



CHM1104H: Separation Science

Course Syllabus – Fall 2022

I TEACHING TEAM

INSTRUCTOR:

Name: Aaron Wheeler

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Office: Lash Miller Building Room 629

Student hours: Tue, Thu 4:00-5:00 PM Eastern Time Zone*

* Student hours will typically be in person, but can be delivered online on an *ad hoc* basis – contact the instructor to schedule this when needed

II COURSE OVERVIEW

COURSE DESCRIPTION:

This course provides theoretical and practical background useful for engaging in cutting-edge chemical separations in chemistry, biology, medicine, engineering, research, and industry. The course covers general separations concepts and principles, with an emphasis on liquid chromatography and its various modes, including partition chromatography, ion chromatography, enantiomer chromatography, size exclusion chromatography, and affinity chromatography. Other topics include gas chromatography, supercritical fluid chromatography, electrophoresis and related techniques, a host of miscellaneous separation (e.g., TLC, FFF, CF) and extraction (e.g., dialysis and filtration, LLE, SPE) modalities, and materials and instrumentation for each of these techniques.

STUDENT LEARNING OUTCOMES:

At the end of this course, successful students will be able to:

- critically evaluate which chemical separations methods are most appropriate to solve a particular separations problem
- critically evaluate which chemical extraction methods are most appropriate to solve a particular extraction problem
- understand standard separations and extraction nomenclature, to be able to interpret literature reports and application notes
- understand the advantages and disadvantages of the various materials and instrumentation options that are available for modern chemical separations and extractions
- understand the theoretical underpinnings of retention and efficiency in various separations modes, allowing for rapid and efficient optimization of resolution
- apply linear solvent strength theory to predict retention in high-performance liquid chromatography

PREREQUISITE COURSE:

This course assumes a basic familiarity with analytical chemistry techniques for instrumental analysis. For students at the St. George campus, this typically means successful completion of CHM317H as a prerequisite course, but exceptions may be granted by the instructor.

READINGS:

The following texts are required reading, but note that the second is available (on an unlimited basis to all students) electronically in the library:

- *Principles of Instrumental Analysis*, Skoog, Holler and Crouch, 6th Edition (Thomson & Brooks/Cole) or 7th Edition (CENGAGE Learning)
- *Introduction to Modern Liquid Chromatography*, Snyder, Kirkland, Dolan, 3rd Edition (Wiley)

III COURSE ORGANIZATION

CLASS TOPICS & SCHEDULE:

Classes will be held in-person on Tuesdays and Thursdays from 3:00 – 4:00 PM Eastern Time Zone in Lash Miller Building Room 157, beginning on September 8 and ending on December 6. Details for which readings accompany each class are given in the course schedule. As the course progresses, we will discuss six topics, with each corresponding to a class notes file (listed below). Each file will be posted to the course website prior to the corresponding classes, and each group of two topics/files constitutes a "module" that will be addressed chronologically throughout the semester – specifically, module 1 (topics 1-2) in Sept-Oct, module 2 (topics 3-4) Oct-Nov, and module 3 (topics 5-6) in Nov-Dec. Each module is associated with a problem set, a virtual laboratory exercise, and a term test.

1. General Separations Concepts and Principles
2. Liquid Chromatography Instrumentation
3. Liquid Chromatography Modes
4. Gas & Supercritical Fluid Chromatography
5. Capillary & Gel Electrophoresis
6. Miscellaneous Techniques (TLC, LLE, SPE, FFF, and others)

COURSE WEBSITE:

The most detailed and up-to-date information about the course is posted on the course website, which can be found by logging in to your Quercus account at <https://q.utoronto.ca>. You are advised to check the course website often, as content (summarized below) will be updated regularly.

- Syllabus and Course Schedule
- Announcements
- Class Notes
- Problem Sets and Keys
- Old Tests and Keys
- Virtual Lab Assignments
- Term Tests and Keys

IV EVALUATION/GRADING SCHEME

OVERVIEW:

Term Tests (in-person only): 90%

Virtual Laboratory Exercises: 10%

MARKING SCHEME & DATES/TIMES:

Your mark in this course comes from three tests (90%) and from your average score on three virtual laboratory exercises (10%). The dates for these assignments are given in the table below. ***There will be no "make-ups," so record these dates and times now and plan to participate accordingly.*** Each test will cover the material in one of the three modules in the course, and thus has (nominally) the same 'weight' or 'importance.' But because anyone can have a bad day (and can make a bad mark on that day), your final mark will be calculated as 40% - test with your highest score, 40% - test with your second-highest score, 10% - test with your lowest score, plus 10% - lab score. For example, if you score a 90, a 70, and a 50 on the tests and have an average of 90 for the virtual lab assessments, your final mark will be a 78.

Assignment	Date and Time (all times Eastern)
Term Test 1	October 6, 2022, 6:00-8:00 PM, Place TBD
Term Test 2	November 3, 2022, 6:00-8:00 PM, Place TBD
Term Test 3	Time and place TBD (after final class)
Virtual Laboratory Exercises	Due online (via Quercus) on October 4, November 1, and December 6, 5:00 PM

TERM TESTS:

There are three in-person term tests, each corresponding to one of the course modules, which will be administered and completed in person. The first two tests have been scheduled for October 6 and November 3 from 6:00-8:00 PM Eastern Time Zone; the third has not been scheduled but will occur after the final class of the semester. Failure to participate in term tests will result in a grade of 'zero'; the only acceptable excuse is an illness or other medical emergency, as addressed below. In such cases, there will be no "makeup assignments"; the instructor will work with you to determine a fair reapportionment of the other marked materials.

VIRTUAL LABORATORY EXERCISES:

On Quercus, you will find three virtual laboratory exercise files, each corresponding to one of the course modules. The first two exercises use the "HPLC Simulator" software package (<http://www.multidlc.org/hplcsim/hplcsim.html>), and the third uses the "PeakMaster" software package (<https://web.natur.cuni.cz/~gas/peakmaster.html>). You are welcome to complete the virtual lab exercises at any time until they are due on October 4 (exercise 1), November 1 (exercise 2), and December 6 (exercise 3), all at 5:00 PM Eastern Time Zone. If you do not submit by the designated dates and times, your mark will be 'zero.' Note that the exercises are designed to be straightforward, and student performance in previous years have generally been good. Don't miss out on this opportunity to compensate for low marks on a test!

PROBLEM SETS AND OLD TESTS:

On Quercus, you will find three problem sets and keys, each corresponding to one of the course modules. The problem sets will not be collected or marked, but working through them is highly recommended to prepare for the tests. Likewise, a set of old tests and keys has been posted, which may also be useful for preparation, but note that the format for the tests in previous years (esp. those that were given online in Fall 2020) will be quite different than the format that will be used this year.

V COURSE POLICIES

GENERAL:

The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. The course instructor will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wishes to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, you are encouraged to reach out to the staff in the university's Equity Offices.

EXPECTATIONS:

Each member of this course is expected to maintain a:

- professional and respectful attitude during all course activities, including classes, term tests, virtual laboratory exercises, and online activities
- personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met
- collection of notes recorded independently based on concepts covered in course activities (students registered with Accessibility Services requiring a class note-taker will have access to this accommodation)
- familiarity with the university policy on Academic Integrity

ABSENCES

The in-person classes will (generally) not be recorded and will not be recorded or available asynchronously. You are advised to attend them, but attendance is not required. On the other hand, completion of the term tests and virtual laboratory exercises is mandatory; absences are only excusable because of illness or other emergency. In such a case, **before the date/time of the term test**, you must (i) inform the instructor by email or other means, and (ii) declare the absence using the "Absence Declaration Tool" on ACORN (<https://www.acorn.utoronto.ca/>) which is found in the "Profile and Settings" menu. In such cases, there will be no "makeup assignments" or credit awarded for "late" submissions; instead, the instructor will work with you to determine a fair reapportionment of the other marked materials.

VI TECHNOLOGY REQUIREMENTS

This course requires the use of computers, and technical challenges are possible. When completing academic work, students are responsible for scheduling enough time to allow for reasonable delays due to technical difficulties to be overcome, so such issues will not be acceptable grounds for deadline extension. Particularly, maintaining an up-to-date independent backup copy of your work is strongly recommended to guard against hard-drive failures, corrupted files, lost computers, etc. Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here: <https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/>, and advice for students more broadly regarding online learning is available here: <https://onlinelearning.utoronto.ca/getting-ready-for-online/>.

VII INSTITUTIONAL POLICIES & SUPPORT

ACADEMIC INTEGRITY:

You are encouraged to discuss course content and to work problem-sets and old tests with your classmates. ***However, the assignments that will be graded in this course (including the virtual laboratory exercises and term tests) must be completed by you and you alone, according to the university's policies on academic integrity.***

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (<https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019>) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

- Using someone else's ideas or words without appropriate acknowledgement
- Submitting your own work in more than one course without the permission of the instructor
- Making up sources or facts
- Obtaining or providing unauthorized assistance on any report
- Using websites (such as Chegg.com) to post course material/questions/answers
- Looking at someone else's answers or collaborating/discussing during a test
- Misrepresenting your identity
- Falsifying institutional documents or grades
- Falsifying or altering any documentation required by the University

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see <https://www.academicintegrity.utoronto.ca/>).

COPYRIGHT:

If a student wishes to copy or reproduce course notes or other course materials (outside of standard use for course activities), he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited. More information regarding this is available here: <https://library.utoronto.ca/copyright/remote-instruction-copyright-considerations>.

ACCESSIBILITY NEEDS:

Students with diverse learning styles and needs are welcome in this course. The University of Toronto is committed to accessibility: if you require accommodations for a disability, or have any other accessibility concerns about the course, please contact [Accessibility Services](#) as soon as possible.

ACCOMMODATIONS FOR RELIGIOUS OBSERVANCES:

Following the University's policies, reasonable accommodations will be made for students who observe religious holy days that coincide with the due date/time of an assignment. Students must inform the instructor *well before the assignment date* to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT:

- Full library service through [University of Toronto Libraries](#)
- Resources on conducting online research through [University Libraries Research](#)
- Resources on academic support from the [Academic Success Centre](#)
- Learner support at the [Writing Centre](#)
- Information for [Technical Support/Quercus Support](#)

ACKNOWLEDGEMENT OF TRADITIONAL LANDS:

The Teaching Team acknowledges the land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca and, most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.