Atomic Physics I 80301 Exam (alternative) II Nov. 4, 2005

1. Low energy states of B are linear combinations of product states formed from $2s$ and $2p$ orbitals. In the LS scheme, orbitals $2s$ and $2p$ can be coupled to form states such as $(2s2s2p)\ {}^2P$ or $(2p)^3\ {}^4P$, while in the jj scheme, these orbitals can be coupled to form states such as $(2s_{1/2}2p_{1/2}2p_{1/2})[1/2]$. Give the spectroscopic designation of all possible *even parity* states in B obtained by coupling $2s$ and $2p$ orbitals in both jj and LS coupling schemes. Show that the total number of magnetic substates is identical in the two coupling schemes.

2. Determine the wavelength (Å) of the transition $(1s3p)\ {}^3P \rightarrow (1s2s)\ {}^3S$ in heliumlike B ($Z = 5$). Assume that the $1s$ orbital is described by a Coulomb wave function in the unscreened nuclear field Z and that the excited $2s$ and $2p$ orbitals are described by Coulomb wave functions in a screened Coulomb field $Z - 1$. Compare your result with the NIST database.

3. Calculate the spontaneous decay rate (s^{-1}) for the $(1s3p)\ {}^3P \rightarrow (1s2s)\ {}^3S$ transition in problem **??** above.

4. Energies (cm^{-1}) of the five lowest levels in one-valence-electron ion La^{+2} are given in the little table below. Determine the multipolarity (E1, M1, ...) of the dominant one-photon decay mode for each of the four excited levels and give the corresponding photon wavelength.

$5d_{3/2}$	0.00
$5d_{5/2}$	1603.23
$4f_{5/2}$	7195.14
$4f_{7/2}$	8695.41
$6s_{1/2}$	13591.14

5. Determine the single-photon decay modes permitted by angular momentum and parity selection rules for the each of the three sublevels $J = (0, 1, 2)$ of the $(2s2p)\ {}^3P$ level in Be. Use your analysis to prove that the $(2s2p)\ {}^3P$ level is stable against single-photon decay nonrelativistically.