JOINT INSTITUTE
交大密西根学院

VK335 Kinetics and Transitions in Materials Engineering

Summer 2022

Instructor:	Yanming Wang, Ph. D.
Office:	Long Bin Building 525
Contact:	(021)3420-6765 5251, yanming.wang@sjtu.edu.cn
Office Hours:	TBD
Classroom:	Online via Feishu
Time:	Tue/Thu 14:00-15:40, Wed 14:00-15:40 (odd weeks)
TA:	Zhiyi Wang
TA Contact:	wellywang@sjtu.edu.cn
TA OH:	TBD

Course Description:
This course discusses fundamental concepts and models for understanding and predicting the kinetics of materials, which mainly include the aspects of chemical reactions, mass transfer, dislocation and interface motions, morphological evolutions and phase transformations.

Credits: 4

Prerequisites: VV216 or equivalent, VK250, VK330

Course Objectives:
1. To teach the calculation of reaction constant and reaction rate
2. To discuss different types of chemical reactions and their corresponding kinetic models
3. To explain the atomistics and mathematics of diffusion phenomena
4. To show examples of various diffusion and interdiffusion processes in material systems

5. To discuss Fick's first and second laws, with demonstrating their solutions under different conditions
6. To discuss the types of dislocations and interfaces, and the features of their motions
7. To explain the capillary effects and their consequences in materials' morphological and structural evolution
8. To teach the theorem and equations developed for order-disorder phase transitions
9. To teach classical nucleation theory and crystal growth mechanisms
10. To show examples of phase transitions in real material systems

Course Outcomes:

After completing VK335, students should be able to:

1. Identify the types of chemical reactions and calculate the reaction rates
2. Analyze the kinetic factors of a real chemical reaction process
3. Explain the mechanisms of diffusion phenomena occurring in different material systems
4. Calculate the concentration evolution during a diffusion process under given boundary conditions
5. Identify different types of dislocation and interface motions with explaining their associated atomistic mechanisms
6. Describe and predict the structural and morphological evolutions of materials by analyzing the capillary and applied forces
7. Construct models for describing the spinodal and order-disorder transformations
8. Predict the nucleation and growth rate of materials under various conditions

Textbook/Required Material:

[1] Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. John Wiley & Sons, 2005.

[2] Readey, Dennis W. *Kinetics in Materials Science and Engineering*. CRC Press, 2017.

[3] 李静波、金海波. *材料动力学理论*. 北京理工大学出版社, 2017 (e-book available from SJTU library).

Week	Dates	Topics
1	5/10	Course introduction and background information
	5/11	Review on thermodynamics of materials
	5/12	First-order, second-order and multi-step reactions
2	5/17	Temperature dependence of the reaction rate constant
	5/19	Heterogenous reactions
3	5/24	Coupled forces and fluxes
	5/25	Driving forces and fluxes for diffusion I
	5/26	Driving forces and fluxes for diffusion II

4	5/31	The diffusion equations
	6/2	Solutions to the diffusion equation I
5	6/7	Solutions to the diffusion equation II
	6/8	Diffusion in multi-component systems
	6/9	Atomistics of diffusion
6	6/14	Diffusion in crystals
	6/16	Diffusion along crystal imperfections
7	6/21	Diffusion in non-crystalline materials
	6/22	Midterm review
	6/23	Midterm (online)
8	6/28	Motion of dislocations
	6/30	Motion of crystalline surfaces and interfaces
9	7/5	Surface evolution due to capillary forces
	7/6	Coarsening due to capillary forces
	7/7	Morphological evolution: diffusional creep and sintering
10	7/12	General features of phase transformations
	7/14	Spinodal and order-disorder transformations
11	7/19	Nucleation
	7/20	Growth of phases in concentration and thermal fields
	7/21	Concurrent nucleation and growth; nonclassical nucleation theory
12	7/26	Solidification; precipitation
	7/28	Final review
13	8/2	-
	8/4	Final exam (tentative)
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Course Policies:

- **Honor Code:** All students in the class are bound by the Honor Code of the Joint Institute (http://umji.sjtu.edu.cn/academics/academic-integrity/honor-code/) as well as the ***Addendum to the Honor Code for Online Teaching***. You may not seek to gain an unfair advantage over your fellow students; you may not consult, look at, or possess the unpublished work of another without their permission; and you must appropriately acknowledge your use of another's work.
- Attendance: Attendance to the lectures, either in-person or on-line, is strongly encouraged. Reasonable explanations need to be given for continuous absence for more than one week.

- Participation: Active participation is highly expected for all students, including interactive activities during the lecture, attendance of instructor office hours, on-line and in-person discussions with instructor and other students in a proper way, etc.
- Assignments: Unless specified, all the assignments are individual assignments, and all submissions must represent the student's own work. Duplicated submission is not allowed and will trigger an honor code violation investigation. However, students are encouraged to discuss course topics and help each other to understand the problems.
- Submission: All assignments should be submitted electronically on Canvas before the specific deadline.
- Exams: Exams will be conducted following all the standard regulations of JI and SJTU. If needed, additional procedures will be announced prior to the exams. Anyone who fail to follow the procedures will be given an 'F' for the exam.

Addendum to the Honor Code for Online Teaching

- The Honor Code in the Context of Online Courses
  The JI Honor Code applies to courses taught in an online fashion in the same way that it does to all courses. It is worth repeating the central tenets here:
  - Engineers must possess personal integrity as students and as professionals. They must honorably ensure safety, health, fairness, and the proper use of available resources in their undertakings.
  - Members of JI are honorable and trustworthy persons.
  - The students, faculty members, and staff members of JI trust each other to uphold the principles of the Honor Code. They are jointly responsible for precautions against violations of its policies.
  - It is dishonorable for students to receive credit for work that is not the result of their own efforts.

  In particular, the parts of the Honor Code regarding conduct during in-class examinations, for coursework, projects etc. apply correspondingly for such work conducted in courses taught online. Additional rules adapted to remote examinations, coursework etc. may be imposed as necessary.

  In addition, students are required to abide by following rules specific to online teaching. These requirements are provisionally considered part of the Honor Code for the current teaching term.

Due to the new types of interaction and the new forms of learning activities there may be further issues that are not covered below. Students should not hesitate to contact their instructor, the Honor Council (jihonor@sjtu.edu.cn) or the FCD (jifcd@sjtu.edu.cn) if they have any questions.

- Online Presence and Activities

  The Joint Institute imposes a “real name” policy for all online activities organized by JI instructors. This policy applies to groups or communication by E-Mail, Canvas, Piazza, Feishu, WeChat and all other platforms where groups are set up by JI or by individual instructors for students attending JI courses, events or other activities.

  Students are required to use their actual name (in Pinyin) as part of their online presence for such groups and when communicating online. Individual instructors may also require students to add their name in Chinese characters (if applicable) and/or their Student ID.

  Unless otherwise noted, such online activities are intended for the exclusive participation of JI students. Account names, meeting IDs, passwords and other information intended to protect the exclusivity of such activities may not be shared with anyone who is not part of the course or activity.

  For example, it is not permissible to give a Feishu meeting ID of a given course to any person who is not enrolled in that course, whether or not the person is a JI student.

- Online Etiquette

  When communicating or otherwise using online groups, students should follow the regulations set down by instructors concerning the use of online tools. Vandalism, spam messages, verbal and other forms of abuse, violation of English-only policies (as detailed by instructors) and disturbance of the learning experience of other students are not permitted.

- Teaching and Learning Materials

  Teaching and learning materials, such as lecture slides, assignments, quizzes, videos etc. are copyrighted and may not be passed on to others without the express permission of the course instructor. This applies in particular to recordings of Feishu lectures and other videos created by instructors.

In particular, it is not permissible to upload videos to sharing platforms (such as Youku, YouTube, etc.) or to post lecture slides, assignment questions, project descriptions etc. on public sites such as SlideShare.

Course Assessment Methods:

Homework:
Homework problems are designed such that the students can apply and exercise the knowledge taught in the lectures. Through solving these problems, the students are expected to digest the knowledge better and turn it into their own scientific understandings and skills, for applying kinetics related theories to practical materials science problems.

Project:
Individual project is assigned to each student with its topic closely combining the course content with practical problems. These problems usually cover several knowledge points of the course with moderate extensions. Thus, the project provides an opportunity for the students to integrate the knowledge they learn from the class, and it serves as a motivation for them to learn outside the class. The project may also provide them an experience of independently solving research problems.

Examination:
Examinations (midterm & final) are means to comprehensively measure the students' level of achievement of the Course Outcomes. The typical types of exam problems include T/F and multiple-choice questions, proofs, derivations, calculations, sketches, and etc. The form of the examinations is expected to be on-line (the students on-campus are encouraged to take the exams in the classroom, but the submission is still via Canvas and handing in the exam papers in person is not accepted).

Grading Policy:

Homework	30%
Midterm Exam	20%
Project	15%
Final Exam	35%
Total	**100%**