

# CHEMISTRY

The Guelph-Waterloo Centre for Graduate Work in Chemistry and Biochemistry (GWC<sup>2</sup>) combines the Department of Chemistry at the University of Waterloo and the Department of Chemistry at the University of Guelph into a comprehensive and all-inclusive school of graduate chemistry and biochemistry. The members of the Centre conduct research in virtually all areas of modern chemistry and biochemistry.

Professional personnel in the Centre comprise those faculty members of the two departments who have been appointed as PhD advisors and have a record of recent research achievement. The Centre is administered by the Director and GWC<sup>2</sup> Program Administrative Coordinator. Its affairs are guided by the Co-ordinating Committee, which consists of the Director, the two departmental Chairs, the two departmental Graduate Program Coordinators, two elected Centre members from each campus, and one elected representative of the graduate student body from each campus. The regulations applying to graduate study in the Centre meet the requirements of the graduate councils and the Senates of the two universities.

The fields of research in which theses can be written normally fall within the categories of:

- Analytical Chemistry
- Inorganic Chemistry
- Nanoscience
- Organic Chemistry
- Theoretical Chemistry
- Polymer Chemistry
- Biological Chemistry or Biochemistry
- Physical Chemistry

The category chosen will normally be referred to as the candidate's major. However, if a suitable topic is chosen, a candidate may pursue research which involves more than one of the categories listed above. Certain course requirements must be fulfilled both for the MSc and for the PhD. These courses are chosen in consultation with the candidate's advisory committee and the graduate officers of the Centre.

## Administrative Staff

### Director of the Centre

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## Graduate Faculty

*This list may include Regular Graduate Faculty, Associated Graduate Faculty and/or Graduate Faculty from other universities.*

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Graduate Faculty Other University

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Graduate Faculty Other University

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Graduate Faculty Other University

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**German Sciaini**

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Graduate Faculty Other University

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Graduate Faculty

**Peter Tremaine**

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Graduate Faculty

**Xiaosong Wang**

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Graduate Faculty Other University

**Adam Wei Tsen**

BS UC Berkeley, PhD Cornell - Assistant Professor, Chemistry, University  
of Waterloo

Graduate Faculty Other University

## MSc Program

### Admission Requirements

An applicant is encouraged to apply for admission if they have an honours bachelor of science degree, or the equivalent, with a minimum standing of 75% in the last two years (domestic students only) from an accredited university. The co-op MSc option is not available to students who have completed a co-op program as undergraduates. These students are, however, eligible for admission to the co-op PhD program. The Co-op and course work programs are available to domestic applicants only.

Applicants whose first language is not English are required to submit evidence of proficiency in the English language or pass the Test of English as a Foreign Language (TOEFL).

### Program Requirements

Students enroll in one of three study options:

1. Thesis,
2. Co-op, or
3. Course work and major research project.

#### Thesis

Students must successfully complete at least four semester-long graduate courses, including both CHEM\*7840 Foundations of Chemistry and Biochemistry Research Literature Review, CHEM\*7940 Master's Seminar, and submit and defend an acceptable thesis.

Both CHEM\*7840 Foundations of Chemistry and Biochemistry Research Literature Review and CHEM\*7940 Master's Seminar are to be completed within two semesters of entering the program. Students are strongly encouraged to take CHEM\*7840 Foundations of Chemistry and Biochemistry Research Literature Review in their first semester of study.

#### Co-op

The academic requirements are the same as in the regular MSc program, but at least two of the required four semester-long courses (including CHEM\*7840 Foundations of Chemistry and Biochemistry Research Literature Review and CHEM\*7940 Master's Seminar) must be completed during the first two semesters of study. COOP\*1100 Introduction to Co-operative Education, a mandatory, non-credit course, is a prerequisite for the first work term and prepares the student for the employment process. This course must be completed the semester prior to the competitive co-op job search semester.

The co-operative education requirements are to successfully complete two consecutive 4-month co-op work terms in an approved laboratory. The student's performance in the workplace is supervised and evaluated by the student's employer using the Work Performance Evaluation tool. The student's progress during the work term is also monitored by Co-operative Education & Career Services, including an official site visit during the co-op work term and a review of the student's official Learning Goals. A Co-op Work Term Report is required for each work term and is graded by an assigned Co-op Faculty Advisor. All evaluation grades will appear on the student's official transcript.

An altered co-op fee payment schedule will be proposed during the admission offer stage.

After returning to campus, the student will complete their course work and research and prepare the MSc thesis.

### Course Work and Major Research Project (MRP)

Students who elect this option must successfully complete eight graduate courses, including CHEM\*7840 Foundations of Chemistry and Biochemistry Research Literature Review, CHEM\*7940 Master's Seminar, and CHEM\*7970 MSc Research Paper. Part-time studies are designed for students whose employment or family responsibilities allow free time for study only in the evenings.

## PhD Program

### Admission Requirements

An applicant is eligible for admission to the PhD program at the discretion of the director. In general, an applicant must possess the qualifications listed for the MSc program, together with a Master of Science degree comparable to those awarded by North American universities and suitable references from the institution at which the MSc degree was awarded. However, direct admission to the PhD program is available to applicants with an overall A standing in an Honours BSc degree.

Applicants whose first language is not English are required to submit evidence of proficiency in the English language or pass the Test of English as a Foreign Language (TOEFL).

### Program Requirements

#### PhD Program

Students in the PhD program must successfully complete three semester-long courses beyond those required for the master of science degree. One of these courses will be CHEM\*7950 PhD Seminar. Students must also pass an oral qualifying examination in their major field, and submit and defend an acceptable thesis.

Students admitted directly to the PhD program from a BSc must successfully complete one semester-long course beyond those required for the master of science degree. In addition, students must also complete CHEM\*7950 PhD Seminar, pass an oral qualifying examination in their major field, and submit and defend an acceptable thesis.

#### PhD Co-operative Option

Students registered in the PhD program may proceed to that degree under the co-operative option. Under this option one of the two required one-term courses, in addition to CHEM\*7950 PhD Seminar and qualifying, must be completed within the first two academic semesters of study in the Centre. COOP\*1100 Introduction to Co-operative Education, a mandatory, non-credit course, is a prerequisite for the first work term and prepares the student for the employment process. This course must be completed the semester prior to the competitive co-op job search semester.

After successful completion of the academic semesters of course work, the co-operative education requirements are to successfully complete three consecutive 4-month co-op work terms in an approved laboratory. The student's performance in the workplace is supervised and evaluated by the student's employer using the Work Performance Evaluation tool. The student's progress during the work term is also monitored by Co-operative Education & Career Services, including an official site visit during the co-op work term and a review of the student's official Learning Goals. A Co-op Work Term Report is required for each work term and is graded by an assigned Co-op Faculty Advisor. All evaluation grades will appear on the student's official transcript.

An altered co-op fee payment schedule will be proposed during the admission offer stage.

Following successful completion of the work year, the student will return to the Centre to continue work on a PhD research project and complete the regular PhD.

## Collaborative Specializations

### Toxicology

The Department of Chemistry participates in the masters/doctoral collaborative specialization in toxicology. Please consult the Toxicology ([calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/toxicology/](http://calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/toxicology/)) listing for a detailed description of the masters/doctoral collaborative specialization. Students choosing this option must meet the requirements of the toxicology collaborative specialization, as well as those of (GWC)2 for their particular degree program. Three toxicology courses must be completed including TOX\*6200 Advanced Topics in Toxicology, and a research project must be conducted with a participating faculty member at the University of Guelph.

## Courses

Except where specified, courses may be offered in any semester subject to student demand and the availability of an instructor.

All courses are given an eight character code with the sixth having the following significance: 1 (inorganic), 2 (analytical), 3 (biochemistry), 4 (theoretical), 5 (physical), 6 (organic), and 7 (polymer).

#### CHEM\*7100 Selected Topics in Inorganic Chemistry Unspecified [0.50]

Discussion of specialized topics related to the research interests of members of the Centre. Special topics could include, for example: bioinorganic chemistry; inorganic reaction mechanisms; synthetic methods in inorganic and organometallic chemistry; homogeneous and heterogeneous catalysis; chemistry of polynuclear compounds.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

#### CHEM\*7120 X-ray Crystallography Unspecified [0.50]

Introduction: crystals, basic concepts; space groups: the reciprocal lattice; x-ray diffraction; the phase problem; structure factors; electron density; small molecule structure solution, structure refinement, structure results, journals and databases, paper writing.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

#### CHEM\*7130 Chemistry of Inorganic Solid State

##### Materials Unspecified [0.50]

Introduction to solid state chemistry, common crystal structures, principles of solid state synthesis, theory and experimental methods for characterizing solids, including thermal analysis techniques, powder x-ray and neutron diffraction methods; special topics to include one or more of the optical, electronic, magnetic, or conductive properties of inorganic materials. A one semester-long undergraduate course (at least third-year level) in inorganic chemistry, preferably with content in structural and/or solid state must be taken prior to registering for this course.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7150 Structure and Bonding in Inorganic Chemistry Unspecified [0.50]**

Free electron, Hückel and extended Hückel methods for molecules and clusters. Perturbation theory. Applications of group theory in inorganic chemistry; Jahn-Teller effects in molecules and solids. Energy bands in one, two and three dimensions. Three semester-long undergraduate courses in inorganic chemistry and one semester-long undergraduate course in quantum mechanics or group theory must be taken before registering for this course.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7170 Advanced Transition Metal Chemistry Unspecified [0.50]**

Magnetochemistry of transition metal compounds. Electronic spectra of complex ions including applications of molecular orbital and ligand field theories. Stabilization of unusual oxidation states and co-ordination numbers. Bonding, structure and reactivity of certain important classes of metal complexes, e.g., metal hydrides, metal-metal bonded species, biologically significant model systems such as macrocycles.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7180 Advanced Organometallic Chemistry Unspecified [0.50]**

Reactions, structure and bonding of organometallic compounds of transition and non-transition metals.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7200 Selected Topics in Analytical Chemistry Unspecified [0.50]**

Special topics could include, for example: trace analysis using modern instrumental and spectroscopic methods; advanced mass spectrometry (instrumentation and interpretation of spectra); analytical aspects of gas and liquid chromatography.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7240 Chemical Instrumentation Unspecified [0.50]**

Instrumental components and optimum application; rudiments of design; electrical, spectral, migrational and other methods.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7260 Topics in Analytical Spectroscopy Unspecified [0.50]**

Atomic emission and absorption spectroscopy; methods of excitation and detection; quantitative applications. Molecular electronic spectroscopy, UV, visible and Raman; instrumental characteristics; applications to quantitative determinations, speciation, measurements of equilibrium, etc. Sources and control of errors and interferences. Determination and description of colour.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7270 Separations Unspecified [0.50]**

Material to be covered is drawn from the following topics: diffusion; isolation of organic material from the matrix; chromatographic techniques - principles of chromatographic separation, gas (GLC, GSC), liquid (LLC, LSC, GPC, IEC), supercritical fluid (SFC) chromatographies; GC-MS, CG-FTIR; electrophoresis, flow field fractionation. An undergraduate level course in instrumental analysis should be taken prior to this course.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7280 Electroanalytical Chemistry Unspecified [0.50]**

A study of electroanalytical techniques and their role in modern analytical chemistry. The underlying principles are developed. Techniques include chronamperometry, chronocoulometry, polarography, voltammetry, chronopotentiometry, coulometric titrations, flow techniques, electrochemical sensors and chemically modified electrodes.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7290 Surface Analysis Unspecified [0.50]**

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7300 Proteins and Nucleic Acids Unspecified [0.50]**

Determination of protein sequence and 3-dimensional structure, protein anatomy; prediction of protein structure; intermolecular interactions and protein-protein association; effects of mutation. Nucleic acid structure and anatomy; DNA and chromatin structure; RNA structure; snRNPs and ribozymes; protein-nucleic acid interactions.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7310 Selected Topics in Biochemistry Unspecified [0.50]**

Discussion of specialized topics related to the research interests of members of the Centre: for example, recent offerings have included peptide and protein chemistry, biochemical toxicology, medical aspects of biochemistry, glycolipids and glycoproteins, redox enzymes, biological applications of magnetic resonance, etc.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7360 Regulation in Biological Systems Unspecified [0.50]**

Mechanisms of regulation of metabolism - enzyme clusters; phosphorylation and protein kinases/phosphatases, repression and induction, protein turnover. Regulation of transcription, translation and mRNA processing. Cell cycle and control of cell division.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7370 Enzymes Unspecified [0.50]**

Mechanisms of rate enhancement. Enzyme kinetics - steady state; inhibitors; bisubstrate enzymes; fast reaction kinetics. Enzyme reaction mechanisms. Structural and genetic modification of enzymes. Catalytic antibodies. Binding processes. Multiple sites and co-operativity. Allosteric enzymes and metabolic control. Catalysis by RNA.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7380 Cell Membranes and Cell Surfaces Unspecified [0.50]**

Membrane proteins and lipids - structure and function; dynamics; techniques for their study; model membrane systems. Membrane transport. The cytoskeleton. Membrane protein biogenesis, sorting and targeting. Signal transduction across membranes. The cell surface in immune responses.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7400 Selected Topics in Theoretical Chemistry Unspecified [0.50]**

Discussion of specialized topics related to the research interests of the members of the Centre. Special topics could include for example: theory of intermolecular forces; density matrices; configuration interaction; correlation energies of open and closed shell systems; kinetic theory and gas transport properties; theory of the chemical bond.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus



**CHEM\*7450 Statistical Mechanics Unspecified [0.50]**

Review of classical and quantum mechanics; principles of statistical mechanics; applications to systems of interacting molecules; imperfect gases, liquids, solids, surfaces and solutions.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7460 Quantum Chemistry Unspecified [0.50]**

Approximate solutions of the Schrodinger equation and calculations of atomic and molecular properties.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7500 Selected Topics in Physical Chemistry Unspecified [0.50]**

Discussion of specialized topics related to the research interests of the members of the Centre. Special topics could include for example: principles of magnetic resonance in biological systems; collisions, spectroscopy and intermolecular forces, surface chemistry; catalysis; electrolyte theory; non-electrolyte solution theory, thermodynamics of biological systems; thermodynamics.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7550 Kinetics - Dynamics Unspecified [0.50]**

Empirical analysis. Kinetic theory of gases. Potential energy surfaces. Unimolecular rates. Relaxation and steady state methods. Diffusion rates. Rates between polar molecules. Energy transfer.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7560 Spectroscopy Unspecified [0.50]**

Aspects of electronic vibrational and rotational spectroscopy of atoms, molecules, and the solid state. Relevant aspects of quantum mechanics, Dirac notation, and angular momentum will be discussed. Group Theory will be presented and its implications for spectroscopy introduced.

Prerequisites: one semester-long undergraduate course in quantum mechanics or the approval of the instructor.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7600 Selected Topics in Organic Chemistry Unspecified [0.50]**

Two or three topics from a range including: bio-organic chemistry; environmental organic chemistry; free radicals; heterocyclic molecules; molecular rearrangements; organometallic chemistry; photochemistry; natural products.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7640 Synthetic Organic Reactions Unspecified [0.50]**

Named organic reactions and other synthetically useful reactions are discussed. The mechanism, stereochemical implications and use in organic synthesis of these reactions will be presented. Examples from the organic literature will be used to illustrate these aspects.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7650 Strategies in Organic Synthesis Unspecified [0.50]**

The synthesis of organic compounds is discussed and emphasis is placed on the design of synthetic routes. Examples drawn from the literature are used to illustrate this synthetic planning.

**Prerequisite(s):** CHEM\*7640

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7660 Organic Spectroscopy Unspecified [0.50]**

Ultraviolet, infrared, resonance spectroscopy and mass spectrometry, with emphasis on applications to studies of organic molecules.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7690 Physical Organic Chemistry Unspecified [0.50]**

Linear free energy relationships; substituent effects and reactive intermediates.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7700 Principles of Polymer Science Unspecified [0.50]**

Introduction to the physical chemistry of high polymers, principles of polymer synthesis, mechanisms and kinetics of polymerization reactions, copolymerization theory, polymerization in homogeneous and heterogeneous systems, chemical reactions of polymers. Theory and experimental methods for the molecular characterization of polymers.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7710 Physical Properties of Polymers Unspecified [0.50]**

The physical properties of polymers are considered in depth from a molecular viewpoint. Rubber elasticity, mechanical properties, rheology and solution behaviour are quantitatively treated.

**Prerequisite(s):** CHEM\*7700

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7720 Polymerization and Polymer Reactions Unspecified [0.50]**

The reactions leading to the production of polymers are considered with emphasis on emulsion and suspension polymerization and polymerization reaction engineering. Polymer degradation, stabilization and modification reactions are also considered in depth.

**Prerequisite(s):** CHEM\*7700

**Department(s):** Department of Chemistry

**Location(s):** Waterloo Campus

**CHEM\*7730 Selected Topics in Polymer Chemistry Unspecified [0.50]**

Discussion of specialized topics of polymer chemistry related to the research interests of the faculty or prominent scientific visitors. Special topics could include, for example: polymer stabilization and degradation; mechanical properties; polymer principles in surface coatings; organic chemistry of synthetic high polymers; estimation of polymer properties; reactions of polymers; polymerization kinetics.

**Department(s):** Department of Chemistry

**Location(s):** Guelph, Waterloo Campus

**CHEM\*7840 Foundations of Chemistry and Biochemistry Research Literature Review Fall and Winter [0.50]**

Students will prepare a written literature review on a topic relevant to their research proposal. Incoming MSc thesis students are required to take this course within the first two semesters of their program and are strongly encouraged to take it in their first semester.

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7940 Master's Seminar Summer, Fall, and Winter [0.50]**

A public seminar and defence of a research proposal, required to be given by all MSc thesis students within two terms of entering this program.

**Co-requisite(s):** CHEM\*7840

**Department(s):** Department of Chemistry

**Location(s):** Guelph

**CHEM\*7950 PhD Seminar Unspecified [0.00]****Department(s):** Department of Chemistry**Location(s):** Guelph**CHEM\*7970 MSc Research Paper Unspecified [0.50]**

An experimental project normally based on the CHEM\*7940 research proposal, supervised by the advisor, taking three to four months to complete. This project may be completed at any time during the student's program, but it must follow CHEM\*7940. A written report is required, and a seminar based on the content of the report will be presented. The report must be completed as per the project/thesis guidelines of the University campus on which the student is registered. This course normally will follow the course CHEM\*7940 Master's Seminar.

**Department(s):** Department of Chemistry**Location(s):** Guelph**CHEM\*7980 MSc Thesis Unspecified [0.00]****Department(s):** Department of Chemistry**Location(s):** Guelph**CHEM\*7990 PhD Thesis Unspecified [0.00]****Department(s):** Department of Chemistry**Location(s):** Guelph