Physics 406: Statistical and Thermal Physics

Instructor: Mark Newman

Fall 2004

1. **Adkins 1.5 and 2.1–2.6:** Introduction to classical thermodynamics. Intensive and extensive thermodynamic variables, conjugate pairs. The zeroth law of thermodynamics, the derivation and definition of temperature.
2. **Adkins 1.9:** Mathematical preliminaries, partial derivatives, the chain rule, the reciprocal and reciprocity theorems.
3. **Adkins 3.1–3.7 (excluding 3.5.3):** The first law of thermodynamics, conservation of energy, heat and work, work done by pressure, surface tension, in a magnetic field. Heat capacity and enthalpy.
4. **Adkins 4.1–4.3, 4.5, 4.6, 4.8:** The second law, Clausius' statement, heat engines, the Carnot engine, irreversibility of heat flow. Carnot's Theorem, the definition of thermodynamic temperature, refrigerators and heat pumps.
5. **Adkins 5.1–5.6.1:** Clausius' Theorem, derivation of entropy, law of increase of entropy. Entropy form of the first law, degradation of energy, heat capacities, free energy, Maxwell relations, free expansion of a gas.
6. **Adkins 7.1–7.3:** Thermodynamic potential functions, internal energy, enthalpy, Helmholtz and Gibbs free energies. Lagrange transforms. Maxwell relations.
7. **Adkins 8.1–8.4, 8.6:** Applications of thermodynamics. Calculation of heat capacities, ratios, differences. Adiabatic expansion of the perfect gas. Elastic rods, springs, and filaments. Surface tension. Magnetic cooling.
8. **Kittel and Kroemer, Ch. 1:** Counting quantum states, simple binary models, spin models, binary alloys. Spin excess, multiplicity, width of the distribution, multiplicity as a function of energy.
9. **Kittel and Kroemer, Ch. 2:** Fundamental assumption of the microcanonical ensemble, many-systems view, the ergodic hypothesis. Systems in equilibrium, the derivation of temperature and entropy, Boltzmann's constant. Properties of entropy, the law of increase of entropy (again), maximization of entropy at equilibrium.
10. **Kittel and Kroemer, Ch. 3, part 1:** Derivation of the Boltzmann distribution and the partition function. Entropy of the Boltzmann distribution, Shannon's formula for the entropy, Helmholtz free energy. Minimization of the free energy.
11. **Kittel and Kroemer, Ch. 3, part 2:** A particle in a box, many particles in a box, the perfect gas. Entropy of a perfect gas, the Gibbs correction, derivation of the equation of state. Sterling's approximation, the Sackur-Tetrode equation, entropy of mixing.
12. **Kittel and Kroemer, Ch. 4:** The Planck distribution, black-body radiation and the Stefan-Boltzmann and Kirchhoff laws. Phonon spectra, the Debye theory of the phonon specific heat.
13. **Kittel and Kroemer, Ch. 5:** Gases with varying numbers of particles, chemical potential, generalization of the first law, the Gibbs distribution.
14. **Kittel and Kroemer, Ch. 6:** Quantum gases 1, the Fermi-Dirac distribution, the Bose-Einstein distribution, the classical limit, chemical potential, energy, pressure, and the ideal gas again.
15. **Kittel and Kroemer, Ch. 7:** Quantum gases 2, the quantum limit. Fermi gases, electron gases, electronic heat capacity, astrophysical examples. Bose gases, Bose-Einstein condensation, liquid helium, superfluidity.
16. **Advanced topics (time permitting):** Phase transitions, ferromagnetism, Landau theory; semiconductors, donors and acceptors, p-n junctions; spin models, Ising model, percolation; computer simulation methods, Monte Carlo methods.