Recitation #7
Quantum 522

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1. In class we saw that for two $\ell = 1$ electrons, there are a total of 2x2 spin and 3x3 orbital combinations making 4x9=36 possible angular momentum combinations. However, we also counted the degeneracy of the carbon outer 2-p electrons as the binomial coefficent $\binom{6}{2} = 15$. Reconcile the two ways of counting.

2. For the first excited state of helium, configuration 1s2s, what is the degeneracy and what are the corresponding terms? Which term is lower in energy? For helium in the ground state $1s^2$ what is the degeneracy and what is the lowest energy term?

3. The radial wave function for the hydrogen atom states with highest angular momentum value $\ell = n - 1$ are

$$R_{n,n-1} = Cr^{n-1}e^{-r/na_0}$$

where the constant is

$$C = \left(\frac{2}{na_0}\right)^{n+1/2} \frac{1}{\sqrt{(2n)!}}$$

Show that

$$\langle n, n-1|r|n, n-1\rangle = a_0 n(n + \frac{1}{2})$$

and

$$\langle n, n-1|r^2|n, n-1\rangle = a_0^2 n^2(n+1)(n + \frac{1}{2})$$

Verify the Bohr correspondence rule by calculating $\Delta r / \langle r \rangle$.