Modern Physics

Fall 2018

Assignment 6: Due Wednesday, November 7.

1. In $^4He^+$, singly ionized helium-4, there are two neutrons, two protons and one electron, so the atomic number Z is 2. What is the energy if the electron is in the level, n=3?
2. What is the energy if the above electron is in the fourth energy level, n=4?
3. If the electron goes from the n=4 level to the n=3 level in singly ionized helium and emits a photon, what is the wavelength of the photon?
4. What is the n=1 energy level of an electron in iron? (Assume there is no screening of the nucleus by other electrons.)
5. What is the n=2 energy level of an electron in Iron
   a) If there is no screening of the nucleus by the n=1 electrons?
   b) If the screening of the nucleus by the n=1 electrons effectively reduces Z by 2 for the iron nucleus.
6. If one of the n=1 levels were vacant in the iron atom above and one of the n=2 electrons made a transition to the n=1 level, what would be the energy and the wavelength of the photon emitted? (Use the energy from 5a. This is called a Kα-line and the wavelength of this line is characteristic of the atom and can be used to identify the presence of that type of atom.)

7. Find the lowest two energy states in a muonium atom that consists of a proton and a muon. A muon has negative charge like the electron but a mass of 106MeV/c^2 compared to the electron's mass of 0.511MeV/c^2.
8. You have a system that consists of three energy levels, $E_1 = -5.0$eV, $E_2 = -3.2$eV and $E_3 = -1.2$eV. What are the possible wavelengths of electromagnetic radiation the system could emit?

Extra Credit

Consider the electronic transitions in singly ionized ^3He from the n=4 to the n=3 level and the same transition in singly ionized ^4He. What would you expect for the fractional difference in the wavelengths for the photon emitted in those two transitions? (I want $\Delta\lambda/\lambda_o$ where λ_o is the wavelength of the photon for the transition in ^3He.) Use the reduced mass for electron's mass, M_e, in both cases, or

$$M_{eff} = \frac{M_e M_{nuc}}{M_e + M_{nuc}}$$