MSE 0048: Thermodynamics of Materials

Course Syllabus – spring 2024

Catalog Description

MSE 0048: Thermodynamics of Materials introduces physical relationships and the fundamental mechanisms of chemical reactions, phase transformations, energy change, phase equilibrium among different states of matters (liquid-gas, gas-gas, etc.). Being a 3-credit course intended for second-year undergraduate students with materials science and engineering major, this course prepares students to the theoretical schemes aid in explaining the change of materials properties on macroscopic level, such as chemical decomposition, defect formation, toughness strengthening, as built upon basic physics and chemistry knowledge. After learning this course, it is anticipated that students can develop insights in addressing the thermodynamic evolution of materials from both qualitative and quantitative perspectives.

Course Instructor

Dr. Jue Gong, jue.gong@scupi.cn

Office hours: Monday 10:00 am – 12:00 pm, Tuesday 02:30-04:30 pm

Office

Room 526, SCUPI New Building

Email

jue.gong@scupi.cn

Prerequisites

PHYS 0174 – Physics for Science and Engineering 1

CHEM 0960 – General Chemistry for Engineers 1

Course Objectives

This course aims to convey the fundamental principles of mathematical laws governing the material thermodynamics. With completion of this course, students should be able to discern material systems with different molecular and atomistic interaction profiles, and to elaborate their physical behaviors with corresponding mathematical modeling. Furthermore, students should also develop the skills of interconversion among heat, work, temperature, energy, entropy, other state-, and non-state functions.

Learning Outcomes for this Course

1) To establish physical insights of material thermodynamics using mathematical laws and to perform mutual dimension operations.

2) To describe the microscopic foundations of change in material properties, such as phase transition, phase equilibrium, amorphization, etc.

3) To develop qualitative and quantitative abilities to interpret complex multi-component material systems.

Lecture Schedule

Wednesday: 8:15-11:00 am, room: Zone 4-204

Textbook

David R. Gaskell, David E. Laughlin, Introduction to the Thermodynamics of Materials, 6th edition, CRC Press, 2018. ISBN: 978-1498757003.

Teaching Assistant

Xinyu Xu: 2020141520107@stu.scu.edu.cn

Grading

Total score of the course grading is 100 points.

Homework: 20%

Class attendance: 10%

Midterm exam: 35%

Final exam: 35%

Exams

There will be two examinations of this course—midterm and final, which are to be tentatively scheduled on 04/22 (Monday) and 07/01 (Monday) of the spring semester, respectively. Exams are close-book, comprising questions including single-choice, Q&A, and mathematical calculation as the formats. A calculator and a double-side equation sheet are allowed for each student. Each exam weighs 30% of the course grade. Students are thus strongly suggested to study and prepare for the exams properly ahead of taking the tests.

Grading Rebuttal

If you disagree with the grading or to dispute wrongful errors made in the grading of an assignment, please bring it to the attention of TA within one week of receiving the assignment back for resolution.

Homework

Homework is based on problems after each chapter of the textbook, and will be posted on Blackboard system after the corresponding lecture. Homework score constitutes 10% of the class grading. Therefore, students are expected to submit after-class homework on time, within a week after the lecture, to avoid any deduction of credit. Collaboration with other students in the class is allowed. However, all rendered write-ups and papers must be individual works and any type of plagiarism will not be tolerated. If you have objection to the received score after getting your homework back, please notify the course teaching assistant. Please also take note of the following homework guidelines:

1) Your homework assignment must be completed in a Word format and submitted electronically through Blackboard system, with naming convention "Course#-name-student ID-Hw#". Handwritten assignments (or snapshots of handwritten works) will not be accepted.
2) Write your name, last four digits of student ID#, and class section# on top of the first page.
3) If you participate in collaboration with other students, please also put their names on the first page of the submitted homework.

Class Attendance

Attendance of lectures is mandatory as it constitutes 10% of the course's total grading. It is highly suggested that you come to class prepared, which includes reviewing last lecture's content, previewing lecture's content, reading online handouts, and going through potential problems, so as to enhance learning efficacy.

Make-up Policy

If you retaking the course, TOEFL/IELTS schedule, sick leave with justified approval, or other issues that make you miss homework, reports, and/or exams, please inform TA and course instructor at your earliest convenience.

Accommodations

If you sustain disability or sickness that requires testing and/or classroom accommodations, please notify the course instructor, TA, and the university's Disability Resources and Services in time. You may be asked to present proof of disability or sickness to be provided the accessibility accommodations.

Academic Integrity

Plagiarism of any forms that include copying peers' works, writings, literatures, and online references without appropriate paraphrasing or full citations, cheating within an exam, infringing copyrighted works or other improper conducts constitutes academic dishonesty. It is a requirement that every student performs independent and collaborations under the academic guidelines set forth by the SCUPI, Sichuan University, and University of Pittsburgh to ensure rightful learning performance.

Tentative Schedule of Course Contents

Sequence of sections covered in this class:

Week	Contents	Descriptions
1 (02/28)	1.1 – 1.12	Introduction of materials thermodynamics (equilibrium, equation of state, Laws of Thermodynamics, etc.)
2 (03/06)	2.1 – 2.13	The First Law of Thermodynamics
3 (03/13)	3.1 – 3.9	The Second Law of Thermodynamics (spontaneous, natural, adiabatic, reversible processes, entropy, etc.)
4 (03/20)	3.10 – 3.19	The Second Law of Thermodynamics (heat engine, work, equilibrium, etc.)
5 (03/27)	4.1 – 4.12	Statistical interpretation of entropy
6 (04/03)	5.1 – 5.16	Fundamental equations and their mutual relationships
7 (04/10)	6.1 – 6.11	Heat capacity, enthalpy, entropy, and The Third Law of Thermodynamics
8 (04/17)	7.1 – 7.12	Phase equilibrium in a one-component system
9 (04/24)	8.1 – 8.11	Physical behaviors of gases Midterm exam: 04/22
11 (05/08)	9.1 – 9.6	Raoult's Law, Henry's Law, thermodynamic properties of one-component system, Gibbs free energy, physical properties of ideal solutions, etc.
12 (05/15)	9.7 – 9.16	Behavior of nonideal solutions, regular solutions, atomistic models of solutions, application of Gibbs-Duhem relation, etc.
13 (05/22)	10.1 – 10.12	Gibbs free energy composition, phase diagrams of binary systems
14 (05/29)	11.1 – 11.11	Reactions of gases
15 (06/05)	12.1 – 12.11	Reactions involving pure condensed phase and gaseous phase
16 (06/12)	13.1 – 13.14	Reaction equilibria in systems containing condensed solution components
17 (06/19)	14.1 – 14.14	Electrochemistry (chemical and electrical driving forces, effects of concentration on electromotive force, Pourbaix diagrams, etc.)
18 (06/26)	15.1 – 15.9	Thermodynamics of phase transformations Final exam: 07/01