Chemistry

This section presents the requirements for programs in:

- Chemistry B.Sc. Honours
- Chemistry with Concentration in Chemical Toxicology B.Sc. Honours
- Chemistry with Concentration in Nanotechnology B.Sc. Honours
- Chemistry B.Sc.
- Chemistry and Earth Sciences B.Sc. Combined Honours
- Chemistry and Physics B.Sc. Combined Honours
- Minor in Chemistry

Graduation Requirements

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

1. the University regulations (see *the Academic Regulations of the University* 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*),

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

Program Requirements

Chemistry
B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (10.5 credits)			
1.	**6.5 credits in:**		6.5
	CHEM 1001 [0.5]	General Chemistry I	
	CHEM 1002 [0.5]	General Chemistry II	
	CHEM 2103 [0.5]	Physical Chemistry I	
	CHEM 2203 [0.5]	Organic Chemistry I	
	CHEM 2204 [0.5]	Organic Chemistry II	
	CHEM 2302 [0.5]	Analytical Chemistry I	
	CHEM 2303 [0.5]	Analytical Chemistry II	
	CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
	CHEM 3100 [0.5]	Physical Chemistry II	
	CHEM 3101 [0.5]	Quantum Chemistry	
	CHEM 3201 [0.5]	Advanced Organic Chemistry I	
	CHEM 3503 [0.5]	Inorganic Chemistry I	
	CHEM 3504 [0.5]	Inorganic Chemistry II	
2.	**1.0 credit from:**		1.0
	CHEM 4907 [1.0]	Honours Essay and Research Proposal	
	CHEM 4908 [1.0]	Research Project and Seminar	
3.	**1.0 credit from:**		1.0
	CHEM 3106 [0.5]	Computational Chemistry Methods Laboratory	
	CHEM 3107 [0.5]	Experimental Methods in Nanoscience	
	CHEM 3205 [0.5]	Experimental Organic Chemistry	
	CHEM 3305 [0.5]	Advanced Analytical Chemistry Laboratory	
4.	**0.5 credit in:**		0.5
	CHEM 3401 [0.5]	Physical Aspects of Biochemistry (or any BIOC course)	
5.	**1.0 credit in** CHEM at the 4000 level, or 0.5 credit in CHEM at the 4000 level and:		1.0
	BIOC 3102 [0.5]	General Biochemistry II	
6.	**0.5 credit in** CHEM at the 3000 or 4000 level		0.5
B. Credits Not Included in the Major CGPA (9.5 credits)			
7.	**2.0 credits in:**		2.0
	MATH 1004 [0.5]	Calculus for Engineering or Physics	
	MATH 1107 [0.5]	Linear Algebra I	
	MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
	or MATH 2007 [0.5]	Elementary Calculus II	
	MATH 2008 [0.5]	Intermediate Calculus	
8.	**1.0 credit from:**		1.0
	PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
	PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I Elementary University Physics II	
9.	**0.5 credit in** Science Continuation (not CHEM)		0.5
10.	**1.0 credit in** Science Faculty Electives at the 1000 level		1.0
11.	**2.0 credits in** Science Faculty Electives or Science Continuation Courses		2.0
12.	**0.5 credit in:**		0.5
	NSCI 1000 [0.5]	Seminar in Science (or approved courses outside the faculties of Science and Engineering and Design)	
13.	**1.5 credits in** approved courses outside the faculties of Science and Engineering and Design (may include NSCI 1000 if not used above)		1.5
14.	**1.0 credit in** free elective.		1.0
Total Credits			**20.0**

Chemistry
with Concentration in Chemical Toxicology
B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (11.5 credits)			
1.	**9.5 credits in:**		9.5
	CHEM 1001 [0.5]	General Chemistry I	
	CHEM 1002 [0.5]	General Chemistry II	
	CHEM 2103 [0.5]	Physical Chemistry I	
	CHEM 2203 [0.5]	Organic Chemistry I	
	CHEM 2204 [0.5]	Organic Chemistry II	
	CHEM 2302 [0.5]	Analytical Chemistry I	
	CHEM 2303 [0.5]	Analytical Chemistry II	
	CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
	CHEM 2800 [0.5]	Foundations for Environmental Chemistry	
	BIOL 2200 [0.5]	Cellular Biochemistry	
	CHEM 3201 [0.5]	Advanced Organic Chemistry I	
	CHEM 3503 [0.5]	Inorganic Chemistry I	
	BIOC 3101 [0.5]	General Biochemistry I	

CHEM 3800 [0.5]	The Chemistry of Environmental Pollutants	
FOOD 4103 [0.5]	Food Safety Risk Assessment	
CHEM 4305 [0.5]	Environmental Chemistry and Toxicology	
BIOC 4708 [0.5]	Principles of Toxicology	
CHEM 4908 [1.0]	Research Project and Seminar	
or CHEM 4907 [1	Honours Essay and Research Proposal	
2. 0.5 credits from:		0.5
CHEM 3205 [0.5]	Experimental Organic Chemistry	
CHEM 3305 [0.5]	Advanced Analytical Chemistry Laboratory	
BIOC 3103 [0.5]	Practical Biochemistry I	
3. 1.5 credit in CHEM or BIOC at the 3000 or 4000 level		1.5
B. Credits Not Included in the Major CGPA (8.5 credits)		
4. 1.5 credits in:		1.5
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1107 [0.5]	Linear Algebra I	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
or MATH 2007 [0	Elementary Calculus II	
5. 1.0 credit from:		1.0
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I Elementary University Physics II	
6. 1.0 credit in:		1.0
BIOL 1103 [0.5]	Foundations of Biology I	
BIOL 1104 [0.5]	Foundations of Biology II	
7. 0.5 credits in:		0.5
FOOD 2004 [0.5]	Scientific Communication in Food Science	
8. 1.5 credits in Science Continuation Courses (not CHEM)		1.5
9. 2.0 credits in approved courses outside the faculties of Science and Engineering and Design (may include NSCI 1000, if not used above)		2.0
10. 1.0 credit in free electives		1.0
Total Credits		**20.0**

Chemistry with Concentration in Nanotechnology B.Sc. Honours (20.0 credits)

A. Credits Included in the Major CGPA (10.5 credits)		
1. 9.0 credits in:		9.0
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
CHEM 2103 [0.5]	Physical Chemistry I	
CHEM 2203 [0.5]	Organic Chemistry I	
CHEM 2204 [0.5]	Organic Chemistry II	
CHEM 2302 [0.5]	Analytical Chemistry I	
CHEM 2303 [0.5]	Analytical Chemistry II	
CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
CHEM 3100 [0.5]	Physical Chemistry II	
CHEM 3101 [0.5]	Quantum Chemistry	
CHEM 3107 [0.5]	Experimental Methods in Nanoscience	
CHEM 3201 [0.5]	Advanced Organic Chemistry I	
CHEM 3503 [0.5]	Inorganic Chemistry I	
CHEM 3600 [0.5]	Introduction to Nanotechnology	
CHEM 4103 [0.5]	Surface Chemistry and Nanostructures	
CHEM 4104 [0.5]	Physical Methods of Nanotechnology	
CHEM 4908 [1.0]	Research Project and Seminar	
2. 1.0 credit from:		1.0
CHEM 3106 [0.5]	Computational Chemistry Methods Laboratory	
CHEM 3205 [0.5]	Experimental Organic Chemistry	
CHEM 3305 [0.5]	Advanced Analytical Chemistry Laboratory	
CHEM 3504 [0.5]	Inorganic Chemistry II	
3. 0.5 credit in:		0.5
CHEM 3401 [0.5]	Physical Aspects of Biochemistry (or any BIOC course)	
B. Credits Not Included in the Major CGPA (9.5 credits)		
4. 2.0 credits in:		2.0
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1107 [0.5]	Linear Algebra I	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
or MATH 2007 [0.5]	Elementary Calculus II	
MATH 2008 [0.5]	Intermediate Calculus	
5. 1.0 credit from:		1.0
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I Elementary University Physics II	
6. 0.5 credit in Science Continuation (not CHEM)		0.5
7. 1.0 credit in Science Faculty Electives at the 1000 level		1.0
8. 2.0 credits in Science Faculty Electives or Science Continuation Courses		2.0
9. 0.5 credit in NSCI 1000 or approved courses outside the faculties of Science and Engineering and Design		0.5
10. 1.5 credits in approved courses outside the faculties of Science and Engineering and Design (may include NSCI 1000, if not used above)		1.5
11. 1.0 credit in free electives.		1.0
Total Credits		**20.0**

Chemistry B.Sc. (15.0 credits)

A. Credits Included in the Major CGPA (6.0 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 2203 [0.5]	Organic Chemistry I	
CHEM 2204 [0.5]	Organic Chemistry II	
CHEM 2302 [0.5]	Analytical Chemistry I	
CHEM 2303 [0.5]	Analytical Chemistry II	

CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
CHEM 3100 [0.5]	Physical Chemistry II	
CHEM 3101 [0.5]	Quantum Chemistry	
2. 0.5 credit from:		0.5
CHEM 3106 [0.5]	Computational Chemistry Methods Laboratory	
CHEM 3205 [0.5]	Experimental Organic Chemistry	
CHEM 3305 [0.5]	Advanced Analytical Chemistry Laboratory	
CHEM 3503 [0.5]	Inorganic Chemistry I	
CHEM 3107 [0.5]	Experimental Methods in Nanoscience	
3. 0.5 credit in CHEM at the 3000-level		0.5
B. Credits Not Included in the Major CGPA (9.0 credits)		
4. 2.0 credits in:		2.0
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1107 [0.5]	Linear Algebra I	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
or MATH 2007 [0	Elementary Calculus II	
MATH 2008 [0.5]	Intermediate Calculus	
5. 1.0 credit from:		1.0
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I Elementary University Physics II	
6. 0.5 credit in Science Continuation (not CHEM)		0.5
7. 1.0 credit in Science Faculty Electives at the 1000 level		1.0
8. 1.5 credit in Science Faculty Electives or Science Continuation Courses		1.5
9. 0.5 credit in NSCI 1000 or approved courses outside the faculties of Science and Engineering and Design		0.5
10. 1.5 credits in approved courses outside the faculties of Science and Engineering and Design (may include NSCI 1000, if not used above)		1.5
11. 1.0 credit in free electives.		1.0
Total Credits		**15.0**

Chemistry and Earth Sciences B.Sc. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (13.5 credits)		
1. 4.0 credits in:		4.0
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
CHEM 2103 [0.5]	Physical Chemistry I	
CHEM 2302 [0.5]	Analytical Chemistry I	
CHEM 2303 [0.5]	Analytical Chemistry II	
CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
CHEM 3100 [0.5]	Physical Chemistry II	
CHEM 3503 [0.5]	Inorganic Chemistry I	
2. 1.0 credit in CHEM at the 4000-level		1.0
3. 1.0 credit in:		1.0
ERTH 1006 [0.5]	Exploring Planet Earth	
ERTH 1009 [0.5]	The Earth System Through Time	
4. 3.0 credits in:		3.0
ERTH 2102 [0.5]	Mineralogy to Petrology	
ERTH 2104 [0.5]	Igneous Systems, Geochemistry and Processes	
ERTH 2105 [0.5]	Geodynamics	
ERTH 2314 [0.5]	Sedimentation and Stratigraphy	
ERTH 2406 [0.5]	Geology and Map Interpretation	
ERTH 2802 [0.5]	Field Geology I	
5. 0.5 credit from:		0.5
ERTH 3203 [0.5]	Sedimentology	
ERTH 3206 [0.5]	Sedimentary Depositional Systems (See Note, below)	
6. 2.0 credits in:		2.0
ERTH 3003 [0.5]	Geochemistry and Geochronology	
ERTH 3204 [0.5]	Mineral Deposits	
ERTH 3207 [0.5]	Metamorphic Petrology and Processes	
ERTH 3806 [0.5]	Structural Geology	
7. 1.0 credit in ERTH at the 4000-level		1.0
8. 1.0 credit from:		1.0
CHEM 4907 [1.0]	Honours Essay and Research Proposal	
CHEM 4908 [1.0]	Research Project and Seminar	
ERTH 4908 [1.0]	Honours Thesis	
ERTH 4909 [0.5]	Research in Earth Sciences (and 0.5 credit in ERTH at the 4000-level)	
B. Credits Not Included in the Major CGPA (6.5 credits)		
9. 1.0 credit in:		1.0
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1107 [0.5]	Linear Algebra I	
10. 0.5 credit from:		0.5
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 2007 [0.5]	Elementary Calculus II	
11. 0.5 credit in:		0.5
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
12. 0.5 credit in:		0.5
ERTH 2004 [0.5]	Maps, Satellites and the Geospatial Revolution	
13. 1.0 credit from:		1.0
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I Elementary University Physics II	
14. 0.5 credit in:		0.5
BIOL 1104 [0.5]	Foundations of Biology II	
15. 0.5 credit in Science Faculty Electives (not CHEM or ERTH)		0.5
16. 0.5 credit in:		0.5
NSCI 1000 [0.5]	Seminar in Science (or approved course outside the faculties of Science and Engineering and Design)	
17. 1.5 credits in approved courses outside the faculties of Science and Engineering and Design		1.5
Total Credits		**20.0**

Note: for **Item 5** above, ERTH 3203 is required if prerequisite conditions are met.

Chemistry and Physics
B.Sc. Combined Honours (20.0 credits)

A. Credits Included in the Major CGPA (13.0 credits)

1. 1.0 credit from:		1.0
PHYS 1001 [0.5] & PHYS 1002 [0.5]	Foundations of Physics I Foundations of Physics II (recommended)	
PHYS 1003 [0.5] & PHYS 1004 [0.5]	Introductory Mechanics and Thermodynamics Introductory Electromagnetism and Wave Motion	
PHYS 1007 [0.5] & PHYS 1008 [0.5]	Elementary University Physics I Elementary University Physics II (with an average grade of B- or higher)	
2. 3.0 credits in:		3.0
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2305 [0.5]	Electricity and Magnetism	
PHYS 2604 [0.5]	Modern Physics I	
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
PHYS 3807 [0.5]	Mathematical Physics I	
3. 1.5 credits from:		1.5
PHYS 3308 [0.5]	Electromagnetism	
PHYS 3606 [0.5]	Modern Physics II	
PHYS 3802 [0.5]	Advanced Dynamics	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	
4. 0.5 credit in PHYS at the 4000 level		0.5
5. 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 2203 [0.5]	Organic Chemistry I	
CHEM 2204 [0.5]	Organic Chemistry II	
CHEM 2501 [0.5]	Introduction to Inorganic and Bioinorganic Chemistry	
CHEM 3100 [0.5]	Physical Chemistry II	
CHEM 3102 [0.5]	Methods of Computational Chemistry	
CHEM 3503 [0.5]	Inorganic Chemistry I	
CHEM 4102 [0.5]	Advanced Topics in Physical Chemistry II	
6. 0.5 credit from:		0.5
CHEM 3106 [0.5]	Computational Chemistry Methods Laboratory	
CHEM 3107 [0.5]	Experimental Methods in Nanoscience	
7. 0.5 credit in CHEM at the 4000 level		0.5
8. 1.0 credit from:		1.0
CHEM 4908 [1.0]	Research Project and Seminar	
PHYS 4909 [1.0]	Fourth-Year Project	
PHYS 4907 plus 0.5 credit in PHYS at the 4000 level		
PHYS 4908 plus 0.5 credit in PHYS at the 4000 level		

B. Credits Not Included in the Major CGPA (7.0 credits)

9. 3.0 credits in:		3.0
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	
MATH 3705 [0.5]	Mathematical Methods I	
10. 0.5 credit from:		0.5
COMP 1005 [0.5]	Introduction to Computer Science I	
ECOR 1606 [0.5]	Problem Solving and Computers	
11. 0.5 credit from:		0.5
MATH 3800 [0.5]	Mathematical Modeling and Computational Methods	
ECOR 2606 [0.5]	Numerical Methods	
12. 0.5 credit from:		0.5
NSCI 1000 [0.5]	Seminar in Science	
Approved courses outside the faculties of Science and Engineering and Design		
13. 1.5 credits in approved courses outside the faculties of Science and Engineering and Design (may include NSCI 1000, if not used above)		1.5
14. 1.0 credit in free electives.		1.0
Total Credits		**20.0**

Minor in Chemistry (4.0 credits)

The Minor in Chemistry is available to degree students registered in programs other than those associated with the Department of Chemistry.

Students are required to present a Minor CGPA of 4.00 or higher at graduation in order to be awarded a Minor in Chemistry.

Requirements:

1. 1.0 credit from:		1.0
CHEM 1001 [0.5] & CHEM 1002 [0.5]	General Chemistry I General Chemistry II	
or		
CHEM 1005 [0.5] & CHEM 1006 [0.5]	Elementary Chemistry I Elementary Chemistry II	
with a grade of B- or higher in CHEM 1006		
2. 3.0 credits in Chemistry at 2000-level or higher		3.0
3. The remaining requirements of the major discipline(s) and degree must be satisfied.		
Total Credits		**4.0**

B.Sc. Regulations

The regulations presented in this section apply to all Bachelor of Science programs. In addition to the requirements presented here, students must satisfy the University regulations common to all undergraduate students including the process of Academic Continuation Evaluation (see the *Academic Regulations of the University* section of this Calendar).

Breadth Requirement for the B.Sc.

Students in a Bachelor of Science program must present the following credits at graduation:

1. 2.0 credits in Science Continuation courses not in the major discipline; **students completing a double major are considered to have completed this requirement providing they have 2.0 credits in Science Continuation courses in each of the two majors;**
2. 2.0 credits in courses outside of the faculties of Science and Engineering and Design (may include NSCI 1000)

In most cases, the requirements for individual B.Sc. programs, as stated in this Calendar, contain these requirements, explicitly or implicitly.

Students admitted to B.Sc. programs by transfer from another institution must present at graduation (whether taken at Carleton or elsewhere):

1. 2.0 credits in courses outside of the faculties of Science and Engineering and Design (may include NSCI 1000) if the student received fewer than 10.0 transfer credits; or,
2. 1.0 credit in courses outside of the faculties of Science and Engineering and Design (may include NSCI 1000) if the student received 10.0 or more transfer credits.

Declared and Undeclared Students

Degree students are considered "Undeclared" if they have been admitted to a degree, but have not yet selected and been accepted into a program within that degree. The status "Undeclared" is available only in the B.A. and B.Sc. degrees. Undeclared students must apply to enter a program upon or before completing 3.5 credits.

Change of Program within the B.Sc. Degree

To transfer to a program within the B.Sc. degree, applicants must normally be *Eligible to Continue* (EC) in the new program, by meeting the CGPA thresholds described in Section 3.1.9 of the *Academic Regulations of the University.*

Applications to declare or change programs within the B.Sc. degree must be made online through Carleton Central by completing a Change of Program Elements (COPE) application form within the published deadlines. Acceptance into a program, or into a program element or option, is subject to any enrolment limitations, and/or specific program, program element or option requirements as published in the relevant Calendar entry.

Minors, Concentrations, and Specializations

Students may add a Minor, Concentration, or Specialization by completing a Change of Program Elements (COPE) application form online through Carleton Central. Acceptance into a Minor, Concentration, or Specialization normally requires that the student be *Eligible to Continue* (EC) and is meeting the minimum CGPAs described in Section 3.1.9 of the *Academic Regulations of the University*, as well as being subject to any specific requirements of the intended Minor, Concentration, or Specialization as published in the relevant Calendar entry.

Experimental Science Requirement

Students in a B.Sc. degree program must present at graduation at least two full credits of Experimental Science chosen from two different departments or institutes from the list below:

Approved Experimental Science Courses

Biochemistry	
BIOC 2200 [0.5]	Cellular Biochemistry
BIOC 4001 [0.5]	Methods in Biochemistry
BIOC 4201 [0.5]	Advanced Cell Culture and Tissue Engineering
Biology	
BIOL 1103 [0.5]	Foundations of Biology I
BIOL 1104 [0.5]	Foundations of Biology II
BIOL 2001 [0.5]	Animals: Form and Function
BIOL 2002 [0.5]	Plants: Form and Function
BIOL 2104 [0.5]	Introductory Genetics
BIOL 2200 [0.5]	Cellular Biochemistry
BIOL 2600 [0.5]	Ecology
Chemistry	
CHEM 1001 [0.5]	General Chemistry I
CHEM 1002 [0.5]	General Chemistry II
CHEM 1005 [0.5]	Elementary Chemistry I
CHEM 1006 [0.5]	Elementary Chemistry II
CHEM 2103 [0.5]	Physical Chemistry I
CHEM 2203 [0.5]	Organic Chemistry I
CHEM 2204 [0.5]	Organic Chemistry II
CHEM 2302 [0.5]	Analytical Chemistry I
CHEM 2303 [0.5]	Analytical Chemistry II
CHEM 2800 [0.5]	Foundations for Environmental Chemistry
Earth Sciences	
ERTH 1006 [0.5]	Exploring Planet Earth
ERTH 1009 [0.5]	The Earth System Through Time
ERTH 2102 [0.5]	Mineralogy to Petrology
ERTH 2404 [0.5]	Engineering Geoscience
ERTH 2802 [0.5]	Field Geology I
ERTH 3111 [0.5]	Vertebrate Evolution: Mammals, Reptiles, and Birds
ERTH 3112 [0.5]	Vertebrate Evolution: Fish and Amphibians
ERTH 3204 [0.5]	Mineral Deposits
ERTH 3205 [0.5]	Physical Hydrogeology
ERTH 3806 [0.5]	Structural Geology
Food Sciences	
FOOD 3001 [0.5]	Food Chemistry
FOOD 3002 [0.5]	Food Analysis
FOOD 3005 [0.5]	Food Microbiology
Geography	
GEOG 1010 [0.5]	Global Environmental Systems
GEOG 3108 [0.5]	Soil Properties
Neuroscience	
NEUR 3206 [0.5]	Sensory and Motor Neuroscience
NEUR 3207 [0.5]	Systems Neuroscience
NEUR 4600 [0.5]	Advanced Lab in Neuroanatomy
Physics	
PHYS 1001 [0.5]	Foundations of Physics I

PHYS 1002 [0.5]	Foundations of Physics II
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion
PHYS 1007 [0.5]	Elementary University Physics I
PHYS 1008 [0.5]	Elementary University Physics II
PHYS 2202 [0.5]	Wave Motion and Optics
PHYS 2604 [0.5]	Modern Physics I
PHYS 3007 [0.5]	Third Year Physics Laboratory: Selected Experiments and Seminars
PHYS 3606 [0.5]	Modern Physics II
PHYS 3608 [0.5]	Modern Applied Physics

Course Categories for B.Sc. Programs

Science Geography Courses

GEOG 1010 [0.5]	Global Environmental Systems
GEOG 2006 [0.5]	Introduction to Quantitative Research
GEOG 2013 [0.5]	Weather and Water
GEOG 2014 [0.5]	The Earth's Surface
GEOG 3003 [0.5]	Quantitative Geography
GEOG 3010 [0.5]	Field Methods in Physical Geography
GEOG 3102 [0.5]	Geomorphology
GEOG 3103 [0.5]	Watershed Hydrology
GEOG 3104 [0.5]	Principles of Biogeography
GEOG 3105 [0.5]	Climate and Atmospheric Change
GEOG 3106 [0.5]	Aquatic Science and Management
GEOG 3108 [0.5]	Soil Properties
GEOG 4000 [0.5]	Field Studies
GEOG 4005 [0.5]	Directed Studies in Geography
GEOG 4013 [0.5]	Cold Region Hydrology
GEOG 4017 [0.5]	Global Biogeochemical Cycles
GEOG 4101 [0.5]	Two Million Years of Environmental Change
GEOG 4103 [0.5]	Water Resources Engineering
GEOG 4104 [0.5]	Microclimatology
GEOG 4108 [0.5]	Permafrost

Science Psychology Courses

PSYC 2001 [0.5]	Introduction to Research Methods in Psychology
PSYC 2002 [0.5]	Introduction to Statistics in Psychology
PSYC 2700 [0.5]	Introduction to Cognitive Psychology
PSYC 3000 [1.0]	Design and Analysis in Psychological Research
PSYC 3506 [0.5]	Cognitive Development
PSYC 3700 [1.0]	Cognition (Honours Seminar)
PSYC 3702 [0.5]	Perception
PSYC 2307 [0.5]	Human Neuropsychology I
PSYC 3307 [0.5]	Human Neuropsychology II

Science Continuation Courses

A course at the 2000 level or above may be used as a Science Continuation credit in a B.Sc. program if it is not in the student's major discipline, and is chosen from the following:

- BIOC (Biochemistry)
- BIOL (Biology) Biochemistry students may use BIOL 2005 only as a free elective.
- CHEM (Chemistry)
- COMP (Computer Science) A maximum of two half-credits at the 1000-level in COMP, excluding COMP 1001 may be used as Science Continuation credits.
- ERTH (Earth Sciences), except ERTH 2415 which may be used only as a free elective for any B.Sc. program. Students in Earth Sciences programs may use ERTH 2401, ERTH 2402, and ERTH 2403 only as free electives.
- Engineering. Students wishing to register in Engineering courses must obtain the permission of the Faculty of Engineering and Design.
- ENSC (Environmental Science)
- FOOD (Food Science and Nutrition)
- GEOM (Geomatics)
- HLTH (Health Sciences)
- ISAP (Interdisciplinary Science Practice)
- MATH (Mathematics)
- NEUR (Neuroscience)
- PHYS (Physics), except PHYS 2903
- Science Geography Courses (see list above)
- Science Psychology Courses (see list above)
- STAT (Statistics)
- TSES (Technology, Society, Environment) except TSES 2305. Biology students may use these courses only as free electives. Integrated Science and Environmental Science students may include these courses in their programs but may not count them as part of the Science Sequence.

Science Faculty Electives

Science Faculty Electives are courses at the 1000-4000 level chosen from:

- BIOC (Biochemistry)
- BIOL (Biology) Biology & Biochemistry students may use BIOL 1010 and BIOL 2005 only as free electives
- CHEM (Chemistry) except CHEM 1003, CHEM 1004 and CHEM 1007
- COMP (Computer Science) except COMP 1001
- ERTH (Earth Sciences) except ERTH 1010, ERTH 1011 and ERTH 2415. Earth Sciences students may use ERTH 2401, ERTH 2402, and ERTH 2403 only as free electives.
- Engineering
- ENSC 2001
- FOOD (Food Science and Nutrition)
- GEOM (Geomatics)
- HLTH (Health Science)
- ISAP (Interdisciplinary Science Practice)
- MATH (Mathematics)
- NEUR (Neuroscience)

PHYS (Physics) except PHYS 1901, PHYS 1902, PHYS 1905, PHYS 2903	
Science Geography (see list above)	
Science Psychology (see list above)	
STAT (Statistics)	
TSES (Technology, Society, Environment) Biology students may use these courses only as free electives.	

Advanced Science Faculty Electives

Advanced Science Faculty Electives are courses at the 2000-4000 level chosen from the Science Faculty Electives list above.

Approved Courses Outside the Faculties of Science and Engineering and Design (may include NSCI 1000)

All courses offered by the Faculty of Arts and Social Sciences, the Faculty of Public Affairs, and the Sprott School of Business are approved as Arts or Social Sciences courses EXCEPT FOR: All Science Geography courses (see list above), all Geomatics (GEOM) courses, all Science Psychology courses (see list above). NSCI 1000 may be used as an Approved Course Outside the Faculties of Science and Engineering and Design.

Free Electives

Any course is allowable as a Free Elective providing it is not prohibited (see below). Students are expected to comply with prerequisite requirements and enrolment restrictions for all courses as published in this Calendar.

Courses Allowable Only as Free Electives in any B.Sc. Program

BIOL 4810 [0.5]	Education Research in Undergraduate Science
CHEM 1003 [0.5]	The Chemistry of Food, Health and Drugs
CHEM 1004 [0.5]	Drugs and the Human Body
CHEM 1007 [0.5]	Chemistry of Art and Artifacts
ERTH 1010 [0.5]	Our Dynamic Planet Earth
ERTH 1011 [0.5]	Evolution of the Earth
ERTH 2415 [0.5]	Natural Disasters
ISCI 1001 [0.5]	Introduction to the Environment
ISCI 2000 [0.5]	Natural Laws
ISCI 2002 [0.5]	Human Impacts on the Environment
MATH 0107 [0.5]	Algebra and Geometry
PHYS 1901 [0.5]	Planetary Astronomy
PHYS 1902 [0.5]	From our Star to the Cosmos
PHYS 1905 [0.5]	Physics Behind Everyday Life
PHYS 2903 [0.5]	Physics Towards the Future

Prohibited Courses

The following courses are not acceptable for credit in any B.Sc. program:

COMP 1001 [0.5]	Introduction to Computational Thinking for Arts and Social Science Students
MATH 0005 [0.5]	Precalculus: Functions and Graphs
MATH 0006 [0.5]	Precalculus: Trigonometric Functions and Complex Numbers
MATH 1009 [0.5]	Mathematics for Business
MATH 1119 [0.5]	Linear Algebra: with Applications to Business
MATH 1401 [0.5]	Elementary Mathematics for Economics I
MATH 1402 [0.5]	Elementary Mathematics for Economics II

Co-operative Education

For more information about how to apply for the Co-op program and how the Co-op program works please visit the Co-op website.

All students participating in the Co-op program are governed by the Undergraduate Co-operative Education Policy.

Undergraduate Co-operative Education Policy

Admission Requirements

Students can apply to Co-op in one of two ways: directly from high school, or after beginning a degree program at Carleton.

If a student applies to a degree program with a Co-op option from high school, their university grades will be reviewed two terms to one year prior to their first work term to ensure they meet the academic requirements after their first or second year of study. The time at which the evaluation takes place depends on the program of study. Students will automatically receive an admission decision via their Carleton email account.

Students who did not request Co-op at the time they applied to Carleton can request Co-op after they begin their university studies. To view application instructions and deadlines, please visit carleton.ca/co-op.

To be admitted to Co-op, a student must successfully complete 5.0 or more credits that count towards their degree, meet the minimum CGPA requirement(s) for the student's Co-op option, and fulfil any specified course prerequisites. To see the unique admission and continuation requirements for each Co-op option, please refer to the specific degree programs listed in the Undergraduate Calendar.

Participation Requirements

COOP 1000

Once a student has been given admission or continuation confirmation to the co-op option s/he must complete and pass COOP 1000 (a mandatory online 0.0 credit course). Students will have access to this course a minimum of two terms prior to their first work term and will be notified when to register.

Communication with the Co-op Office

Students must maintain contact with the co-op office during their job search and while on a work term. All email communication will be conducted via the students' Carleton email account.

Employment

Although every effort is made to ensure a sufficient number of job postings for all students enrolled in the co-op option of their degree program, no guarantee of employment can be made. Carleton's co-op program operates a competitive job search process and is dependent upon current market conditions. Academic

performance, skills, motivation, maturity, attitude and potential will determine whether a student is offered a job. It is the student's responsibility to actively conduct a job search in addition to participation in the job search process operated by the co-op office. Once a student accepts a co-op job offer (verbally or written), his/her job search will end and access to co-op jobs will be removed for that term. Students that do not successfully obtain a co-op work term are expected to continue with their academic studies. The summer term is the exception to this rule. Students should also note that hiring priority is given to Canadian citizens for co-op positions in the Federal Government of Canada.

Registering in Co-op Courses

Students will be registered in a Co-op Work Term course while at work. The number of Co-op Work Term courses that a student is registered in is dependent upon the number of four-month work terms that a student accepts.

While on a co-op work term students may take a maximum of 0.5 credit throughout each four-month co-op work term. Courses must be scheduled outside of regular working hours.

Students must be registered as full-time before they begin their co-op job search. All co-op work terms must be completed before the beginning of the final academic term. Students may not finish their degree on a co-op work term.

Work Term Assessment and Evaluation

To obtain a Satisfactory grade for the co-op work term students must have:

1. A satisfactory work term evaluation by the co-op employer;
2. A satisfactory grade on the work term report.

Students must submit a work term report at the completion of each four-month work term. Reports are due on the 16th of April, August, and December and students are notified of due dates through their Carleton email account.

Workplace performance will be assessed by the workplace supervisor. Should a student receive an unsatisfactory rating from their co-op employer, an investigation by the co-op program manager will be undertaken. An unsatisfactory employer evaluation does not preclude a student from achieving an overall satisfactory rating for the work term.

Graduation with the Co-op Designation

In order to graduate with the co-op designation, students must satisfy all requirements for their degree program in addition to the requirements according to each co-op program (i.e. successful completion of three or four work terms).

Note: Participation in the co-op option will add up to one additional year for a student to complete their degree program.

Voluntary Withdrawal from the Co-op Option

Students may withdraw from the co-op option of their degree program during a study term ONLY. Students at work may not withdraw from the work term or the co-op option until s/he has completed the requirements of the work term.

Students are eligible to continue in their regular academic program provided that they meet the academic standards required for continuation.

Involuntary or Required Withdrawal from the Co-op Option

Students may be required to withdraw from the co-op option of their degree program for one or any of the following reasons:

1. Failure to achieve a grade of SAT in COOP 1000
2. Failure to pay all co-op related fees
3. Failure to actively participate in the job search process
4. Failure to attend all interviews for positions to which the student has applied
5. Declining more than one job offer during the job search process
6. Continuing a job search after accepting a co-op position
7. Dismissal from a work term by the co-op employer
8. Leaving a work term without approval by the Co-op manager
9. Receipt of an unsatisfactory work term evaluation
10. Submission of an unsatisfactory work term report

Standing and Appeals

The Co-op and Career Services office administers the regulations and procedures that are applicable to all co-op program options. All instances of a student's failure during a work term or other issues directly related to their participation in the co-op option will be reported to the academic department.

Any decision made by the Co-op and Career Services office can be appealed via the normal appeal process within the University.

International Students

All International Students are required to possess a Co-op Work Permit issued by Immigration, Refugees and Citizenship Canada before they can begin working. It is illegal to work in Canada without the proper authorization. Students will be provided with a letter of support to accompany their application. Students must submit their application for their permit before being permitted to view and apply for jobs on the Co-op Services database. Confirmation of a position will not be approved until a student can confirm they have received their permit. Students are advised to discuss the application process and requirements with the International Student Services Office.

B.Sc. Honours Chemistry: Co-op Admission and Continuation Requirements

- Maintain full-time status in each study term;
- Be eligible to work in Canada (for off-campus work)
- Have successfully completed COOP 1000 [0.0]

In addition to the following:

1. Registered as a full-time student in the B.Sc. Honours Chemistry program;
2. Successfully completed 5.0 or more credits;
3. Obtained an Overall CGPA of at least 6.50 and a Major CGPA of at least 8.00. These CGPAs must be maintained throughout the duration of the degree.

B.Sc. Honours Chemistry students must successfully complete three (3) work terms to obtain the Co-op Designation.

Work Term Course: CHEM 3999
Work/Study Pattern:

Year 1		Year 2		Year 3		Year 4		Year 5	
Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern
Fall	S	Fall	S	Fall	S	Fall	W	Fall	S
Winter	S	Winter	S	Winter	S	Winter	W	Winter	S
Summer		Summer	W	Summer	W	Summer	W		

- Maintain full-time status in each study term;
- Be eligible to work in Canada (for off-campus work)
- Have successfully completed COOP 1000 [0.0]

Admissions Information

Admission Requirements are for the 2023-24 year only, and are based on the Ontario High School System. Holding the minimum admission requirements only establishes eligibility for consideration. The cut-off averages for admission may be considerably higher than the minimum. See also the **General Admission and Procedures** section of this Calendar. An overall average of at least 70% is normally required to be considered for admission. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. The overall average required for admission is determined each year on a program by program basis. Consult admissions.carleton.ca for further details.

Note: Courses listed as *recommended* are not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Admissions Information

Admission requirements are based on the Ontario High School System. Prospective students can view the admission requirements through the Admissions website at admissions.carleton.ca. The overall average required for admission is determined each year on a program-by-program basis. Holding the minimum admission requirements only establishes eligibility for consideration; higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. All programs have limited enrolment and admission is not guaranteed. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Consult admissions.carleton.ca for further details.

Note: If a course is listed as *recommended*, it is not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Degrees

- B.Sc. (Honours)
- B.Sc. (Major)
- B.Sc.

Admission Requirements

B. Sc. Honours

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. For most programs including Biochemistry, Bioinformatics, Biotechnology, Chemistry, Combined Honours in Biology and Physics, Chemistry and Physics, Computational Biochemistry, Food Science, Nanoscience, Neuroscience and Biology, Neuroscience and Mental Health, and Psychology, the six 4U or M courses must include Advanced Functions, and two of Biology, Chemistry, Earth and Space Sciences, or Physics. (Calculus and Vectors is strongly recommended).

Specific Honours Admission Requirements
For the Honours programs in Earth Sciences, Environmental Science, Geomatics, Interdisciplinary Science and Practice, and Physical Geography, Calculus and Vectors may be substituted for Advanced Functions.

For the Honours programs in Physics and Applied Physics, and for double Honours in Mathematics and Physics, Calculus and Vectors is required in addition to Advanced Functions and one of 4U Physics, Chemistry, Biology, or Earth and Space Sciences. For all programs in Physics, 4U Physics is strongly recommended.

For Honours in Psychology, a 4U course in English is recommended.

For Honours in Environmental Science, a 4U course in Biology and Chemistry is recommended.

Advanced Standing

Applications for admission beyond first year will be assessed on their merits. Applicants must normally be *Eligible to Continue* in their year level, in addition to meeting the CGPA thresholds described in Section 3.1.9 of the Academic Regulations of the University. Advanced standing will be granted only for those subjects deemed appropriate for the program and stream selected.

B.Sc. Major and B.Sc.

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. The six 4U or M courses must include Advanced Functions and two of Calculus and Vectors, Biology, Chemistry, Earth and Space Science, or Physics (Calculus and Vectors is strongly recommended). For the B.Sc. Major in Physics, 4U Physics is strongly recommended.

Advanced Standing

Applications for admission beyond first year will be assessed on their merits. Applicants must normally be *Eligible to Continue* (EC) in their year level. Advanced standing will be granted only for those subjects deemed appropriate for the program and stream selected.

Co-op Option

Direct Admission to the First Year of the Co-op Option
Applicants must:

1. meet the required overall admission cut-off average and prerequisite course average. These averages may be higher than the stated minimum requirements;
2. be registered as a full-time student in the Bachelor of Science Honours program;
3. be eligible to work in Canada (for off-campus work placements).

Note that meeting the above requirements only establishes eligibility for admission to the program. The prevailing job market may limit enrolment in the co-op option.

Note: continuation requirements for students previously admitted to the co-op option and admission requirements for the co-op option after beginning the program are described in the Co-operative Education Regulations section of this Calendar.

Chemistry (CHEM) Courses

CHEM 0999 [0.0 credit]
Chemistry Matters

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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1005, CHEM 1101.
Prerequisite(s): Ontario 4U/M in Chemistry or equivalent.
Lectures and tutorial four hours a week, laboratory three hours every other 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.
Includes: Experiential Learning Activity
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 and tutorial four hours a week, laboratory three hours every other week.

CHEM 1003 [0.5 credit]
The Chemistry of Food, Health and Drugs
Aspects of chemistry relating to food, food additives, drugs (illicit and beneficial) and their relation to metabolism and health. Topics may include: proteins, carbohydrates, fats, vitamins, 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
No science background required. Topics include drug origins, laws, metabolism and dependence, pharmaceutical industry, over the counter medications, placebo effect, antibiotics, pain killers, stimulants, alcohol, marijuana, hallucinogens, birth control and steroids. Students in Science programs may use this course only as a free elective.
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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1001, CHEM 1101.
Lectures and tutorial four hours a week, laboratory three hours every other 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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 1000 (no longer offered), CHEM 1002.
Prerequisite(s): CHEM 1001 or CHEM 1005.
Lectures and tutorial four hours a week, laboratory three hours every other week.

CHEM 1007 [0.5 credit]
Chemistry of Art and Artifacts
The chemistry of arts and artifacts created throughout the ages (Paleolithic, Neolithic, Bronze, Iron, Middle and Modern) will be examined. Basic chemical principles will be explored and reviewed when required. Students in Science programs may use this course only as a free elective.
Lectures three hours a week.

CHEM 1008 [0.5 credit]
Inquiry in Chemistry Research
Students experience the journey of research in chemistry by using inquiry-based principles to answer complex societal questions. Students practice developing research questions and study designs, perform data analysis, and are introduced to scientific literacy and communication, EDI, and meta-cognition.
Includes: Experiential Learning Activity
Prerequisite(s): first year standing in Chemistry.
Workshop 3 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.
Includes: Experiential Learning Activity
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 every other 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.
Includes: Experiential Learning Activity
Precludes additional credit for BIOC 2300, CHEM 2101 (no longer offered) and CHEM 2102 (no longer offered).
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002, MATH 1004, MATH 1107, PHYS 1007 and PHYS 1008 or PHYS 1003 and PHYS 1004.
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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 2207.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002.
Lectures three hours a week and laboratory 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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 2208 and CHEM 2206.
Prerequisite(s): CHEM 2203.
Lectures three hours a week and laboratory 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.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002.
Lectures three hours 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.

CHEM 2302 [0.5 credit]
Analytical Chemistry I
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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 2300.
Prerequisite(s): CHEM 1006 with a minimum grade of B-, or CHEM 1002 or CHEM 1101 and (MATH 1007 or MATH 1004).
Lectures three hours a week, laboratory three hours a week.

CHEM 2303 [0.5 credit]
Analytical Chemistry II
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.
Includes: Experiential Learning Activity
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, and (MATH 1007 or MATH 1004).
Lectures three hours a week, laboratory three hours a week.

CHEM 2400 [0.5 credit]
Independent Research I
Students carry out a laboratory research project under the supervision of a faculty member from the Department of Chemistry. A research report must be submitted by the last day of classes for evaluation by the Chair and Faculty supervisor.
Includes: Experiential Learning Activity
Prerequisite(s): restricted to Honours students having second-year standing in a Chemistry program with an overall CGPA of 10.0 or higher, and approval of the Chair and a Faculty supervisor.
Laboratory research for at least three hours a week over two terms.

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. Limited enrolment course. Priority is given to students in Environmental Science/ Engineering.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 2103, MATH 2007 and MATH 2008.
Lectures three hours a week, tutorial one hour per 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.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 3101 or PHYS 3701.
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, Bourne-shell programming, and Python scripting are also introduced.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 3102 (may be taken concurrently).
Laboratory three 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.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 3100.
Laboratory 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, tutorial one and a half hours per 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, tutorial one and a half hours per 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.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 2204 or CHEM 2206 and CHEM 3201.
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.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 2302 or CHEM 2303.
Laboratory four hours a week.

CHEM 3400 [0.5 credit]
Independent Research II
Students carry out a laboratory research project supervised by a Chemistry faculty member. A research report must be submitted by the last day of classes for evaluation by the Chair and Faculty supervisor; expectations of student performance and evaluation exceed that of CHEM 2400.
Includes: Experiential Learning Activity
Prerequisite(s): restricted to Honours students having third-year standing in a Chemistry program with an overall CGPA of 10.0 or higher, and approval of the Chair and a Faculty supervisor.
Laboratory research for at least three hours a week over two terms.

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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 3507.
Prerequisite(s): CHEM 2501.
Lectures three hours a week, tutorial one hour a week and laboratory 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.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 3508.
Prerequisite(s): CHEM 3503.
Lectures three hours a week, tutorial one hour a week and laboratory 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): (BIOC 2300 or CHEM 2103) and one of CHEM 2207 or CHEM 2203.
Lecture three hours a week.

CHEM 3701 [0.5 credit]
Chemistry in Practice for the 21st Century
Students explore different sectors of chemical industry; developments in sustainability; principles, analytical frameworks, and applications of green chemistry; environmental protections; and Canadian regulatory frameworks. Students investigate novel issues in industrial chemistry, build scientific literacy skills, and practice communicating scientific information to diverse audiences.
Prerequisite(s): BIOC 2300 or CHEM 2103, CHEM 2204, CHEM 2303, CHEM 2501.
Workshop three hours a week.

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
Includes: Experiential Learning Activity

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.

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.
Also offered at the graduate level, with different requirements, as CHEM 5108, for which additional credit is precluded.
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.
Also offered at the graduate level, with different requirements, as CHEM 5207, CHEM 5208, for which additional credit is precluded.
Lectures three hours a week.

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.

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.
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.
Also offered at the graduate level, with different requirements, as CHEM 5406, for which additional credit is precluded.
Lectures three hours a week.

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 4207 [0.5 credit]
Bio-Organic Chemistry
The course covers 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. Content will focus on reactions and mechanisms that contribute to their biological activities.
Prerequisite(s): CHEM 3201 and CHEM 3202, or permission of the department.
Also offered at the graduate level, with different requirements, as CHEM 5010, for which additional credit is precluded.
Lectures three hours a week.

CHEM 4301 [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. Optimization of all operating parameters.
Prerequisite(s): CHEM 2103 and one of CHEM 2302 or CHEM 2303.
Also offered at the graduate level, with different requirements, as CHEM 5607, for which additional credit is precluded.
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. 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.
Prerequisite(s): CHEM 2103 or BIOC 2300, and one of CHEM 2302 or CHEM 2303.
Also offered at the graduate level, with different requirements, as CHEM 5109, for which additional credit is precluded.
Lectures and seminars three hours a week.

CHEM 4305 [0.5 credit]
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, and studying aspects of toxicant disposition and biotransformation. Emphasis on contemporary problems in human health and the environment.
Prerequisite(s): CHEM 2203 or CHEM 2207, and CHEM 2800 or CHEM 2103, or BIOC 3101 or permission of the department.
Also offered at the graduate level, with different requirements, as CHEM 5606, for which additional credit is precluded.
Lectures 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.
Includes: Experiential Learning Activity
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.
Also offered at the graduate level, with different requirements, as CHEM 5905, for which additional credit is precluded.
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 4505 [0.5 credit]
Application of Physical Methods to Electron Transfer Chemistry
Spectroscopic techniques (i.e. UV-visible NIR, IR, EPR) and electrochemistry methods that are used to study photochemical and thermal intermolecular and intramolecular electron transfer in transition metal complexes are presented. Electron transfer theory and redox-active (non-innocent) ligands are discussed.
Prerequisite(s): CHEM 3504.
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
Students conduct an independent research study using library resources, and prepare a critical review and study proposal on a topic approved by a faculty supervisor. A written report and oral poster presentation of the work are required before a grade can be assigned.
Includes: Experiential Learning Activity
Precludes additional credit for CHEM 4908, FOOD 4907 and FOOD 4908.
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.
Includes: Experiential Learning Activity
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 and permission of the department.
Laboratory and associated work equivalent to at least eight hours a week for two terms.