

Modern Physics 330: Exam # 3

Open notes, open textbook calculator ok. 1 hour.

#1) For the $n=3$ level of hydrogen:

a) How many electron states are there in total, including spin?

b) What is the energy eigenvalue E_3 in electron volts? recall $E_1 = -13.6\text{eV}$

c) Write the multiplets of total $\vec{J} = \vec{L} + \vec{S}$ for $n = 3$ in the notation nL_j . Show that the total number of states summed over multiplets equals your result in part (a).

d) Calculate the spin orbit correction for each multiplet in part (c) using,

$$E_{SO} = \frac{a}{\hbar^2} \langle 2\vec{L} \cdot \vec{S} \rangle,$$

where a is positive number with dimensions of energy.

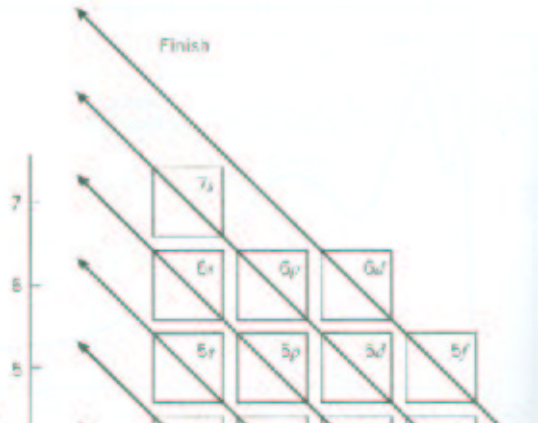
e) What is the physical reason that the multiplets remain degenerate as a result of this splitting?

f) What is the order of magnitude you expect for the ratio E_{SO}/E_3 ?

#2)

- a) Using the diagram below, write the configuration for the ground state of the potassium K ($Z=19$).

- b) What is the physical reason that the lower ℓ -states get filled first?



#3) What are the electric-dipole allowed transitions for the hydrogen $3D_{\frac{3}{2}}$ state?

#4) Positronium is an electron-positron bound state. It is almost identical to the hydrogen atom except that now the proton is replaced by a positron, and the positron's mass is equal to the electron's mass.

a) What is the ground state energy?

b) What would you expect for the hyperfine splitting relative to that in hydrogen?