ORGANIC REACTIONS
Chem223 (Winter 2022)

Lectures: Mondays 10:30-11:20 am Wednesdays 9:30-10:20 am Fridays 8:30-9:20 am

Tutorials: Fridays 11:30 am – 1 pm, on weeks 2, 4, 7, 9, 11 and 12 (to be confirmed).

Location: Kingston Hall 201 (lectures), Chernoff 118 (labs), tutorials through Zoom for first 6 weeks, then possibly in Nicol room 321 (section 005), Goodwin room 254 (section 006), and through Zoom (section 007), to be confirmed.

Course instructor: Dr Anne Petitjean
Chernoff Hall, room 410
anne.petitjean@chem.queensu.ca
613 533 6587

Lab instructor: Dr Jason Vlahakis
Chernoff Hall, room 215
jason.vlahakis@chem.queensu.ca
613 533 6000 ext. 77769

Office Hours (through Zoom for 1st 6 weeks, TBD for 2nd six weeks): Wednesdays 10:30-11:30 am, or by appointment, through Zoom during 1st six weeks, and possibly in my office, Chernoff 410, after that, to be confirmed.

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. Conduct experiments in extraction, reaction, purification and characterization of organic compounds, 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 CHE118, 1st floor of Chernoff Hall. Lab coats and googles are mandatory.

Grading Scheme

Tutorial problems (first 3 remote)	10%	Retain five best marks, out of six tutorials
Midterm examination # 1 (onQ)	10%	Monday January 31st, 6-7 pm (should only take 1 h)
Midterm examination # 2	20%	Monday March 7th, 6-8 pm (should only take 2 h)
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.

Laboratory: The laboratory portion of this course is supervised by Dr. Jason Vlahakis (vlahakis@queensu.ca) and will consist of **five Virtual Laboratory Experiments** (and possibly an additional **three In-Person Laboratory Experiments** if permitted after Feb 28, 2022). Students will watch a training video and **individually** write and submit a laboratory report for each virtual experiment. These can be completed at any time convenient for the student before the submission deadline, but it is highly recommended that you adhere to the suggested time frames. The prelab/lab report is submitted together as **one** Word document (as an assignment named Lab 1, Lab 2, Lab 3, Lab 4, and Lab 5) within onQ, and will be marked electronically by TAs. Watching each video will take about 1 hour and writing each laboratory report will probably take about 3 – 5 hours. More information about specific labs will be posted on onQ – follow closely the posted information/marking schemes. **WEIGHT for LABS:** If we are NOT permitted to return to in-person labs after Feb 28, 2022, the lab reports for Virtual Experiments 1, 2, 3, 4, and 5, will be worth 5% each, giving a total weight of 25% to the laboratory portion of the course. If we ARE permitted to return to in-person labs after Feb 28, 2022, the lab reports for Virtual Experiments 1, 2, 3, 4, and 5, will be worth 3.5% each, and in-person Experiments 6, 7, and 8 will be worth 2.5% each, giving a total weight of 25% to the laboratory portion of the course. The in-person labs will be mainly performance-based and will not require a full lab report. More detailed Lab Info/Schedule/Due Dates will be posted within the CHEM 223 onQ site. The lab reports have strict due dates. You can watch the Virtual Lab videos at the suggested times in the schedule, or at any other convenient time for your schedule, but **lab reports are all due at strict exact times, always plan ahead, no extensions will be given. Normally lab reports are due within one week, we have extended this due date now to 2 weeks after the recommended start time.**

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.

Academic Integrity: The following statement on academic integrity builds on a definition approved by Senate and is designed to make students aware of the importance of the concept and the potential consequences of departing from the core values of academic integrity. It is highly recommended that this statement be included on all course syllabi. Instructors may also consider including this statement with each assignment.
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 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.

Turnitin Statement: Queen's University has partnered with the third-party application Turnitin to help maintain our standards of excellence in academic integrity. Turnitin is a suite of tools that provide instructors with information about the authenticity of submitted work and facilitates the process of grading. Submitted files are compared against an extensive database of content, and Turnitin produces a similarity report and a similarity score for each assignment. A similarity score is the percentage of a document that is similar to content held within the database. Turnitin does not determine if an instance of plagiarism has occurred. Instead, it gives instructors the information they need to determine the authenticity of work as a part of a larger process.

Copyright of Course Materials: Course materials created by the course instructor, including all slides, presentations, videos, 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 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. The Senate Policy for Accommodations for Students with Disabilities was approved at Senate in November 2016 (see https://www.queensu.ca/secretariat/sites/webpublish.queensu.ca.uslcwww/files/files/policies/senateandtrustees/ACADACCOMMPOLICY2016.pdf). 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. The Senate Policy on Academic Consideration for Students in Extenuating Circumstances is available at http://www.queensu.ca/secretariat/sites/webpublish.queensu.ca.uslcwww/files/files/policies/senateandtrustees/Academic%20Considerations%20for%20Extenuating%20Circumstances%20Policy%20Final.pdf
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. Arts and Science undergraduate students can find the Faculty of Arts and Science protocol and the portal where a request can be submitted at: http://www.queensu.ca/artsci/accommodations. Students in other Faculties and Schools who are enrolled in this course should refer to the protocol for their home Faculty. 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' Name: 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.** Also, as indicated in Academic Regulation 8.3, students must write all final examinations in all on-campus courses on the Kingston campus (the Covid situation may require revisions of the details around final examination).

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 chem212 is a pre-requisite for chem223, 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 chem212) and chemical functions for chem223.

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		[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 #3	11 and 23 p530]
(ii) Reductive amination (and Strecker synthesis of amino-acids)		
b) Organometallic addition: reaction with aldehydes an ketones		[Clayden Chapter 9]
c) Wittig reaction	Exp #6	[Clayden Chapter 11]
1.4 Oxidation of carbonyl compounds		[Clayden Chapter 9]
a) Oxidation of aldehydes		[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 carbo**xyl** 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 #5	[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 semipinacol 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) [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 [Clayden Chapter 26]
  c) Reaction of ester enolates (acylation at carbon) [Clayden Chapter 26]

Section 5 Conjugated systems

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]

Exp #1–5 are virtual, Exp #6–8 in-person (if permitted). Exp #1 Steam Distillation of Cinnamaldehyde, Exp #4 Chromatography, Exp #7 EAS – Friedel–Crafts Alkylation.