

# MSE 316: Thermodynamics and Kinetics of Materials

<i>Course description:</i>	Laws of thermodynamics, solution thermodynamics, free energy composition diagrams, mechanisms and kinetics of diffusion; solidification behavior, interfaces and phase boundaries, phase transformations in solids, oxidation and corrosion.
<i>Number of credits:</i>	3
<i>Course Coordinator:</i>	A. Bandyopadhyay
<i>Prerequisites by course:</i>	MSE 201
<i>Prerequisites by topic:</i>	Phase equilibrium and phase diagram interpretation, physical chemistry, introductory materials science, differential equations.
<i>Postrequisites:</i>	None
<i>Textbooks/other required materials:</i>	<ol style="list-style-type: none"><li>1. Easterling, E. and Porter, D. <i>Phase Transformations in Metal and Alloys</i>. CRC Press, 1992, 2/e.</li></ol>
<i>Course objectives:</i>	<ol style="list-style-type: none"><li>1. Introduction to laws of thermodynamics.</li><li>2. Introduction to solution thermodynamics applied to chemical and phase equilibrium.</li><li>3. Introduction to free energy composition diagrams.</li><li>4. Derivation of diffusion equations, description of diffusion sources, boundary conditions, temperature dependence.</li><li>5. Mechanisms of diffusion.</li><li>6. Introduction to solidification behavior of metals and alloys.</li><li>7. Applications ---- Czochralski crystal growth.</li><li>8. Isothermal transformation diagrams, mechanisms promoting C-type isothermal behavior.</li><li>9. Analysis of continuous cooling behavior, CT diagrams, quench factor.</li><li>10. Diffusional and diffusionless phase transformations.</li><li>11. Stages in precipitation --- GP zones, coherency, overaging.</li><li>12. Introduction to oxidation mechanisms of materials.</li><li>13. Introduction to electrochemical reactions --- half cell reactions, electrode potentials.</li><li>14. Analysis of electrode polarization --- polarization diagrams.</li><li>15. Treatment of the exchange current density and the Tafel equation.</li><li>16. Introduction to the mixed potential theory of corrosion.</li></ol>
<i>Topics covered:</i>	<ol style="list-style-type: none"><li>1. Laws of thermodynamics.</li><li>2. Solution thermodynamics for chemical and phase equilibrium.</li><li>3. Free energy composition diagrams.</li><li>4. Rate equations of homogeneous and heterogeneous reactions.</li><li>5. Diffusion.</li><li>6. Solidification behavior: Nucleation and growth.</li><li>7. Phase transformations in materials.</li><li>8. Precipitation hardening in aluminum alloys.</li><li>9. Oxidation of materials.</li><li>10. Electrochemical reactions and polarization diagrams.</li><li>11. Mixed potential theory of corrosion.</li></ol>
<i>Expected student outcomes:</i>	<ol style="list-style-type: none"><li>1. Knowledge of enthalpy, entropy and free energy.</li><li>2. Knowledge of ideal and regular solutions and free energy of mixing.</li><li>3. Knowledge of the type of variable that affects heterogeneous reaction rates ---</li></ol>

- nucleation, interfacial energy, interface equilibrium, diffusion, defects and impurities, temperature.
4. An understanding of the effect of diffusion rates, types of source, sinks, mechanisms, on composition changes.
  5. Recognition and understanding of solute redistribution during solidification and its significance in practical applications.
  6. Knowledge of the mechanisms and behavior of important transformations --- decomposition of austenite, formation of bainite and martensite, formation of strengthening precipitates.
  7. Commercial application of these principles in heat treatment.
  8. An understanding of oxidation behavior of materials.
  9. An understanding of the nature of polarized electrochemical reactions and an introduction of their application in corrosion behavior of metals.

*Class schedule:* Three 50-minute lecture sessions per week, for one semester

*Laboratory schedule:* None

*Contribution to meeting the professional component:* Engineering Topics

*Relationship of course to program objectives:* Meets:  

1. School of MME Educational Objectives: 1, 2, 3
2. School of MME Program Outcomes: (a), (h), (l)
3. ABET EC2000, Criterion 3: (a), (h), (l)

*Prepared by:* A. Bandyopadhyay

*Date:* May 6, 2013

#### **POLICIES**

**A. Reasonable Accommodation** (the nature of the particular course determines which one applies):

- **Pullman Campus.** Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center.
- **WSU Online Course.** Reasonable accommodations are available in online classes for students with a documented disability. All accommodations must be approved through your WSU Disability Services office. If you have a disability and need accommodations, we recommend you begin the process as soon as possible. For more information contact a Disability Specialist on your home campus: Pullman or WSU Online (<http://accesscenter.wsu.edu>), Spokane (<http://spokane.wsu.edu/students/current/studentaffairs/disability/>), Tri-Cities (<http://www.tricity.wsu.edu/disability>), Vancouver (<http://studentaffairs.vancouver.wsu.edu/student-resource-center/disability-services>).

#### **B. Academic Integrity**

WSU expects all students to behave in a manner consistent with its high standards of scholarship and conduct. Students are expected to uphold these standards both on and off campus and acknowledge the university's authority to take disciplinary action. The Standards of Conduct for Students can be found at <http://conduct.wsu.edu>.

#### **C. WSU Safety**

WSU is committed to maintaining a safe environment for its faculty, staff, and students. Safety is the responsibility of every member of the campus community and individuals should know the appropriate actions to take when an emergency arises. In support of our commitment to the safety of the campus community the University has developed a Campus Safety Plan, <http://safetyplan.wsu.edu>. It is highly recommended that you visit this web site as well as the University emergency management web site at <http://oem.wsu.edu/> to become familiar with the information provided.