PHY 491
Home Work Assignment #3
September 19-26, 2011

3.1

What is the total number of configurations for an open shell atom with 4 electrons in the p-shell (p^4), as in the oxygen atom. Just give the number.

What are the different multiplets ${}^{2S+1}L_J$ for this open shell atom? Give their degeneracies.

What is the lowest energy multiplet according to the Hund's rule, before allowing for spin orbit interaction?

What is the lowest energy multiplet after spin orbit interaction is included $\left(H_{SO} = \lambda_{SO}\vec{L}.\vec{S}\right)$?

What is the spin orbit splitting?

3.2

Using Hund's three rules, work out the lowest energy multiplets of d^1, d^3, d^4, d^7 and f^1, f^3, f^7. Compare your results given in the Table 1 and 2 of Chapter 11, Diamagnetism and Paramagnetism, of Kittel.

Calculate the Lande g-factors associated with these lowest energy multiplets.

(Once you know how to do it for a few cases it should be straight forward for the rest)

3.3

The wave function of the hydrogen atom in its ground state (1s) is $\psi = (\pi a^3)^{-1/2}\exp(-r/a)$. Here a is the Bohr radius. Show that for this state $< r^2 >= 3a^2$ and calculate the diamagnetic susceptibility for 1 mole of atomic hydrogen. The correct answer is $-2.36x10^{-6}\,cm^3/mole$.

3.4

For the multiplet (L,S,J)

Show that the average magnetization M for N atoms the presence of an external uniform magnetic field B along the z direction is given by

$$M = Ng_J\mu_B JB_J(x);\;\; x = g_J\mu_B JB/k_BT$$

Where the Brillouin function $B_J(x) = \frac{2J+1}{2J}coth\left(\frac{(2J+1)x}{2J}\right) - \frac{1}{2J}\coth\left(\frac{x}{2J}\right)$