Chapter 9
Bonding: Molecules and Solids

- What is the *thermodynamic limit*?

Microstates, Macrostates, and Entropy
- If a group of random walkers are released in a small corner of a box, they will eventually fill the entire space evenly. Explain why.
- What is a *microstate*? What is a *macrostate*?
- What is the *multiplicity* of a macrostate?
- How do you find the probability of a macrostate?
- How do you determine which of a system's macrostates is its equilibrium state?
- What is the *entropy* of a macrostate?

9.2 Entropy and Temperature
- How is *temperature* defined in terms of entropy?
- How do you define pressure in terms of entropy?
- What is the *thermodynamic identity*?

Heat Engines
- What is a *perpetual motion machine* of the *first kind*? *Second kind*?
- What is a *heat engine*?
- Why must it expel waste heat?
- What is the *efficiency* of a heat engine?
- Why does the efficiency have an upper limit? What is it?

9.3 The Boltzmann Distribution
- In what circumstances does the Boltzmann distribution apply?
- What is a *thermal reservoir*?
- Under Boltzmann statistics, what is the relative probability a system will be in microstate A versus microstate B?
- What is the probability that the system is in a particular microstate A?
- What is the *Boltzmann factor*?

- What is the *partition function*?
- How can one calculate the average energy of a system in terms of the partition function?
- What is the *occupation number* of a microstate?
- How do you find the average occupation of a macrostate?
- What is the *density of states*?

9.4 Classical Averages

- What is the *Maxwell speed distribution*?

9.5 Quantum Distributions

- What do we mean by *indistinguishable* particles? What kinds of particles are indistinguishable?
- What is the difference between *bosons* and *fermions*?
- What is the *Pauli exclusion principle*?
- When dealing with a system of indistinguishable particles, we number system microstates by the number of particles in a particular particle microstate, instead of specifying the microstate of each particle. Explain how that works.
- What are the *Bose-Einstein* and *Fermi-Dirac* distributions?
- What does μ signify for bosons? For fermions?
- Explain how bosons and fermions distribute themselves in, for instance, a harmonic oscillator, at low temperature.
- What is the *Fermi energy*?

9.6 The Quantum Gas

- What are the potential energy levels of the electrons in a 3D infinite square well?
- What does the *Fermi surface* (the collection of electrons with the highest energies) look like?
- Why don't metals have as high as conductivity as one might expect, given how many electrons are wandering free inside?
- How is the *work function* in the photoelectric effect explained by the Pauli Exclusion Principle?
- What is a *Bose-Einstein condensate*?
- What is a *superfluid*? SECMassless Bosons: The Photon Gas
- What is the chemical potential of photons, and what does that signify about them?
- Explain the difference between *spontaneous emission*, *spontaneous absorption*, and *stimulated emission*.
- What is *population inversion* and why is it necessary for a laser to work?