CHM 3411, Dr. Chatfield, Spring 2018
Problem Set 6
Due Monday, Feb 26

Suggested "warmups" (not to turn in): Discussion questions 9A.1-3; Exercises [(b) unless otherwise specified]] 9A.1,2,3,5,6a,7,8a,9,10

These problems explore hydrogenic atoms.

1. You should be able to answer the following question in your head or with simple calculations, without consulting a table of hydrogenic wavefunctions. Remember that the total number of nodes is equal to n-1, the wavefunction contains a factor of ρ^l, where l is the angular momentum quantum number, and m_l occurs in the imaginary exponential in ϕ ($e^{im_l\phi}$). With that in mind, consider the following wavefunction for the hydrogen atom:

$$\psi = N(6 - 6\rho + \rho^2)e^{-\rho/2}$$

   a. How many radial nodes does this function possess?
   b. What are the l and m_l quantum numbers for this state?
   c. What orbital is this (1s, 2s, 3s, $3p_z$ etc)?
   d. What is the energy of this state?
   e. Verify that this wavefunction is orthogonal to the wave function for a 1s orbital (see Table 9A.1).

2. Calculate the average potential energy of a 2s electron in Li^{2+} (this is an excited state, since there is only one electron and it is the 2s orbital instead of the 1s orbital). [Note that the average kinetic energy is easily obtained from this. The average kinetic energy is the difference between the total energy (which is constant) and the average potential energy.]

3. Determine the classical turning point for an electron in the 1s orbital of a hydrogen atom. In this case, the turning point is really a distance from the nucleus (i.e. a value of r). [Remember that the classical turning point is the point at which the potential energy is equal to the total energy. At that point, kinetic energy is zero, and so the particle can go no farther.]

4. Write the expression for the radial distribution of a 3p electron in He^+ (a 3p electron corresponds to an excited state in this case) and determine the radius at which the electron is most likely to be found. You may use the mass of an electron (m_e) instead of the reduced mass (μ), since they will be nearly the same.

5. Atkins Problem 9A.11: The distribution of isotopes of an element may yield clues about the nuclear reactions that occur in the interior of a star. Show that it is possible to use spectroscopy to confirm the presence of both $^4He^+$ and $^3He^+$ in a star by calculating the wavenumbers of the n=3 → n=2 and of the n=2 → n=1 transitions for each isotope.