

Faculty of Science Course Syllabus
Department of Chemistry
Chem 4201: Advanced Topics in Separations
WINTER, 2022

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

Instructor: Dr. Alan Doucette alan.doucette@dal.ca

Office Hours: Monday, 12:35 – 1:30 pm & Wednesday 10:30 – 11:15 am ¹

I will be available in my office (Chemistry, room 506) at these times. *You can also reach me online (Microsoft Teams). Feel free to request a specific appointment time if office hours do not work for you. I check email 7 days a week.*

Lectures: IN PERSON DELIVERY: MWF, 11:35 am – 12:25 pm (LSC C206) ²

ONLINE DELIVERY: Remote participation in all lectures will be provided through our Microsoft Teams group. ³ Lectures be livestreamed and recorded and later accessible through Microsoft Teams.

ASYNCHRONOUS LECTURES: Video recordings will be made available on my YouTube Channel ([ShortChemistry](#)). These videos will replace 3-4 in-person classes when I am away and unable to lecture. Links to these videos will be posted on the course Brightspace webpage.

Tutorials: Optional tutorials may be scheduled as requested, typically as we approach a midterm.

¹ All times listed in this syllabus are in Atlantic Standard Time (AST)

² In the event of campus closure, lectures will continue to be offered remotely at times scheduled

³ A laptop with video camera & microphone is recommended for remote classroom participation

Course Description

Classical methods (solvent and solid phase extraction) are discussed, with emphasis on equilibrium. Column chromatography topics include gas and liquid systems are described, including their coupling to analytical detectors. Multidimensional techniques as well as electrophoretic separations are also presented. Examples in biological analysis are drawn from the current literature.

Course Prerequisites

CHEM 2201.03 (grade of C- or better)

Cross listing: Chem 5201.03

Course Materials

- Course website: Brightspace (accompanied by my YouTube channel, ShortChemistry). Included is a complete set of lecture notes, pre-recorded lecture videos, problem sets and recommended reference materials.

Communication

Announcements related to the course will be communicated through the course website. Additionally, please check your Dalhousie email regularly for course related communications. It is preferred that you post course-material related questions on the Brightspace discussion board, so that my comments can be shared with the entire class.

Course Assessment

The following grading scheme will be used for Chem 4201:

| Component | Weight (% of final grade) | Date |
|---------------------|----------------------------------|---|
| Test 1 | 14 or 21% ^a | Feb 7 (50 min, in class) ^{b,c} |
| Test 2 | 14 or 21% ^a | Mar 21 (50 min, in class) ^{b,c} |
| Presentation | 15% | <i>last 3 weeks of class</i> |
| Assignments | 15% | 3 total (<i>dates provided in class</i>) |
| Final exam | 35% | <i>Scheduled by Registrar ^d</i> |

^(a) The highest score of your two tests will be weighted 21%, and your lowest will be 14%

^(b) Testing dates & delivery method are subject to change if this class is significantly impacted by Covid (including hosting online tests and presentations) All changes will be through a consensus agreement with the class prior to implementation.

^(c) Makeup test dates are Feb 8 and Mar 22 (2:00-3:00 pm); please notify me if you wish to write the makeup for any reason.

^(d) Final exam will be conducted in two parts, with up to 1.5 hours per section and with a 1-hour break in between. The final exam encompasses all material covered throughout the term, including those topics covered through student presentations.

**** All assessment components in this class must be completed individually.***

Other course requirements

All students will be required to meet with the instructor (in person or Microsoft Teams), approximately 1 week prior to their in-class presentation (max 1.5 hours) to provide and receive feedback on your in-class presentations.

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

| | | | |
|---------------------|---------------------|---------------------|--------------------|
| A+ (90-100) | B+ (77-79.9) | C+ (65-69.9) | D (50-54.9) |
| A (85-89.9) | B (73-76.9) | C (60-64.9) | F (<50) |
| A- (80-84.9) | B- (70-72.9) | C- (55-59.9) | |

Course Objectives/Learning Outcomes

- Understand the relationship between pH and charge state for polyprotic species
- Classify various forms of analytical separation
- Determine optimal conditions to isolate compounds based on component characteristics, including size, charge and polarity.
- Use diagrams to illustrate chromatographic and electrophoretic separation platforms
- Identify the principle instrumental components used in chromatography and electrophoresis
- Relate how poor chromatographic practices lead to band broadening and describe how to minimize the effects
- Calculate peak width based on plate and rate theory
- Support the application of the most appropriate mode of separation for isolation of specific components from one another
- Apply equations to solve for retention/ migration time in chromatography and electrophoresis
- Predict the extraction efficiency of a compound based on acid/base characteristics, and translate these values into purity of said compound
- Discuss the limitations of calibration methods in reporting the amount of analyte in an unknown
- Describe how analytical separation platforms are coupled to various detectors, including mass spectrometry.
- Organize relevant information into a logical and informative presentation
- Design a PowerPoint presentation that illustrates and outlines a modern application of analytical separations
- Critique student presentations
- Derive questions based on information presented in class

Missed or Late Academic Requirements due to Student Absence

At this time, we remain in a pandemic, with several restrictions and recommendations described by Nova Scotia Public Health and by Dalhousie University. This includes policies on mask wearing, vaccination, testing, and physical distancing. All students are required to comply with health and safety requirements on campus and should be considerate of others' health concerns. Non-compliance may be reported under the Code of Student Conduct.

At the time of writing this, case numbers are on a steep incline. It is unknown whether there may be partial (or complete) campus closures throughout the winter term. Even if campus remains open, this does not preclude the fact that individuals may still be affected. As recommended by public health, if you are feeling ill or displaying flu-like symptoms, ***stay home!*** It is for this precise reason that all lectures will be available in person as well as remotely. You may also prefer to meet with me online rather than in person. This will also be accommodated.

If, due to illness, you are unable to attend a scheduled meeting, presentation, midterm, or are unable to complete an assignment within the scheduled period, **you must contact the instructor prior to the missed event.** A **student declaration of absence form** is required for accommodating any missed graded component. Makeup test dates are posted, and your presentation will be rescheduled to the next available opportunity. If the makeup test is also missed, marks may be redistributed to other assessment components to determine a final grade. Please note that the makeup test may not necessarily be identical to the original test.

If you miss the final exam, I must be notified within 24 hours, and a student declaration of absence form must be completed. A makeup will be scheduled at a mutually agreeable time. The final exam must be written to complete the course.

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

All midterms, the final exam, and assignments are to be completed individually. While student presentations are delivered individually, the class is strongly encouraged to collaborate and provide feedback on early drafts of the presentation. Classroom discussions will be a regular feature of our lectures.

Course Content**INTRODUCTORY CONCEPTS** (~3 lectures)

- (a) Historical perspectives
- (b) Forms of separation
- (c) Units/ dilutions
- (d) Calibration
- (e) Detectors

EXTRACTIONS (~5 lectures)

- (a) Acid/base chemistry
- (b) Solvent extraction
- (b) Partition coefficient/ distribution coefficient
- (c) Purity/ Yield

CHROMATOGRAPHY (~10 lectures)

- (a) Instrumentation
- (b) Plate/ rate theory
- (c) Gas and liquid chromatography
- (d) Column formats (IEX, SEC, Affinity)
- (e) Extra column broadening
- (f) Multidimensional separations
- (g) Coupling to mass spectrometry

ION MOBILITY & ELECTROPHORESIS (~7 lectures)

- (a) Ion Mobility Spectrometry
- (b) Principles of electrophoretic separation
- (c) Capillary electrophoresis
- (d) Isoelectric focusing, SDS PAGE
- (e) Microfluidics
- (f) Protein precipitation

STUDENT PRESENTATIONS (~7 lectures)

List of potential topics is provided.

Topics explore modern applications of separation science.

First student presentation tentatively scheduled for March 23.

NOTE: You are also responsible for the material delivered through the student presentations. This will be covered on your final exam.

OTHER (4 lectures)

Two classes will be spent writing tests

One class will a workshop in preparation for your presentation

I'm hoping there will be time for a review immediately prior to your tests.

University Policies and Statements

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

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-studentconduct.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/servicessupport/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-toget-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-andupdates.html>

A Presentation on Current Topics in Separation Science (Winter 2022)

Your presentation is intended to outline a *current topic* in the field of separations. The suggested topics are meant to complement, but not duplicate the material already covered in this class (see course outline). You will be presenting your topic individually and are given the choice of giving a live presentation (in class), or creating a pre-recorded video, such as those I have posted on YouTube. Regardless of the method of delivery, other students from the Chem 4201/ 5201 class will watch your presentation and together with the instructor, will ask questions at the conclusion of your presentation.

All students enrolled in Chem 4201/5201 are responsible for the material you will personally present through your lecture. This material will be examined on the final exam. No two presentations will cover the exact same material. As your presentation is an integral component of this class, it is my objective to ensure that every student does the best job possible, not only in the delivery of the material, but also in determining the specific content to emphasize. In addition to your presentation, your slides/ recording will be made available to the class as part of their collection of course reference material.

Presentation Format:

All presentations and associated discussions will take place after the second in-class test and occupy the bulk of lecture time (Mar 23 – Apr 6). Your final presentation date will be selected by the instructor. Each presentation should aim to be **12 min long**, allowing ~5 min of question & discussion from the audience (including the instructor). Live presentations must be conducted using Powerpoint or similar electronic format (no ‘chalk talks’). Pre-recorded videos may involve a multitude of visual aids. Your presentation file (slides, video) should be uploaded to the instructor a minimum 24 hours prior to your presentation, which will be shared with the class. Pre-recorded videos will only be posted to YouTube upon written permission by the student.

Workshops:

To aid the development of your presentation, you will work with the instructor and members of the class. Your first task is to pick a topic and will involve a short meeting with the instructor. This can be done via email exchange, but ideally should involve a discussion with the instructor. You should have selected one or two key references and outline the general topic you wish to cover. Remember no two topics can be identical. Topics must be approved by the instructor, and occur on a first come, first serve basis.

You will next participate in a presentation workshop, (scheduled during class time Mar 4). This workshop is intended to share a ‘rough outline’ of your presentation, seeking feedback from a group of your peers. You should have a good sense of the material you want to discuss, with at least a couple of completed slides that demonstrate the final look and style of your presentation. At this time, I may suggest specific content to add, emphasize or remove, and will also comment on the delivery style.

Workshops continued:

For those intending live presentations, your second workshop will be scheduled outside of class at a mutually agreed time (up to 90 min, roughly 1 week prior to final talk). Together with a small group of your peers (typically 3 at a time), you will deliver a formal ‘practice talk’, with feedback from your peers and instructor. The aim of these meetings is to make final tweaks to your presentation and ensure that everyone does the best possible job in clearly presenting their material, while ensuring that relevant material is presented for the benefit of the class.

For those intending a pre-recorded video, the above-described workshop should take place prior to recording your video and will involve a ‘dry run’ of your talk, overlaid with your visual aids. It is recommended that this meeting takes place a minimum 2 weeks prior to your final presentation.

Summary of Dates:

Topic Selection: Feb 18. The earlier the better. First come, first served.

Workshop 1: Mar 4. In class. Complete an outline of talk, along with a couple of slides.

Workshop 2: ~1 week prior to live presentation, scheduled outside of class. Be prepared to deliver a fully rehearsed talk and give/ receive feedback.

Assessment:

The presentation constitutes 15 % of your total grade, with breakdown as follows:

| | |
|---------------------------------|---------|
| a) Workshop #1 (rough outline) | 2 marks |
| b) Workshop #2 (full rehearsal) | 5 marks |
| c) Formal presentation | 8 marks |

A detailed grading sheet will be provided later. Note that the rehearsal talk, presented during your second workshop, will place less emphasis on your delivery style. Also, since pre-recorded talks have the opportunity for multiple takes and/or edit mistakes, the standards of your delivery will be higher than a live presentation. Components of your presentation that factor into the final grade include:

- ✦ *Depth and implications of science*
- ✦ *Interest level of the content presented*
- ✦ *Speaking style and enthusiasm*
- ✦ *Quality of visual aids*
- ✦ *Your level of understanding of the material (based on audience questions)*

Topic Selection:

A list of past topics is provided as a general guide, though you are free to pick any topic with an emphasis on separations. A literature search (science citation index / web of science) of your topic would be a good place to start, as I am sure it will yield numerous hits. I do not mind if the topic

is close to your own interests or research – in fact, I highly encourage it! But you should not be presenting data generated directly from your personal research. If you're stuck on a topic, please meet with me to discuss.

Once you have selected a potential topic, you must meet with me to discuss the idea. All topics must be approved by the instructor. Include a minimum of two peer-reviewed references (please attach links to these references) and a descriptive title for your presentation. It would be helpful to also provide a short paragraph description of what you hope to cover. Topics will be assigned on a first come, first serve basis, with a tentative presentation date determined by the instructor. No two presentations will cover the identical material.

***** Deadline for *selection and approval* of your topic is Friday Feb 18 *****

Late topic selections will result in a 1-point daily deduction from your total presentation grade. Similarly, students who present late will result in a 1-point daily penalty, unless extenuating circumstances are present.

List of potential topics (for inspiration – your choice can be anything!)

1. Metabolomics / lipidomics or other 'omics fields
2. Coupling separations to mass spectrometry
3. Membrane Filtration
4. Capillary gel electrophoresis
5. Micellar Electrokinetic chromatography (MEKC)
6. Centrifugation
7. Digital Microfluidics (DMF)
8. Industrial applications of separations
9. Affinity-based separations
10. Optoelectronic Tweezers
11. Aptamer selection
12. Solid phase microextraction
13. Immobilized Enzyme Reactors (IMERS)
14. Chiral Separations
15. Preparative Separations
16. New stationary phase design/ construction
17. Green Separations
18. Field Potable Devices and Application

It is hoped that the students gain an appreciation of the many forms of separation, and how essential they are to analytical science (and everyday life). You are welcome to choose any topic on this list, to combine multiple topics, or to select from topics not presented.

Assignments (Chem 4201)

This course includes three independent assignments associated with class material. These involve aspects of the course that are not readily testable on midterms and exams.

- Your first assignment will be calculation-based and involve the creation of a ‘mini’ program in MS Excel to calculate charge states of a polyprotic species.
- The second assignment will involve the creation of a (short) report, communicating your selected presentation topic in written format (plus a picture) to a general audience.
- The final assignment will involve the creation of questions stemming from the student presentations

These assignments are each expected to constitute individual work. They will be distributed in class and be given a minimum 1 week to complete.

Assignments are each worth 5 points, for a total 15% of the final course grade.