Thermodynamic Foundation of Materials
Materials 200A, Fall 2011

1. ***Statistical Mechanics Fundamentals*** – readings from Kittel and Kroemer "Thermal Physics" (K&K)

9/22/11 Thurs. **1. Discrete States of Physical Systems (K&K Ch. 1):** Fundamental Assumption of Statistical Thermodynamics; Enumeration of States; Multiplicity Function; Exactly Solvable Binary Model Systems; Sharpness of the Multiplicity Function; Ensemble Averages of Physical Properties

9/27/11 Tue **2. Entropy and Temperature (K&K Ch. 2):** Two Systems in Thermal Contact: Most Probable Configuration; Definition of Temperature; Definition and Physical Meaning of Entropy; Law of Increase of Entropy; Laws of Thermodynamics

9/29/11 Thur **3. Boltzmann Distribution and Helmholtz Free Energy (K&K Ch. 3):** Thermal Equilibrium with a Reservoir; Boltzmann Factor; Partition Function as Repository of Thermal Properties; Helmholtz Free Energy

10/4/11 Tue **4. Boltzmann Distribution and Helmholtz Free Energy (K&K Ch. 3):** Principle of Minimum Free Energy; Entropy of Mixing; Pressure; Ideal Gas Law; Thermodynamic Identities; Maxwell Relations; Equipartition

10/6/11 Thur **5. Thermal Radiation (K&K Ch. 4);** Planck Distribution Function; Planck Law and Stefan-Boltzmann Law; Emission and Absorption: Kirchhoff Law; Phonons in Solids: Debye Theory (Reading Assignment only)

10/11/11 Tue **6. Thermal Radiation (K&K Ch. 4);** Electrical (Johnson) Noise; Fluctuation/dissipation; Einstein's Derivation of Planck's Law: The Concept of Stimulated Emission; (Not contained in Text; covered from Handout)

10/13/11 Thur **7. Chemical Potential and Gibbs Distribution (K&K Ch. 5):** Diffusive contact; Definition of Chemical Potential; Chemical Potential of Ideal Gas; Thermodynamic Identity, v2; Chemical Potential and Potential Energy

10/18/11 Tue **8. Chemical Potential and Gibbs Distribution (K&K Ch. 5):** Internal/external chemical potential and examples; Diffusive Equilibrium w/ reservoirs: Gibbs Factor and Gibbs Sum; review of the various ensembles; activity

10/20/11 Thur **9. Ideal Gas (K&K Ch. 6):** Quantum statistics; Fermi-Dirac and Bose-Einstein Distribution Functions; Classical Ideal Gas as Limit at Low Concentrations; Ideal gas with internal degrees of freedom.

10/25/11 Tue **10. Ideal Gas(K&K Ch. 6):** Ideal gas properties: Chemical Potential, Free Energy, Pressure, Total Energy, Heat capacity; Reversible Isothermal and Isentropic Expansion; Irreversible Expansion into a Vacuum; **Gibbs Free Energy (K&K Ch. 9, p262-266):** Gibbs v. Helmholtz; Gibb's and chemical potential;

10/27/11 Thur **11. Midterm examination**

2. ***Application of Thermodynamic Fundamentals to Materials*** – readings from DeHoff, chaps 7-10, 12

11/1/11 Tue **12. Phase transformations (K&K Ch. 10/DeHoff Ch. 7)** Interacting molecules; multiphase unary systems; Phase Diagrams in Pressure-Temperature Space; (meta)stability; Coexistence curves- Clausius-Clapeyron; Triple and Critical points

11/3/11	Thur	**13. Van der Waals Model (K&K Ch. 10):** VdW gas: molecular interactions and excluded volume; VdW equation of state and (in)stability. **Solution Thermodynamics (DeHoff Ch. 8)**: Partial Molar Properties; relation with chemical potential; Mixing and reference states; Relating partial and total molar properties (graphical construction)
11/8/11	Tue	**14. Solution Thermodynamics (DeHoff Ch. 8):** Absolute and relative activity; Ideal solutions; Real (non-ideal) solutions; Dilute Solution Behavior (Henry's law, Raoult's law); Models of non-ideal solutions; Quasi-chemical models and miscibility gaps; Osmotic pressure and depletion interactions.
11/10/11	Thur	**15. Multicomponent Heterogeneous Systems (DeHoff Ch. 9 & 10):** Equilibrium Conditions; Gibbs Phase Rule; Structure and Interpretation of Binary Phase Diagrams
11/15/11	Tue	**16. Multicomponent Heterogeneous Systems (DeHoff Ch. 9 & 10):** Structure and Interpretation of Binary Phase Diagrams, cont.; Eutectic and peritectic diagrams; Free Energy Curves and Common Tangent Construction;
11/17/11	Thur	**17. Multicomponent Heterogeneous Systems (DeHoff Ch. 9 & 10):** Three-phase Equilibria in Binary Systems; Thermodynamic Models for Binary Phase Diagrams; Miscibility gap and spinodal decomposition
11/22/11	Tue	**18. Capillarity Effects (DeHoff Ch. 12):** Nucleation and interfaces; Surface tension and free energy; Curvature
11/24/11	Thur	**Thanksgiving holiday**
11/29/11	Tue	**19. Capillarity Effects (DeHoff Ch. 12):** Surface excess properties; Laplace equation and mechanical derivation; Effect of (curved) interfaces on phase equilibria and chemical potential
12/1/11	Thur	**20. Capillarity Effects (DeHoff Ch. 12):** Contact angles and Youngs Equation; Adsorption and surfactants; Equilibrium Crystal Shapes: Wulff plot, Gibbs-Wulff construction; Roughening and fluctuations; Capillary waves

Grading: 20% Problem Sets; 30% Midterm; 50% Final

Problem Sets: Psets will generally be posted online Thursday, and due before noon on Friday, 8 days later, to Alana in the Materials office

Website: http://www.engr.ucsb.edu/~saleh/#[[MAT200A]]

Final Exam: 12/6/11 Tue 4-7 pm; 1335 Eng II

Texts: "Thermal Physics", Kittel & Kroemer (K&K), chaps. 1–6, 9, 10.
"Thermodynamics in Materials Science", DeHoff, chaps 7-10, 12.

Lecture: Tue/Thur 2—3:45 pm, with short break; 1335 Eng II

Lecturer:
Omar Saleh

Office 1361A Engr II Tel: x8814 E-mail: saleh@engineering.ucsb.edu
Office Hours: Thur 3:45-4:45pm (i.e. after lecture); or by appointment

Teaching Assistants:
Greg Su
E-mail: gsu@umail.ucsb.edu
Alex Young
E-mail: ayoung@engineering.ucsb.edu
Discussion hours: Wed 4-5pm, 1335 Eng II; or by appointment