University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of General Engineering
Master of Science and Engineering

Course Syllabus

1. General Information:

Alpha-numeric codification: CIIM 6019
Course Title: THERMODYNAMICS AND PHASE EQUILIBRIA
Number of credits: 3
Contact Period: 3 hours of lecture per week

2. Course Description:

English: Study of the thermodynamic principles and concepts applied to materials science, which will permit the analysis of the stability of the phases of a material based on thermodynamic considerations. The thermodynamics of solutions, fusion and vaporization processes, and surfaces and interfaces will be studied. Discussion of thermodynamic concepts applied to the study of binary and pseudo-binary systems with corresponding phase diagrams, including metastable phases. Analysis and application of ternary phase diagrams.

Spanish: Estudio de los principios y conceptos termodinámicos aplicados a la ciencia de materiales que permitirá el análisis de la estabilidad de las fases de un material basado en consideraciones termodinámicas. Se estudiará la termodinámica de soluciones, de los procesos de fusión y vaporización y de superficies e interfaces. Discusión de los conceptos termodinámicos aplicados al estudio de sistemas binarios y seudo-binarios con los diagramas de fase correspondientes, incluyendo fases metaestables. Análisis y aplicación de los diagramas de fase ternaries

3. Pre/Co-requisites and other requirements:

Graduate student with permission of the Program Coordinator.

4. Course Objectives:

By the end of the course students will:
- Relate the importance of thermodynamic principles to materials science.
- Apply basic concepts of solutions theory in the analysis of phase equilibrium.
- Apply the Gibbs phase rule.
- Evaluate the temperature dependence of Gibbs Free Energy and 'k' for reactions and phase transitions.
- Identify and use sources of thermodynamic data.
- Apply equilibrium concepts to electrochemical systems.
- Use thermodymamic principles to interpret the feasibility of chemical reactions and phase transformations.
- Relate Gibbs Free Energy to the construction of Phase Diagrams.
- Apply thermodynamic principles to the origin of eutectic and peritectic reactions, intermediate compounds and metastable phases in metallic, ceramic and polymeric systems.
- Identify the conditions for phase stability.
- Apply thermodynamic principles to the construction of ternary phase diagrams.
- Compare invariant reaction in ternary metallic, ceramic and semiconductor systems.

5. Instructional Strategies:

☒conference ☐discussion ☐computation ☐laboratory

☐seminar with formal presentation ☐seminar without formal presentation ☐workshop

☐art workshop ☐practice ☐trip ☐thesis ☒special problems ☐tutoring

☐research ☐other, please specify:

6. Minimum or Required Resources Available:

No specific resources are required.

7. Course time frame and thematic outline

Outline	Contact Hours
- Introduction. First and second law of thermodynamics. The Helmholtz and the Gibbs Free Energy. The third law of thermodynamics	7
- Theory of solutions. Partial molar quantities. Temperature dependence of activity. Raoult's law. Dilute solutions and Henry's law.	6
- The Gibbs-free energy and the equilibrium constant. Heterogeneous reactions. Sources of thermodynamic data. Free energy equations. Electrochemical systems. Electrochemical cells thermodynamics. Electrolysis.	7
- Gibbs energy of phases of variable composition. Single component. G surface in T,P space. G vs T at constant pressure. Fusion. Binary systems: Chemical potentials, Gibbs Phase rule, activity, G vs T vs X surfaces.	8
- Binary phase diagrams. Simple isomorphous, phase separation and spinoidal decomposition in metallic, ceramic and polymeric systems. Origins of invariant reactions, partial solid solubility. Intermediate solutions, compounds and metastable phases. Factors affecting phase stability in metallic and ceramic systems. Polymer solutions and mixtures.	8
- Ternary Phase Diagrams. Ternary space model, Gibbs triangle. Isothermal sections, tie-lines. Ternary invariant reactions in metallic, ceramic and semiconductor systems. Pseudo-binary systems. Examples	8
- One exam	1
Total hours: (equivalent to contact period)	45

8. Grading System

☒Quantifiable (letters) ☐ Not Quantifiable

Standard Curve:

100-90 A; 89-80 B; 79-70 C; 69-60 D; 59-0 F

9. Evaluation Strategies

	Quantity	Percent
☒ Exams	1	20
☒ Final Exam	1	20
☐ Short Quizzes		
☒ Oral Reports	2	30
☒ Monographies	2	30
☐ Portfolio		
☒ Projects		
☐ Journals		
☒ Other, specify:		
TOTAL:		100%

10. Bibliography:

Textbook:

Hillert, M. (2008). *Phase equilibria, phase diagrams and phase transformations: Their thermodynamic basis*. (2nd ed.). Cambridge, UK; New York: Cambridge University Press. [Available at the Circulation Collection (QD503 .H554 1998, UPRM General Library]

Other resources:

Gaskell, D. R. (2008). *Introduction to the thermodynamics of materials* (5th ed.). New York: Taylor & Francis. [Available at the Circulation Collection (TN673 .G33 2003, UPRM General Library]

Lee, H.-G. (1999). *Chemical thermodynamics for metals and materials* [e-book]. London: Imperial College Press. There is no newer version. [Available online via EBSCO EBooks Collection, UPRM General Library]

Machlin, E. S. (2007). *An introduction to aspects of thermodynamics and kinetics relevant to materials science* (3rd ed.). Oxford: Elsevier. [TA403.6 .M25 1991, UPRM General Library]

Selected articles from specialized journals available in: *Science Direct* (http://www.sciencedirect.com) [Available online via ScienceDirect, UPRM General Library]

11. According to Law 51: Students will identify themselves with the Institution and the instructor of the course for purposes of assessment (exams) accommodations. For more information please call the Student with Disabilities Office which is part of the Dean of Students Office at (787) 265-3864 or (787) 832-4040 extensions 2040 or 3372.

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