and Composites
Liquid crystalline state of polymers; morphology of block copolymers and polymer blends; plasticizers and fillers for tailoring properties; depression of glass transition and melting temperature; phase stability of polymer composites; mechanical properties; self assembled systems; polymer nano-composites for electronic devices; common experimental techniques.

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.

CHEM 5503 [0.5 credit] (CHM 8354)
Chemical Speciation in the Natural Environment
Metal-organic interactions in the aquatic environment. Evaluation of analytical techniques and their capability for quantitative determination of chemical species (as opposed to total element-determination) in the natural environment. Electrochemical techniques for determination of chemical speciation of nutrient and toxicant elements present in the natural environment.

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 5705 [0.5 credit] (CHM 9109)
Ecotoxicology
Concepts of ecotoxicology, emphasizing whole ecosystem response to hazardous contaminants. Impacts of chronic and acute exposure of ecosystems to toxicants, the methods of pesticide, herbicide and pollutant residue analysis and the concept of bound residues.
Also listed as BIOL 6403 [BIO 9104].
Prerequisite(s): BIOL 6402 (BIO 9101)/CHEM 5708 (CHM 8156).

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 5801 [1.0 credit] (CHM 8256)
Seminar I
A seminar course in which students are required to present a seminar on a topic not related to 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.

CHEM 5802 [1.0 credit] (CHM 8257S)
Seminar II
A seminar course in which 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.

CHEM 5805 [1.0 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.
Also listed as BIOL 6405.

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 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

CHEM 6909 [12.0 credits]
Ph.D. Thesis

Food Science (FOOD) Courses

FOOD 5100 [0.5 credit]
Advanced Food Processing and Technology
Major techniques used in food processing and preservation of raw agricultural materials. Targeted food groups include dairy, cereal grains and oilseeds.

FOOD 5101 [0.5 credit]
Advanced Nutrition and Metabolism
Metabolism of macronutrients in the human body. Detailed catabolic and anabolic reactions of carbohydrates, lipids and proteins. Regulatory control points in healthy and diseased states. Discussion of the literature pertaining to nutrition, metabolism and disease.

FOOD 5102 [0.5 credit]
Food Biotechnology
Developments in biotechnology related to food production and quality. Traditional food biotechnology and novel biotechnological methods related to the production of food; the use of traditional food crops in other bio-industries. Aspects of microbiology and genetic engineering.

FOOD 5103 [0.5 credit]
Cellular Redox in Health and Disease
Crucial interactions of free radicals with biomolecules in living organisms. Procedures for detecting cellular and DNA damage, lipid and protein oxidation products; the link between oxidative stress and chronic diseases.

FOOD 5104 [0.5 credit]
Theory and Principles of Food Quality and Control
Sampling plans and statistical methods. Physical, chemical, biological and microbiological tests in quality control as it relates to food safety and regulation.
Also offered at the undergraduate level, with different requirements, as FOOD 4001, for which additional credit is precluded.

FOOD 5105 [0.5 credit]
Functional Foods and Nutraceuticals
Study of the scientific basis for bioactive components of functional foods and nutraceuticals, their sources, chemistry, process technology, efficacy, safety and regulation. The relationship between chemical structure and functionality; interactions between compounds in food. Precludes additional credit for CHEM 5103 (no longer offered).
Prerequisite(s): FOOD 3001.

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