

CHEM 223
Organic Reactions
Winter, 2025

Course Description: CHEM 223 is an organic chemistry course that builds on concepts introduced in CHEM 211 and CHEM 212 and will primarily focus on expanding your repertoire of organic reactions, while also emphasizing mechanistic aspects of some important chemical transformations. Examples of industrial chemical processes will be used throughout the course to demonstrate the practical applications of these reactions. The laboratory component of this course will provide students with experience in organic synthesis and the practical aspects of the chemistries covered in lecture.

Instructor (Lectures): Dr. Graeme Howe

Office: Chernoff Hall, Room 512

Email: graeme.howe@queensu.ca

Office Hours: [REDACTED]

Instructor (Labs): Dr. Jason Vlahakis

Office: Chernoff Hall, Room 215

Email: vlahakis@queensu.ca

Office Hours: By appointment

Lectures:

[REDACTED]

Labs:

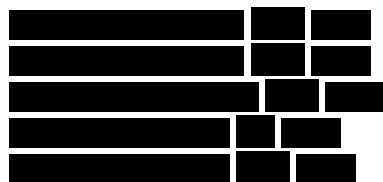
Labs will be held in room [REDACTED] Lab coats and goggles are mandatory. The laboratory will consist of 10 in-person laboratory experiments. The first lab check-in sessions will begin the very first week (Jan 6–7, 2024), depending on your section. Please purchase the 2025 CHEM 223 Laboratory Manual and carbon-copy lab notebook in Chemistry Stores (Room 109, Chernoff Hall) before your first lab session, if possible. You will work with a lab partner to conduct experiments and write a combined lab report each week, submitted to your TA. The lab manual has further details, and a Schedule of Lab Experiments is posted on the CHEM 223 onQ site, along with an Announcement concerning laboratory information.

[REDACTED]

Tutorials:

Tutorials will begin during the week of January 13th and will be held on **weeks 2, 4, 6, 8, and 11** (see below for specific dates). All sections will be held on [REDACTED] Please pay attention to your tutorial section and be sure to attend the appropriate tutorial, as indicated below:

[REDACTED]



Course website: This course is supported by an OnQ site associated with course registration. All materials associated with this course, including grades and lecture materials, will be distributed via the OnQ page.

Intended Learning Outcomes:


Upon completion of this course, students will be able to:









1. Identify functional groups (carbonyls, carboxylic acids and derivatives, alkenes, alkynes, and conjugated systems), and predict/rationalize their reactivity.
2. Write detailed mechanisms for important chemical reactions involving these functional groups.
3. Integrate developed understandings of different functional group reactivities to facilitate predictions of multistep reaction sequences.
4. Propose starting materials, reagents, and/or products for chemical conversions involving carbonyls, carboxylic acids and derivatives, alkenes, alkynes, and conjugated systems.
5. Connect chemical reactivity to important examples from the real world.
6. Use tools and laboratory techniques commonly required for the synthesis of organic molecules, and critically analyze and communicate scientific results.

Textbook: *Organic Chemistry*, 2nd Edition; Clayden, J.; Greeves, N.; Warren, S. Oxford University Press, New York, 2012.

Note: The following chapters of this textbook were covered in CHEM/ENCH 211 and CHEM/ENCH 212: Chapters 2, 4, 5, 7, 8, 12, 14, 15, 16, and 17. As such, you are expected to be entirely comfortable with all the material covered in these chapters.

Grading Scheme

- Tutorial problems 10% Best 4 out of 5 marks will be counted towards your grade
- Midterm #1 10% 

Student number	Exam location
	
	
	
	

- Midterm #2 20% TBD (tentatively during Week 8)
- Final Exam 35% Scheduled by Queen's University Exams Office
- Laboratory 25%

Students must pass **BOTH** the lecture and the laboratory components ($\geq 50\%$) to pass the course. If a student does not pass both components, they will effectively fail the course and be allocated a letter grade of "F". No midterm rewrites will be permitted.

All components of this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to Queen's Official Grade Conversion Scale:

Queen's Official Grade Conversion Scale

Grade	Numerical Course Average (Range)
A+	90-100
A	85-89
A-	80-84
B+	77-79
B	73-76
B-	70-72
C+	67-69
C	63-66
C-	60-62
D+	57-59
D	53-56
D-	50-52
F	49 and below

Department of Chemistry Policy on Missed Labs: Laboratory work is an integral part of this course. All labs must be completed to pass the course. It is the responsibility of the student to notify the Lab Coordinator when a lab cannot be completed at the scheduled time. In exceptional circumstances, the following considerations will be given if a scheduled lab cannot be completed at the assigned time. Whenever possible, provisions will be made for a make-up lab preferably shortly before or after the missed experiment. The lab may be completed during the following academic year and a course mark of IN will be assigned until the missing work is completed. In rare circumstances, other accommodations may be made. For further information please consult the Laboratory Manual or Lab Coordinator.

Calculator Policy: The lecture component of this course will not require the use of a calculator. As such, calculators are not permitted during the midterm or final examinations.

Suggested Time Commitment: Success in this course will require regular studying – cramming before a midterm or the final **WILL NOT** translate to success in CHEM 223! Instead, you should expect to invest 6 – 8 hours of private studies per week, in addition to attending all in-person lectures, tutorials, and labs. Each week, you should spend time studying the material covered in lecture, even during weeks without assignments or exams. Keeping up with the lecture material is extremely important for the development of your chemical intuition, and because topics will feed into and build off of each other, failure to do so will make it very difficult to catch up if you fall behind. Consider reviewing materials available from the

Queen's Student Academic Success Services (SASS; <https://sass.queensu.ca/>) to promote the development of good study habits and organizational skills.

CHEM 223 is a pre-requisite for an extremely important (and extremely fun!) course for Chemistry Majors/Specialists (CHEM 397) and for Biochemistry Majors/Specialists (CHEM 398/399), so prioritizing your success in this course is likely essential to avoid any delays in your graduation.

Attendance: Organic chemistry can only be learned by doing (laboratories, writing mechanisms, evaluating molecular reactivity in writing, etc.), and NOT by simply reading or watching videos. As such, attendance at all lectures, tutorials, and labs is essential for success. Please make every effort to attend all components of this course, else you will risk falling behind and struggling with the course material.

While I will make every effort to record lectures and post the recordings to the course website, please note two things:

1. Invariably, technical issues will result in a subset of lectures going unrecorded. Every effort will be made to avoid these technical problems, but please expect that some lectures will not be recorded. You will still be expected to understand the material covered during any lectures that are not recorded, so in-person attendance at ALL lectures is STRONGLY ENCOURAGED.
2. Past iterations of this course have demonstrated that recorded lectures are ineffective as the sole means of content delivery. As such, students who opt to digest the course material via recorded lectures **WILL NOT** perform as well in this course as students who attend live lectures. The recordings are provided as study supplements so that students can revisit concepts covered in class to reinforce their understanding of said material.

If you fall ill, a combination of the recorded lectures and office hours should be used to ensure that you develop an adequate understanding of the lecture material that you missed.

Queen's Policy Statement on Academic Integrity: Queen's University is dedicated to creating a scholarly community free to explore a range of ideas, to build and advance knowledge, and to share the ideas and knowledge that emerge from a range of intellectual pursuits. Queen's students, faculty, administrators and staff therefore all have responsibilities for supporting and upholding the fundamental values of academic integrity. Academic integrity is constituted by the five core fundamental values of honesty, trust, fairness, respect and responsibility and by the quality of courage. These values and qualities are central to the building, nurturing and sustaining of an academic community in which all members of the community will thrive. Adherence to the values expressed through academic integrity forms a foundation for the "freedom of inquiry and exchange of ideas" essential to the intellectual life of the University.

The following statements from "The Fundamental Values of Academic Integrity" (2nd edition), developed by the International Center for Academic Integrity (ICAI), contextualize these values and qualities:

1. **Honesty** Academic communities of integrity advance the quest for truth and knowledge through intellectual and personal honesty in learning, teaching, research, and service.
2. **Trust** Academic communities of integrity both foster and rely upon climates of mutual trust. Climates of trust encourage and support the free exchange of ideas which in turn allows scholarly inquiry to reach its fullest potential.
3. **Fairness** Academic communities of integrity establish clear and transparent expectations, standards, and practices to support fairness in the interactions of students, faculty, and administrators.

4. **Respect** Academic communities of integrity value the interactive, cooperative, participatory nature of learning. They honor, value, and consider diverse opinions and ideas.
5. **Responsibility** Academic communities of integrity rest upon foundations of personal accountability coupled with the willingness of individuals and groups to lead by example, uphold mutually agreed-upon standards, and take action when they encounter wrongdoing.
6. **Courage** To develop and sustain communities of integrity, it takes more than simply believing in the fundamental values. Translating the values from talking points into action -- standing up for them in the face of pressure and adversity — requires determination, commitment, and courage.

Students are responsible for familiarizing themselves with and adhering to the Senate [regulations](#) concerning academic integrity, along with [Faculty or School](#) specific information. Departures from academic integrity include, but are not limited to, plagiarism, use of unauthorized materials, facilitation, forgery and falsification. Actions which contravene the regulation on academic integrity carry sanctions that can range from a warning, to loss of grades on an assignment, to failure of a course, to requirement to withdraw from the university.

Students are responsible for familiarizing themselves with the regulations concerning academic integrity and for ensuring that their assignments and their behaviour conform to the principles of academic integrity. Information on academic integrity is available in the Arts and Science Calendar (see Academic Regulation 1 <http://www.queensu.ca/artsci/academic-calendars/regulations/academic-regulations/regulation-1>), on the Arts and Science website (see <https://www.queensu.ca/artsci/students-at-queens/academic-integrity>), and from the instructor of this course. Departures from academic integrity include plagiarism, use of unauthorized materials, facilitation, forgery and falsification, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the university.

Policy on the Use of Generative Artificial Intelligence (AI) Tools: Using generative AI writing tools such as ChatGPT in your submitted work is not permitted in this class. This type of use constitutes a Departure from Academic Integrity. Only original work is expected to be submitted in this course. The use of an artificial intelligence tool like ChatGPT is not permitted, and **under no circumstances** should students use Generative AI (such as ChatGPT) to help write lab reports. Lab reports must be written by students using their own words, and appropriate references always cited. The penalties can be severe, including sanctions and withdrawal from University. Any lab reports including generative AI sections will be given a mark of zero, followed by further unpleasant actions. Graders will clearly notice AI language in all lab reports. It is considered a departure from academic integrity and is not acceptable.

Copyright of Course Materials: Course materials created by the course instructor, including all slides, presentations, handouts, tests, exams, and other similar course materials, are the intellectual property of the instructor. It is a departure from academic integrity to distribute, publicly post, sell or otherwise disseminate an instructor's course materials or to provide an instructor's course materials to anyone else for distribution, posting, sale or other means of dissemination, without the instructor's express consent. A student who engages in such conduct may be subject to penalty for a departure from academic integrity and may also face adverse legal consequences for infringement of intellectual property rights.

Accessibility Statement: Queen's is committed to an inclusive campus community with accessible goods, services, and facilities that respect the dignity and independence of persons with disabilities. Course materials are available in an accessible format or with appropriate communication support upon request.

Please contact **Meredith Richards** in the Department of Chemistry in one of the following ways:

Email: ugadm@chem.queensu.ca

Phone: 613-533-6000 (extension 75518)

In person: Chernoff 200

Accommodations: Queen's University is committed to working with students with disabilities to remove barriers to their academic goals. Queen's Student Accessibility Services (QSAS), students with disabilities, instructors, and faculty staff work together to provide and implement academic accommodations designed to allow students with disabilities equitable access to all course material (including in-class as well as exams). If you are a student currently experiencing barriers to your academics due to disability related reasons, and you would like to understand whether academic accommodations could support the removal of those barriers, please visit the [QSAS website](#) to learn more about academic accommodations or start the registration process with QSAS by clicking *Access Ventus* button at [Ventus | Accessibility Services | Queen's \(queensu.ca\)](#)

VENTUS is an online portal that connects students, instructors, Queen's Student Accessibility Services, the Exam's Office and other support services in the process to request, assess, and implement academic accommodations.

To learn more go to: <https://www.queensu.ca/ventus-support/students/visual-guide-ventus-students>

Academic Consideration for Students in Extenuating Circumstances: Academic Consideration is a process for the University community to provide a compassionate response to assist students experiencing unforeseen, short-term extenuating circumstances that may impact or impede a student's ability to complete their academics. This may include but is not limited to:

- Short term Physical or Mental Illness or Injury (stomach flu, anxiety/depression, mononucleosis, concussion, broken bones, surgery, medical treatments, etc.)
- Traumatic Event/Confidential (Bereavement, serious injury, illness or required treatment for a significant other/family member or a traumatic event such as divorce, sexual assault, social injustice, etc.)
- Requirements by Law or Public Health Authorities (court dates, jury duty, requirements to isolate, etc.)
- Significant Event (varsity athletic event, distinguished event, serving in the Reserve Forces, etc.)

Queen's University is committed to providing academic consideration to students experiencing extenuating circumstances. For more information, please see the [Senate Policy on Academic Consideration for Students in Extenuating Circumstances](#).

Each Faculty has developed a protocol to provide a consistent and equitable approach in dealing with requests for academic consideration for students facing extenuating circumstances. For more information, undergraduate students in the Faculty of Arts and Sciences should consult the Faculty's webpage on [Academic Consideration in Extenuating Circumstances](#) and submit a request via

the [Academic Consideration Request Portal](#). Students in other Faculties and Schools who are enrolled in this course should refer to the protocol for their home Faculty.

Students are encouraged to submit requests as soon as the need becomes apparent and to contact their instructor and/or course coordinator as soon as possible once academic consideration has been granted. Any delay in contact may limit the options available for academic consideration.

For more information on the Academic Consideration process, what is and is not an extenuating circumstance, and to submit an Academic Consideration request, please see the Faculty of Arts and Science's [Academic Consideration website](#). ASO courses include links to information on Academic Consideration on your Course Homepage in onQ.

Timing of Final Examinations: Once the exam schedule has been finalized, the exam date will be posted on your SOLUS account. The exam dates for each term are listed on the Faculty of Arts and Science webpage under "[Important Dates](#)." Student exam schedules for the Fall Term are posted on SOLUS immediately prior to Thanksgiving and on the Friday before Reading Week for the Winter Term. Students should **delay finalizing any travel plans until after the examination schedule has been posted**. Exams will **not be moved or deferred** to accommodate employment, travel/holiday plans or flight reservations. For information regarding what is considered extenuating circumstances and qualifications for Academic Consideration, please visit the [Faculty of Arts and Science's Academic Consideration webpage](#).

If you are unable to attend an exam and receive approval for a deferred proctored exam, a further deferral of that exam will not be accommodated.

Acknowledgement of Territory

Let us acknowledge that Queen's University occupies traditional Anishinaabe and Haudenosaunee territory. To acknowledge this traditional territory is to recognize its longer history, one predating the establishment of the earliest European colonies. It is also to acknowledge this territory's significance for the Indigenous Peoples who lived, and continue to live, upon it and whose practices and spiritualities are tied to the land and continue to develop in relationship to the territory and its other inhabitants today. Indigenous communities in Kingston/Katarokwi continue to reflect the area's Anishinaabe and Haudenosaunee roots. There is also a significant Métis community and First Peoples from other Nations across Turtle Island present here today. To read more about the history of the land, see the [Queen's Encyclopedia](#) and to learn more about land acknowledgements, see the [Office of Indigenous Initiatives](#).

Discussion Guidelines

University is a place to share, question and challenge ideas. Each student brings a different lived experience from which to draw upon. To help one another learn the most we can from this experience please consider the following guidelines.

1. Make a personal commitment to learn about, understand, and support your peers.
2. Assume the best of others and expect the best of them.
3. Acknowledge the impact of oppression on the lives of other people and make sure your writing is respectful and inclusive.
4. Recognize and value the experiences, abilities, and knowledge each person brings.
5. Pay close attention to what your peers write before you respond. Think through and re-read your writings before you post or send them to others.
6. It's ok to disagree with ideas, but do not make personal attacks.

7. Be open to being challenged or confronted on your ideas and to challenging others with the intent of facilitating growth. Do not demean or embarrass others.
8. Encourage others to develop and share their ideas.

Course Outline (tentative; all chapters refer to Clayden):

Helpful review: Chapter 5 – ‘Organic Reactions’

Section 0: Intro – reactive partners (brief CHEM 212 review) and functional groups for CHEM 223

Section 1: Nucleophilic addition reactions

- 1.1. Properties of the carbonyl group – Ch. 6
- 1.2. Nucleophilic addition to the carbonyl group – Ch. 6, p. 125 – 137
- 1.3. Organometallic reagents – Ch. 9
- 1.4. Nucleophilic acyl substitution – Ch. 10
- 1.5. Nucleophilic acyl addition/condensation – Ch. 11
- 1.6. Conjugate additions – Ch. 22, p. 498 – 513
- 1.7. Nucleophilic aromatic substitution – Ch. 22, p. 514 – 527.
- 1.8. Oxidation of carbonyl compounds – Ch. 9; Ch. 36, p953-955

Section 2: Enols and Enolates

- 2.1 Alkylation of enolates – Ch. 25
- 2.2 The Aldol reaction – Ch. 26, p614 – 640.

Section 3: Addition reactions to alkenes and alkynes

- 3.1 Properties of the π system in alkenes and alkynes
- 3.2 Electrophilic addition of H-X and H-OH – Ch. 19
Addition to alkenes
Addition to alkynes
- 3.3 Radical addition to alkenes – Ch. 37
- 3.4 Addition of X_2 – Ch. 19
- 3.5 Hydration of alkenes and alkynes – Ch. 19
Oxymercuration/reduction
Hydroboration
- 3.6 Epoxidation of alkenes
Epoxide formation – Ch. 19
Epoxide opening (acidic vs. basic conditions) – Ch. 19, p438
- 3.7 Osmium tetroxide dihydroxylation – Ch. 19; Ch. 34, p905
- 3.8 Pinacol and semi-pinacol rearrangements – Ch. 36, p. 945-949
- 3.9 Ozonolysis – Ch. 19; Ch. 34, p906-907
Ozonide formation
Reductive and oxidative treatments
- 3.10 Reduction of alkenes and alkynes
Hydrogenation – Ch. 23, p534-535

Section 4: Oxidation and reductions

- 4.1 Reducing agents and catalytic hydrogenation – Ch. 23
- 4.2 Chemoselectivity and protecting groups – Ch. 23
- 4.3 Dissolving metal reductions – Ch. 23, p541
- 4.4 Reductive aminations – Ch. 23
- 4.5 Birch reduction – Ch. 23
- 4.6 Swern oxidation – Ch. 23

Section 5: Cycloadditions and rearrangements (time permitting)

- 5.1 Diels Alder reaction – Ch. 34

- 5.2 1,3-dipolar cycloadditions – Ch. 34, p901
- 5.3 Beckmann rearrangement – Ch. 36, p958