



CHM 416H: Separation Science

Course Syllabus – Fall 2023

I TEACHING INSTRUCTOR



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Office: Lash Miller Building Room 139A

Student hours: Any time with a prior-arranged appointment *

* Student hours will typically be in person in LM 139A, but can be conducted online via a scheduled appointment, including evenings, on request.

Instructor Bio: Professor Michael Thompson obtained his undergraduate degree from the University of Wales, UK and his PhD in analytical chemistry from McMaster University. Following a period as Science Research Council PDF at Swansea University he was appointed Lecturer in Instrumental Analysis at Loughborough University. He then moved to the University of Toronto where he is now Professor of Bioanalytical Chemistry. He has held a number of distinguished research posts including the Leverhulme Fellowship at the University of Durham and the Science Foundation Ireland E.T.S Walton Research Fellowship at the Tyndall National Institute, Cork City. He is recognized internationally for his pioneering work over many years in the area of research into new biosensor technologies and the surface chemistry of biochemical and biological entities. He has made major contributions to the label-free detection of biological macromolecule interactions and surface behavior of cells using ultra high frequency acoustic wave physics. He has also pioneered the development of anti-fouling surface modification, in particular antithrombogenic and anti-microbial adhesion materials. Thompson has served on the Editorial Boards of a number of major international journals including *Analytical Chemistry*, *The Analyst*, *Talanta*, *Analytica Chimica Acta* and *Biosensors and Bioelectronics*. He is currently Editor-in-Chief of the monograph series “Detection Science” for the Royal Society of Chemistry, UK. He has been awarded many prestigious international prizes for his research including The Robert Boyle Gold Medal of the Royal Society of Chemistry, Horizons Prize of the RSC, E.W.R. Steadier Award of the Chemical Society of Canada, the Theophilus Redwood Award of the Royal Society of Chemistry, the E.T.S. Walton

Award of the Science Foundation of Ireland and the Fisher Scientific Award in Analytical Chemistry of the Chemical Society of Canada. He was made a Fellow of the Royal Society of Canada in 1999.

II COURSE OVERVIEW

COURSE DESCRIPTION:

This course provides theoretical and practical background useful for engaging in chemical separations in chemistry, biology, clinical biochemistry, engineering, research, and industry. The course first introduces chemical separation principles, including the partition concept. This leads to a treatment of the theory gas chromatography followed by a description of GC instruments with an emphasis on detector technology. An analogous look at high performance liquid chromatography (HPLC) includes theory and basic instrument design with conventional detector technology. The combination of HPLC with various forms of mass spectrometry will then be covered, which will also involve applications of the technique in medical science. There will be a focus on other advanced separation techniques such as ion chromatography, supercritical fluid chromatography, conventional electrophoresis, capillary zone electrophoresis, and size exclusion chromatography.

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

Classes will be held in-person on Tuesdays and Thursdays from 3:10 – 4:00 PM Eastern Time Zone in University College Room 152 beginning on September 7th and ending on December 4th. There will be no classes in Reading week beginning November 6th.

Topics in approximate order of presentation:

COURSE SCHEDULE & RELEVANT SESSIONAL DATES:

DATES	UNIT/WEEK	TOPICS
Sept. 7	1	Separations concepts and principles; partition chromatography
Sept. 11 – Sept. 15	2	Theory of chromatography; theoretical plate concept; band broadening; resolution
Sept. 18 – Sept. 22	3	Description of the gas chromatographic instrument; sample introduction; columns and stationary phases
Sept. 25 – Sept. 29	4	Criteria for GC detection; detection devices for GC;
Oct. 2 – Oct. 6	5	The GC- mass spectrometer combination; introduction to supercritical fluid chromatography.
Oct. 9 – Oct. 13	6	Introduction to high performance liquid chromatography; types; columns – conventional and capillary
Oct. 16 – Oct. 20	7	Comparison with ion mobility mass spectrometry technique; demonstration visit to Dept. GC-MS, HPLC-MS facilities
Oct. 23 – Oct. 27	8	Detector systems for HPLC; the HPLC-MS combination; electrospray device and technology
Oct. 30 – Nov. 3	9	Ion chromatography; applications
Nov. 6 – Nov. 10	10	NO CLASS - READING WEEK
Nov. 13 – Nov. 17	11	Theory electrophoresis; gel electrophoresis techniques; applications
Nov. 20 – Nov.24	12	Capillary zone electrophoresis; instrument; CZE applications in biology / medicine
Nov. 27- Dec 1	13	Size exclusion chromatography; affinity chromatography; field flow fractionation technique; solid phase extraction
Dec 4	14	Future of separation science

COURSE MATERIALS:

Presentation PP slides will be forwarded by personal email to all class members at least 24 hours before a scheduled lecture. Selected notes and articles of relevance to the course will be disseminated in the same manner.

IV EVALUATION/GRADING SCHEME

Evaluation will consist of an assignment and a course essay as follows:

Assignment - 50% of final mark – due October 19th.

Essay – 50% of final mark - due on the final day of the semester December 6th.

A list of suggested essay topics will be provided approximately 4 weeks before the end of the semester. Class members can chose their own topic with approval from the Instructor.

V COURSE POLICIES

- Each member of this course is expected to maintain a:
 - (i) professional and respectful attitude during all course activities, including classes, laboratories, tutorials, and online activity.
 - (ii) personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met.
 - (iii) 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)
 - (iv) familiarity with the university policy on Academic Integrity (overleaf)
- 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. As a Course Instructor, I will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wish 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, we encourage you to reach out to the staff in our Equity Offices.
- Required: process for signaling course absences and requesting make-up tests or other missed pieces of work.

If you are absent from your studies due to illness or other reasons and unable to complete course work (e.g., a term test or an assignment) then a piece of written documentation is required. The following four items are the recognized forms of documentation:

1. Absence Declaration via ACORN (please note the circumstances under which an absence declaration can and cannot be submitted)
2. U of T Verification of Illness or Injury Form
3. College Registrar's letter
4. Letter of Academic Accommodation from Accessibility Services

Students who complete the ACORN Absence Declaration form must additionally contact me/the course coordinator/the course administrator to discuss their situation within five business days of the missed piece of work. This is essential action for any consideration to be granted.

For extended absences and for absences due to non-medical reasons, make sure to contact your College Registrar's Office. They can help you decide between a request for an extension or other types of academic consideration.

If you suspect or know that you have a disability that is affecting your studies, learn about the services and supports available through Accessibility Services. A disability can be physical disability, sensory disability, a learning disability, mental health disorder or a short-term disability like an injury. If you are not sure whether you have a disability, you can confidentially contact Accessibility Services with your questions.

- Required: information regarding used of artificial intelligence tools. Please refer to the “U of T Syllabus Language – Use of Generative AI in Assignments” document for guidance regarding this: <https://www.viceprovostundergrad.utoronto.ca/wp-content/uploads/sites/275/2023/04/Syllabus-Language-for-Gen-AI-April-2023.pdf>. There is recommended language in terms of “can use”, “can use in certain instances” and “cannot use”. For more information, see: <https://teaching.utoronto.ca/resources/generative-artificial-intelligence-in-the-classroom/>.
- Communication with instructor (e.g., I will respond to email within 24 hrs. on weekdays).
- Privacy language and appropriate use of course materials: For additional information, see the syllabus “Copyright” section.
- Policy for late assignment submissions (e.g., x% will be deducted daily).
- Policy for reweighting due to missed pieces of academic work: For students missing one term test for a valid reason, the missed test grade will be calculated based on individual performance on the other two term tests and the class average of the other two tests. For students missing two or more tests for valid reasons the mark for the missing tests will be replaced by a cumulative, two-hour assessment to be written in-person. This assessment will cover all aspects of both the laboratory and classroom components of the course.
- Assignment/laboratory report submission methods (e.g., use Quercus only).
- Process for requesting re-grading of course work.

VI TECHNOLOGY REQUIREMENTS

- Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here:

<https://www.vicereprovtstudents.utoronto.ca/covid-19/tech-requirements-online-learning/>

- Advice for students writing online assessments (quizzes etc.):
<https://studentlife.utoronto.ca/task/online-exams-and-tests/>
- This course requires the use of computers, and technical issues are possible. When working on a piece of 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.

VII INSTITUTIONAL POLICIES & SUPPORT

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

(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:

In laboratory reports:

1. Using someone else's ideas or words without appropriate acknowledgement.
2. Submitting your own work in more than one course without the permission of the instructor.
3. Making up sources or facts.
4. Obtaining or providing unauthorized assistance on any report. **Please note that the use of websites (such as Chegg.com or the course discussion board) to post laboratory report material/questions or to post/access answers to questions is an academic offence under the University of Toronto's Code of Behaviour on Academic Matters. Alleged instances of this nature are forwarded to the Faculty of Arts & Science Student Academic Integrity office.**

On quizzes and term tests:

1. Using or possessing unauthorized aids. **Please note that the use of websites (such as Chegg.com or the course discussion board) to post quiz/term test questions or to post/access answers to questions is an academic offence under the University of Toronto's Code of Behaviour**

on Academic Matters. Alleged instances of this nature are forwarded to the Faculty of Arts & Science Student Academic Integrity office.

2. Looking at someone else's answers or collaborating/discussing answers during a quiz or term test.
3. Misrepresenting your identity.

In general academic work:

1. Falsifying institutional documents or grades.
2. 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 www.academicintegrity.utoronto.ca/).

Plagiarism Detection

Required: note for instructor: *Ouriginal (<https://teaching.utoronto.ca/tool-guides/plagiarism-review-ouriginal/>) is a very highly recommended tool directly integrated into Quercus that will assist in detecting textual similarities between compared works. **Students must be informed at the start of the course if an instructor will be using Ouriginal.** If you plan to use this tool, the course syllabus must include the following statement (as is):*

"Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (<https://uoft.me/pdt-faq>)".

COPYRIGHT

Required: note for instructor: *sample statements for policies regarding class recordings are available here: <https://teaching.utoronto.ca/ed-tech/audio-video/sample-statements/>*

If a student wishes to copy or reproduce class presentations, course notes or other similar materials provided by instructors, he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited.

ACCESSIBILITY NEEDS

Students with diverse learning styles and needs are extremely 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, tutorial, class or laboratory session. Students must inform the instructor **before** the session/assignment date to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT

The following are some important links to help you with academic and/or technical service and support:

- General student services and resources at [Student Life](#)
- 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 [Quercus Support](#)

ACKNOWLEDGEMENT OF TRADITIONAL LANDS

: <https://indigenous.utoronto.ca/about/land-acknowledgement/>): We wish to acknowledge this 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.