Exam #4

- Exam #4 will cover
  - Chapters 7.4, 7.5
  - Chapter 8
  - Chapter 9.5, 9.6
  - Chapter 11.1

Things You Should Memorize

- Eigenvalues of spin, orbital, and total angular momentum operators
- Potential energy of a magnetic moment in a magnetic field
- Possible states and properties for combining two spin ½ particles
- Symmetry of hydrogen wave functions under particle interchange $(-1)^L$
- Spectroscopic notation
- Hund's rules
- Selection rules for radiative transitions
- Definition for density of states

Things You Should Know

- What happens when you place a magnetic moment in a magnetic field?
- What is the potential energy of a magnetic moment in a magnetic field?
- Know the relation between magnetic moment and angular momentum
  - Both orbital and spin
- Describe the Stern-Gerlach experiment and its results
- Know the eigenvalues associated with the operators L^2, S^2, J^2, L_Z, S_Z, J_Z
- Understand the results when Stern-Gerlach analyzers are used in series

Things You Should Know

- Know how to construct spin and space wave functions for identical particles
- What do symmetric and antisymmetric wave functions refer to?
- What is the exchange force and how does it arise?
- Review the wave functions and energies associated with the infinite potential well problem
- Know the properties of the wave function for identical fermions and bosons

Things You Should Know

- Know the Pauli exclusion principle
- Know how to build the periodic table using the Pauli exclusion principle
  - Including explaining why the 4s level lies lower than the 3d level for example
- Be able to explain the ionization potential data of elements
- Why does screening occur?

Things You Should Know

- Know how to add angular momentum
- Be able to explain how the spin-orbit interaction arises
- Be familiar with the spin-orbit interaction term in the Hamiltonian
- Be able to give an order of magnitude estimate for the spin-orbit splitting and the associated magnetic field
- What are "good" quantum numbers for the hydrogen atom?
- Be able to write down spectroscopic notation
- What do we mean by the fine structure in hydrogen?

Things You Should Know

- Know how to apply the independent particle method (say for an infinite well)
- Explain the origin of LS coupling
- Know Hund's rule and be able to explain their origin
- Know the difference between the normal and anomalous Zeeman effect
- Be able to draw the fine structure, normal Zeeman, and anomalous Zeeman splittings
- Be able to draw the allowed transitions (selection rules) between these states

Things You Should Know

- Be able to explain the density of states
- Be able to explain the difference between MB, FD, and BE statistics and be familiar with the associated factors
- Be able to write down possible states when particles obey the above statistics
- Know Fermi-Dirac factor at T=0
- Know what the Fermi energy and temperature are
- Know the values of the Fermi energy and temperature are for a typical metal

Things You Should Know

- What is the free electron model?
- Be able to derive the Fermi energy in the free electron model
- Be able to draw n(E) for the free electron model
- Be able to explain the heat capacity contribution from free electrons
- What is the degeneracy pressure?
- What is the typical degeneracy pressure for a typical metal?
- What application does the degeneracy pressure have in astrophysics

Things You Should Know

- Be able to explain the resistivity versus temperature curves for metals and semiconductors
- Be able to explain why bands are formed in a solid using the isolated atom approach and the periodic lattice approach
- Be able to draw the energy levels of two atoms as they are brought close together
- Be able to explain the large mean free path in metals (at low temperatures)
- What is the band structure of a metal, semiconductor, and insulator and what does this say about the conductivity of each?

Problems You Could See

- Calculate the potential energy difference between atoms in a magnetic field
- Draw a diagram of S and S_Z in a magnetic field
- Write down the possible spin states for two spin ½ particles
- Write down ground state and excited electronic configurations of elements
- Write down possible ground or excited states in spectroscopic notation, determine which ones are allowed by the Pauli exclusion principle, and order remaining states in energy
- Evaluate the eigenvalues for L·S (ie dot product of operators)

Problems You Could See

- Draw the fine structure of hydrogen
- Draw the normal or anomalous splittings for an atom
- Draw the allowed transitions between states
- Give ground state and excited state energies and degeneracies for the infinite well for different quantum statistics
- Calculate the density of states given an expression for N
- Calculate the Fermi-Dirac factor
- Calculate the number of electrons in a given energy range
- Estimate the number of conduction electrons in a given metal (using the number of atoms per volume and the Fermi energy)
- Calculate the Fermi energy and temperature for a given metal