Department of Chemistry Online Course Syllabus

Chem 1302: Polymer Physical Chemistry, WINTER 2023

I. CONTACTS

INSTRUCTORS

Name: Eugenia Kumacheva
Email: eugenia.kumacheva@utoronto.ca
Office: LM 527a
Online student hours: by appointment via email

Eugenia Kumacheva is a University Professor, Distinguished Professor of Chemistry and Canada Research Chair in Advanced Polymer Materials. Her research interests are in the field of Soft Matter, i.e., polymers, colloids, liquid crystals and biological soft matter.

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

Mitch Winnik is a University Professor. His research interests span both fundamental and applied aspects of polymer chemistry, including block copolymer self-assembly, polymers for mass cytometry (a bioanalytical application), polymers for radioimmunotherapy, and mechanistic aspects of polymer coatings.

II COURSE OVERVIEW

COURSE DESCRIPTION:
This course presents the structural, thermodynamic transport and mechanical properties of polymers with respect to the underlying physical chemistry of polymers in melts, solutions, and glassy, crystalline, and rubbery elastic solid state. Theoretical models, experiments used in studies of polymer physical properties and characteristic relationships between polymer structure and properties will be discussed. This course is organized by topics (see course outline below)

READINGS:
Required: Painter P.C.; Coleman, M.M. *Essentials of Polymer Science and Engineering (ISBN 978-1-932078-75-6)* Available for 24 h loan from the Chemistry library. (A black and white scan of this text will be posted on Quercus)
Supplemental: Young, R.L.; Lovell, P.A. *Introduction to Polymers*, 2nd ed

Lodge, T.P., Hiemenz, P.C. *Polymer Chemistry,* 3rd ed 2020 (available online)

Sperling, L.H., *Physical Polymer Science*, 2nd or 3rd ed. (available online)

LECTURE NOTES.

III HOW THE COURSE IS ORGANIZED

Lectures: **Wednesdays, 5 - 7 pm EST in LM 123**

Lectures will be delivered in person.

Office hours: by appointment

IV EVALUATION/GRADING SCHEME

RELEVANT SESSIONAL DATES AND MARKING SCHEME:

Dates	Assignments	Weight
February 8	Problem set 1	25%
March 8	Problem set 2	25%
TBA	Final assignment: *Research proposal (oral presentation)	25%
TBA	Final assignment: Research proposal (term paper)	25%

Problem sets are to be submitted on Quercus by 10 am in 5-7 days after their release on Quercus. The date and time of submission will be specified on the problem set.
Please write your answers in ink. You can import plots from Excel of Origin. You MUST submit a SINGLE .PDF FILE containing LEGIBLE answers in the correct order. This is an absolute requirement for the assignment to be graded: multiple files/images of any kind (e.g. .jpg, .tif) will not be accepted.

Instructions for the final assignment (research proposals) will be posted.

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.

Course Outline

1. Basic concepts, Polymer liquids, molecular weight distributions, critical concentrations.
2. Polymer ideal chains. Molecular Interactions. Molecular dimensions. Models describing molecular dimensions. Polymer real chains. Excluded volume. Flory's theory. Self-similarity and polymer molecules. Scaling theory
3. Polymer thermodynamics Flory - Huggins theory Phase separation Phase diagrams
4. Polymers on surfaces
5. Methods of Polymer Characterization
6. Mechanical properties of polymers. Tensile strength E', E", G', G" Five regions of viscoelastic behavior, Time-temperature superposition. Introduction to Polymer viscosity: Shear -rate and concentration dependence.
7. Gels, the gel point, sol and gel fractions, introduction to the theory of rubber elasticity
8. Brief introduction to polymer diffusion. Dynamic light scattering and how it works.
9. Polymer dynamics: More about polymer diffusion. Rouse and Zimm models. Intrinsic viscosity. Introduction to entanglements.
10. Polymer glasses and the crystalline state. Glass transition and the concept of free volume. Physical properties of crystalline polymers. How chains pack in crystals?

V COURSE POLICIES

- Communication with instructor (e.g. I will try to respond to email within 24 hrs on weekdays).

- Online expectations regarding etiquette/participation ("*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 language and appropriate use of course materials:

Notice of video recording and sharing (Download and re-use prohibited)
This course, including your participation, will be recorded on video and will be available to students in the course for viewing remotely and after each session.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by copyright. Do not download, copy, or share any course or student materials or videos without the explicit permission of the instructor.

For questions about recording and use of videos in which you appear please contact your instructor.

Instructor Permits Audio Recordings (No Distribution Rights)

Students may create audio-recordings of the lectures for their personal use. Recordings are intended to permit lecture content review so as to enhance understanding of the topics presented. Audio-recordings are not substitutes for attending class.

Students should note that since audio recordings are to be permitted, their voice may be recorded by others during the class. Please speak to the instructor if this is a concern for you.

In accordance with the Accessibility for Ontarians with Disabilities Act, 2005, persons who have special needs will be accommodated.

Students agree to the following terms when creating audio recordings of lectures:

- Recordings are not to be distributed without the permission of the instructor via the Internet, using social media such as Facebook, peer-to-peer file sharing such as One Drive or Dropbox, or other distribution channels.
- Recordings are not to be shared with other classmates unless they are to be used in collaborative assignments, or if the instructor permits for other reasons.

Non-compliance with these terms violates an instructor's intellectual property rights and the Canadian Copyright Act. Students violating this agreement will be subject to disciplinary actions under the Code of Student Conduct

- **Submission methods and penalties for late submission**
- Deadlines for assignment submissions and late policy (e.g. 10% will be deducted daily).
- Submission methods (Quercus only).
- Process for requesting re-grading of course work: contact the course instructor.
- There will be no make up tests.
- In case of a personal emergency that would delay submission of an assignment, please contact the course instructor.

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

TOPIC 1 **Classification of polymers, polymer structure, composition, architecture general concepts of molecular weight distribution**

TOPIC 2 **Conformations and dimensions of ideal and real polymer molecules (chains). Scaling.**

TOPIC 3 **Thermodynamics of polymer solutions and blends**

TOPIC 4 **Polymers on surfaces**

TOPIC 5 **Polymer characterization**

TOPIC 6 **Brief introduction to dynamic light scattering**

TOPIC 7 **Mechanical properties of polymers (E', E", G',G"), time-temperature superposition**

TOPIC 8 **Gels, rubber elasticity**

TOPIC 9 **Polymer dynamics in solution (Rouse, Zimm models)**

TOPIC 10 **Polymer dynamics in melts (entanglements)**

TOPIC 11 **Polymer crystals**