(Materials) Kinetics (MAT 206)

Spring 2021

Course motivation: ***Understanding the effect of reactions and transformations in evolving material systems.*** While thermodynamics tell us what the final state should be, kinetics tells us if and how the system will reach its final state. The details for how quickly or in what manner the system evolves would guide you in determining the processing of a material. Such information would also help you predict if the performance of your material would be stable during its operational lifetime. *This course will prepare you for being an effective materials engineer or scientist,* ***independent of your specialization***. This semester we will apply kinetics in the context of understanding and controlling microstructural evolution in ceramic materials.

Because we are spending most of the semester applying equilibrium phase diagrams and the principles of solution thermodynamics, *ENS 202 is a pre-requisite for this course*. We will only ***review*** the construction of binary phase diagrams, so please dust-off your ENS 202 notes and refresh your memory, as we don't really have time to teach the fundamentals of solutions and equilibrium phase diagrams again.

Instructor: Cleva OW-YANG
cleva@sabanciuniv.edu
office: FENS 1025
216/483-9592

Teaching Assistants: Onur Zihrli: onurzirhli@sabanciuniv.edu
Abdulrahman Al-Nadhari: abdulrahman@sabanciuniv.edu

Lecture hours:	Tuesdays	14:40-16:30	Zoom & Room FENS G032
	Fridays	12:40-13:30	Zoom & Room FENS G032
Recitation hour(s):	Fridays	16:40-18:30	Zoom

Office hours: *After* lectures for Prof. Ow-Yang, or by appointment. The TAs will announce the time and location of their office hours.

1. **Cell phones:** Please turn your cell phone off during class. You're in university now and should pay full attention in class—calculate how much you are paying for each class hour. More importantly, it is rude to be looking at your phone, when you are engaging in a discussion. Just because the adults around you are doing it doesn't make it appropriate.
2. **Lecture notes**: Take notes during lecture. Only selected parts of my lecture notes, basically outlines, will be posted onto SUCourse. These are intended to ***supplement your own notes***. I strongly recommend recopying your own notes, to aid in digestion of the concepts covered. In fact, as I am still developing this course this semester, the posted lecture notes will be very sparse. Therefore, ***take notes***. Lectures and recitations are delivered synchronously, so you can ask questions immediately, including asking me to re-explain something a different way. The video archive exists for you to review.
3. **Time management**: As listed above, you are expected to spend three ***waking*** hours a week in lecture. I strongly recommend spending one hour for each lecture hour, reviewing the lecture

notes and supplementing your understanding with reading from the course references. Numerous exercises and problems are available for you to practice, given for homework and in lecture.

4. **Homework**: … is to be done in small groups. By struggling on the problem sets and learning from the solutions discussed in recitation, this approach is the best way to learn how to apply the concepts that we cover in lecture to solving real engineering problems. In this regard, *homework will not be graded*. The problem sets will be posted on SUCourse. Do show up to recitation to participate in the problem-solving discussion.

5. **Exams**: There will be no exams. Instead, there will be short quizzes in every lecture. You must upload your quiz submission to SUCourse. Do NOT clog my email inbox. I promise not to read emailed quizzes.

6. **Term project**: You will have an opportunity to demonstrate a deeper understanding of course concepts in a term project. Topic list will be posted after the Add/Drop date.

7. **Grading**: 50% of your course grade will be determined from the term project and 50% from in-class quizzes. ***The grade that you earn in this course will reflect your level of mastery of the concepts covered.*** Every year, at least one student attempts to negotiate to do a special project or to do *anything* to pass the course; please note that I do not negotiate, and such requests actually damage the case of the plaintiff.

8. **Textbook**: There will not be an official course textbook. Instead, I will be developing the course from several texts, which are listed in the Course References below. Your notes from ENS 205 and ENS 202 will be very helpful resources for this course.

9. **Lab:** There will be a few optional labs to develop some intuition for topics we discuss in lecture. Although they will be conducted in your kitchen, they are designed to be useful for practical engineers. These labs will be held during the Common Free Hours. Instructions for the lab kits will be provided around the Add/Drop.

10. **Course References (Supplemental reading)**: all items are available at the IC
    a. Kinetics of Materials, by Dennis W. Readey
    b. Thermodynamics of Materials, Vol. 2, by David V. Ragone
    c. Phase Transformations in Metals and Alloys, by D.A. Porter & K.E. Easterling (Chapter 1 is an excellent review of the thermodynamics that you will need for this course!)
    d. Kinetics of Materials, by Robert W. Balluffi, Sam Allen, W. Craig Carter
    e. Physical Chemistry, by Peter W. Atkins

11. **Learning Outcomes**:
    a. Be able to describe atomistic models of diffusion, their practical validation, and their use in applied studies
    b. Be able to build models of evolving surfaces and interfaces in the context of thermodynamic descriptions
    c. Be able to describe the model of nucleation and growth for homogeneous and heterogeneous systems
    d. Be able to describe models for diffusionless transformation and apply these models in practical application

Course Syllabus: *(Tentative plan)*

Semester Week #	Dates	Topic	Notes
Week 1	23/02-26/02	Thermodynamics of solutions (Thermo review)	Equilibrium; changes to the internal energy—Gibbs free energy; solutions; binary phase diagrams (Chap. 1 of P&E)
Week 2	02/03-05/03	Equilibrium phase diagrams & chemical potential of solutions (PS1)	
Week 3	09/03-12/03	Equilibrium phase diagrams & chemical potential of solutions (PS2)	The chemical potential and activity; what phase diagrams tell us; solutions & physical meaning of the activity coefficient
Week 4	16/03-19/03	Diffusion: atomistic dynamics leading to microstructural transformation (PS3)	atomistic models of diffusion; ceramic powder processing by solid-state reaction
Week 5	23/03-26/03	Diffusion: atomistic dynamics leading to microstructural transformation (PS4)	
Week 6	30/03-02/04	Surfaces and Interfaces: crystallography and microstructure	Modeling the energetics of surfaces
Week 7	06/04-09/04		
Week 8	13/04-16/04	Solidification (PS6)	Evolution of systems containing surfaces
Week 9	20/04-23/04	Solidification (PS7)	building models of surfaces and interfaces; thermodynamic descriptions microstructural evolution on surfaces and at interfaces
Week 10	27/04-30/04	Nucleation and Growth (N&G) for phase transformations (PS8)	N&G theory: thermodynamics & kinetics; homogeneous crystallization; heterogeneous crystallization; in liquid and in solid solutions
Week 11	04/05-07/05		
Week 12	09/05-14/05	Ramadan Holidays (no classes)	
Week 13	16/05-21/05	Diffusionless phase transformations (PS8)	Martensitic, displacive changes in crystal structure
Week 14	23/05-28/05	Term project presentations	