Chem H2A Problem Set 2 Extra Problem: Term Symbols

We normally denote the electronic states of the Hydrogen atom with a set of four quantum numbers:

$|n, l, m_l, m_s>$

There is also a fifth quantum number, s, the electron spin quantum number, but that's always ½ so we don't include it. For multi-electron atoms, we replace l and s with L and S, where L is the TOTAL orbital angular momentum quantum number, and S is the TOTAL electron spin quantum number. In this case, S is N/2 where N is the number of unpaired electron spins. Spectroscopists use TERM SYMBOLS to describe the angular momentum state of an atom:

^{2S+1}L

where the letter corresponding to the L quantum number is used (e.g., 0,1,2… becomes S, P, D…) . For example, the 1s ground state of Hydrogen is called the "doublet S" state (L=0, S=1/2), and the 2p state is called the "doublet P" state (L=1, S=1/2):

^2S , ^2P

Note that the quantum number n doesn't show up in the Term Symbol.

Question A: The Nitrogen atom has a ground state term symbol ^4S. How many unpaired spins are there in this ground state?

Russell-Saunders Coupling (LS Coupling). L and S can couple (the magnetic moments can interact) in an atom in a way that is described by a third, new quantum number J which can have multiple values:

J = L + S, L+S-1, …|L-S| and the term symbol now reads: $^{2S+1}L_J$

Question B: What are the possible values of J for the ^2S and ^2P states of the H atom? Write the Term Symbols for these states.

Question C: Explain why the brightest emission line from Sodium atoms at 589 nm is actually TWO lines at 589.0 nm and 589.6 nm. This emission is called, in fact, the "Sodium Doublet". HINT: This emission line is due to the [Ne]3p → [Ne]3s transition in Na.