PHYS 2604
Assignment #7

Given: Thursday, November 12, 2009
Due: Thursday, November 19, 2009 **in class**

1. The Bohr model for hydrogen says that the orbital electron can be found only at certain fixed distances from the proton, the larger radii corresponding to larger principal quantum numbers. Assume that the electron in a hydrogen atom is moved outward to larger radii. Which of the following quantities increase and which decrease: angular momentum, total energy, potential energy, kinetic energy, frequency of rotation? Explain why in each case.

2. Using the reduced mass results, calculate the wavelength of the Balmer series line for the transition from $n_u = 4$ to $n_l = 2$ for the three isotopes of hydrogen: ${}^1H$, hydrogen; ${}^2H = D$, deuterium; and ${}^3H = T$, tritium. This line is called the H_β line.

   This is very similar to Example 4.8 in Thornton and Rex, which contains all the numerical information you need.

3. The frequencies of the spectral lines of a **hypothetical** one electron atom (not hydrogen) are given by the following relation:

   $\nu = 864 \times 10^{12} \left(\frac{1}{n_u^2} - \frac{1}{n_l^2}\right) Hz$, where the n's are principal quantum numbers.

   a) Find the wavelengths (in nm) of the first three lines of the series terminating on the ground state.

   b) What is the photoelectric threshold wavelength of this atom?

   c) Construct the energy level diagram. Show the values of the energies (in eV) of the first four levels and show, with labeled arrows, the transitions corresponding to the wavelengths in parts (a) and (b).

   d) What is the binding energy of the electron when it is in the state $n = 3$?

   e) State and clearly explain the possible interactions when a large number of these hypothetical atoms in the ground state are bombarded by (i) a beam of electrons having 2.90 eV of kinetic energy; (ii) a beam of 2.90 eV photons.

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4. A 10 kg satellite circles the earth once every 2 hours in an orbit having a radius of 8000 km.

a) Assuming that Bohr's quantization of angular momentum postulate applies to satellites just as it does to an electron in a hydrogen atom, find the principal quantum number of this orbit of the satellite. (Assume the earth is stationary.)

b) Show from Bohr's angular momentum postulate and Newton's law of gravitation that the radius of an earth-satellite orbit is proportional to the square of the quantum number, $r = kn^2$, where the constant of proportionality is given by

$$k = \frac{\hbar^2}{Gm^2M}$$

where G is the gravitational constant, m is the mass of the satellite, and M is the mass of the earth.