MAT E 664 Kinetics of Materials

Winter 2026 (Lecture B1)

Class Time: Mon, Wed 14:00 - 15:20 **Location: HC 2-14**

Instructor:
Tian Tian, PhD
tian.tian@ualberta.ca
DICE 12-245
Office Hours: By appointment

Course Description:
Principles of materials kinetics: relationship between thermodynamics and kinetics, irreversible thermodynamics, and driving forces for mass transport. Molecular diffusion, diffusion equations, and rate equations for chemical reactions. Analytical and numerical methods for kinetic problems. Kinetic phenomena in materials systems: polymer growth, phase transformations, nucleation, coarsening and grain growth, electrochemical and corrosion kinetics, and kinetics in light-responsive materials.

Prerequisites: Basic knowledge of thermodynamics and materials engineering concepts is expected. Prior coursework in materials kinetics, diffusion, phase transformations, or transport phenomena (e.g., MAT E 202, 301, 335, 336, 373) is recommended but not required. Familiarity with basic numerical methods and scientific computing (e.g., Python) is expected.

TA Information:
Hanlin Wang - hanlin7@ualberta.ca

Lab / Seminar Sections:
This course does not have a formal lab / seminar section.

Course Objectives & General Content:
This course introduces graduate students to the fundamental theories of materials kinetics, with emphasis on irreversible thermodynamics, driving forces for mass transport, fluxes, and rate processes in materials systems. Core topics include diffusion, reaction kinetics, and the coupling of transport and reactions, with analytical and numerical approaches to kinetic analysis. Applications to representative materials systems are used to illustrate how kinetic principles inform the interpretation, modeling, and prediction of materials behavior.

Learning Outcomes:
By the end of this course, students should be able to:

1. Describe fundamental concepts in materials kinetics, including driving forces, fluxes, and rate equations.
2. Explain the relationship between thermodynamics, irreversible processes, and kinetic behavior in materials systems.
3. Apply diffusion and reaction kinetics principles to analyze transport-controlled and reaction-controlled processes.
4. Solve representative kinetic problems using analytical, semi-analytical, and numerical approaches.
5. Analyze coupled transport–reaction phenomena in materials systems under physically motivated assumptions.
6. Formulate simplified kinetic models to interpret or predict materials evolution in selected applications.

Marking Scheme:

Activity	**(A)Synchronous**	**Due/Scheduled**	**Weight**
Assignments*	Asynchronous submission in Canvas	As per Canvas	25%
Final Project**	Synchronous In-class presentation	TBD	30%
Final Examination**	Synchronous	20-Apr-2026 (Monday) @ 1:00 p.m.	45%

* 4 assignments (3 highest out of 4)
** Research-related topic presentation in class (2 lectures)
*** Open book exam. See Final Examination requirements

The Faculty recommended grade point average for a 300 level course is 3.0. Instructors have the leeway to deviate from this average and can assign grades based on their own scheme. All grades are approved by the department chair (or delegate). The office of the Dean has final oversight on all grades.

Term Work

All term work solutions will be posted no later than the last day of classes. All term work will be returned to students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work, shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

Final Examination
The final examination is an in-person, written examination.
Permitted materials:

- Copies of textbook and reference book chapters
- Copies of course materials (lecture notes, handouts)
- Self-prepared equation sheets

Not permitted:

- Communication with other individuals during the examination
- Use of electronic devices
- Use of generative AI tools (online or offline)

University-approved calculators may be brought into the examination; however, calculators are **not required** for this exam.

Text and References

- Balluffi, R. W., Allen, S. M., Carter, W. C., & Kemper, R. A. (2005). Kinetics of materials. Wiley-Interscience. https://onlinelibrary-wiley-com.login.ezproxy.library.ualberta.ca/doi/book/10.1002/0471749311
- Mauro, J. C. (2021). Materials kinetics : transport and rate phenomena. Elsevier. https://www-sciencedirect-com.login.ezproxy.library.ualberta.ca/book/monograph/9780128239070/materials-kinetics
- Levenspiel, O. (1999). *Chemical Reaction Engineering*. Wiley VCH Imprint. https://search.library.ualberta.ca/permalink/01UOA_INST/1lcd9n9/alma991043660812509116
- Porter, D. A., Easterling, K. E., & Sherif, M. Y. (2021). *Phase transformations in metals and alloys.* (Fourth edition / David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif.). CRC Press.

https://search.library.ualberta.ca/permalink/01UOA_INST/1lcd9n9/alma991043908861509116

Generative AI Usage and policies

The course follows the University of Alberta's academic integrity principles that require responsible, transparent, and ethical use of generative artificial intelligence (AI) tools in coursework.

- **Permitted educational uses of generative AI**
  Students are encouraged to use generative AI tools to support learning in the following ways:
  1. Digesting and summarizing course materials.
  2. Obtaining explanations of difficult or unfamiliar concepts.
  3. Assisting with grammar, clarity, and writing mechanics (without altering technical content or meaning).

- **Use of AI in assignments and problem solving**
  Generative AI **must not** be used as a shortcut to obtain solutions to assignments, quizzes, or examinations. Step-by-step derivation and independent reasoning are essential components of learning this course and must reflect the student's own work.

- **Class-provided Gemini Gem for Socratic Learning**
  To promote equity and responsible experimentation with AI, students who wish to use generative AI as a learning companion for the course materials may access a class-provided Socratic learning tool via Google Gemini Gem:

  https://gemini.google.com/gem/1c118102b2d1

  - The Gemini interface is a chat-based AI system that is free to use for University of Alberta students and faculty.
  - When accessed using a University of Alberta account, user data are not used for model training.
  - This Gem is tuned for Socratic learning. It responds by asking guided questions and prompting reflection rather than directly providing final answers.

- **Limitations and responsibility**
  Generative AI systems may produce errors, incomplete reasoning, or unrealistic suggestions. All AI-assisted content must be critically evaluated and verified through independent calculations and course materials. Responsibility for the

learning process and submitted work rests entirely with the student; the instructor is not responsible for errors arising from the use of AI tools.

Online course materials

All presentations given by the instructor during the class will be available as online materials through Canvas and the group website.

Tentative Course Syllabus

MAT E 664 – Kinetics of Materials

Part I: Theory of Kinetics and Transport Phenomena

- Thermodynamics versus kinetics in materials systems
- Irreversible thermodynamics and its connection to kinetic processes
- Molecular diffusion
- Driving forces for mass transport and associated fluxes

Part II: Methods for Solving Kinetic Problems

- Diffusion problems and analytical solutions
- Laplace transform methods for diffusion equations
- Numerical approaches to diffusion and transport problems
- Fundamentals of reaction kinetics
- Coupling of chemical reactions with mass transport

Part III: Selected Topics in Materials Kinetics

Topics selected to reflect core concepts and representative applications in materials kinetics. Depending on the students' background distribution, these may include

- Polymer growth kinetics
- Phase transformations in materials
- Coarsening and grain growth
- Classical and non-classical nucleation theory
- Electrochemical and corrosion kinetics
- Kinetics in light-responsive and photoactive materials

Part IV: Student Project Presentations

- Student-led project presentations on selected topics in materials kinetics
- Two lecture sessions allocated for oral presentations (approximately 15 minutes per student)

UNIVERSITY AND FACULTY POLICIES

COURSE OUTLINE POLICY

The policy about course outlines can be found in Course Requirements, Evaluation Procedures and Grading of the University Calendar, see https://calendar.ualberta.ca/

RESPECT AND PROFESSIONALISM

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards. University is an opportunity for students to explore areas of interest and to potentially pursue a career in a specific field. The Faculty of Engineering prepares students to uphold industry standards to become a Professional Engineer (P. Eng). Respect, professionalism, and accountability must be upheld within the Faculty of Engineering.

Harassment and discrimination are serious issues that have a negative effect on culture and therefore the Student Conduct Policy states that no student shall discriminate against or harass any person or group of persons. The Faculty expects an environment free of harassment, discrimination, and bullying. Please refer to the Definitions for Discrimination, Accommodation and Harassment.

SAFETY DURING LEARNING ACTIVITIES

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control. Anyone found to be unable to function safely, due to intoxication, harassment or discriminatory behaviour, or other reasons, in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Code of Behaviour or Student Conduct Policy. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of an unsafe work/learning environment.

AUDIO/VIDEO RECORDING

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan. Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study, and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. The use of unauthorized personal listening, communication, recording, photographic and/or computational devices is strictly prohibited. Students should refrain from bringing any unauthorized electronic device into an examination room, including cell phones, high tech watches, high tech glasses or other such devices.

ACADEMIC INTEGRITY

Students at the University of Alberta must follow, in its entirety, the **Code of Student Behavior.** Failure to know the Code is not an acceptable excuse for breaking the Code.

If you have not already done so, make sure you review the Code, which is found here along with other resources: https://www.ualberta.ca/natural-applied-sciences/portfolio/education/academic-integrity-and-discipline.html

Engineering students studying in the province of Alberta should also follow the

Code of Ethics

by The Association of Professional Engineers and Geoscientists of Alberta (APEGA), which is found here: https://www.apega.ca/members/legal-obligations

The Code of Student Behavior should not be too hard to follow. Listen to your instructor, be a good person, and do your own work, as this will lead you toward a path to success. Failure to follow the Code can result in a grade of 'F' for the course, a transcript remark, suspension, and even expulsion from the university.

"Integrity is doing the right thing, even when no one is watching"
C.S. Lewis

Engineering at Alberta

NEED HELP?

There are a lot of services available to students on campus and in Edmonton, and sometimes it's hard to know where to go. While this isn't a comprehensive list, the services shown here should at least give you some ideas about where to start. If you're still not sure, check out the services just beneath this box—they'll give you the guidance you're looking for.

DON'T KNOW WHERE TO GO?

Student Service Centre

The U of A's central hub to find the right help for your needs.
uab.ca/ask

24/7 HELP

Empower Me (international)
1-833-628-5589

Edmonton Distress Line
780-482-4357 (HELP)

WELLNESS

Wellness Supports
Free 1:1 support for students in the areas of housing, finances, academics, personal wellness, life skill development, family dynamics, system navigation, and any area of life where there is a desire to invite change.
P: 780-492-1619 | E: wellness@ualberta.ca
M-F, 8:30am-4:30pm (Sep-April), 8:00am-4:00pm (May-Aug)

Counselling and Clinical Services
Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation.
P: 780-492-5205 | M, R, F, 8:00am-4:00pm; T, W, 8:00am-7:00pm

Interfaith Chaplains' Association
Get guidance, care, and support, whether or not you identify with a particular faith. Make an appointment.
P: 780-492-0339 | E: interfaithchaplains@ualberta.ca

The Landing
Offers drop-in support on matters of gender and sexual diversity.
P: 780-492-4949 | E: thelanding@su.ualberta.ca | M-R, hours vary

Peer Support Centre
Anonymous, confidential help from trained students. By appointment only.
P:780-492-4268 | E: psc@su.ualberta.ca | M-F, 9:00am-8:00pm

Sexual Assault Centre
Free, anonymous, and confidential drop-in counselling.
P: 780-492-9771 | E: sexualassaultcentre@ualberta.ca
M-F, 9:00am-8:00pm

University Health Centre
An on-campus health clinic that provides medical services to staff, students, and their spouses and children.
P: 780-492-2612 | E: hws@ualberta.ca | M-F, 8:30am-4:00pm

ACADEMIC

Engineering Student Services
Drop-in, first-come, first-served advising.
E: enggadvising@ualberta.ca

Engineering Student Success Centre
Drop-in tutoring for first-year courses.
E: dessc@ualberta.ca

Academic Success Centre
Many services to maximize your academic success. E: success@ualberta.ca | M-F, 8:30am-4:30pm

Academic Accommodations
Connects students with disabilities to accommodations. E: arrec@ualberta.ca
M-F, 8:30am-4:30pm

Office of the Student Ombuds
Call for complex problems and conflict mediation.
P: 780-492-4689 | E: ombuds@ualberta.ca

FINANCIAL

Student Service Centre
For awards and other funding supports.
uab.ca/ask

Campus Food Bank
Many food support options available. E: info@campusfoodbank.com

SOCIAL

Unitea
Arrange a time to socialize with a peer.
E: unitea@ualberta.ca

BearsDen
U of A webpage. Find student groups, local events, and volunteer opportunities.

WORRIED ABOUT SOMEONE?

Helping Individuals at Risk (HIAR)
If you're worried about someone because of the things they've been saying or doing, or there's a noticeable change in their behaviour (often in multiple ways), contact HIAR, who will protect your confidentiality and help decide how best to support the person.

780-492-4372
hiarua@ualberta.ca

CONFIDENTIAL SUPPORT

Office of Safe Disclosure and Human Rights

The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy.

780-492-7357
osdhr@ualberta.ca