MSE111: Materials Kinetics and Processing
Fall 2018

Class times

Lectures:
T, R 1:30pm - 2:20pm; CLSSRM-127.
Lectures will start promptly; *you are expected to arrive on time* to hear important announcements that include the learning objectives for each lecture.

Discussion:
F 1:30pm - 3:20pm; COB2-267.

Course goals

Kinetic principles will be applied to the study of mass transport processes, reactions, and phase transformations in engineering materials, with an emphasis on the solid state. Topics will include thermal (including catalytically assisted) activation, reaction rates and pathways, nucleation and growth, epitaxy and templating, control of micro- and nano-structure, and kinetic considerations in electrochemistry. Applications and case studies relevant to processing and property retention of metals, polymers, ceramics, semiconductors and nanomaterials will be considered.

Learning outcomes

To achieve the *course learning outcomes*, you will

- demonstrate advanced understanding of the kinetic principles that underpin materials processing;
- apply these principles in the context of processing metals, polymers, ceramics, semiconductors and nanomaterials to achieve materials and/or devices with specified properties;
- apply kinetics-related diagrammatic and numerical data, quantitative techniques and critical thinking skills, to address materials processing problems.

You will practice the related skills in homework and discussion exercises. You will demonstrate your proficiency formally in the midterm and final examinations.

The course learning outcomes will contribute to your attainment of the following *program learning outcomes* (marked with an asterisk):

(a) An ability to apply knowledge of mathematics, science, and engineering*
(b) An ability to design and conduct experiments, as well as to analyze and interpret data

(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability*
(d) An ability to function on multidisciplinary teams
(e) An ability to identify, formulate, and solve engineering problems*
(f) An understanding of professional and ethical responsibility*
(g) An ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global, environmental, economic, and societal context
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues*
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*

Lead instructor (lectures and discussion)

Christopher Viney (cviney@ucmerced.edu)

Office hours:
M 4:00pm - 5:00pm; GRAN-130
W 6:00pm - 7:00pm; GRAN-115

E-mail is not a substitute for attending office hours, and it is not a useful medium for obtaining help with homework.

Prerequisites

(MATH 021 or equivalent exam) and (PHYS 008 or PHYS 008H or equivalent exam) and (CHEM 002 or CHEM 002H or equivalent exam) and ENGR 130, which may be taken concurrently.
Open only to major(s): Bioengineering, Materials Sci and Engineering, Physics, Environmental Engineering, Mechanical Engineering, Chemical Sciences, Computer Science and Engineering. Open only to standing(s): Junior, Senior.

Text

The scope of this class is not covered by any textbook. Your class notes will be your primary source of reference material. In addition, readings from current research and professional literature will be assigned.

Discussion

Learning a subject is enhanced by ***interacting with*** the subject – which includes discussing concepts and solving practice problems. Your discussion section is

designed to support your efforts to learn the course material by working with it in as many ways as possible. Attendance will be recorded.

Homework

Homework is a critical component of this course and is designed to help you learn, understand and practice the material. Seven sets of homework exercises will be issued during the semester. Homework is due on the dates indicated in the detailed schedule provided to course participants via CatCourses. ***Late homework will not be accepted without proof of medical or similarly grave extenating circumstances.***

You are encouraged to work with your peers when doing homework. However, each student must turn in his/her own homework assignment and it must reflect his/her own work. You must explicitly identify all peers with whom you worked.

Exams

There will be two in-class midterm exams as indicated on the detailed schedule. There will also be a comprehensive final exam. *There will be no make-up exams.* If you are sick during a regularly scheduled exam, please bring a note from the university clinic or your own doctor verifying your illness. Your course grade will then be determined by the rest of your work.

Crib sheets will not be allowed during any of the exams. However, calculators will be allowed when necessary, provided that they are not used to store data or formulae pertaining to the course.

Grade determination

Your final grade will be based on the following components:

- homework (20%).
- first midterm (20%)
- second midterm (20%)
- final exam (40%)

Note that grades will not be assigned on a curve, but will be based on an absolute measure of your work.

Dropping the course

Please see the UC Merced General Catalog and the Registrar's / Student First website for details.

CatCourses

The CatCourses site F18-BEST 204 01/MSE 111 01 will be used for periodic course announcements, and for distributing class notes, discussion exercises, homework sets, and (some) solutions. You can also check the scores that you have received on your homework assignments and exams.

Warning: pay no attention to any letter grade that is reported on CatCourses, *except* for the final grade.

Special accommodations

UC Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. If you qualify for accommodations because of a disability, please submit a letter from the Disability Services Center to me in a timely manner (during the first three weeks of the semester, except for unusual circumstances) so that your needs may be addressed. Student Affairs determines accommodations based on documented disabilities.

We will make every effort to accommodate all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please speak with the lead instructor (CV) during the first week of class regarding any potential academic adjustments or accommodations that may arise due to religious beliefs.

Academic honesty and conduct

Students are expected to complete their own work and to abide by the UC Merced Academic Honesty Policy, which can be found on the Student Life website under the "Office of Student Conduct" link. Any work submitted by a student in this course for academic credit will be the student's own work.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, (for example) in the form of an email, an email attachment file, an online file in a shared folder, a diskette or external drive, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.

You must do your own work during examinations. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Note that the handouts and notes provided in this course are for your *personal* use only. Re-posting such materials on sites such as (for example) "Course Hero" is an explicit violation of this agreement.

Students and instructors are expected to honor UC Merced's Founding Principles of Community: http://www.ucmerced.edu/about-uc-merced/principles-community.

Resources

Counseling and Psychological Services
The mission of UC Merced Counseling and Psychological Services (CAPS) is to support the mental health and well-being of our students. It is the intention of all CAPS staff to provide a safe, confidential atmosphere of acceptance and accessibility to professionals in the field of psychology.

Contact Information (Confidential Help)
Phone: (209) 228-4266
counseling@ucmerced.edu
https://counseling.ucmerced.edu/

Discrimination & Sexual Violence Prevention
The University of California is committed to creating and maintaining a community where all individuals who participate in university programs and activities can work and learn together in an environment free of harassment, exploitation or intimidation.

Contact Information
Phone: (209) 285-9510
msalvador2@ucmerced.edu, Michael Salvador, Director of Compliance
https://dsvp.ucmerced.edu/

CARE Office
Campus Advocacy, Resources, & Education (CARE) provides prevention education for the UC Merced community to achieve an environment free from the threat of sexual violence, dating/domestic violence, and stalking. They provides free and confidential assistance for all UC Merced affiliates (including Undergraduate students, Graduate students, Staff and Faculty. Stop by KL 107.

Contact Information (Confidential Help)
Campus Advocate: Lynna (209) 386-2051
Valley Crisis Center: 24/7 Hotline (209) 722-4357
https://care.ucmerced.edu/

Food Assistance (CalFresh)
CalFresh is a monthly stipend system that allows you to purchase food for no cost at all on your part. If you qualify for work study you most likely qualify for CalFresh.

Contact Information
Phone: 209-228-4187
calfreshoutreach@ucmerced.edu
https://healthpromotion.ucmerced.edu/calfresh-outreach

Final thoughts

If you are in trouble (behind in homework, doing worse in the course than you would like, etc.) for whatever reason, please let the lead instructor know. Help and advice are available.

Because this is a 4-unit course, you should plan to do *at least* 12 hours of work on it, per week. Here is one suggestion for how to spend this time effectively:

- reading assigned material: 2 hours/week
- attending lectures and office hours: 3 hours/week
- attending and participating in discussion: 2 hours/week
- homework: 3 hours/week
- review, and preparation of review notes: 2 hours/week

It is a good idea to explicitly block out time for all these activities in your schedule. The same is true for your other courses too!

MSE111 / BEST204--Materials Kinetics and Processing--Fall 2018 Schedule

Week	Day	Date	Lecture (provisional scope and contents)	Discussion	HW
1	M	20-Aug			
	T	21-Aug			
	W	22-Aug	(Instruction begins)		
	R	23-Aug	Lecture 1: Introduction. Kinetics in the context of MSE. Practical relevance. Dispelling fake news about catalysts.		
	F	24-Aug		none	
2	M	27-Aug			
	T	28-Aug	Lecture 2: Chemical reactions in gases and liquids. Collisions, RMS speed, average kinetic energy, collision time scales. Maxwell-Boltzmann distribution. Activation energy.		
	W	29-Aug			
	R	30-Aug	Lecture 3: Arrhenius equation. Reaction mechanism, elementary reactions, reaction intermediate, order of reaction, experimental rate law, rate determining step.		
	F	31-Aug		D1	
3	M	3-Sep	Labor Day		
	T	4-Sep	Lecture 4: Reactions involving (co)polymers. The copolymer equation.		
	W	5-Sep			
	R	6-Sep	Lecture 5: Diffusion in gases, liquids and solids. Graham's Law. Random walks. Einstein–Smoluchowski relation.		
	F	7-Sep		D2	
4	M	10-Sep			
	T	11-Sep	Lecture 6: Diffusion in solids. Mechanisms of diffusion. Evidence for vacancies. Kirkendall Effect. Dependence on temperature.		
	W	12-Sep			
	R	13-Sep	Lecture 7: Fickian and non-Fickian cases. Fick's First Law. Diffusion coefficient. Mean diffusion distance.		HW1 due
	F	14-Sep		D3	
5	M	17-Sep			
	T	18-Sep	Lecture 8: Fick's Second Law. Thin film solution. Infinite source solution. Analogy with heat flow.		
	W	19-Sep			
	R	20-Sep	Lecture 9: Diffusion in metals. Review of Fe-C phase diagram. Carburization and decarburization.		
	F	21-Sep		D4	
6	M	24-Sep			
	T	25-Sep	Lecture 10: Diffusion in ceramics. Mobile defects in ceramics. Formation of metal oxides. Semiconducting behavior of metal oxides. Oxygen sensors. Nuclear waste containment.		
	W	26-Sep			
	R	27-Sep	Lecture 11: Diffusion in semiconductors. Doping.		HW2 due
	F	28-Sep		D5	
7	M	1-Oct			
	T	2-Oct	Lecture 12: (Re)view of concepts from the thermodynamics of mixing. Ideal, regular, and real solutions. Chemical potential. Activity.		
	W	3-Oct			
	R	4-Oct	Lecture 13: Equilibrium. Relationship between free energy vs. temperature plots and phase diagrams. Driving force for phase transformations. Homogeneous nucleation in solids.		
	F	5-Oct		D6	

Week	Day	Date	Lecture (provisional scope and contents)	Discussion	HW
8	M	8-Oct			
	T	9-Oct	Lecture 14: *Rate* of homogeneous nucleation. Heterogeneous nucleation. Factors that favor nucleation. Widmanstätten (micro)structures.		
	W	10-Oct			
	R	11-Oct	Lecture 15: GP zones and related metastable intermediate (micro)structures associated with heterogeneous nucleation.		HW3 due
	F	12-Oct		Midterm 1	
9	M	15-Oct			
	T	16-Oct	Lecture 16: Spinodal decomposition.		
	W	17-Oct			
	R	18-Oct	Lecture 17: Classification of solid state phase transformations. Massive transformations. Martensitic transformations. Shape memory alloys.		
	F	19-Oct		D7	
10	M	22-Oct			
	T	23-Oct	Lecture 18: (Shift focus from nucleation to growth.) Interface roughness. Continuous growth, lateral growth, and faceting. Relationship between growth velocity and undercooling.		
	W	24-Oct			
	R	25-Oct	Lecture 19: Grain structure in castings. Dendrite formation. Partition coefficient for solidification. Non-equilibrium solidification.		HW4 due
	F	26-Oct		D8	
11	M	29-Oct			
	T	30-Oct	Lecture 20: Constitutional supercooling. Scheil equation (non-equilibrium Lever Rule).		
	W	31-Oct			
	R	1-Nov	Lecture 21: Heat flow in solidification. Biot number. Dimensional analysis.		
	F	2-Nov		D9	
12	M	5-Nov			
	T	6-Nov	Lecture 22: Diffusion-controlled precipitate growth. Overall phase transformation rate. Generalized treatment of phase transformations that depend on more than one system variable. Generalization of "phase transformation" concept.		
	W	7-Nov			
	R	8-Nov	Lecture 23: Real volume vs. extended volume. Avrami equation. Measurement of fraction transformed. Relationship between Avrami plots and isothermal transformation diagrams.		HW5 due
	F	9-Nov		Midterm 2	
13	M	12-Nov	Veterans Day (observed)		
	T	13-Nov	Lecture 24: A closer look at surface energy. Ostwald ripening. Young-Laplace equation. Gibbs-Thomson equation.		
	W	14-Nov			
	R	15-Nov	Lecture 25: Concentration enhancement in matrix near a precipitate. Coarsening rate. Dispersion strengthening. Diffusion during sintering. Environmental hazards of handling powders.		
	F	16-Nov		D10	
14	M	19-Nov			
	T	20-Nov	Lecture 26: Nanosynthesis. Hydrophobic interactions. Self-assembly of amphiphiles. Nanoparticle shape and size control.		
	W	21-Nov	Non-Instructional Day		
	R	22-Nov	Thanksgiving Holiday		
	F	23-Nov	Thanksgiving Holiday		

Week	Day	Date	Lecture (provisional scope and contents)	Discussion	HW
15	M	26-Nov			
	T	27-Nov	Lecture 27: Self-assembly of biological materials (with emphasis on protein fibers). Hierarchical molecular order. Role in present in future technologies.		HW6 due
	W	28-Nov			
	R	29-Nov	Lecture 28: Kinetics and electrochemistry. Epilog.		
	F	30-Nov		D11	
16	M	3-Dec			
	T	4-Dec	(Lecture 29:) Wiggle room / review.		
	W	5-Dec			
	R	6-Dec	(Lecture 30:) Wiggle room / review.		HW7 due
	F	7-Dec	(Instruction ends)	(D12)	
17	M	10-Dec			
	T	11-Dec			
	W	12-Dec			
	R	13-Dec			
	F	14-Dec	**Final Exam (11:30am–2:30pm)**		