Course Outline

MATS2006

Diffusion and Kinetics

Materials Science and Engineering

Science

T3, 2020

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Dr Kevin J. Laws	k.laws@unsw.edu.au	Room 301, School of Materials Science and Engineering (Building E10) by appointment	Phone: 9385 5234
Lecturer	Dr Kim Lapere	k.lapere@unsw.edu.au	Room 133 Dalton Building (F12) School of Chemistry by appointment	Phone: 9385 4708
Lecturer	Dr Rakesh Joshi	r.joshi@unsw.edu.au	Room 448, School of Materials Science and Engineering (Building E10) by appointment	Phone: 9385 4324

2. Course information

Units of credit: 6

Pre-requisite(s):

Timetabling website: TBA

Teaching times and locations:

	Lecture	Lecture	Lecture	Lab
Day	Monday	Wednesday	Friday	See Moodle for details
Time	9:00-11:00	11:00-1:00	9:00-11:00	
Weeks	1-3, 5, 7-10	1-5, 7-10	1-5, 7-10	

2.1 Course summary

Introduction to solid state diffusion, atomistics of diffusion, Fick's first and second laws; thin film solution and tracer diffusion measurements, semi-infinite and infinite diffusion couples - diffusion in a concentration gradient; temperature effects; surface, grain boundary and dislocation pipe diffusion; diffusion in ionic solids, interdiffusion and the Kirkendall effect, measurement of variable diffusion coefficients; thermodynamics vs. Kinetics, elementary and non-elementary reactions, reaction order, activation energy, Arrhenius law, irreversible and reversible reactions, degree of reaction; heterogeneous reactions, kinetics of solid state-gas (fluid) reactions, elementary steps, rate-controlling steps, intrinsic kinetics, chemisorptions, mass transfer in the gas phase and fluid, multicomponent system, Knudsen diffusion, shrinking core model.

2.2 Course aims

In this course you will be introduced to the fundamentals of kinetics and diffusion mechanisms pertinent to engineering materials. When successfully completed, you will be able to apply these fundamentals to quantify transport phenomena that occur in various materials processing applications.

2.3 Course learning outcomes (CLO)

At the successful completion of this course you (the student) should be able to:

1. Correctly use the language of chemical kinetics including: rate, rate law, order, molecularity, elementary and overall reaction, half-life; isolation method, pseudo-order, rate determining step, reactive intermediate, steady state approximation; mechanism; activation energy, frequency factor; catalyst; potential energy surface, reaction coordinate, steric factor, transition state
2. Understand the role of microstructural features such as grain boundaries, dislocations and point defects in diffusion and kinetics
3. Derive fundamental kinetics and diffusion laws and use these to model material processes and behaviours
4. Interpret and quantify time dependent chemical kinetics and mass transfer processes which occur in materials, materials processing and synthesis operations

2.4 Relationship between course and program learning outcomes and assessments

Course Learning Outcome (CLO)	LO Statement	Program Learning Outcome (PLO)	Related Tasks & Assessment
CLO 1	Correctly…	1.2 & 1.3	1, 2, 3 & 4
CLO 2	Understand...	1.2 & 1.3	1 & 2
CLO 3	Derive…	1.1, 1.2 & 1.3	1, 2 & 3
CLO 4	Interpret…	1.1, 1.2 ,1.3 & 2.1	1, 2, 3 & 4

3. Strategies and approaches to learning

3.1 Learning and teaching activities

(Based on UNSW Learning Guidelines)

- *Students are actively engaged in the learning process.*

It is expected that, in addition to attending classes, students will read, write, discuss, and engage in analysing the course content.

- *Effective learning is supported by a climate of inquiry where students feel appropriately challenged.*

Students are expected to be challenged by the course content and to challenge their own preconceptions, knowledge, and understanding by questioning information, concepts, and approaches during class and study.

- *Learning is more effective when students' prior experience and knowledge are recognised and built on.*

Coursework, tutorials, assignments, laboratories, examinations, and other forms of learning and assessment are intended to provide students with the opportunity to cross-reference these activities in a meaningful way with their own experience and knowledge.

- *Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts*

The course content is designed to incorporate both theoretical and practical concepts, where the latter is intended to be applicable to real-world situations and contexts.

Lectures: The core concepts will be taught in lectures, students will have access to the lectures notes before class for annotation during the lecture. Students will be engaged in the learning process through class discussions and problem-solving questions independently and working together with partners and groups

Labs: Experimental techniques and procedures will be taught through laboratories classes and laboratory reports following the class. Students will actively complete the experiments gaining experience of important materials testing and characterisation techniques. Students will be able to reflect on the experiments and learn to process data through the lab reports after class.

3.2 Expectations of students

- Students must attend at least 80 % of all classes with the expectation that students only miss classes due to illness or unforeseen circumstances
- Students must read through lecture notes and lab sheets prior to class
- During class, students are expected to engage actively in class discussions
- Students should work through lecture, tutorial and textbook questions
- Students should read through the relevant chapters of the prescribed textbook.
- Students should complete all assessment tasks and submit them on time.
- Students are expected to participate in online discussions through the Moodle page

4. Course schedule and structure

This course consists of 54 hours of class contact hours per term. You are expected to take an additional 96 hours of non-class contact hours to complete assessments, readings and exam preparation spread over the term.

Week	Course Section	Topics	Activity
1	Kinetics	Introduction Reaction rates Catalysis, Enzymes	
2		Molecular reactions Tutorial	Exam
3	Diffusion Fundamentals	Introduction to diffusion Diffusion in Liquids	
4		Diffusion in gasses Diffusion in solids Diffusion in thin films	
5		Tutorial	Exam
6	Study break		
7	Applied Diffusion and Kinetics	Introduction to applied diffusion and kinetics Real world applications Nucleation, Crystallisation & Growth	Lab class
8		Recrystallisation & Transformation	Lab class
9		Grain Boundary & Interface Diffusion Everyday Diffusion & Kinetics Cases	Lab class
10		Tutorial	Lab class

5. Assessment

5.1 Assessment tasks

Assessment task	Description	Weight	Due date
Kinetics exam:	The exam covers all kinetic content. Students will be asked to understand simple and complex kinetic systems, determine and apply rate equations, and interpret real data in terms of the theory provided.	25%	In class Week 2
Diffusion fundamentals exam:	Based on all diffusion fundamentals content. Students will be asked to understand basic principles of diffusion, fundamental theory, examples of diffusion process, and possible application.	30%	In class Week 5
Applied Diffusion and kinetics exam:	Based on all applied diffusion and kinetics class content. Students will be asked understand and apply simple fundamental aspects of diffusion and kinetics in commonplace examples and processes.	35%	Exam Period
Laboratory reports:	Small group exercise in the laboratory, determining initial reaction rates and correlating concentration dependence to order of the reaction. Concludes with a written report	10%	At end of lab class

Further information

UNSW grading system: https://student.unsw.edu.au/grades

UNSW assessment policy: https://student.unsw.edu.au/assessment

5.2 Assessment criteria and standards

Assessment criteria and standards for each assessment tasks are available on the course Moodle page.

5.3 Submission of assessment tasks

- UNSW operates under a Fit to Sit/ Submit rule for all assessments. If a student wishes to submit an application for special consideration for an exam or assessment, the application must be submitted prior to the start of the exam or before an assessment is submitted. If a student sits the exam/ submits an assignment, they are declaring themselves well enough to do so. Information on this process can be found here: https://student.unsw.edu.au/special-consideration. Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.
- Lab reports submitted after the due date for submission will receive a 10% of maximum grade penalty for every day late, or part thereof.
- Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity

and Diversity Unit: https://student.unsw.edu.au/disability. Early notification is essential to enable any necessary adjustments to be made.

- Rules governing conduct during exams are given at: https://student.unsw.edu.au/exam-rules

4.4. Feedback on assessment

Lab reports: Students will receive their mark and individualised feedback on the areas they excelled at and which areas of the reports that were not answered correctly. Feedback will be provided through Moodle, two weeks after submission.

Exams: Students will receive their marked exams indicating what questions were answered correctly and incorrectly. Overall comments and worked solutions may be provided to the class.

6. Academic integrity, referencing and plagiarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site https://student.unsw.edu.au/plagiarism*,* and
- The *ELISE* training site http://subjectguides.library.unsw.edu.au/elise/presenting

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct.

7. Readings and resources

Kinetics

- P.W. Atkins and J. De Paula, Elements of Physical Chemistry, 5th edition, Oxford University Press, 2009.

Diffusion

- Marcel Mulder, Basic Principles of Membrane Technology Kluwer Academic Publishers, ISBN-13:978-0-7923-4248-9
- Paul Shewmon, Diffusion in Solids, 2nd Edition, ISBN-13: 978-0873391054
- J. E. Brady, J. W. Russell and John R. Holum, Chemistry Matter and Its Changes, John Wiley & Sons, Inc. New York, 3 Edition, 2000 (Chapter 13)

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

- Levenspiel, Chemical Reaction Engineering, John Wiley & Sons, any edition, freely available in electronic version.
- H. Y. Sohn, Fundamentals of the Kinetics of Heterogeneous Reaction Systems in Extractive Metallurgy, Rate Processes of Extractive Metallurgy (Eds. H Y Sohn and M E Wadwsworth), Plenum Press, 1979.
- H S Ray, Kinetics of Metallurgical Reactions, International Science Publisher, 1993.
- N.J. Themelis, Transport and Chemical Rate Phenomena, Gordon and Breach, 1995.
- DA. Porter and K.E. Easterling, Phase Transformations in Metals and Alloys, Chapman & Hall, London, 1991.
- P.Shewmon, Diffusion in Solids, 2nd Edition, Minerals, Metals & Materials Society, Warrendale, PA, 1989.
- Robert Reed-Hill, Physical Metallurgy Principles, PWS-Kent Pub. 1992

8. Administrative matters

School Office: Room 137, Building E10 School of Materials Science and Engineering
School Website: http://www.materials.unsw.edu.au/
Faculty Office: Robert Webster Building, Room 128
Faculty Website: http://www.science.unsw.edu.au/

9. Additional support for students

- The Current Students Gateway: https://student.unsw.edu.au/
- Academic Skills and Support: https://student.unsw.edu.au/academic-skills
- Student Wellbeing, Health and Safety: https://student.unsw.edu.au/wellbeing
- Disability Support Services: https://student.unsw.edu.au/disability-services
- UNSW IT Service Centre: https://www.it.unsw.edu.au/students/index.html
- Assessment Implementation Procedure: https://www.gs.unsw.edu.au/policy/documents/assessmentimplementationprocedure.pdf
- Special Consideration: https://student.unsw.edu.au/special-consideration