Chemistry
UNIVERSITY OF TORONTO

CHM1104H: 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

CLASS TOPICS:

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 6th. There will be no classes in Reading week beginning November 6th. Topics in approximate order of presentation:

1. General Separations Concepts and Principles; partition chromatography
2. Theory of gas-chromatography
3. Instruments for GC
4. Supercritical fluid chromatography
5. High performance liquid chromatography
6. Detection in HPLC
7. HPLC- mass spectrometry
8. Ion chromatography
9. Gel electrophoresis and capillary zone electrophoresis
9. Size exclusion chromatography
10. Miscellaneous techniques such as thin-layer and field flow fractionation chromatography

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 2 assignments and a course essay as follows:

Assignment 1- 25% of final mark – due October 17th.

Assignment 2 – 25% of final mark – due November 20th.

Essay 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.

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 behavior 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 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
- School of Graduate Studies' Policies and Guidelines

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.