

**Faculty of Science Course Syllabus (Section A)****Department of Chemistry***Chemistry 4401/5401 (CRN 10459/13310)**Synthesis in Organic Chemistry**Fall 2021*

***Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.***

Instructor(s): Dr. Alex Speed      aspeed@dal.ca

Lectures:      Tuesday/Thursday 10:05–11:25      (Chemistry 125)

Office hours: By Appointment, Room 413 Chemistry Building, or remotely, on Teams or Zoom.

Course delivery: In-person, Chemistry 125. Lectures will not be recorded, however lecture notes will be made available on Brightspace.

**Please do not wear strongly scented products to lecture or office hours. For more information, see Dalhousie's "Scent Free" Policy (See link in Section C of Syllabus on last page).**

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**Course Description:** A number of important organic reactions are examined in depth with particular attention to regioselectivity and the development of relative or absolute stereochemistry. Applications of these reactions in the synthesis of complex molecules are illustrated with recent examples from the literature.

**Course Prerequisites:** The prerequisite to this course is CHEM 3401 or an equivalent at another university. CHEM 3404 is helpful, but not required. **Organic synthesis is a cumulative discipline, and it is expected that you have retained knowledge of reactions and concepts covered in preceding courses.**

**Course Exclusion:** CHEM 4401 and CHEM 5401 are the cross-listed classes for undergraduate students and graduate students respectively. Credit cannot be obtained for both CHEM 4401 and CHEM 5401. Students enrolled in CHEM 5401 will write tests with slightly different questions to CHEM 4401.

**Learning Objectives:** The aim of this class is to provide the tools to understand advanced concepts in selectivity in organic chemistry. We will begin by reviewing terminology and descriptors associated with stereochemistry. We then discuss regioselectivity and stereoselectivity in pericyclic reactions. We will then explore acyclic stereocontrol of selected reactions through three-dimensional consideration of reagent approach and conformation. Modern asymmetric catalysis will then be introduced. The course will then finish with an overview of radical chemistry, including modern C-H functionalization and photoredox catalysis. We will refine concepts of chemoselectivity that have been taught in preceding organic courses. At the end of the course, students will be able to analyze and predict the stereochemical outcome of common reactions, develop strategies for controlling stereochemistry in synthesis, and be able to design chemical reactions using radical processes.

### Course Materials

There is no required textbook for this course, however the following resources may be beneficial in the course:

- “*Organic Chemistry*” by Jonathan Clayden, Nick Greeves, Stuart Warren. Oxford University Press, 2<sup>nd</sup> Edition, 2012. (This is the textbook used in CHEM 3401 at Dalhousie).
- A comparable textbook is available online:  
“*Advanced Organic Chemistry, Part B: Reactions and Synthesis*”, 5th Edition, by Carey and Sundberg, Springer, 2007.  
This book is available on-line courtesy of the Canadian Research Knowledge Network. To Dal students on campus, this text-book is available at the following URL:
  - <https://link.springer.com/book/10.1007/978-0-387-44899-2>
  - **for home use of this**, or any other Dalhousie Library resource, modify URL to include the proxy server as follows. If the URL starts with https://, remove this, otherwise an error will be encountered:  
<http://link.springer.com.ezproxy.library.dal.ca/book/10.1007/978-0-387-44899-2>
- I encourage using molecular models to understand conformation and selectivity, and these will be permitted during examinations, however they are not required.
- Avogadro is free software that allows models of molecules to be constructed and rotated. It is available at: <https://avogadro.cc/>
- Practice problems and their solutions will be made available on a close to weekly basis on Brightspace.
- Successful study habits in organic chemistry typically involve actively 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.

### 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:  
**Home Access: See above for how to modify URLs to use Dalhousie’s proxy server if you are off campus. Otherwise you will encounter a paywall. On campus, the URLs can directly be used.**

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

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

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

Dalhousie Scifinder [http://libraries.dal.ca/research/sciences\\_research/sfs.html](http://libraries.dal.ca/research/sciences_research/sfs.html)

**Scifinder** is a useful, although sometimes frustrating tool for searching the chemical literature

- **Databases**

<http://www.sigmaaldrich.com> Catalogue of large chemical supplier, with physical properties and select NMR spectra of compounds

[http://sdb.sdb.aist.go.jp/sdb/cgi-bin/direct\\_frame\\_top.cgi](http://sdb.sdb.aist.go.jp/sdb/cgi-bin/direct_frame_top.cgi) Database of NMR spectra.

[http://ccc.chem.pitt.edu/wipf/MechOMs/evans\\_pKa\\_table.pdf](http://ccc.chem.pitt.edu/wipf/MechOMs/evans_pKa_table.pdf) Convenient table of pKas

<http://www.chem.wisc.edu/areas/reich/pkatable/> Extensive database of pKas

### Course Assessment

Component	Weight (% of final grade)	Date
Two in-class tests (80 minutes)	40 % (20 % each)	R, Oct 14 <sup>th</sup> ; R, Nov 18 <sup>th</sup>
One in-class quiz (40 minutes)	10 %	R, Dec 2 <sup>nd</sup>
Final exam (3 hours)	50 %	(Scheduled during examination period by the Registrar)

The first test will focus on the material from the first part of the course, the second test will focus on material taught between the first test and the second test, and the quiz will focus on material taught after the second test. However, since the course builds on cumulative knowledge, the second test and quiz are to some extent cumulative. The final exam will cover all aspects of the course, and while the weight on various sections will be approximately equal, to some extent the final exam questions will test on accumulated knowledge.

#### For 4401:

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)

#### For 5401:

The following grading scheme for graduate students will be used:

A+ (90-100) B+ (77-79)

A (85-89) B (73-76) F(<70)

A- (80-84) B- (70-72)

**Course Policies**

If you are ill or experiencing a personal emergency at the time of a midterm test or quiz, 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. Sick notes from a medical professional are not required. In the case of excused absences for a midterm test or quiz, a fair, but more challenging make-up test may be offered at my discretion, or alternatively the balance of the grade may be shifted 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, an alternate grading scheme may also be applied to a student showing substantial improvement on the final exam relative to in-class tests/quiz. In this scheme, the best combination of the final exam, and only two of the in-class tests/quiz would be applied, with the final exam replacing the grade of the dropped in-class test or quiz. This option will be offered at my discretion, when the grade on the final exam is substantially higher than that obtained on at least one 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.

**Course Policies related to Academic Integrity**

Since practice assignments are ungraded, students may choose to work together or separately on the practice problems. The tests, quiz, and final exam are written individually, and will be closed-book.

**Course Content:** The following topics may be covered in the course. The order of the topics in each sub-section, and pace of instruction may vary, so lecture number are only approximate.

**Part 1: Introduction to synthesis/ stereochemical terminology**

Lecture 1:

Stereochemistry- Terminology refresher  
The importance of stereochemistry  
Resolution (salts, kinetic, dynamic kinetic)

Lecture 2:

Determination of configuration/ enantiomeric excess  
Overview of strategies to control stereochemistry

Lecture 3:

Overview of modern synthetic chemistry  
Linear vs convergent synthesis  
Retrosynthetic analysis/ synthetic planning

**Part 2: Pericyclic Chemistry**

Lecture 4:

Overview of classes of pericyclic reaction  
Frontier Molecular Orbital Analysis  
Dewar Zimmerman Analysis

Lecture 5:

Cycloadditions: Diels-Alder reaction- regio and stereoselectivity

Cycloadditions: Dipolar cycloadditions

Lecture 6:

Sigmatropic Reactions: The Cope and Claisen variants

Lecture 7:

Electrocyclic reactions

Photochemical cycloadditions

**Part 3: Acyclic Stereocontrol**

Lecture 8:

Contrast with cyclic stereocontrol

Conformational analysis

A1,3 Strain

Directed Reactions (epoxidation, hydrogenation, cyclopropanation)

Lecture 9 and 10:

Diastereoselective Aldol (Zimmerman Traxler and Ireland Models)

Diastereoselective (and enantioselective) allylation

**Test on first part of course material.**

Lecture 11:

The Evans Auxiliary

Asymmetric Alkylation

Asymmetric Auxiliary Diels-Alder

Lecture 12:

Asymmetric Aldol

Directed 1,3 diol reductions

Lecture 13:

Carbonyl addition models

**Part 4: Asymmetric Catalysis**

Lecture 14:

Theory Behind Asymmetric Catalysis

CBS Catalysts

BOX Ligand

Lecture 15:  
Asymmetric Hydrogenation  
Sharpless epoxidation and dihydroxylation  
Jacobsen epoxidation and HKR

Lecture 16:  
Iminium and enamine catalysis  
Chiral Brønsted Catalysis

Lecture 17:  
Copper Carbene catalysis  
Diastereoselective Olefin Metathesis  
Diazaphospholene case-study

**Test on second part of course material.**

### **Part 5: Radical Chemistry**

Lecture 18:  
Terminology for radical mechanisms (arrows, initiation, propagation, termination)  
Classical Tin hydride chemistry  
Norrish and Barton photochemistry

Lecture 19:  
C-H Activation Chemistry  
Minisci Chemistry  
Photoredox chemistry

Lecture 20:  
HAT/Photoredox chemistry  
Metallaphotoredox chemistry

Lecture 21:  
Organic photosensitizers  
Electrophotoredox chemistry

### **Quiz on Third Part of Material**

Lecture 22:  
Wrapping everything together.



**Faculty of Science Course Syllabus (Section B)  
Fall/Winter 2021-22**

**Department of Chemistry**

*Chemistry 4401/5401 (CRN 10459/13310)*

*Synthesis in Organic Chemistry*

**University Policies and Statements**

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

**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](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](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](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](mailto:elders@dal.ca)).

**Information:** [https://www.dal.ca/campus\\_life/communities/indigenous.html](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](https://www.dal.ca/academics/important_dates.html)

**University Grading Practices**

[https://www.dal.ca/dept/university\\_secretariat/policies/academic/grading-practices-policy.html](https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html)

**Faculty of Science Course Syllabus (Section C)  
Fall/Winter 2021-22**

*Chemistry 4401/5401 (CRN 10459/13310)  
Synthesis in Organic Chemistry*

**Student Resources and Support**

**Advising**

**General Advising:** [https://www.dal.ca/campus\\_life/academic-support/advising.html](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](https://www.dal.ca/campus_life/communities/indigenous.html)

**Black Students Advising Centre:** [https://www.dal.ca/campus\\_life/communities/black-student-advising.html](https://www.dal.ca/campus_life/communities/black-student-advising.html)

**International Centre:** [https://www.dal.ca/campus\\_life/international-centre/current-students.html](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](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](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](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](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>

**Dalhousie COVID-19 information and updates:** <https://www.dal.ca/covid-19-information-and-updates.html>