

**Lecture 1**

- Introduction
- Some History (mostly taken from Reif)
- Some Thermodynamic Concepts
- Entropy
- Example: Ideal Gas Entropy
- What Those Large Numbers Mean
- Quantum Mechanics and Counting States

**Lecture 2**

- Reading
- Entropy and the Number of States
- Why is the Number of States Maximized?
- Aside—Entropy and Information
- Macroscopic Parameters
- The Temperature

**Lecture 3**

- Pressure
- Chemical Potential
- First Derivatives versus Second Derivatives
- Probability
- Averages
- Probabilities for Continuous Variables.
- The Binomial Distribution

**Lecture 4**

- Example—A Spin System
- The Boltzmann Factor
- The Gaussian Distribution

**Lecture 5**

- Reading
- The Boltzmann Factor
- Systems with Several Forms of Energy
- Diversion: the Maxwell Velocity Distribution
- Aside—the Gamma Function
- The Partition Function

### Lecture 6

- Entropy and Probabilities
- Heat Capacity
- Reversible Processes
- Pressure
- Pressure in a Low Density Gas, I
- Pressure in a Low Density Gas, II

### Lecture 7

- States of a Particle in a Box.
- Partition Function for a Single Particle in a Box
- Partition Function for  $N$  Particles in a Box
- Helmholtz Free Energy
- The Free Energy and the Partition Function

### Lecture 8

- Reading
- Classical Statistical Mechanics
- A Classical Harmonic Oscillator
- Classical Cavity Radiation

### Lecture 9

- A Quantum Harmonic Oscillator
- Quantum Cavity Radiation
- More on Blackbody Radiation

### Lecture 10

- Johnson Noise
- Debye Theory of Lattice Vibrations
- The Nyquist Frequency

### Lecture 11

- Reading
- Parting Shot on Oscillators
- Integrals Related to Planck's Law
- The Chemical Potential
- Getting a Feel for the Chemical Potential

**Lecture 12**

- The Gibbs Factor
- Example: Binding of  $N$  Molecules
- More on the Chemical Potential—Energy to Add a Particle
- Example: Chemical Potential and Batteries

**Lecture 13**

- Example: Magnetic Particles in a Magnetic Field
- Example: Impurity Ionization
- Example: K&K, Chapter 5, Problem 6
- Fermi-Dirac and Bose-Einstein Distributions

**Lecture 14**

- Reading
- The Ideal Gas Again
- The  $N$  Particle Problem
- The Ideal Gas From the Grand Partition Function
- Internal Degrees of Freedom

**Lecture 15**

- Examples of  $Z_{\text{int}}$
- Ideal Gas Processes
- The Gibbs Paradox Revisited

**Lecture 16**

- The Sackur-Tetrode Entropy and Experiment
- The Ideal Fermi Gas
- Heat Capacity of a Cold Fermi Gas

**Lecture 17**

- Reading
- More on Fermi Gases
- Other Fermi Gases
- Neutron Stars

**Lecture 18**

- Bose-Einstein Gases
- Superfluid Helium

### **Lecture 19**

- Heat and Work
- The Carnot Cycle
- Other Thermodynamic Functions

### **Lecture 20**

- Reading
- Gibbs Free Energy
- Chemical Equilibrium
- The Law of Mass Action
- Application: pH
- Other Ways of Expressing the Law of Mass Action

### **Lecture 21**

- The Direction of a Reaction
- Application: the Saha Equation
- Phase Transitions
- Phase Diagrams

### **Lecture 22**

- First Order and Second Order Phase Transitions
- The Clausius-Clapeyron Equation
- The van der Waals Equation of State

### **Lecture 23**

- Reading
- Phase Transitions and the van der Waals Equation of State
- Droplets

### **Lecture 24**

- A Simple Model of Ferromagnetism
- Superconductors, the Meissner Effect, and Magnetic Energy
- The Ising Model

### **Lecture 25**

- Cooling by Expansion
- Throttling Processes
- The Joule-Thomson Effect
- Cooling by Pumping
- The Helium Dilution Refrigerator
- Isentropic Demagnetization
- Laser and Evaporative Cooling

**Lecture 26**

- Reading
- Semiconductor Basics
- Electron Distribution in Semiconductors
- Law of Mass Action for Semiconductors
- Electron Distribution in Doped Semiconductors

**Lecture 27**

- Electron Distribution in Degenerate Semiconductors
- Ionization of Donors and Acceptors
- Electron-Hole Interactions
- The  $p$ - $n$  Junction

**Lecture 28**

- Reading
- The Depletion Region in a  $p$ - $n$  Junction
- A Reverse Biased  $p$ - $n$  Junction
- A Forward Biased  $p$ - $n$  Junction

**Lecture 29**

- The Maxwell Velocity Distribution
- Cross Sections
- Example: Cross Section for Smooth Hard Sphere Elastic Scattering
- Reaction Rates
- The Collision Rate and the Mean Free Path

**Lecture 30**

- Transport
- Transport Coefficients
- Diffusivity
- A Bit More on the Diffusivity
- Thermal Conductivity
- Viscosity

**Lecture 31**

- Reading
- The Boltzmann Transport Equation
- The Boltzmann Equation and Simple Diffusion
- Diffusion and the Fermi-Dirac Distribution
- Electrical Conductivity
- Diffusion Equations

**Lecture 32**

- Sample Solution of the Diffusion Equation: Equilibrating Bar
- The Dispersion Relation
- Random Walks and Diffusion
- Sample Solution: A Temperature Oscillation
- The Diffusion of a One Dimensional Bump

**Lecture 33**

- Time Independent Solutions of the Diffusion Equation
- Continuity Equation for Mass
- Sound Waves in a Gas
- Wave Functions for a Sound Wave
- Heat Losses in a Wave