

**CHEN 5390: Graduate Chemical Reaction
Engineering Chemical and Biological Engineering
Spring 2026 Syllabus**

Overview:

Reaction engineering is a core component of chemical and biological engineering. Understanding the fundamentals of reaction kinetics and their implications for process design is important for research areas ranging from alternative energy to metabolic engineering to polymers to nanomaterials. A particular focus of this course will be on interpreting reaction kinetics in terms of molecular scale events. The course will begin with a review of “top-down” reaction engineering and reactor design, then shift to a discussion of the physical chemistry governing reactive processes. Finally, these perspectives will be interfaced with a discussion of complex systems of a few, to many coupled reactions. Examples and applications will include reactions catalyzed by surfaces and enzymes, electrochemical systems, polymerization, and other unique cases such as chemical oscillators.

Instructor: Will Medlin, Chemical and Biological Engineering, medlin@colorado.edu, Office: D123, Ph. 303-492-2148.

Advanced Teaching Assistant: Varun Awasthi, varun.awasthi@colorado.edu

Emails: Please **include “CHEN 5390” in the subject line**. Instructors will attempt to be prompt but do not expect turnaround in under 24 hours.

Lectures: MW, 12:35-1:50 in room BIOT E1B11

Office Hours: Mon 3:30-4:30 (Will); Tue 11-12 (Will); Wed 4:00-5:30 (Varun). These hours may be adjusted (by announcement) over the course of the semester.

Textbooks: Reading will primarily be assigned from the following:

- (1) “Fundamentals of Chemical Reaction Engineering” by Davis & Davis
(free at <https://authors.library.caltech.edu/records/arr0q-97509>)
- (2) *Optional:* “Chemical Kinetics” by Laidler (1987). (*Necessary excerpts will be posted*)

Additional resources you may find useful, excerpts will occasionally be posted

“Chemical reactor analysis and design fundamentals”

<https://sites.engineering.ucsb.edu/~jbrow/chemreacfun/>

“Reaction Kinetics” by Pilling & Seakins (1995) (More conceptual than Laidler book)

Format:

This class will not consist of 75 minutes of straight lecture, and textbook material will not be covered in its entirety during class. We will use class time to discuss key concepts, applications, and examples. We will generally do a short recap, talk about conceptual problems, work longer quantitative examples, and ask/answer questions. Active participation is expected; you must complete reading beforehand. Iclicker polling, and we will likely use other tools as well.

Objectives:

- ***With your help, make this the class where you learn the most; I also hope to make this the course you find most interesting.***
- Increase your understanding of and ability to apply reaction engineering concepts, especially in your research.
- Develop a conceptual understanding of the equations and processes.
- Improve your problem-solving ability.

- Improve your ability to work in teams.

Expectations:

- I expect you to attend all classes and be on time.
- I expect you to participate in class.
- I expect you will have completed reading assignments and taken the reading quiz on Canvas prior to class.

The major responsibility for learning must be by reading the book and doing the homework. We will not spend much time in class repeating material covered by the text. Instead, we will use class time to discuss the more difficult concepts, as well as applications and examples.

Canvas Course website: canvas.colorado.edu

Course handouts, reading assignments, other files, announcements, HW assignments and solutions, reading quizzes, previous exams, and additional useful information will be posted on Canvas.

Grading:	Clicker participation	10% or 5%
	Homework sets	25%
	Reading quiz participation	10% or 5%
	Midterm	25%
	Final exam	30% or 40%

Two grading scales are shown; I will use the one that gives you a higher score at the end of the semester. Grade cutoffs will be guaranteed at A- > 88.0%, B- > 78.0%, C- > 65.0%. These cutoffs may be adjusted, but only in your favor.

Exams: A mid-term exam will be scheduled near the mid-point of the semester, tentatively March 2 at 4:30 pm in E1B11, and the final exam will be given at 4:30pm on Monday, April 27 in E1B11. The format of the exams will be specified during the course. **NO MAKE-UP EXAMS WILL BE GIVEN.**

In class: Conceptual problems will be given nearly every class. To allow for a few missed classes, up to 15% of questions that are missed will be dropped when computing the concept tests grade. The class average on the concept tests has historically been an A- or better.

Class participation:

A total of 2 bonus points will be added to the final numerical average for each student who satisfies the following criteria:

- (1) The student must offer an individual question, comment, or response during classroom discussion that is ***related to the technical material covered in the course*** (i.e., administrative questions such as “When is the next exam?” don’t count) at least once during a total of 8 different classroom periods.
- (2) Each student must keep track of the specific dates on which they completed the above requirements. They must then *submit a memo by email* to Prof. Medlin prior to the final exam date that lists the dates on which the classroom participation occurred.

Reading quizzes:

A total of 5-10% of your class grade will be determined by short problem sets related to the assigned reading for each class. These will generally consist of multiple-choice problems as well as a component where you submit a question or comment you have related to the reading. The goal of this

latter component is to encourage you to actively engage the material, and to create an individual dialog between you and the instructor. **Assignments must be completed independently on CULearn before 8 am** the day of each class. I will look over the assignments before class each morning to help in identifying the most important topics to cover during the class period.

The question you ask me can concern any topic related to the assigned reading. You may also make comments about what you liked or did not like in the reading (be specific!), or ask questions about real-world applications of topics covered in the text. Be creative!! Questions or comments must be specific (“I don’t understand kinetics” is not acceptable); I will be the final judge of whether each question counts, and I will notify you if your question does not count and explain why. *I will often respond to your question over Canvas if I don’t think we will address it in class.* You may also ask any other question (for example, a question concerning material covered in the previous class) and we will try to address it, but **it will not count toward reading question assignments.**

Homework: Approximately 6 homeworks will be posted on CULearn throughout the semester. The final homework may carry a heavier grading weight than the other homeworks, serving as a mini-project. This will be announced in advance. Homeworks will generally be due on Thursdays by midnight, with some exceptions. Below are a few guidelines.

- Illegible homework will not be accepted and will be returned with zero credit for that portion (please be neat!).
- The method of solution showing all steps must be clearly presented to achieve full credit! Deductions will be made for missed steps.
- Homework solutions must be presented in the proper units or the students will receive a zero for that problem (read the homework problem statement carefully!)
- All computer spreadsheet or program solutions must show the formulas and data used to make the calculations, or these must be attached separately. Deductions will be made if formulas or data are not shown.
- No late homework will be accepted! The student will receive a zero for that assignment.

Prerequisites

Undergraduate course in kinetics / reaction engineering or instructor consent.

Other important information

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the [Honor Code](#). Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part of adhering to the Honor Code. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from Student Conduct & Conflict Resolution and will be subject to academic sanctions from the faculty member. Visit [Honor Code](#) for more information on the academic integrity policy.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website](#). Contact Disability Services at 303-492-8671 or DSinfo@colorado.edu for further assistance. If you have a temporary medical condition, see [Temporary Medical Conditions](#) on the Disability Services website.

If you have a temporary illness, injury or required medical isolation for which you require adjustment, please contact the instructor.

Accommodation for Religious Obligations

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, please let the instructor know at least three weeks in advance of any conflicts you have with exams or assignments. See the [campus policy regarding religious observances](#) for full details.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information does not always align with how they identify. If you wish to have your preferred name (rather than your legal name) and/or your preferred pronouns appear on your instructors' class rosters and in Canvas, visit the [Registrar's website](#) for instructions on how to change your personal information in university systems.

Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral

standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, marital status, political affiliation, or political philosophy.

Additional classroom behavior information

- [Student Classroom and Course-Related Behavior Policy](#).
- [Student Code of Conduct](#).
- [Office of Institutional Equity and Compliance](#).
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Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits [protected-class](#) discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email OIEC@colorado.edu. Information about university policies, [reporting options](#), and [OIEC support resources](#) including confidential services can be found on the [OIEC website](#).

Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure the person impacted receives outreach from OIEC about resolution options and support resources. To learn more about reporting and support a variety of concerns, visit the [Don't Ignore It page](#).

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact [Counseling and Psychiatric Services \(CAPS\)](#), located in C4C, or call (303) 492-2277, 24/7.

Acceptable Use of AI in This Class

You may use gen AI tools on assignments in this course. It is recommended that their use be limited to the following tasks: grammar checks; generating ideas or outlines; summarizing or synthesizing research, with proper critical evaluation; generating preliminary codes for solving problems.

Regardless of how you use them, if you use gen AI tools on assignments in this class, document your usage as outlined in the [Chicago Manual of Style](#).

Tentative Schedule – expect changes to be made!

Kinetics at the Macro Scale (~4 weeks)

- Empirical rate laws, Arrhenius equation (2 lectures)
- Mole balances and rate measurement (2)
- Residence time distribution (2)
- Energy balances (2-3)

Reading

Davis Ch 1
“ Ch 2-3
“ Ch 8
“ Ch 9

Catalytic kinetics (~4 weeks)

- Surface reactions, Heterogeneous Catalysis (4)
- Mass transfer effects (2)
- Enzyme kinetics (1)
- Polymerization and chain reactions (2)

Davis Ch 5
Davis Ch 6
Davis Ch 4
Various

Microscale Kinetics (~4 weeks)

- Potential energy surfaces, Boltzmann distribution (1)
- Collision theory (1)
- Transition state theory (3)
- Unimolecular rate theory (1)
- Photochemistry, State-to-state kinetics, and Reaction dynamics (1)
- Kinetic isotope effects (2)

Laidler Ch 4
“
“ & Ch 11
P&S Ch 5
P&S Ch 4
Handouts

Special Topics (~2 weeks)

- Energy balances
- Oscillatory systems, runaway reactions
- Large kinetic systems, Regression, Sensitivity analysis
- Other special topics

Handouts
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