Thermodynamics and Statistical Mechanics in Materials Science ENG ME/MS 505

Introduction

The goal of this course is to provide graduate students embarking on research in Materials Science and Engineering, and advanced undergraduate students a solid introduction to the applications of thermodynamics in materials science. The course will provide a comprehensive treatment of the laws of thermodynamics and their applications to equilibrium and the properties of materials. It will provide a foundation to treat general phenomena in materials science and engineering, some examples of which include chemical reactions and phase equilibria. Relations pertaining to multiphase equilibria as determined by a treatment of solution thermodynamics will be developed including graphical constructions that are essential for the interpretation of phase diagrams. The treatment will include electrochemical equilibria and surface thermodynamics. The course also weaves in selected elements of statistical thermodynamics as they relate to macroscopic equilibrium phenomena.

Course Schedule

Monday, Wednesday 12-2 PM

Required Textbook

1) Introduction to the Thermodynamics of Materials, David R Gaskell, Fifth Edition, Taylor & Francis

Other Useful Reference Textbooks

2) Modern Thermodynamics: From Heat Engines to Dissipative Structures, Dilip Kondepudi and Ilya Prigogine, Wiley, 2002

3) I also plan to post handwritten notes from other sources as the need arises. In particular the statistical mechanics portion of the course (roughly 15-20% of the course) will be covered through written notes.

Instructor

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Mandatory Topics

- 1. Introduction
- 2. First and second laws
- 3. Statistical interpretation of entropy
- 4. Auxiliary functions
- 5. Heat capacity, enthalpy, entropy, and the third law of thermodynamics
- 6. Phase equilibrium in one component systems.
- 7. Behavior of gases
- 8. The behavior of solutions
- 9. Gibbs free energy function, binary systems
- 10. Reactions involving gases
- 11. Reactions involving condenses phases
- 12. Reactions involving components in condensed phase solutions
- 13. Phase diagrams of binary systems

Extra topics only if time allows (We have typically not been able to get to these in prior offerings. It really depends on how the class is doing overall.)

- 14. Thermodynamics of surfaces
- 15. Introduction to irreversible thermodynamics
- 16. Electrochemistry

Grading:

2 Midterms – 50%, Final – 40%, Class participation - 10%

Note that I will be providing problems sets (about six sets), but will not be grading them. Instead every two weeks, I plan to devote 0.5 hrs to problem solving in class, the problem will be chosen randomly from the previously handed out set and the students will be called upon to solve it on the blackboard. Your probability of getting called to the black board increases as the semester progresses and you have not been called yet. Solutions to problem sets will be provided.

Instructor Office hours:

Tue -1 to 3 PM