ORGANIC REACTIONS
CHEM 223 (Winter 2024)

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Office Hours [redacted] Mondays 11:30 am–12:30 pm, Fridays 10:30–11:30 am, or by appointment.

Course website: this course is supported by an OnQ site associated with course registration. See https://onq.queensu.ca

Intended Student Learning Outcomes:

1. Identify functional groups and associated reactivity, in particular that of carbonyl, carboxyl, alkene, alkyne, and conjugated systems.
2. Write complete mechanisms for common reactions involving these functional groups.
3. Integrate knowledge from different chemical functions, allowing to complete a reaction sequence, towards total synthesis.
4. Propose reagents and products for chemical conversions involving carbonyl, carboxyl, alkene, alkyne, and conjugated systems.
5. Connect chemical reactivity with real-life examples.
6. Use tools and laboratory techniques commonly required for the synthesis of organic molecules, and critically analyze and communicate scientific results.

Course outline: See end of this document.

Textbooks: 'Organic Chemistry', Clayden, Greeves and Warren, 2nd edition.
Placed on reserve in the library: 'Organic Chemistry' by Carey (7th or 8th edition; it does not matter) offers simpler, more accessible chapters and problems. A good support book.

Labs: held in room [redacted]. Lab coats and googles 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 8–9, 2024), depending on your section. Please purchase the 2024 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.

Grading Scheme

Tutorial problems	10%	Retain five best marks, out of six tutorials
Midterm examination # 1	10%	
Midterm examination # 2	20%	
Final examination	35%	Scheduled by the exams office
Laboratory	25%	

Grading Method: 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

Students must pass BOTH the lecture ad lab components (≥ 50% or D-) to pass the course. If a student does not pass both components of the course, he/she will fail the course and be allocated a letter grade of F.

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 consult the course instructor and/or the lab coordinator.

Calculator Policy: The lecture component of this course does not require the use of calculators. As a result, calculators are not allowed during mid-term and final examinations.

Suggested Time Commitment: In this course, you should expect to invest on average 6–8 hours per week of private studies, in addition to attending all in-person lectures, tutorials and labs. Make sure to **regularly** study the **lecture material** (priority!) every week, even in the absence of assignments / exams. A habit of keeping up with the **lecture material** is critical for this course, as things pile up quickly, and everything is connected. It will be hard to follow and catch up if you fall behind! Visit Queen's SASS to boost your organization skills and avoid 'cramming' (never good, especially for retention…). CHEM 223 is a pre-requisite for the very important CHEM 397 core course (Chemistry major/specialization) or CHEM 398/399 lab course (Biochemistry major/specialization), so make this course a priority so that your graduation does not risk being delayed.

Attendance: All lectures, tutorials and labs must be attended in person by each student, unless sick. Recorded lecture videos will **not** be made available on onQ, as these proved **ineffective** for learning in this course in 2022. In case of illness, the scanned lecture material (pdf) made available on onQ may be used to catch up, in addition to peers' notes. When feeling better, you are invited to attend

office hours (see above) for any clarification or complement. Organic chemistry can only be learned by doing (labs, writing mechanisms, dissecting molecules in writing), and not through plain watching or reading. Hence, attending these lectures, tutorials and labs is **essential** for success!

Feed-back: On the one hand, CHEM 223 students are provided academic feed-back from tutorials, lab reports and mid-term exams. The pedagogical team is making all efforts to provide feed-back within 2 weeks of receiving work, but everyone is busy, so your patience is appreciated. On the other hand, instructors and TAs welcome your feed-back on the course as early as day 1. We all aim to make the course as productive as possible (within limits), so **do not hesitate to communicate early any suggestions** on how to make it more accessible and effective from your student's perspective (waiting until the end of the term will do no good…). Communication channels include direct interactions (after class/lab, office hour, informal drop-in), emails, tutorial and lab TAs, and your DSC rep (https://www.facebook.com/QueensChemistryDSC/)

Academic Integrity: Queen's students, faculty, administrators, and staff all have responsibilities for upholding the fundamental values of academic integrity; honesty, trust, fairness, respect, responsibility and courage (see www.academicintegrity.org). These values 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 (see the Senate Report on Principles and Priorities http://www.queensu.ca/secretariat/policies/senate/report-principles-and-priorities).
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 https://www.queensu.ca/artsci/undergraduate/student-services/academic-integrity), and from the instructor of this course. Departures from academic integrity include plagiarism, use of unauthorized materials, facilitation, forgery and falsification, and go against 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.

Copyright of Course Materials: Course materials created by the course instructor, including all slides, notes, presentations, videos, tutorial and lab texts, 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 supports 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 Statement
Queen's University is committed to achieving full accessibility for people with disabilities. Part of this commitment includes arranging academic accommodations for students with disabilities to ensure they have an equitable opportunity to participate in all of their academic activities. If you are a student with a disability and think you may need academic accommodations, you are strongly encouraged to contact the Queen's Student Accessibility Services (QSAS) and register as early as possible. For more information, including important deadlines, please visit the QSAS website at: http://www.queensu.ca/studentwellness/accessibility-services/

Academic Considerations for Students in Extenuating Circumstances
Queen's University is committed to providing academic consideration to students experiencing extenuating circumstances that are beyond their control and are interfering with their ability to complete academic requirements related to a course for a short period of time.
Detailed information and request portal access may be found at:
https://www.queensu.ca/artsci/undergraduate/student-services/academic-consideration
If you need to request academic consideration for this course, you will be required to provide the name and email address of the instructor/coordinator. Please use the following:
Instructors' Names: Dr. Petitjean and Dr. Vlahakis
Instructors' email address: See above

Location and Timing of Final Examinations: The exam dates for each Term are listed on the Faculty of Arts and Science webpage under "Important Dates." Student exam schedules for the Winter Term are posted on the Friday before Reading Week. **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.**

Course Outline (tentative):
Note that you are responsible for, and will be tested on, ***in-class material****. If you miss a class, please make an effort to get copies of the notes from that day. Information for the lectures will be posted on OnQ but complete narrative may not be systematically posted (available upon request). Also keep in mind that CHEM 212 is a pre-requisite for CHEM 223, and, as such, you are expected to be completely comfortable with all the material from this class*.

Helpful review: Clayden Chapter 5 'Organic Reactions'

Section 0: Introduction; Reactive partners (review from CHEM 212) and chemical functions for CHEM 223.

Section 1 Nucleophilic addition to the carbonyl group (aldehydes and ketones)

1.1 Properties of the carbonyl group		[Clayden Chapter 6]
General scheme of addition		
1.2 Reversible additions		
a) Hydration and cyanation		[Clayden Chapter 6]
b) Hemiacetals and acetals		[Clayden Chapters 6, 11]
c) Imines, enamines, oximes and hydrazones	Exp #1	[Clayden Chapter 11]
Application to compound identification and Wolff–Kishner reduction		[Clayden Chapter 23 p540]

1.3 Irreversible additions

a) Hydride reduction — [Clayden Chapters 6 p130−132,
(i) Reduction of aldehydes and ketones — Exp #4 — 11 and 23 p530]
(ii) Reductive amination (and Strecker synthesis of amino acids)

b) Organometallic addition: reaction with aldehydes and ketones — [Clayden Chapter 9]

c) Wittig reaction — Exp #5 — [Clayden Chapter 11]

1.4 Oxidation of carbonyl compounds — [Clayden Chapter 9]

a) Oxidation of aldehydes — Exp #1 — [Clayden Chapter 9]

b) Oxidation of alcohols — [Clayden Chapter 9]

c) Baeyer-Villiger oxidation — [Clayden Chapter 36, p 953−955]

Section 2 Reactions of carboxylic acids and derivatives

2.1 Properties of the carboxyl group — [Clayden Chapter 10]

2.2 Formation of esters, acyl chlorides and anhydrides — Exp #2 — [Clayden Chapter 10]
Application to industrially relevant esters

2.3 Hydrolysis of carboxylic acid derivatives — [Clayden Chapter 10]
Esters, amides, nitriles

2.4 Interconversion of carboxylic acid derivatives

a) Acyl chlorides to amides, esters, and anhydrides

b) Anhydrides to amides and esters

c) Trans-esterification

2.5 Reduction of carboxylic acid derivatives

a) Hydride reduction: to alcohols, amines and aldehydes — [Clayden Chapter 23, p531−534]

b) Organometallic additions: to alcohols, ketones — [Clayden Chapter 10, p216−220]

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 — [Clayden Chapter 19]

a) To alkenes

b) To alkynes

3.3 Radical addition to alkenes — [Clayden Chapter 37]

3.4 Addition of X_2 — Exp #6 — [Clayden Chapter 19]

3.5 Hydration of alkenes and alkynes — [Clayden Chapter 19]

a) Oxymercuration/reduction

b) Hydroboration

3.6 Epoxidation of alkenes

a) Epoxide formation — [Clayden Chapters 19]

b) Epoxide opening (acidic *vs* basic conditions) — [Clayden Chapters 19 p438]

3.7 Osmium tetroxide di-hydroxylation — [Clayden Chapters 19, 34 p905]

3.8 Pinacol and semi-pinacol rearrangements — [Clayden Chapter 36, p945−949]

3.9 Ozonolysis — [Clayden Chapters 19, 34 p906−907]

a) Ozonide formation

b) Reductive vs oxidative treatments

3.10 Reduction of alkenes and alkynes

a) Hydrogenation — [Clayden Chapter 23 p534−535]

b) Reduction by dissolved metals — [Clayden Chapter 23 p543]

Section 4 Formation and reaction of enols and enolates

4.1 Acidity of H α to carbonyl and carboxyl groups — [Clayden Chapter 20]

4.2 Halogenation (haloform reaction) — Exp #8 — [Clayden Chapter 20]

4.3 Alkylation of enolates — [Clayden Chapter 25]

a) Mono-carbonyl and derivatives (enolates and enamines)

b) Di-carbonyl

c) Malonic ester and acetoacetic acid syntheses

4.4 Aldol reactions		[Clayden Chapter 26]
a) Simple aldol reaction		[Clayden Chapter 26]
b) Aldol reaction + condensation	Exp #9-10	[Clayden Chapter 26]
c) Reaction of ester enolates (acylation at carbon)		[Clayden Chapter 26]

Section 5 Conjugated systems [Time permitting]

5.1 Definition and properties of conjugated systems		[Clayden Chapter 22]
5.2 C=C-C=C conjugated systems		[Clayden Chapter 19 p435]
a) Conjugate addition of HBr and HCl		
b) Conjugate addition of bromine (Br_2)		
5.3 The Diels−Alder reaction, an example of pericyclic transformations		[Clayden, Chapter 34]