Introduction to Polymer Chemistry (3 credits)
CHEM 4221
Fall Semester 2019
8:15–9:30 A.M. • T/Th • 231 Smith Hall
Online content: https://umn.instructure.com/

Instructor: Professor Theresa M. Reineke (239 Smith Hall - treineke@umn.edu)

Instructor Office Hours: Prof. Reineke will have office hours in 239 Smith Hall from 9:30-10:30 am on many Tuesdays and Thursdays throughout the semester or by appointment.

Co-instructor: Dr. Piril Ertem (sertem@umn.edu), office: 11 Smith Hall, office hours by appointment

Teaching Assistant: Bo Zhang (zhan5777@umn.edu), office: 210 Amundson Hall
Emily Wilborn (wilbo018@umn.edu), office: 662 Kolthoff Hall

Teaching Assistant Office Hours: Bo’s office hours are Wednesday 9:30 – 11:30 AM (tentative) in Amundson 161C. Emily’s office hours are Monday and Friday from 12:00 – 1:00 PM in the third-floor study lounge of Kolthoff Hall. The TAs will also be available to meet with students throughout the semester. If you would like to schedule a meeting, please make your request by e-mailing Bo or Emily with a few possible meeting times.

Prerequisites: CHEM 2302 Organic Chemistry II & CHEM 3501 Introduction to Thermodynamics, Kinetics, and Statistical Mechanics OR instructor consent.


E-mail: All students should be reachable at their University-wide e-mail (X500@umn.edu) accounts. In addition to the Canvas site, the instructor and TA will use e-mail throughout the semester to contact you with information about the class.

Assignments: There are a number of practice problems throughout the chapters of the book. There will also be several homework assignments posted on the Canvas site throughout the semester. It is highly encouraged that you do these problems, but these assignments will not be collected nor graded. The homework problems and problems in the book will often be directly related to exam questions, so you are strongly encouraged to do and understand all of the problems in the assignments. Answer keys will be available after the assignments are posted.

Exams: There will be three in-class midterm exams on the following tentative dates (*dates subject to change):

Thursday 3 October 2019
Tuesday 5 November 2019
Tuesday 10 December 2019

One comprehensive, 2-hour, final exam will be given during the finals week. This semester the final exam date, time, and room are: Saturday, December 14th 2019 from 4:00 P.M. – 6:00 P.M. in 231 Smith Hall.
There will be no makeup examinations. If you miss an exam for a documented personal emergency, University-sponsored activity, or other unavoidable or legitimate circumstances AND have complied with the notification requirement (i.e., you must notify the instructor of circumstances as soon as possible and provide documentation requested by the instructor) the instructor will work with you and will provide a mechanism to make up for the missed exam.

**Grading:** The midterm exams each count for 25% of your grade (75% total) and the final exam counts for 25% of your grade. Tentative curve is: $A = 90-100\%; \ B = 80-89\%, \ C = 70-79\%, \ D = 60-69\%, \ F = < 60\%$. This curve is subject to change based on class averages.

**Academic integrity:** A discussion and definition of academic integrity can be found the UMN Office for Student Academic Integrity website (http://www.oscai.umn.edu/). The policy in this class is zero tolerance. Cheating on exams will not be tolerated and cases of students in violation will be considered dishonest and the proper sanctioning guidelines will be followed (http://oscai.umn.edu/sanctioning-guidelines).

**Books on reserve in Walter Library:**

**Topics:**
We will cover a broad range of polymer synthesis techniques/topics. Students will be introduced to concepts that include step-growth polymerization, chain polymerization, ring-opening polymerization, controlled polymerization, living polymerization, emulsion polymerization, stereoregular polymerization, copolymerizations, and various polymer modification techniques. Emphasis in this course will be on polymerization mechanisms, properties, and kinetics. In addition, there will be a focus on the consequences of polymerization processes on the resultant attributes of the long chain molecule products. End-group identity, tacticity, chain length distribution, branching, comonomer sequence statistics, and other molecular characteristics will be covered. Molecular characterization techniques will be discussed with emphasis on molecular weight characterization and various spectroscopic techniques. Much of the material in the first 5 chapters of Hiemenz and Lodge will be covered in this class (not necessarily in the order presented in Hiemenz and Lodge). In addition, other selected topics not covered in the book but relevant to the subject of polymer chemistry will also be discussed.

**Tentative Lecture Schedule (subject to change): (yellow highlight denotes 2019 updates)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Tuesday, 9/3/19:</td>
<td>Syllabus, course overview, intro to polymers (Ch. 1)</td>
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<tr>
<td>Thursday, 9/5/19:</td>
<td>Basic polymer terms, molecular weight (Ch. 1)</td>
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<tr>
<td>Tuesday, 9/10/19:</td>
<td>Molecular weight, intro to step growth polymerization (Ch. 1, Ch. 2)</td>
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<td>Thursday, 9/12/19:</td>
<td>Step growth/condensation reactions: polyesters, polyamides (Ch. 2)</td>
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<td>Tuesday, 9/17/19:</td>
<td>Step growth: polyurethanes, epoxy resins, rxn extent, rates (Ch. 2)</td>
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Thursday, 9/19/19:  Step growth: kinetics (Ch. 2)
Tuesday, 9/24/19:  Step growth: stoichiometric imbalance (Ch. 2)
Thursday, 9/26/19:  Thermal properties, glass transition, plasticizers (notes)
Tuesday, 10/1/19:  Thermal properties, TGA/DSC (notes)
Thursday, 10/3/19:  Exam 1
Tuesday, 10/8/19:  Chain growth polymerization: initiation of free radical (Ch. 3)
Thursday, 10/10/19:  Chain growth polymerization: initiation kinetics, termination (Ch. 3)
Tuesday, 10/15/19:  Chain growth: steady state radical concentration, propagation (Ch. 3)
Thursday, 10/17/19:  Chain growth: propagation kinetics, kinetic chain length (Ch. 3)
Friday, 10/18/19:  GRAD EXAM 1
Tuesday, 10/22/19:  Chain growth: radical lifetime (Ch. 3)
Thursday, 10/24/19:  Chain growth: termination, (Ch. 3)
Tuesday, 10/29/19:  Chain growth: chain transfer to solvent (Ch. 3)
Thursday, 10/31/19:  Chain growth: chain transfer and kinetic chain length (Ch. 3)
Tuesday, 11/5/19:  Exam 2
Thursday, 11/7/19:  Controlled polymerization: anionic and cationic (Ch. 4)
Tuesday, 11/12/19:  Controlled polymerization: cationic & living kinetics (Ch. 4 & notes)
Thursday, 11/14/19:  Controlled polymerization: RAFT (Ch. 4 and notes)
Friday, 11/15/19:  GRAD EXAM 2
Tuesday, 11/19/19:  Controlled polymerization: ATRP and NMP (Ch. 4)
Thursday, 11/21/19:  ROMP and copolymers (Ch. 5)
Tuesday, 11/26/19:  Reactivity ratios (Ch. 5)
Thursday, 11/28/19:  No class Enjoy Thanksgiving Break!
Tuesday, 12/3/19:  Polymer microstructure (Ch. 5)
Thursday, 12/5/19:  Natural Polymers: Nucleic acids/proteins/Polysaccharides: controlled condensation polymerization (notes)
Tuesday, 12/10/19:  Exam 3
Saturday, 12/14/19:  Comprehensive Final Exam 4:00pm - 6:00pm

CHEM/CHEN/MATS 8221
Synthetic Polymer Chemistry (4 credits)

Prerequisites: Undergrad organic chemistry course, undergrad physical chemistry course OR instructor consent.

CHEM/CHEN/MATS 8221 students are responsible for everything in CHEM 4221.

Grading: Like the undergraduate version of this class (CHEM 4221), your grade will be based on the in-class midterm exams and one final exam. In addition you will be given several special extra assignments throughout the semester that are designed for graduate students. The assignments will involve two extra exams on a series of literature articles related to current topics in polymer chemistry. The points you earn for the undergraduate portion of the class will account for 80% of your final point total and the points you earn for these special extra assignments will account for 20% of your final point total. Grades for CHEM/CHEN/MATS 8221 will be assigned on a separate curve than the undergraduate version of this class, CHEM 4221, for all students.
University of Minnesota Policies:

Student Conduct Code
The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected to adhere to the Board of Regents Policy: Student Conduct Code. To review the Student Conduct Code, please see: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf.

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom
Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. For complete information, please reference: http://policy.umn.edu/education/studentresp.

Scholastic Dishonesty
You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. (Student Conduct Code: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf) If it is determined that a student has cheated, the student may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see: http://policy.umn.edu/education/instructorresp.

The Office for Community Standards has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: https://communitystandards.umn.edu/avoid-violations/avoiding-scholastic-... If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class-e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.
Makeup Work for Legitimate Absences
Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see: http://policy.umn.edu/education/makeupwork.

Appropriate Student Use of Class Notes and Course Materials
Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: http://policy.umn.edu/education/studentresp.

Grading and Transcripts
The University utilizes plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>A</td>
<td>4.000 - Represents achievement that is outstanding relative to the level necessary to meet course requirements</td>
</tr>
<tr>
<td>A-</td>
<td>3.667</td>
</tr>
<tr>
<td>B+</td>
<td>3.333</td>
</tr>
<tr>
<td>B</td>
<td>3.000 - Represents achievement that is significantly above the level necessary to meet course requirements</td>
</tr>
<tr>
<td>B-</td>
<td>2.667</td>
</tr>
<tr>
<td>C+</td>
<td>2.333</td>
</tr>
<tr>
<td>C</td>
<td>2.000 - Represents achievement that meets the course requirements in every respect</td>
</tr>
<tr>
<td>C-</td>
<td>1.667</td>
</tr>
<tr>
<td>D+</td>
<td>1.333</td>
</tr>
<tr>
<td>D</td>
<td>1.000 - Represents achievement that is worthy of credit even though it fails to meet fully the course requirements</td>
</tr>
<tr>
<td>S</td>
<td>Represents achievement that is satisfactory, which is equivalent to a C- or better.</td>
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</table>

For additional information, please refer to: http://policy.umn.edu/education/gradingtranscripts.

Sexual Harassment
"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy: https://regents.umn.edu/sites/regents.umn.edu/files/policies/Sexual_Harassment_Sexual_Assault_Stalking_Relationship_Violence.pdf

Equity, Diversity, Equal Opportunity, and Affirmative Action
The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity_Diversity_EO_AA.pdf.
Disability Accommodations
The University of Minnesota views disability as an important aspect of diversity, and is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

- If you have, or think you have, a disability in any area such as, mental health, attention, learning, chronic health, sensory, or physical, please contact the DRC office on your campus (UM Twin Cities - 612.626.1333) to arrange a confidential discussion regarding equitable access and reasonable accommodations.

- Students with short-term disabilities, such as a broken arm, can often work with instructors to minimize classroom barriers. In situations where additional assistance is needed, students should contact the DRC as noted above.

- If you are registered with the DRC and have a disability accommodation letter dated for this semester or this year, please contact your instructor early in the semester to review how the accommodations will be applied in the course.

- If you are registered with the DRC and have questions or concerns about your accommodations please contact your (access consultant/disability specialist).

Additional information is available on the DRC website: (UM Crookston - https://www.crk.umn.edu/units/disability-resource-center, UM Duluth - http://www.d.umn.edu/disability-resources, UM Morris - http://www.morris.umn.edu/academicsuccess/disability/, UM Rochester - http://r.umn.edu/student-life/student-services/disability-resources, UM Twin Cities - https://diversity.umn.edu/disability/) or e-mail (UM Crookston - myers062@crk.umn.edu, UM Duluth - access@d.umn.edu, UM Morris - hoekstra@morris.umn.edu, UM Rochester - sdzavada@r.umn.edu, UM Twin Cities - drc@umn.edu) with questions.

Mental Health and Stress Management
As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: http://www.mentalhealth.umn.edu.

Academic Freedom and Responsibility: for courses that do not involve students in research
Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.*

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser, the associate dean of the college, or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost.

* Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".