BIO 421 Independent Studies in Biology I 3-1-3
This course is intended for final-year students who wish to pursue in-depth study of a particular area of biology or who have a special need for a biology course that would otherwise not be available during their final semester of course work. This course can only be done in close collaboration with a faculty advisor from within the Department of Biological Sciences, and may not be used as a supplement to a student's honours project. Requirements for this course will be agreed upon by a committee of professors from within the Department of Biological Sciences.
Pre-requisite: Permission of the committee
Students with credit for BIO 371 cannot also receive credit for BIO 421.
Coordinator: Professor Chamoux

BIO 422 Independent Studies in Biology II 3-1-3
This course represents an additional semester of independent work, either a continuation of or a separate course from BIO 421, meant for final-year students who wish to pursue in-depth study of a particular area of biology or who have a special need for a biology course that would otherwise not be available during their final semester of course work. This course can only be done in close collaboration with a faculty advisor from within the Department of Biological Sciences, and may not be used as a supplement to a student's honours project. Requirements for this course will be agreed upon by a committee of professors from within the Department of Biological Sciences.
Pre-requisite: Permission of the committee
Students with credit for BIO 372 cannot also receive credit for BIO 422.
Coordinator: Professor Chamoux

BIO 428 Advanced Physiology 3-3-0
This course will examine how animals adapt to environmental stresses such as extremes of temperature of altitude, hypoxia, water limitation and dietary changes. Short-term (acute), medium-term (acclimatory) and chronic (evolutionary) adaptations will be discussed.
Pre-requisite: BIO 336; Pre-or Co-requisite: BIO 337
Offered in even-numbered winters
Students with credit for BIO 328 cannot also receive credit for BIO 428.

BIO 433 Advanced Exercise Science 3-3-0
This course examines selected topics in Exercise Physiology. Through traditional lectures, directed readings, seminars, and case studies, students will study short-term and long-term adaptations to exercise. We will also examine the scientific principles underlying sports-related topics such as optimizing exercise performance, injuries, and injury repair.
Prerequisite: BIO 336 or EXS 327
Students with credit for BIO 333 cannot also receive credit for BIO 433.
Note: See Exercise Science 433. Students may not take this course for credit if they have received credit for EXS 433.

BIO 492 Honours Research Project I 3-1-6
An introduction to the planning, execution and reporting of biological research offered to students matching eligibility criteria. Each student is required to choose a research problem and, in consultation with a departmentally approved supervisor, draw up a formal research proposal of work to be undertaken. The final mark in this course will be based on the research proposal, preliminary research completed on the stated project, and presentation of a poster during the final week of classes. Satisfactory completion of BIO 492 with a minimum mark of 75%, with a minimal score of 70% in each graded component, is required for enrolment in BIO 493.
Prerequisite: Permission of committee
Co-requisite or prerequisite: BIO 386
Students with credit for BIO 421 cannot also receive credit for BIO 492.

BIO 493 Honours Research Project II 3-1-6
A continuation of BIO 492 offered to students matching eligibility criteria. The student will complete all research as outlined in the research proposal. The final mark in this course will be based on the quality and amount of research completed, presentation of a departmental seminar during the final week of classes, open to the public, based on research findings, and submission of a final written honours thesis. Enrolment in BIO 493 is conditional upon completing BIO 493 with a minimum mark of 75%. Satisfactory component, is required to complete the Honours program.
Prerequisite: Permission of committee
Students with credit for BIO 422 cannot also receive credit for BIO 493.

Chemistry

Faculty

Mihai Scarlete,
Ph.D. (McGill), Ph.D. (Politehina Inst., Bucharest); Professor

Dale Wood,
B.Sc., Ph.D. (UNB);
Associate Professor

Program Overview

The Chemistry Department offers three distinct programs — Chemistry Honours, Chemistry Major, and Chemistry Minor. All of our programs provide students with a balanced, rich, and practical education in all sub-disciplines of Chemistry (Analytical, Biochemical, Inorganic, Organic, and Physical) and students graduating with a Chemistry degree from Bishop's University have had an excellent record of being admitted to graduate schools and professional programs (Medicine, Dentistry, Pharmacy, Education, etc.) or in finding employment in their field.

Class sizes in chemistry courses are small, which promotes close personal interaction between members of the faculty and students. The faculty are also directly involved in all undergraduate laboratories, which enhances personal contact and results in a friendly and very productive learning in experimental chemistry.

The Chemistry Department has an excellent set of modern instruments, such as a 400 MHz NMR and a GC/MS, which are used by undergraduates in their laboratory courses and in research projects. This is in contrast to most universities where many instruments are reserved for graduate students. Hands-on, extensive training on this modern instrumentation and equipment greatly benefits our students and ensures that they are very well prepared for graduate studies or future employment.

Undergraduate Programs

It is strongly recommended that students enrolled in Department of Chemistry programs follow the order of courses outlined in the tables below. Some Chemistry courses are offered on two-year rotations, so failure to follow the suggested course sequence may result in students not being able to fulfill their degree requirements in the normal time frame.

Table 1. First year of study in the 4-year Chemistry Honours and Major programs

Fall Semester	Winter Semester
CHM191 and CHL191	CHM192 and CHL192
BIO196 and BIL196	PHY192 and PHL192
PHY191 and PHL191	MAT192
MAT191	Humanities Option
ELA116	Humanities Option

Chemistry Honours (84 credits) HONCHE

The Chemistry Honours program fulfills the academic requirements for membership in the Chemical Institute of Canada and for accreditation by l'Ordre des chimistes du Québec. (For membership in the latter, it is necessary to possess a working knowledge of the French language.) The Chemistry Honours program is a four-year program that prepares a student for graduate studies in chemistry, as well as for direct professional employment. The program requires 37 three-credit one-semester courses, one 3-credit full year course, and a full year, 6-credit research project in the final year for a total of 120 course credits. In addition, students must also complete the 15 co-requisite lab courses. The Chemistry Honours degree program is shown in Table 1.

Entrance Requirements for Honours

To be eligible to enter the third year of the Honours Chemistry program, a student must achieve a minimum average of 70% in the required second year Chemistry courses (CHM 111, CHM 211, CHM 121, CHM 131, CHM 141, CHM 341 and all co-requisite labs). To be eligible to enter the final year of the Honours Chemistry program, a student must achieve a minimum average of 70% in the third year required Chemistry courses (CHM 311, CHM 225 or CHM 245, CHM 231 or CHM 331 and all co-requisite labs).

Table 2. Honours Chemistry Program[1]

	Fall Semester	Winter Semester
Year 2	CHM 111 and CHL 111	CHM 211 and CHL 211
	CHM 121	CHM 131
	CHM 141 and CHL 141	CHM 341 and CHL 341
	BIO 201	BCH 210
	PHY 206 and PHL 206[2]	Option[3]
Year 3	CHM 311	Chem. Option[6]
	CHM 231 and CHL 231[4]	CHM 225 and CHL 225[7]
	Science option[5]	BCH 313 and BCL 313
	Option[3]	Option[3]
	Option[3]	Option[3]
Year 4	CHM 331 / CHL 331[4]	CHM 245 and CHL 245[7]
	CHM 471[8]	CHM 471[8]
	CHM 499[9]	CHM 499[9]
	BIO 386[10]	Option[3]
	Option[3]	Option[3]

[1] All Chemistry students must take any two Humanities lecture courses in the first year. Students with a D.E.C. may be credited with these options.

[2] PHY 206 will be required for non-Cégep students. Cégep students already completed this course. They will replace it by a free science elective.

[3] Chemistry Honours students must take one lecture course from the Humanities or the Social Sciences, one science option and one lecture course from any of the Sciences. All other options are free electives. If a course has a co-requisite lab then the lab must be taken as well.

[4] CHM231 / CHM331 and their co-requisite labs are offered on a rotating basis, so the order in which they are taken may flip depending on the year the student entered the program.

[5] Students doing honours are encouraged to take a science option based on the field of their specialization:
Physical chemistry: MAT 108 or PHY 206 or MAT 206
Analytical chemistry: MAT 103 or MAT b310
Organic chemistry: BCH 311 or BIO 208
Environment: MAT 103

[6] Students registered in the honours program will have to complete a CHM 400 level course in the field of their honours research project as an independent study.

[7] CHM 225 and CHM 245, and their co-requisite labs are offered on a rotating basis, so the order in which they are taken may flip depending on the year the student entered the program.

[8] CHM 471 is a full-year, 3-credit course.

[9] CHM 499 is a full-year, 6-credit research project.

[10] Honours students should register in BIO 386 – Scientific writing. Permission from the instructor is required. If denied, this course can be replaced by a free elective.

Chemistry Major (72 credits) MAJCHE

The Chemistry Major program prepares students for industrial or other employment that requires an extensive knowledge of chemistry. The program has sufficient flexibility to allow students to obtain a second major or a minor in another academic discipline. The program fulfills the academic requirements for membership in the Chemical Institute of Canada and for accreditation by l'Ordre des Chimistes du Québec. (For membership in the latter, it is necessary to possess a working knowledge of the French language.) The four-year Chemistry Major program requires 39 three-credit one-semester courses and one 3-credit full year course for a total of 120 course credits. In addition, students must complete the 18 co-requisite lab courses. The Chemistry Major degree program is shown in Table 2. Students in a minor program in another division may, with permission of the Department, reduce science options to a minimum of 9 credits.

Table 3. Chemistry Major Program1

	Fall Semester	Winter Semester
Year 2	CHM 111 and CHL 111	CHM 211 and CHL 211
	CHM 121	CHM 341 and CHL 341
	CHM 141 and CHL 141	BCH 210
	BIO 201	CHM 131
	PHY 206 and PHL 206[2]	Option3
Year 3	CHM 231 and CHL 231[4]	CHM 225 and CHL 225[5]
	CHM 311	BCH 313 and BCL 313
	Option[3]	Option[3]
	Option[3]	Option[3]
	Option[3]	Option[3]
Year 4	CHM 331 and CHL 3314	CHM 245 and CHL245[5]
	CHM 371[6]	CHM 3716
	Option[3]	Option[3]
	Option[3]	Option[3]
	Option[3]	Option[3]

[1] All Chemistry students must take any two Humanities lecture courses in their first year of study. Students with a D.E.C. may be credited with these options.

[2] PHY 206 will be required for non-Cégep students. Cégep students already completed this course. They will replace it by a free science elective.

[3] Students must take one course from either the Humanities or the Social Sciences and five lecture courses from any of the Sciences. All other options are free electives. If a course has a co-requisite lab then the lab must be taken as well.

[4] CHM 231 and CHM 331, and their co-requisite labs are offered on a rotating basis, so the order in which they are taken may flip depending on the year the student entered the program.

[5] CHM 225 and CHM 245, and their co-requisite labs are offered on a rotating basis, so the order in which they are taken may flip depending on the year the student entered the program.

[6] CHM 371 is a full-year, 3-credit course.

Chemistry Minor (24 credits) MINCHE

A Chemistry Minor will be awarded for the completion of CHM 111, CHM 211, CHM 121, CHM 131, CHM 141, and their co-requisite labs, together with 3 one-semester 3-credit courses (and their co-requisite labs) chosen from CHM 311, CHM 411, CHM 231, CHM 331, CHM 341, BCH 210 or BCH 313. Students taking a Chemistry Minor have a one-lecture course (3 credits) reduction towards the credits necessary for their degree.

Recommended Electives

MAT 108 and MAT 206 are recommended electives for students pursuing a career in Physical Chemistry.
MAT 103 and MAT 310 are recommended electives for students pursuing a career in Analytical Chemistry.
BCH 311 and BIO 208 are recommended electives for students pursuing a career in Organic Chemistry.
MAT 103 is a recommended elective for students pursuing a career in Environmental Chemistry.

Accreditation by l'Ordre des Chimistes du Quebec and the Canadian Institute for Chemistry

The OCQ and CIC are professional orders that oversee and accredit Chemistry, Biochemistry, and related disciplines in Quebec and Canada respectively. In order to meet the accreditation standards of these orders, a student must meet the following criteria.

L'Ordre des Chimistes du Québec

A student must earn a minimum of 55 credits in Chemistry, of which 18 credits must be for laboratory work and 30 credits must be for lecture courses. The OCQ considers 3 credits of course or lab work to be the equivalent of 45 hours of class time and personal work (3 course credits in Chemistry at Bishop's is 36 hours of class time) and 1 credit of laboratory work to be the equivalent of 45 hours of lab time (1 lab-credit in Chemistry at Bishop's is 40-50 hours and thus is equivalent to 3 credits for the OCQ). The chemistry credits offered at Bishop's are divided in the following manner.

1. 9 course credits and 2 lab credits of physical chemistry.
2. 9 course credits and 3 lab credits of analytical chemistry.
3. 9 course credits and 2 lab credits of organic chemistry.
4. 6 course credits and 1 lab credit of inorganic chemistry.
5. 6 course credits and 1 lab credit of biochemistry.
6. 3 course credits on scientific writing.
7. 3 course credits as advanced option in any field of chemistry.

Canadian Institute for Chemistry

The CIC expects a program to involve a total of about 1000 hours of laboratory and classroom work in chemistry, with the minimum hours of each being about 400. The laboratory hours should be distributed in such a way that every student is exposed to meaningful laboratory experience in at least four (and preferably five) of the five sub-disciplines (analytical chemistry, biochemistry, inorganic, organic and physical chemistry).

The core program beyond the first-year level shall include the equivalent of 12 chemistry courses including at least one in each of the five sub-disciplines of chemistry. In addition, there should be a selection of advanced offerings in the core disciplines and in other subjects such as for instance theoretical chemistry, solid state chemistry, natural products, polymers, advanced instrumentation, research thesis, etc. to bring the total number of hours of instruction to that described above. The program must also include at least 15 course credits in two or more of mathematics (algebra, calculus, statistics), physics, computer science and biology. In the case of pure chemistry programs, at least 6 credits in each of calculus and physics will be required. The inclusion of other cognate subjects as well as some liberal arts requirements is to be encouraged.

List of Chemistry Courses

General Chemistry

CHM 191 General Chemistry I 3-3-0
A course for students lacking Collegial Chemistry NYA or its equivalent.
Atoms, molecules, and ions. Chemical formulae and equations. Thermochemistry. Electronic structure of atoms. Periodic Table and properties of elements. Chemical bonds. Physical properties and structure. Chemical kinetics
Co-requisite: CHL 191

CHL 191 Introductory Chemistry Laboratory I 1-0-4
A series of experiments in Introductory Chemistry to complement Chemistry 191 which must be taken concurrently.
Co-requisite: CHM 191

CHM 192 General Chemistry II 3-3-0
A course for students lacking Collegial Chemistry NYB or its equivalent.
Solutions. Chemical equilibrium. Acids and Bases. Gases, Solids, and Liquids. Ionic equilibria.
Prerequisites: CHM 191 (or permission of instructor) or Collegial Chemistry
Co-requisite: CHL 192

CHL 192 Introductory Chemistry Laboratory II 1-0-4
A series of experiments in Introductory Chemistry to complement CHM 192 which must be taken concurrently.
Co-requisite: CHM 192

Organic Chemistry

CHM 111 Organic Chemistry I: Introductory 3-3-0
An introductory structural survey of the most commonly encountered organic functional groups that are present in carbon compounds, emphasizing their significance in biologically important molecules (lipids, carbohydrates, amino acids, proteins, steroids, and other types of natural products). Stereochemistry and the fundamental principles behind essential organic reaction mechanisms will be stressed throughout. Some basic definitions and nomenclature will be introduced.
Prerequisites: CHM 191 and CHM 192 or Collegial Chemistry NYA and NYB
Co-requisite: CHL 111

CHL 111 Organic Chemistry Laboratory I 1-0-4
Experiments in the separation and purification of organic compounds including the use of chromatography. Introduction to functional group analysis and organic synthesis.
Co-requisite: CHM 111

CHM 211 Organic Chemistry II: Introductory 3-3-0
This course is a continuation of Chemistry 105 and will elaborate upon the chemistry of the organic functional groups and their involvement in organic synthesis, emphasizing the importance of electronic factors (resonance, induction, acidity, electrophiles, nucleophiles, leaving groups, and carbenium ions) in influencing organic reaction mechanisms. Spectroscopic analysis (NMR,IR) and the importance of molecular obritals are introduced briefly.
Prerequisite: CHM 111 or Collegial Chemistry BFB
Co-requisite: CHL 211

CHL 211 Organic Chemistry Laboratory II 1-0-4
Further experiments in organic synthesis and in chromatographic separations. An introduction to multi-step synthesis.
Co-requisite: CHM 211.

CHM 311 Organic Chemistry III 3-3-0
A more advanced discussion of organic reaction mechanisms; stereochemistry and conformational analysis; molecular rearrangements; pericyclic reactions; oxidations; tautomerism.
Pre-requisite: CHM 111 and CHM 211

CHL 311 Organic Chemistry Laboratory III 1-0-4
Laboratory and spectroscopic techniques used in the synthesis, separation, and purification of simple organic compounds.

CHM 411 Organic Chemistry IV 3-3-0
The importance of electrophiles, nucleophiles, leaving groups, eliminations and dehydrations in the chemistry and reaction mechanisms of organosilicon, carbonyl, and biologically-important compounds.
Pre-requisite: CHM 311.

CHL 300 Advanced Methods in Organic Chemistry 1-0-4
Advanced laboratory techniques as applied to multistep syntheses and natural product isolation.
Pre-requisite: CHL 311, CHL 211, and CHL 111

Inorganic Chemistry

CHM 121 Inorganic Chemistry I 3-3-0
The principles of nuclear, atomic, metallic, ionic, molecular structure. Valence bond and molecular orbital theory. Molecular and orbital symmetry.
Prerequisites: CHM 191 and CHM 192 or Collegial Chemistry NYA and NYB

CHM 225 Inorganic Chemistry II 3-3-0
This course provides students with a survey of inorganic chemistry. The course begins with the general chemistry of the inorganic elements (properties, oxidation states, introduction to their chemistry). This is followed up with two distinct sections. 1) Transition Metal Chemistry will look at crystal and ligand field theory, Werner complexes, and introduce organometallic complexes. 2) Main Group Chemistry will look at the structure and bonding of a selection of compounds from each group of the p-block.
Pre-requisites: CHM 121, CHM 131 / CHL 131, CHM 111 / CHL 111
Co-requisites: CHL 225

CHL 225 Inorganic Chemistry II Lab 1-0-4
This lab is comprised of experiments that provide an illustration of many of the topics covered in CHM 225. It combines experimental methods typical of inorganic chemistry (e.g. inert atmosphere) with the use of the instrumentation necessary to probed the properties of interest (e.g. FT-IR, UV-Vis, Magnetochemistry
Co-requisites: CHM 225

CHM 245 Instrumental Analysis 3-3-0
This course provides students with in depth coverage of the theory of instrumental methods of analysis. The topics covered will be chromatography theory and chromatographic methods, atomic absorption and emission spectrometry, and electrochemical methods.
Pre-requisites: CHM 121, CHM 131 / CHL 131, CHM 141 / CHL 141
Co-requisites: CHL 245

CHL 245 Instrumental Analysis Lab 1-0-4
This lab focuses mainly on learning to use the Department's extensive suite of chromatographic instrumentation (GC, GC-MS, HPLC, LC-MS) by performing numerous analyses on each instrument. The analyses will illustrate the importance of chromatography as an analytical method by using examples from forensic, environmental, and food and beverage science.
Co-requisites: CHM 245

CHM 421 Advanced Inorganic Chemistry 3-3-0
Selected topics in inorganic chemistry covering all aspects of inorganic chemistry from the alkali metals to the noble gases.
Pre-requisite: CHM 225

Physical Chemistry

CHM 131 Physical Chemistry I 3-3-0
Ideal and real gases; chemical kinetics and mechanism; an introduction to thermodynamics and chemical equilibrium; ionic equilibria and electrochemistry. This course may be taken online by students who are not registered in a Bishop's Chemistry Program, subject to approval by the instructor.
Prerequisites: CHM 191, CHM 192, MAT 191, MAT 192, PHY 191, and PHY 192 or Collegial Chemistry NYA and NYB, Math NYA and NYB, and Physics NYA and NYB.

CHL 131 Physical Chemistry Laboratory I 1-0-4
A series of experiments in Physical Chemistry to complement CHM 131.
Co-requisite: CHM 131

CHM 231 Physical Chemistry II 3-3-0
Chemical thermodynamics; Zeroth Law and equations of state; First Law and thermochemistry; the Second Law and chemical equilibrium; the Third Law and introduction to statistical thermodynamics; thermodynamic databases; phase equilibrium; calculation of chemical equilibrium in complex systems. Maple-assisted calculus and computations in physical chemistry. This course may be taken online, subject to instructor approval.
This course is currently only offered in odd-numbered years.
Pre-requisite: CHM 131
Co-requisite: CHL 231

CHL 231 Physical Chemistry Laboratory II 1-0-4
Experiments related to the topics of Chemistry 223 which must be taken concurrently by full-time Bishop's students.
This course is currently only offered in odd-numbered years.
Co-requisites: CHM 231

CHM 331 Physical Chemistry III 3-3-0
Maple-assisted computational statistical mechanics and kinetic theory of gases; gas reactions, chemical dynamics. Quantum chemistry, and spectroscopy; atomic structure, atomic orbitals, and atomic spectra (AAS, XPS, ESCA, EDX,...); introduction to molecular orbitals: LCAO, hybridization. Molecular electronic structure and molecular spectroscopy (physical principles of IR/Raman, rotovibrational spectra, ESCA, EPR and NMR spectroscopies).
This course is currently only offered in even-numbered years.
Pre-requisites: CHM 131, CHM 211
Co-requisite: CHL 331 for all Chemistry students and for all biochemistry students planning to do honours research projects in the area of physical chemistry

CHL 331 Physical Chemistry Laboratory III 1-0-4
Experiments related to topics of CHM 331, which must be taken concurrently by chemistry students and by biochemistry students who are planning to do honours research projects in the area of physical chemistry.
This course is currently only offered in even-numbered years.
Co-requisite: CHM 331

CHM 431 Computational Chemistry and Molecular Modelling 3-3-0
Maple-assisted calculations of molecular orbitals and molecular modelling subroutines; from H2+ molecular ion, via [Ni(En)3]2+ and cis-platin (cancer chemotherapy), to cholesterol and cyclosporin; symmetry and point group analysis of molecular vibration; hybridization and Simple-Huckel Molecular Orbital calculations. Semi-empirical and ab initio methods; calculation of reaction and

activation energies via modern alternatives to the Hartree-Fock self-consistent field method; density functional. Combinatorial processing parent-compound libraries and Spartan-assisted CSDB.
This course may be taken online (conditions apply, including instructor's permission and level of enrolment)
Pre-requisites: CHM 231 and CHM 331

Analytical Chemistry

CHM 141 Analytical Chemistry 3-3-0
Data handling, stoichiometric calculations, gravimetric analysis, acid-base equilibria and titrations, redox equilibria and titrations, complexometric titrations, precipitation reactions and titrations, electrochemical cells and electrode potentials.
Prerequisites: CHM 191 and CHM 192 or Collegial Chemistry NYA and NYB
Co-requisite: CHL 141

CHL 141 Analytical Chemistry Laboratory 1-0-4
Quantitative analysis of unknown samples by volumetric, gravimetric, and spectrometric methods will be carried out.
Co-requisite: CHM 141

CHM 245 Instrumental Analysis 3-3-0

This course provides students with in depth coverage of the theory of instrumental methods of analysis. The topics covered will be chromatography theory and chromatographic methods, atomic absorption and emission spectrometry, and electrochemical methods.
Prerequisites: CHM 121, CHM 131, CHL 131, CHM 141 and CHL 141

CHL 245 Instrumental Analysis Laboratory 1-0-4
This lab focuses mainly on learning to use the Department's extensive suite of chromatographic instrumentation (GC, GC-MS, HPLC, LC-MS) by performing numerous analyses on each instrument. The analyses will illustrate the importance of chromatography as an analytical method by using examples from forensic, environmental, and food and beverage science.
Co-requisite: CHM 245

CHM 341 Principles and Practices of Chemical Spectroscopy and Mass Spectrometry 3-3-0
Theory and applications of multinuclear magnetic resonance, UV/VIS, EPR, and electron spectroscopies for chemical analysis. Mass spectrometry and hyphenated methods. Use of chemical spectroscopy and mass spectrometry for the identification of organic compounds. 2D- and imaging techniques, including MRI. This course may be taken online.
Pre-requisites: CHM 131, CHM 141, and CHM 211
Co-requisite: CHL 341

CHL341 Principles and Practices of Chemical Spectroscopy and Mass Spectrometry Laboratory 1-0-4
Experiments related to topics of CHM 341, which must be taken concurrently by chemistry and biochemistry students.
Co-requisite: CHM 341

CHM 442 Surface and Interface Analysis 3-0-9
This course will provide students with an overview of routine and state-of-the-art analytical methods for the characterisation of surfaces and interfaces. Students will understand how radiation is used to determine properties of surfaces and interfaces. Current applications using peer-reviewed scientific literature will be discussed. Students will understand the underlying principles of the methods discussed and will know how they are applied to real-world problems. Students will be able to critically analyse measurement challenges and propose analytical methodology for the characterisation of surface properties.
Prerequistes: CHM 141, CHL 141, CHM 191, CHL 191, CHM 192, CHL 192, CHM 341, CHL 341

Chemical Literature and Research Projects

CHM 371F Scientific Writing and Chemical Literature for Major Students 3-0-0
This course introduces the Chemistry Major student to chemical information retrieval and requires two major term papers – one in the Fall semester, one in the Winter semester – each presented also in two short oral presentations. Students will use SciFinder/Chemical Abstracts to perform searching in structure/substructure, reaction, and bibliographic databases. The literature searching will be used in preparing the two term papers, chosen from a list of topics approved by the Chemistry Department, under the direction of a different member of faculty for each.
Chemistry Major students must enrol in CHM 371 as part of their degree program and may only take this course in their final year. Students receiving credit for CHM 371 cannot also receive credit for CHM 471

CHM 471F Scientific Writing and Chemical Literature for Honours Students 3-0-0
This course introduces the Chemistry Honours student to chemical information retrieval and requires two major term papers – one in the Fall semester, one in the Winter semester – each presented also in two short oral presentations. Students will use SciFinder/Chemical Abstracts to perform searching in structure/substructure, reaction, and bibliographic databases. The literature searching will be used in preparing the two term papers, chosen from a list of topics approved by the Chemistry Department, under the direction of a different member of faculty for each.
Honours Chemistry students must enrol in CHM 471 as part of their degree program and may only take this course in their final year. Students receiving credit for CHM 471 cannot also receive credit for CHM 371.

CHM 491 Independent Study 3-0-0

CHM 492 Independent Study 3-0-0

CHM 499 Honours Chemistry Research Project 6-0-12
Under the guidance of a faculty member, the student does an experimental research project requiring approximately 12 hours per week in both the Fall and Winter semesters, and presents the results of the project in a seminar and a written dissertation. The project chosen must be approved in advance by the Department, and may be in any field of chemistry plus material science.
Prerequisites: Third Year Honours Chemistry registration or permission of the Department.

General Interest Courses

CHM 181 The Chemistry of Everyday Life 3-3-0
This course will discuss the chemistry underlying some everyday, or easily recognizable, products, processes, and policies. These may include: the chemistry of pollution, warfare, polymers and plastics, household products, and food.
This course cannot be taken for credit by students who have received credit for CHM 191 or the collegial equivalent course, Chemistry NYA, or equivalent credit elsewhere.
Course registration requires the instructor's permission.

CHM 182 The History and Science of Beer and Brewing 3-3-0
Beer is among the world's most popular beverages and the industry continues to grow at both the megabrewery and microbrewery levels. This course is a general interest course on the nature of beer from a historical, sociological, and scientific perspective. The diverse nature of beer will be explored, as well as how the beverage has developed from its origins many thousands of years ago to what it has become today. Of particular emphasis will be the development of a general understanding of the brewing process, and the science and engineering involved. Various examples of beer's impact on society and culture will also be discussed.
This course cannot be taken for science credit.

CHM 183 Experiential Learning Project in Brewing 3-0-9
This course is designed specifically for non-science students interested in gaining experience in brewing beer from scratch. Specifically, students will engage in recipe development by starting with a known formula and make changes, subtle or otherwise, to create a beer that is distinctly their own. The goal is to gain an understanding and appreciation of brewing process as well as the roles that the ingredients of beer (water, malt, hops, yeast, adjuncts) play in the taste, aroma, and mouth-feel of the final product. Due to limited space and the anticipated popularity of this course, interested students must submit a brief proposal outlining the beer they would like to produce and their reason for wanting to take the course. Two students per semester will be selected by the course instructor (Dr. Dale Wood) to participate.
Pre or Corequisites: CHM 182 – The History and Science of Brewing

CHM 185 The Science of Cooking 3-3-0
Food processing is one of the most common activities worldwide, but do we really know what is happening at the molecular level? This course is a general interest course on the chemistry of cooking and is designed to answer questions such as: Why does plunging food in ice water not stop the cooking process? What is happening when baking? And why does deep-fried food taste best and brown better when the oil is older? A particular emphasis will be placed on understanding what chemical transformations are involved during food processing. This course is normally offered during the spring session.
This course cannot be taken for science credit.

CHM 441 Quality Control and Product Analysis as Exemplified by Beer and Brewing 3-0-9
This course will familiarize interested students with the concepts of Quality Control and Product Analysis using beer and the brewing process as an industrial model. Students will gain hands-on experience brewing their own beer with the goal of producing a consistent, high-quality product by tracking the parameters that affect the critical steps in the brewing process. In particular, students will study the effects of temperature, pH, nutrient concentration, and yeast type and how they affect the mash-in, boil (hopping), and fermentation processes, using GC-MS, NMR, HPLC, and other applicable instrumentation. Due to space considerations, this course will be limited to two students per semester, with preference given to students in their final year of study.
Pre or Corequisites: BCH 210,CHM 131, CHM 141, CHM 111, CHM 211, CHM 341 and corequisite labs

Advanced Courses

CHM 435 Advanced Topics in Organic Chemistry 3-3-0
Advances topics in organic chemistry like stereoselective chemistry, radical chemistry and organometallic chemistry will be introduced through discussions and analysis of representative chemical transformations.

CHM 436 Total Synthesis in Organic Chemistry 3-3-0
In this course we will look at important total synthesis of natural products, analyze the chemical steps and propose alternative routes.

Brewing Science Courses

BRS 401 Brewing Water 3-3-0
Water, referred to as Hot Liquor in brewing jargon, provides the medium in which all of the chemical and biochemical reactions that are involved in producing beer take place. Additionally, the mineral content of the Hot Liquor is a critical factor in determining many of the final characteristics of the beer, provides many of the essential elements for healthy yeast growth, and contributes enormously to mash pH. This course provides an in depth, comprehensive look at water, its properties, and how its mineral contents affect all aspects of beer and the brewing process. Students cannot receive credit for both BRS 401 and BRS 501. If the student intends to enroll in the Graduate Certificate in Brewing Science, they should not take any of the BRS 40x courses because they cannot be counted for credit toward both a B.Sc. and a Graduate Certificate.

BRS 402 Malt and Malting 3-3-0
Malt is produced by the germination of grain (barley, wheat, rye, etc.) followed by application of heat (kilning). It is the heat regimen, together with the type of grain that determines the characteristics of the malt. The malt is the source of the starch that is converted to sugars which the yeast ferments to produce alcohol and it is also primarily responsible for the colour of the beer. Malt is also an important contributor to flavour, aroma, characteristics of the foam (head), mouth feel, and other characteristics of the beer. This course will cover malt from farming and harvesting of the grain, through the transformations of the malting process, to its chemical and biochemical transformations in the brew house. Students cannot receive credit for both BRS 402 and BRS 502. If the student intends to enroll in the Graduate Certificate in Brewing Science, they should not take any of the BRS 40x courses because they cannot be counted for credit toward both a B.Sc. and a Graduate Certificate.

BRS 403 Hops 3-3-0
Hops is the ingredient that contributes the characteristic bitterness of beer. It is also responsible for much of the flavours and aromas of beer, particularly those observed in heavily hopped beers such as India Pale Ale, American Pale Ale, and even hoppier double IPAs. The first section of this course will cover the farming, harvesting and processing of hops. The second section will cover hop chemistry, focusing on the resins (bittering agents) and essential oils (flavour and aroma contributors) of the hop cone and their transformations during the brewing process. Students cannot receive credit for both BRS 403 and BRS 503. If the student intends to enroll in the Graduate Certificate in Brewing Science, they should not take any of the BRS 40x courses because they cannot be counted for credit toward both a B.Sc. and a Graduate Certificate.

BRS 404 Microorganisms in the Brewery 3-3-0
The role of brewer's yeast in the brewing process, particularly its fermentation of sugars to produce alcohol, is fairly well known. However, yeast is also responsible for producing dozens, if not hundreds, of chemical compounds as it metabolizes the sugars, amino acids, and other components during fermentation. Many of these compounds contribute significantly to the flavour and aroma of beer. Other microorganisms, such as wild yeast and bacteria, are also potential contributors to the complex chemistry and biochemistry that occurs in the fermenter; sometimes to the benefit of the beer but more often to its detriment. This course will look at all of the microorganisms that are commonly found in the brewery and provide a detailed description of their chemistry and thus their impact on beer flavour and aroma.
Prerequisites: CHM 211 and BIO 201

BRS 405 Chemical Analysis of Beer and its Ingredients 3-3-0
As a food product, beer is rigorously controlled at both the federal and provincial levels of government. Part of this process is ensuring that a number of analytical parameters are accurately reported (e.g. alcohol by volume). Many other properties of beer are indicators of the efficacy of the brewing process and whether the brewer is producing a quality product. Analysis of the ingredients of beer (water, malt, hops, yeast) is essential to ensure that standards of quality necessary to produce good beer are met. This course will provide students with an in depth look at the chemical analyses commonly used to analyse beer and its precursors, using the methods database of the American Society of Brewing Chemists. Students will use what they learn to analyse the ingredients and the beer that they use / produce in the co-requisite practicum in brewing.
Prerequisites: CHM 141, CHL 141, CHM 245 and CHL 245

BRS 406 The Business of Brewing 3-3-0
There is a great deal of time and hard work that goes into planning, building, equipping, and running even a small microbrewery. When a microbrewery fails, it is generally because the ownership doesn't have a particular skill set, whether it be on the brewing side or on the business side. This course will take students through all of the steps necessary to get a microbrewery from the planning to the operation stage, and also introduce them to the business knowledge necessary for running a successful microbrewery.
Co-requisite: BRS 405