MASC 503 – Thermodynamics of Materials

Fall, 2019

Lectures
M/W 3:00 - 4:50 pm, OHE 100D

Course Description
Thermodynamics of Materials is intended for graduate students in Materials Science and Engineering. The goal of the course is to introduce students to a broad treatment of classical thermodynamics and its applications to equilibrium properties of materials. The course will provide a thermodynamic framework for the treatment of general phenomena in materials science, e.g. chemical reactions, diffusion, and point defects. However, the course will focus on maps of equilibrium states such as phase diagrams. Course topics include the laws of thermodynamics, statistical mechanics, phase equilibria, phase transformations, and phase diagrams of binary and ternary alloys.

Learning Objectives
Students at the end of the course will be equipped with a foundation on classical thermodynamics and statistical mechanics that will allow them to:

1. Understand the laws of thermodynamics and their application to mechanical and electromechanical systems, and solutions;
2. Be familiar to both classical thermodynamics and statistical mechanics and be able to link macroscopic to microscopic properties;
3. Understand phase equilibrium of single component systems and mixtures;
4. Be able to describe the thermal behavior of solid materials and phase transitions;
5. Be able to read, analyze, and construct phase diagrams

Instructor
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Teaching Assistant: Chang Liu (liu396@usc.edu)
Office hours with TA: Mondays 10 am – 12 pm at VHE 514

Required Readings and Supplementary Materials
Lecture notes will be provided and contain all required content. The books listed below are reference supplementary readings.
Introduction to the Thermodynamics of Materials, 6th edition, by David R. Gaskell & David E. Laughlin, CRC Press, Taylor and Francis Group, 2018.
Thermodynamics in Materials Science, 2nd edition, by Robert DeHoff, CRC Press, Taylor and Francis Group, 2006.
Statistical Mechanics, 1st edition, by Donald Allan McQuarrie, University Science Books, Sausalito, 2000.
Molecular Thermodynamics, Richard Dickerson, Benjamin, Menlo Park, 1969.

Principles of Phase Diagrams in Materials Science, by Paul Gordon, McGraw Hill, New York, 1968.
Fundamentals of Materials Science and Engineering: An Integrated Approach, 5th edition, William D. Callister and David G. Rethwisch, 2015, ISBN: 9781119234395.

Assessment
The learning outcome will be assessed by three midterm tests, an open book quiz, and a final exam. The midterms and the final test are closed book and closed notes. Midterm tests will be given roughly every four weeks about topics covered in the lectures during each period. The final exam is cumulative and include topics covered in all lectures.

Grading Breakdown

Assignment	% of Grade
Midterm 1	20
Midterm 2	20
Midterm 3	20
Quiz	10
Final Exam	30

Important Dates
Midterm 1: Monday, September 23th
Midterm 2: Monday, October 21th
Midterm 3: Wednesday, November 20th
Quiz: Due on November 20th
Final exam: Monday, December 16th 2 - 4 pm.

Course Schedule: A Weekly Breakdown

	Topics	Readings	Exams
Week 1	Thermodynamics Introduction First Law of Thermodynamics	Gaskell and Laughlin Ch 1 and 2 DeHoff Ch 1-2, Ch 3 Dickerson: Ch 3	
Week 2	First/Second Law of Thermodynamics	Gaskell and Laughlin Ch 2 and 3 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	
Week 3	Second Law of Thermodynamics	Gaskell and Laughlin Ch 3 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	
Week 4	Thermodynamic Relations Third Law of Thermodynamics	Gaskell and Laughlin Ch 4 and 6 DeHoff Ch 3 and 4 Dickerson: Ch 3, 4	**Mid Term 1**
Week 5	Statistical Mechanics: Ensembles and Thermodynamic Connection	McQuarrie Ch 2 and 3	
Week 6	Statistical Mechanics: Boltzmann, Fermi-Dirac, and Bose Einstein Statistics	McQuarrie Ch 4	

Week 7	Statistical Mechanics: Ideal Monatomic and Diatomic Gases	McQuarrie Ch 5 and 6	
Week 8	Statistical Mechanics: Partition Functions and Ideal Polyatomic Gases	McQuarrie Ch 7 and 8	**Mid Term 2**
Week 9	Phase Equilibria of Single Component Systems	Gaskell and Laughlin Ch 7 and 8 DeHoff Ch 5 and 7	
Week 10	Thermodynamics of Solutions	Gaskell and Laughlin Ch 9 and 10 DeHoff Ch 8 Dickerson: Ch 6	
Week 11	Thermodynamics of Reactions	Gaskell and Laughlin Ch 11 and 12 DeHoff Ch 11 Dickerson: Ch 5	
Week 12	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	
Week 13	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	**Mid Term 3 Quiz**
Week 14	Phase Diagrams of Binary Systems	DeHoff Ch 9 Gordon: Ch 4 Callister and Rethwisch: Ch 10	
Week 15	Phase Diagrams of Ternary Systems	DeHoff Ch 10	
FINAL	Final Examination	Cumulative	**Final**

Academic Conduct:
Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" https://policy.usc.edu/scampus-part-b/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:
Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. https://engemannshc.usc.edu/counseling/

National Suicide Prevention Lifeline - 1-800-273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. http://www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. https://engemannshc.usc.edu/rsvp/

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: http://sarc.usc.edu/

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. https://equity.usc.edu/

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. https://studentaffairs.usc.edu/bias-assessment-response-support/

The Office of Disability Services and Programs
Provides certification for students with disabilities and helps arrange relevant accommodations. http://dsp.usc.edu

Student Support and Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. https://studentaffairs.usc.edu/ssa/

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. https://diversity.usc.edu/

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible, http://emergency.usc.edu

USC Department of Public Safety – 213-740-4321 (UPC) and 323-442-1000 (HSC) for 24-hour emergency assistance or to report a crime.
Provides overall safety to USC community. http://dps.usc.edu