Analytical Spectroscopy and Separations

Department of Chemistry

CHEM3201, Winter 2025/26

Dalhousie University operates in the unceded territories of the Mi'kmaw, Wolastoqey, and Peskotomuhkati Peoples. These sovereign nations hold inherent rights as the original peoples of these lands, and we each carry collective obligations under the Peace and Friendship Treaties. Section 35 of the Constitution Act, 1982, recognizes and affirms Aboriginal and Treaty rights in Canada.

We recognize that African Nova Scotians are a distinct people whose histories, legacies, and contributions have enriched the part of Mi'kma'ki known as Nova Scotia for over 400 years.

Course Instructor(s)

Name	Email	Office
Lecturers		
Dr. Malama Chisanga	malama.chisanga@dal.ca	Room 511, Chem Building
Dr. Alan Doucette	alan.doucette@dal.ca	Room 509, Chem Building
Lab instructor:		
Dr. Mark Wall	mark.wall@dal.ca	Room 109, Chem Building

Lectures: MWF 11:35-12:25, Studley LSC-COMMON AREA C234, (1st lecture: 7th January 2026)

Course Delivery: Lectures: In person
Labs, quizzes, midterms, and exams will also be delivered in person.

Laboratories: Weekly 4-hour labs, Chemistry Rooms 111-114P. Labs begin the week of 19th January 2026.

Course Description

An introduction to the fundamentals of instrumental chemical analysis is presented, with emphasis on separation and spectroscopy, along with sample treatment, data handling, and the interpretation of experimental results. Instrumental tools to be covered include chromatography, mass spectrometry, and vibrational spectroscopy (IR & Raman), as well as enhanced spectroscopies (SERS: surface-enhanced Raman scattering), with applications illustrated in biological, environmental and health-related fields.

Course Prerequisites

CHEM 2201 or equivalent. Grade of C- or better.

Objectives/Learning Outcomes:

- To understand the fundamental concepts underpinning separation science (chromatography, mass spectrometry) and molecular spectroscopies (IR, Raman, SERS) applied to chemical analysis.
- To describe the principle of operations behind separation and spectroscopic instrumental tools.
- To familiarize with sample preparation workflows for qualitative and quantitative analysis involving separation and spectroscopy techniques.
- To apply separation science and spectroscopy to provide solutions to problems in chemical analysis and sensing related to bioanalytical, environmental and biomedical sciences.

Course Materials

Textbooks:

This will be the first time this course is taught in this format. The course comprises two sections (separations and spectroscopy), which will be taught independently by two professors: Dr. Alan Doucette (separations *(Part 1)*: Jan-Feb) and Dr. Malama Chisanga (spectroscopy *(Part 2)*: Feb-April). Students are encouraged to take their own lecture notes as supplementary material to the course instructors' teaching notes and to the textbooks and manuscripts listed below.

- Ramaley, Wentzell, Doucette and Guy (2016), *An Introduction to Analytical Chemistry*, 8th Ed. Available (free) as a pdf file from the course website (Brightspace).
- Peter J. Larkin (2018), *Infrared & Raman – Principles and Spectral Interpretation*, 2nd Ed, Elsevier.
- Malama Chisanga, Howbeer Muhamadali, David Ellis & Roy Goodacre. *Enhancing disease diagnosis: biomedical applications of surface-enhanced Raman scattering*, Applied Science, 2019, **9**, 1163.

Laboratory Manual: Available electronically through the laboratory Brightspace site.

Laboratory Notebook: For recording observations and data during labs. Please refer to the notebook requirements provided on Brightspace.

Technology: For online participation, a computer with a webcam/microphone is recommended.

Safety: Approved safety glasses (CSA-Z94-3 or ANSI Z87) and knee-length lab coats are required. Both are available for purchase at the Dalhousie bookstore. See **Note K** for more safety requirements.

Web Site

The lecture and lab portions of the course each run their own Brightspace sites. Please consult each regularly, as all learning materials will primarily be shared via Brightspace.

Office Hours

Thursday, 2-3 pm (Dr. Chisanga)
Wednesday, 3-4 pm (Dr. Doucette). One-on-one appointments can be arranged by appointment.

Course Assessment

LECTURE

Component	Weight	Date(s)
Term Test #1	20 %	Thursday, February 26, 6:00 – 8:00 pm [(A)]
Quizzes (x3)	15 %	Jan 9; Jan 30; Feb 13. During lectures, ~25 min/quiz
(End of Part 1)		
Term Test #2	10 %	Tuesday, March 31, 6:00 – 7:00 pm [(A)]
Quizzes (x3)	5%	March 6; March 13; March 20
(End of Part 2)		During lectures, ~20 min/quiz
Final Exam *(Spectroscopy only)*	20 %	Scheduled by the Registrar [(B)]
TOTAL	**(70 %)**	

LAB [(C)]

Component	Weight	Date(s)
Pre-labs	1%	Due before each lab[(E)]
Reports	20%*	Due 1-week after each lab by 11:30 pm[(F)]
Research Project Presentation	5%	March 30th – April 2nd[(G)]
Proposal	1%	Sunday, March 1st at 11:30 pm
Notebook	2%	Assessed at the end of each lab period[(H)]
SUBTOTAL	**(30%)**	

Notes and Policies on Course Assessments:

(A) **Term tests 1 and 2** are each offered in the evening, which allows you more time to write the tests. **Midterm 1 and 2 tests will be held in Room 135 of the Dunn Building (Department of Physics and Atmospheric Science)**. We will begin the test promptly at 6:00 pm, so please arrive ~10 min early. If you miss a midterm or quiz, please submit a student declaration of absence form and contact the instructor. Scheduling make-ups or transferring grades to other course components will ultimately be at the instructor's discretion in liaison with the affected students.

Students with a direct course conflict will be offered the choice to write a makeup test (date and time to be determined) or to transfer marks to other course portions. If you have such a conflict, you must notify the instructor as soon as possible and provide supporting evidence for your class conflict.

(B) **Final exam**: Scheduled by the registrar's office with a date provided later in the term. This will be a 3-hour exam based solely on the lecture material covered in Part 2 (spectroscopy) of the 3201 course. When transferring grades from a missed midterm or quiz onto the final exam, the marks will transfer into the equivalent 'section' of the exam that covers the equivalent material.

(C) **Laboratory** components of the course total 30%. You do not need to pass the lab to pass this course (nor to pass the lecture to pass the course). However, students requesting a future lab exemption must submit a request to Dr. Wall. Any student seeking a future exemption must have **completed** a

minimum of 6 of 7 lab experiments in person, submitting each of their post-lab report and obtaining a passing lab grade (15/30) as well as obtaining a letter grade for the CHEM3201 course (A – F) within the last two years (i.e., Winter 2024 or Winter 2025).

Labs end strictly at 5:30 pm each day. Please budget at least 15 minutes at the end of every lab period to clean up your workspace and copy data. Be efficient in the lab and manage your time to ensure you can complete all parts of an experiment. Otherwise, you may not have the experimental data to fully complete the lab report questions in the discussion section of the submitted lab report.

(D) Lab Manual: The CHEM3201 lab manual will be provided digitally on Brightspace. This document contains safety information, theory, background, and experimental details, as well as the pre-lab and post-lab report questions. The lab manual serves as a primary resource in addition to the textbook, and students are required to read the relevant sections prior to attending the lab and to prepare their laboratory notebook with the information for that day.

(E) Pre-lab questions, located in the CHEM3201 lab manual, must be completed and recorded in your hardcover notebook prior to conducting the experiment for that day and will be checked at the start of each lab period. It is encouraged to complete the pre-lab well in advance of the experiment and seek assistance from your teaching assistants or instructor if you encounter any confusion.

(F) Lab Reports are submitted as a PDF on Brightspace as a group and are due by 11:59 pm on the listed due dates. If completed before the due date, reports may be submitted earlier. Only digital copies in PDF format will be accepted. A single 1-week extension period on any one lab is offered to each group without question for any given experiment, after which, late reports are subjected to an immediate 15% grade penalty up to 1-week. After this week, grade sheets will no longer be accepted.

A template for lab reports will be provided through Brightspace. Lab reports will comprise three sections: experimental, data, and results. These sections will have word limits to encourage concise and efficient communication. Figures, tables and supplementary data will not count towards the word limits for a given section.

(G) Research projects will be carried out in the last three weeks of the lab course from a selection of provided topics, which may include techniques and instrumentation not covered in the regularly scheduled experiments. The purpose of the research project is to give students an introduction to literature searching, experimental design, problem solving, and oral scientific communication.

This project will include the submission of a research project proposal. The Research Project Proposal is due on Sunday, March 1st at 11:30 pm, which will outline your experimental design to answer your research question related to your chosen project.

(H) Lab Notebook and workspace will be inspected by the instructor or TA at the end of each lab session. Satisfactory cleanup and sharing of raw data will award the group their lab performance mark for that day. If a request by the teaching team is given to the group to improve their workspace, the request must be completed by the students prior to leaving and awarding the lab performance mark. If students leave prior to cleaning up their workspace and sharing raw data, they may not receive full marks.

(I) Missed labs: Your first missed lab does not require any documentation. Further missed labs will require a declaration of absence form and emailed to mark.wall@dal.ca. Students must request a makeup by emailing Dr. Mark Wall at mark.wall@dal.ca and providing availability. All labs run from 1:30 pm – 5:30 pm Monday to Thursday. In the event of lab cancellations due to closures, an email and Brightspace announcement will be made with information regarding possible makeup (potentially utilizing the Friday afternoon) or alternative grading.

(J) Safety: Students must complete a Workplace Hazardous Materials Information System (WHMIS) and Laboratory Safety training within the last three years. Links to register and the location to upload completion certificates can be found in Brightspace. The due dates for the WHMIS course are January 11th, and Laboratory Safety, January 18th, by 11:59 pm.

(K) Intellectual honesty regarding data collection will be monitored throughout each experiment by the collection of your raw data and lab notebook review at the end of each experiment. The fabrication or copying of data from another student constitutes an academic integrity violation, and suspected cases will be brought to the Academic Integrity Officer (AIO) for review.

Dalhousie Grade Scale

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (0-49)
A- (80-84)	B- (70-72)	C- (55-59)	

A+, A, A- Considerable evidence of original thinking; demonstrated outstanding capacity to analyze and synthesize; outstanding grasp of subject matter; evidence of extensive knowledge base.

B+, B, B- Evidence of grasp of subject matter, some evidence of critical capacity and analytical ability; reasonable understanding of relevant issues; evidence of familiarity with the literature.

C+, C, C- Evidence of some understanding of the subject matter; ability to develop solutions to simple problems; benefitting from his/her university experience.

D Evidence of minimally acceptable familiarity with subject matter, critical and analytical skills (except in programs where a minimum grade of 'C' or "C+" is required).

Lecture Format

Lectures will be delivered in person in Studley LSC-COMMON AREA C234.

Course Policies

Absences. Missing a test simply requires a declaration of absence form. SDAs may be used only twice in the same course. Missed labs require contacting the lab instructor to arrange a makeup time. Do so ***as soon as possible*** (phone, email, or in person).

University closures. The university could close unexpectedly for several reasons. Short-term closures may result in missed lab work. All attempts will be made to provide an in-person or online makeup lab. In-class tests/quizzes will normally be rescheduled to the next lecture. Evening midterm tests and final exam will be rescheduled as soon as possible, and notice will be given.

Longer-term university closures may affect the lecture and/or lab components, necessitating more substantial changes to the syllabus, including the material covered and the assessment components offered. This will require a redistribution of the assessments. This may alter the relative weight of lecture vs lab material or reduce the number of the assessment components.

E-mail. Use e-mail for issues related to administrative matters or short queries related to content.

Electronics. Cell phones should be turned off during lectures and labs.

Academic Integrity. A significant component of this course is problem solving, and students can work together on textbook exercises if that enhances their learning. Online resources, including AI software (e.g., ChatGPT), can assist with practice problems but cannot be used to complete lab reports or prelab questions. Suspected violations of academic integrity will be treated in accordance with university policy.

Extended Class/Lab Disruptions.

We all realize that the classes and/or labs can be disrupted for several reasons. In past years, Dalhousie has had to close (for multiple weeks) due to hurricanes, power outages, storms, COVID, and labour disruptions.

If lectures, assessments (tests), or labs are disrupted by any of the above events, we will do our best to minimize the disruption. If we miss an in-class quiz due to a short-term closure, the test will be administered on the next available lecture day. A short-term power outage could cancel a midterm – we will notify you as soon as possible when the new test date will be (if possible). Miss a lab? We will try to reschedule or develop alternative learning tools (e.g., online resources) that are less disruptive.

Missed labs or class assessments may require modifications to the syllabus grading scheme. We will notify you of this and present a revised course syllabus, IF needed, as soon as possible following the disruption.

Lecture Content

Week # and Date ***Assessment***

Part 1: Separation science (Dr. Alan Doucette):

Week 1: Jan 7 – 9 ***Quiz 1***
Acid/base chemistry

Week 2: Jan 12 – 16
Solvent extraction

Week 3: Jan 19 – 23
Chromatography basics

Week 4: Jan 26 – 30 ***Quiz 2***
Gas chromatography

Week 5: Feb 2 – 5
Liquid chromatography

No classes on Feb 6: Munro Day

Week 6: Feb 9 – 13 ***Quiz 3***
Mass spectrometry

No classes on Feb 16: Nova Scotia Heritage Day

Feb 16 – 20 *WINTER BREAK*

Week 7: Feb 23 ***Midterm/Exam 1***
Mass spectrometry

Part 2: Spectroscopy (Dr. Malama Chisanga):

Week 7: Feb 25 – 27
Light-matter interaction: basics of wave & quantum theories, energy levels and spectroscopy

Week 8: Mar 2 – 6 ***Quiz 4***
Principles of IR: Molecular vibrations, selection rules, FT-IR, instrumentation, sample handling

Week 9: Mar 9 – 13 ***Quiz 5***
Raman spectroscopy: Polarisability, Raman spectrometers, Raman vs. IR

Week 10: Mar 16 – 20 ***Quiz 6***
Advanced spectroscopy: Basics of plasmonics, colloids and engineered surfaces

Week 11: Mar 23 – 27
SERS 1: Resonance concept, enhancement mechanisms, quantitative SERS, analytical performance

Week 12: Mar 30 – Apr 2 ***Midterm 2***
In-class workshop, SERS 2: Practical challenges, quantification & reproducibility

No classes on April 3: Good Friday

Week 13: Apr 7 – 9
SERS 3: Applications: Biosensing, environmental monitoring, COURSE REVIEW

Lab Schedule

Experiment 1 – Analysis of Caffeine in Redbull

Experiment 2 – Anacin®: Analysis of a two-component mixture by reversed-phase HPLC

Experiment 3 – Temperature Programmed GC: An Exercise in Environmental Monitoring

Experiment 4 – Mass Spectrometry for Forensics Analysis of Illicit Drugs

Experiment 5 – Introduction to Spectroscopy

Experiment 6 – Raman/IR identification of unknown powders

Experiment 7 – SERS quantification of uric acid

Research Project – A three-week self-directed analytical study from a choice of topics

Students will complete these experiments in a consecutive order. **Experiment 1 will begin in the week of January 19th**.

Lab Schedule by Section

Sect.	Day	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Exp. 6	Exp. 7	Research Project
B01	Monday	Jan. 19 1:30 – 5:30pm	Jan. 26 1:30 – 5:30pm	Feb. 2 1:30 – 5:30pm	Feb. 9 1:30 – 5:30pm	Feb. 23 1:30 – 5:30pm	Mar. 2 1:30 – 5:30pm	Mar. 9 1:30 – 5:30pm	Mar. 16 – Mar. 30 1:30 – 5:30pm
B02	Tuesday	Jan. 20 1:30 – 5:30pm	Jan. 27 1:30 – 5:30pm	Feb. 3 1:30 – 5:30pm	Feb. 10 1:30 – 5:30pm	Feb. 24 1:30 – 5:30pm	Mar. 3 1:30 – 5:30pm	Mar. 10 1:30 – 5:30pm	Mar. 17 – Mar. 31 1:30 – 5:30pm
B03	Wednesday	Jan. 21 1:30 – 5:30pm	Jan. 28 1:30 – 5:30pm	Feb. 4 1:30 – 5:30pm	Feb. 11 1:30 – 5:30pm	Feb. 25 1:30 – 5:30pm	Mar. 4 1:30 – 5:30pm	Mar. 11 1:30 – 5:30pm	Mar. 18 – Apr. 1 1:30 – 5:30pm
B04	Thursday	Jan. 22 1:30 – 5:30pm	Jan. 29 1:30 – 5:30pm	Feb. 5 1:30 – 5:30pm	Feb. 12 1:30 – 5:30pm	Feb. 26 1:30 – 5:30pm	Mar. 5 1:30 – 5:30pm	Mar. 12 1:30 – 5:30pm	Mar. 19 – Apr. 2 1:30 – 5:30pm

Detailed information about each experiment is available on the CHEM3201 lab Brightspace course.

University Policies and Statements

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 at 1321 Edward St or elders@dal.ca. Additional information regarding Mi'kmaq and Indigenous Relations (including the Elders in Residence program, Land Acknowledgements, Understanding Our Roots, and much more) can be found at: https://www.dal.ca/about/mission-vision-values/mikmaq-indigenous-relations.html

Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about/mission-vision-values/global-relations.html

Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all 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. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/campus_life/ssc.html).

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

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 (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: https://www.dal.ca/about/mission-vision-values/equity-diversity-inclusion-and-accessibility/about-office-equity-inclusion.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. The full Code of Student Conduct can be found at: https://www.dal.ca/content/dam/www/about/leadership-and-governance/governing-bodies/code-student-conduct.pdf

Fair Dealing Policy

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/fair-dealing-policy.pdf

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.

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