

Faculty of Science Course Syllabus
Department of Chemistry
Chemistry 3401 (CRN 20431)
Intermediate Organic Chemistry
Winter 2021

Instructors: **Lecture (Online):** Dr. Alex Speed; aspeed@dal.ca;

Office Hours: Please request office hours by e-mail. They will be conducted by Zoom or Teams. I welcome any and all requests regarding the material, but **please** read the syllabus carefully before asking me questions about the delivery of the course itself.

Laboratory (Online): Dr. Reinaldo Moya Barrios; rbarrios@dal.ca; Office Hours Via Teams – scheduled hours (TBA) or by appointment. You are welcome to e-mail Dr. Moya-Barrios if you would like to make an appointment for a specific time. Please put CHEM3404 in the subject line.

See Brightspace details on the online lab component.

Lectures: The course content will be delivered in an asynchronous manner on Brightspace. January 6th 2021 to April 8th 2021.

Laboratories: Weekly laboratory material will be uploaded to Brightspace, asynchronous format. Synchronous Teams meetings will be scheduled throughout the term in the regular scheduled Thursday and Friday, 1:35 -5:25 pm timeslot. January 6th 2021 to April 8th 2021. First lab module will be released on January 21st.

Course Description

Topics presented include aromatics, heterocycles, amines, enolate anions and other methods for forming C-C bonds, concerted reactions, carbohydrates and some heteroatom chemistry. There is a continuing emphasis on the principles of mechanistic organic chemistry. Lab modules will describe reaction procedures and techniques. Students will work independently on the laboratory modules, preparing tables of reactants and products and proposing reactions mechanisms for the reactions presented. Lab modules will also focus on the characterization of reaction products and mixtures using spectroscopic techniques, with particular emphasis on nuclear magnetic resonance (NMR). In addition, lab modules will present students to retrosynthetic analysis and synthesis design.

Course Prerequisites

Organic chemistry involves both a great deal of memorization and understanding. Much like a language, you must possess a memorized vocabulary (reactions), but also a correct understanding of syntax and grammar (thinking mechanistically and knowing how and when to apply reactions) to have success in this course. You are expected to have a FLUENT command and understanding of the material from CHEM 2401 and 2402. Being able to draw correct Lewis structures, produce legible structures with reasonable geometry, evaluate resonance contributors and draw curved arrow mechanisms will be necessary for success in this course. Organic synthesis is a cumulative discipline, and it is expected that you have

retained knowledge of reactions and concepts covered in preceding courses. You will be both explicitly and implicitly tested on material covered in CHEM 2401/2402.

Course Objectives/Learning Outcomes

Organic synthesis allows the synthesis of molecules that broadly impact our lives through application in healthcare, materials science, food processing and fundamental research. Organic chemistry has the reputation of being a difficult topic, however the degree of difficulty depends on how you approach the subject. While the study of organic chemistry does involve substantial memorization, you will gain the most understanding with the least amount effort from this course by seeking to understand trends in the chemistry you see, rather than treating each reaction as an isolated concept to be memorized. Appreciating trends and patterns gives you the maximum ability to apply what you have learned to predict the outcome of reactions that are new, either to you, or to science.

In CHEM 3401, we will examine some of the most important carbon-carbon bond forming reactions, including reactions on aromatic heterocycles. An overview of chemistry for introduction and manipulation of common heteroatoms is provided. Simple stereochemical considerations are introduced. After successful completion of the course, students will be able to formulate multi-step syntheses of molecules of moderate complexity, containing multiple functional groups, with some knowledge of how to develop strategy based on considerations of reactivity.

Class Structure: The class will be in an asynchronous format using Brightspace software. Lectures will consist of a combination of voice-annotated powerpoint slides, and videos of mechanisms being drawn which will be hosted on Panopto (accessible through Brightspace). If your internet connection is not fast enough to properly display the materials, please let Dr. Speed know as soon as possible so that lower fidelity course materials can be provided. Evaluation material will be returned via e-mail or via Brightspace. You will require some method of drawing structures to return to me. **Please work out your strategy for returning answers in advance of the due-dates evaluations and tests. I cannot guarantee I can provide technical support on the day of the due date. Please also put your last name in the filename!** Acceptable options include:

1) Drawing the answers either free-hand or on a printout of the evaluations and returning the answers by either photographing or scanning them. Note there is free software (for example CamScanner) that allows you to generate high-quality scanned PDF files using your phone camera. I will prefer this option to ensure that the file-sizes of returned work is manageable. I recognize most people will not have access to a printer, so detailed instructions for organizing your free-hand drawings on blank paper will be provided on the tests. **Returning the answers in one document is strongly encouraged, since each student sending multiple files will lead to confusion, and a delay in grading your work.**

2) Drawing the answers on the test PDF using a tablet equipped with stylus and drawing function. If you have the appropriate equipment and can draw legibly with this technique, this will be a good option.

3) If you do not have access to a camera, scanner, or tablet, completing the answers using ChemDraw will be permissible. Dalhousie has a site licence for ChemDraw. Please let me know if this option is the case, as you may require a time-extension to be able to produce legible answers using this technique. This is the least preferred option.

Office Hours: Office hours may be set up using either Teams or Zoom by e-mailing me first. In-person office hours will not be possible, even if you are on campus, to promote physical distancing.

Remote Course Materials:

A computer with an internet connection will be required to view the course presentations and slides. As stated above, one of a camera, scanner, tablet/stylus, or ChemDraw will be required to return test answers. If using a scanner or camera, you will require blank or lined paper.

Course Materials

- *“Organic Chemistry”* by Jonathan Clayden, Nick Greeves, Stuart Warren. Oxford University Press, 2nd Edition, 2012. This book is available at the bookstore (and online), and will be the textbook I provide readings from.

This is the link to the book on the bookstore website:

<https://bookstore.dal.ca/CourseSearch/?course%5b%5d=SUB,WINT21,CHEM,CHEM3401,&>

- I encourage using molecular models to understand conformation and selectivity.
- Non-graded practice problems and their solutions will be made available on a regular basis. Successful study habits in organic chemistry typically involve actively, frequently, and repetitively practicing drawing mechanisms for the reactions under study, rather than simply reviewing the mechanism and attempting to reproduce the mechanism for the first time under evaluation.

Laboratory:

- All laboratory activities will be online.
- All work must be independent.
- Presentation of the lab material will be asynchronous.
- Each week there will synchronous online office hours where you can meet with your Instructor and discuss the material being presented in the lab modules, lab report questions and questions related to data analysis in general. The rest of the week the Instructor will be available via email.
- All the necessary laboratory information will be available in the CHEM3401 Brightspace site or in the indicated websites (see list below).
- The laboratory work will be divided in six (6) modules.
- Module 1 will be introductory and will provide you with fundamental tools that you will need this semester, such as how to process raw NMR data using TopSpin, how to conduct a proper literature search and how to prepare a synthesis.
- The content and instructions for each of these modules will be posted online on the Monday of the scheduled week in the form of slide presentations. This material will be accompanied with videos that will facilitate your understanding of a particular topic or procedure.
- The data provided in each module will be analyzed and discussed in lab reports that will be due two weeks after the module was posted. More details on lab reports can be found in Brightspace.
- At least one of the labs will have a synchronous/active learning component. More details will be available in Brightspace.
- No lab exemption will be given for these virtual labs in future years.

Useful Websites

Various websites are available containing information that complements that presented in the course, or may be of use in assignments.

- **Primary literature:**

There are many journals. A small set of important chemistry journals are shown below:

American Chemical Society Journals: <http://pubs.acs.org>

Royal Society of Chemistry Journals: <http://www.rsc.org/journals-books-databases/>

Angewandte Chemie International Edition: (German Chemical Society):

[http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1521-3773](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1521-3773)

Scifinder Scholar is a useful tool for searching the chemical literature

Dalhousie Scifinder Scholar: <https://libraries.dal.ca/research/scifinder-scholar.html>

- **Databases**

Aldrich: Chemical Catalogue, with physical properties and select NMR spectra of compounds

<http://www.sigmaaldrich.com>

SDBS: Database of NMR, IR, MS spectra for many compounds.

http://sdb.sdb.aist.go.jp/sdb/cgi-bin/direct_frame_top.cgi

Evans' pKa Table: Convenient table of pKas

http://ccc.chem.pitt.edu/wipf/MechOMs/evans_pKa_table.pdf

Bordwell pKa database: Extensive database of pKas

<https://organicchemistrydata.org/hansreich/resources/pka/>

Course Assessment

Component	Weight (% of final grade)	Date
Three tests	40 % (each is equal weight)	M, Feb 1 st ; F, Mar 5 th , W, Mar 31 st
Three Assignments	10 % (each is equal weight)	M, Jan 18 th ; W, Feb 24 th F, Mar 19 th
Final exam	30 %	(Scheduled by Registrar)
Laboratory	20 %	(See Brightspace for dates)

A passing grade (11/20) is required in the laboratory section to pass the class.

The assignments will be take-home assignments based on course material. I intend these to provide early feedback with a relatively low value to identify concepts you may struggle with in advance of the tests. Accordingly, you will obtain maximum benefit from these if you work your own, rather than in collaboration.

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D	(50-54)
A (85-89)	B (73-76)	C (60-64)	F	(<50)
A- (80-84)	B- (70-72)	C- (55-59)		

Course Policies

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If you are ill or experiencing a personal emergency at the time of a midterm test, e-mail Dr. Speed to inform him of the situation, and fill out a Student Declaration of Absence (SDA) form on Brightspace when you are able. If you are experiencing technical issues that prevent completion of an online test, exam, or assignment, please also e-mail Dr. Speed, and I will attempt to accommodate the issue. Sick notes are neither required nor permitted during the 2020/2021 academic year because of the current burden on the healthcare system. I do not typically offer make-up midterm tests, however in the case of excused absences for midterm test due to illness or another appropriate situation, the grading evaluation will remain 13.3% per completed midterm test, with the balance shifting to the final. Students suffering prolonged illness may wish to contact me or the Assistant Dean of Student Affairs to explore their options. Since I wish to recognize improvement, this alternate grading scheme may also be applied to a student showing substantial improvement on the final exam relative to in-class tests at my discretion (ie the lowest test will be dropped). For this to happen, the grade on the final exam would have to be higher than at least two of the midterm tests. Students who miss the final exam for a valid reason will be offered the opportunity to write a make-up final exam.

I realize this is a tough year for many people, and I seek to be reasonable in making accommodations for students that are fair and maintain the integrity of the course. While I can't guarantee every circumstance can be accommodated, please reach out to me if any aspect of the course structure is posing difficulty for you, and we can attempt to find a solution.

Course Content Includes

(Detailed readings will be assigned in class).

Part 1. Refresher on Functional Group Interconversion and Redox Chemistry

- Week of Jan 6th: Interconversion of carbonyl compounds – Chapter 10 (p 214-220), Chapter 23 (p 528-538), Chapter 23 (p 544-548).
- Week of Jan 11th Hydroboration/Oxidation
- Week of Jan 11th Protecting Groups (p 548-560)
- Week of Jan 11th Umpolung – Class Notes

Part 2. Carbonyl Chemistry

- Stabilized anion chemistry –
 - Week of Jan 18th Enolate formation and alkylation Chapter 20 (p 449-470), Chapter 25 (p 584-602)
 - Week of Jan 25th The Aldol and Claisen reactions and condensations– Chapter 26 (p 614-655)
 - Week of Feb 1st The Wittig and Horner-Wadsworth-Emmons reactions
- Conjugate addition – Chapter 22 (p 499-514), Chapter 25 (p 602-613)
 - Week of Feb 8th Conjugate addition
 - Week of Feb 8th Conjugate Substitution

Week of Feb 15th Reading Week

Part 2. Aromatic and Alkene Chemistry

- Reactions on benzenoid aromatics –
 - Week of Feb 22nd Electrophilic Aromatic Substitution Chapter 21 (p 471-497), Chapter 29 (p723-755)
 - Week of March 1st Nucleophilic aromatic substitution – Chapter 22 (p 514-526)
 - Week of March 1st Sandmeyer Reaction
- Organometallic Chemistry
 - Week of March 8th Aromatic Metalation: Chapter 9 (p 182-190),
 - Week of March 8th Cross-coupling: Chapter 40 (p 1069-1078 as background, then p 1078-1098)
 - Week of March 15th Alkene chemistry: metathesis, hydrogenation, and pi allyl chemistry (class notes)
- Heterocyclic Structure and Reactivity – Class Notes
 - Week of March 22nd Functionalization of pyridines
 - Week of March 22nd Functionalization of pyrroles, furans, thiophenes, and indoles

Part 3. Further reactivity

- Week of March 29th Heterocyclic synthesis – Chapter 30 (p 757-788)
- Week of April 5th Pericyclic reactions – Chapter 34 (p 877-896)

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Missed or Late Academic Requirements due to Student Absence

As per Senate decision instructors may not require medical notes of students who must miss an academic requirement, **including the final exam**, for courses offered during fall or winter 2020-21 (until April 30, 2021). Information on regular policy, including the use of the Student Declaration of Absence can be found here: https://www.dal.ca/dept/university_secretariat/policies/academic/missed-or-late-academic-requirements-due-to-student-absence.html.

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Code: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness

Statement: <http://www.dal.ca/cultureofrespect.html>

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates)

https://www.dal.ca/academics/important_dates.html

University Grading Practices

https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Student Resources and Support

Advising

General Advising https://www.dal.ca/campus_life/academic-support/advising.html

Science Program Advisors: <https://www.dal.ca/faculty/science/current-students/academic-advising.html>

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Black Students Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports

Library: <https://libraries.dal.ca/>

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Studying for Success: https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Copyright Office: <https://libraries.dal.ca/services/copyright-office.html>

Fair Dealing Guidelines <https://libraries.dal.ca/services/copyright-office/fair-dealing.html>

Other supports and services

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html

Student Advocacy: <https://dsu.ca/dsas>

Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Safety

Biosafety: <https://www.dal.ca/dept/safety/programs-services/biosafety.html>

Chemical Safety: <https://www.dal.ca/dept/safety/programs-services/chemical-safety.html>

Radiation Safety: <https://www.dal.ca/dept/safety/programs-services/radiation-safety.html>

Scent-Free Program: <https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html>