Physics 780.04 Winter Quarter 2009
Dr. Herbst

HOMEWORK ASSIGNMENT # 2
DUE: TUESDAY, 3 FEBRUARY

1. Bernath, page 154, Problem 10

2. Bernath, page 154, Problem 11

3. Use the simple independent electron model without electron-electron repulsion to calculate the three ionization potentials of lithium. Compare your results with experimental values. Can you think of a more appropriate independent-electron approximation? Hint: consider the possibility of electrons screening the nucleus from other electrons.

4. Bernath, page 153, Problem 8

5. Enumerate the Russell-Saunders term symbols for the terms ("multiplets") arising from the configurations np^4 and nd^2. Order these according to increasing energy. Explain why the terms for np^4 are the same as those for np^2. Then enumerate the possible J values for the p^4 terms, label the states, and calculate the spin-orbit splittings in terms of *A*.

6. Determine and order the terms arising from the first excited configuration of nitrogen. Then determine whether any of these can emit rapidly to the ground $2s^2 2p^3\ {}^4S$ term.

7. For an np^2 configuration, use j-j coupling to enumerate the allowed J (j_1,j_2) states with the help of the Pauli Exclusion Principle. Order these in energy with the help of the Russell- Saunders terms and the principle that increasing j_i's lead to increasing energy. The Pauli Principle in j-j coupling can be restated in terms of the quantum numbers j_i, $m_{j,i}$.

8. In the Paschen-Back limit, the Zeeman field is so strong that the individual L and S vectors precess independently around the field direction z. (In other words, L_z and S_z are constants of the motion.) If the Zeeman-spin-orbit Hamiltonian is given by the expression

$$H = -\mu_{\mathbf{m}} \bullet \mathbf{B} + A\mathbf{L} \bullet \mathbf{S}$$

use first-order perturbation theory to determine the Zeeman - spin orbit energies $E(M_L,M_S)$ for an atom in a ${}^2P$ multiplet in the Paschen-Back limit. The so-called "weak field" limit, where the spin-orbit interaction dominates, is more complex and is discussed in your text. Essentially, one must determine average values for L_z and S_z as L and S precess around J, which precesses around the field direction.