CHM 426H: Introduction to Polymer Chemistry
Fall 2020 Course Syllabus

I CONTACTS

INSTRUCTOR
Name: Mitch Winnik
Email: m.winnik@utoronto.ca
Office: LM 520
Online student hours: by appointment via email

TEACHING ASSISTANT
Name: Megan Roberts
Email: megan.roberts@mail.utoronto.ca
Online student hours: by email appointment

II COURSE OVERVIEW

COURSE DESCRIPTION:
This course is an introduction to polymer chemistry. The first part of the course will describe the shapes and sizes of polymer molecules, molecular weight determination, polymer properties in solution and in the solid state. This part will also include phase separation and self-assembly. The second part of the course will focus on polymer synthesis with an emphasis on polymerization mechanisms and on controlling end groups. Examples will illustrate selected applications.

STUDENT LEARNING OUTCOMES:
By the end of this course, students will be able to:

- identify and describe different polymer structures and understand how the chemical structure affects the properties of a polymer in solution and in the solid state.
- understand different techniques used to characterize polymer materials in the solid state and in solution.
- understand different techniques to determine molecular weights and molecular weight distribution of polymers
- use Excel or other spreadsheet programs to fit osmotic pressure data or polymer viscosity data to determine molecular weights.
- understand various polymerization mechanisms and how they can be used to construct polymers of different compositions.

PREREQUISITE COURSE(S): CHM220H1/CHM222H1, CHM247H1/ CHM249H1. CHM325H is recommended.

This course assumes you have a fundamental understanding of basic organic chemistry and organic reaction mechanisms; and basic physical chemistry (including thermodynamics and reaction kinetics).

READINGS:
Required: Painter P.C.; Coleman, M.M. *Essentials of Polymer Science and Engineering* (ISBN 978-1-932078-75-6).

Supplemental: Young, R.L.; Lovell, P.A. *Introduction to Polymers*, 2nd ed.
Sperling, L.H., *Physical Polymer Science*, 2nd or 3rd ed.

III HOW THE COURSE IS ORGANIZED

Classes will be delivered online per the meeting schedule and recorded.
Tutorials will be delivered online per the meeting schedule.

Classes: **Tuesdays** **5 - 7 pm EST, online via BB Collaborate.**
Tutorials: **Fridays** **2 – 3 pm EST, online**
A list of course topics is presented at the end of this syllabus.

TUTORIALS
Early tutorials will demonstrate how to use online programs to draw chemical structures, as well as how to fit data using Excel and how to transfer plots from Excel to PowerPoint and to Word. Later tutorials will be devoted to answering questions from the students about material presented in class.

IV EVALUATION/GRADING SCHEME

RELEVANT SESSIONAL DATES AND MARKING SCHEME:

Dates	Assignments	Weight
Oct 20	Term test 1	15/25%
Dec 01	Term test 2	15/25%
Sep,22,29,Oct 6, Nov 3,17	Problem Sets (5)	20%
Due Friday Nov 27, by 5 pm	Term paper	40%

The higher term test mark 25%, the lower term test mark 15%

Problem sets are to be submitted on Quercus by 10 am (EDT/EST) on the Monday following the assignment.

*Term tests are open book. Course textbooks, course notes and calculators are allowed as is the use of the internet, but you must work individually.

Note: if an unexpected technical issue occurs with a university system (e.g., Quercus services, network outage) that affects availability or functionality, it may be necessary to revise the timing or weighting of the assessments.

V COURSE POLICIES

- Communication with the instructor: students should email from their U of T email account. Please allow 24 hours for a response on **weekdays**; generally, I will not respond on weekends.
- All online interactions are expected to conform with the University statement regarding a positive learning environment: "*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. U of T does not condone discrimination or harassment against any persons or communities*."
- Privacy and appropriate use of course materials: Classes and tutorials will be recorded, and the recordings made available for a limited time through Quercus. These recordings should be considered private and for the use of students registered in the course **only**. They may not be shared or reposted in any way. Students may not make their own recordings, either for personal use or distribution. Students with accessibility requirements should contact the course instructor to make appropriate arrangements.
- Late policy for all term work submissions: a penalty of 5% of the maximum mark per day (10% for problem sets) will be deducted daily for term work submitted past the deadline unless:
    - An extension had been agreed to by the instructor prior to the deadline
    - An emergency arose and any notification/documentation was completed in accordance with the Rules and Regulations as posted in the Faculty of Arts & Science Calendar
- Submission methods and deadlines: students are responsible for checking the time, date, and submission process for each item of term work. Generally, submissions will be made through Quercus.

Students are responsible for notifying the course instructor of any absences; accommodation for missed term work will be considered on a case-by-case basis.

VI TECHNOLOGY REQUIREMENTS

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/

Advice for students more broadly regarding online learning is available here: https://onlinelearning.utoronto.ca/getting-ready-for-online/

This course requires the use of computers, and of course, sometimes things can go wrong when using them. You are responsible for ensuring that you maintain regular backup copies of your files, use antivirus software (if using your own computer), and schedule enough time when completing an assignment to allow for delays due to technical difficulties. Computer viruses, crashed hard drives, broken printers, lost or corrupted files, incompatible file formats, and similar mishaps are common issues when using technology, and are not acceptable grounds for a deadline extension.

VII INSTITUTIONAL POLICIES AND SUPPORT

ACADEMIC INTEGRITY

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:

In papers and assignments:

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 assignment.

On tests and exams:

1. Using or possessing unauthorized aids.
2. Looking at someone else's answers during an exam or test.

3. Misrepresenting your identity.

In 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 https://www.academicintegrity.utoronto.ca/).

Use of Turnitin

Normally, students will be required to submit their course essays to Turnitin.com 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 Turnitin.com reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of the Turnitin.com service are described on the Turnitin.com web site.

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.

ADDITIONAL SERVICES and 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 Technical Support/Quercus Support

VIII LIST OF TOPICS TO BE COVERED

1. Introduction

Classification of polymers
Overview of polymer structure, composition, architecture
General concepts of molecular weight distribution

2. Experimental determination of the shapes and sizes (molecular weights) of macromolecules

Conformation of macromolecules
End-group analysis (especially NMR)
Osmometry
Scattering techniques
Viscometric techniques

3. Polymer solutions

Polymer interactions in solutions; concentration regimes, solvent quality
Solution and melt thermodynamics (Flory-Huggins theory)
Solubility parameter approach
Association in polymer solution and melts
Phase separation

4. Polymers in the bulk state

Melts and amorphous states
Glass transition
Crystalline polymers
Morphology
Macroconformation, packing, chain folding
Kinetics of crystallization
Mechanical properties of polymers.

5. Polymer synthesis: anionic, cationic, and ring opening living polymerization

Polymerization of styrene, methacrylates, tetrahydrofuran, ethylene oxide.
Block copolymer synthesis

6. Polymer synthesis: Free radical polymerization

Kinetics and mechanism
Controlling M_n, chain transfer
Copolymerization and reactivity ratios

7. "Living/controlled" Radical polymerization

Nitroxide mediated polymerization (NMP, also called SFRP)

Reversible addition-fragmentation transfer (RAFT) polymerization
Atom transfer radical polymerization (ATRP)
Comparison of "living/controlled" radical polymerization and free radical polymerization

8. Step-growth polymerization

Mechanism and statistics of step-growth polymerization
Gel formation

9. Polymer synthesis: other topics

Ring-opening metathesis polymerization