

Department of Materials Science and Engineering
MSE 322 Materials Science & Engineering
Thermodynamics in Materials Systems (4 credits)

Catalog Description:

Quantitative applications of thermodynamics to systems of interest to metallurgical and ceramic engineers. Detailed review of thermodynamic quantities and equations of state. Offered: A

Prerequisites:

Junior standing in MSE Department

Textbooks and other required materials:

The textbook, "Stoichiometry and Thermodynamics of Metallurgical Processes," by Y. K. Rao (Cambridge University Press, 1985) is recommended; reprint of it is available from the Ceramic Book & Literature Service of Marietta, Ohio.

Course objectives:

1. Describe equations of State: ideal and non-ideal gases, solids & liquids.
2. Apply laws of thermodynamics: closed systems; isolated systems.
3. Describe entropy: relationship to irreversibility in Carnot cycle.
4. Apply the concept of free energy and chemical potentials.
5. Evaluate equilibrium constants: standard free energy change.
6. Analyze phase equilibrium: melting, vaporization and sublimation.
7. Apply concepts to metal, ceramic and polymer systems.

Topics Covered:

Thermodynamic state of a system
State Properties
Equation of state
First law of thermodynamics
Closed systems
Thermochemistry
Heat of reaction
Heat capacity
Second law of thermodynamics
Carnot cycle
Irreversibility and efficiency
Concept of entropy
Third law of thermodynamics
Absolute entropy: Nernst theorem
Entropy as a measure of disorder
Free energy

- Helmholtz free energy as a measure of capacity to do work
- Gibbs free energy
- Equilibrium-state
 - Homogeneous (all-gas) systems
 - Heterogeneous (multi-phase) systems
 - Equilibrium constant and standard free energy change
- Theory of solutions
 - Activity, fugacity and free energy (or chemical potential)
 - Partial molar free energies of components
 - Relative partial molar quantities
 - Ideal solutions and Raoult's law
 - Dilute solutions and Henry's law
- Applications to selected systems
 - Ellingham charts and stabilities of condensed oxides
 - Reduction and oxidation reactions
 - Phase equilibria

Class Schedule:

- Three, one-hour lectures weekly
- Two quiz-sections (AA and AB)

Contribution of course to meeting the professional component:

The course for the most part emphasizes the engineering since aspects and the design-calculations are at an introductory-level. The students are required to master digital computer (FORTRAN) programs used to determine equilibrium phase-fractions and state properties.

Contribution of course to program objectives:

This course provides an integrated framework that enables the students to readily absorb new concepts from the many different areas of materials science and engineering. The general principles and their applications to specific systems expand the student's horizon and thus result in strengthened degree programs.

Prepared by: Y. K. Rao, Professor, October 02, 2000