Recitation Problems for Week 8, Thursday

6.C3. When light passes through cold clouds of hydrogen gas in space, light is absorbed, and then radiated in a random direction. This spectrum is similar to but also different from the emission spectrum from a source of very hot hydrogen. How do the emission and absorption spectra differ?

6.C4. A helium atom in which one of the electrons have been removed has a set of energy levels like hydrogen, $E_n = -E_{he}/n^2$, where the constant for helium, E_{he} is the constant for hydrogen times Z^2, with Z the number of protons in the Helium nucleus. What are the energy levels for this Helium?

6.C7. A large collection of hydrogen atoms are heated up such that the first four levels are occupied. What are the wavelengths of the emitted photons from these atoms?

6.S42. You have a container of cold hydrogen gas that you wish to study by shooting electrons and photons at it. (a) Using a beam of electrons, what is the minimum kinetic energy of an electron in the beam that will be able to ionize a hydrogen atom? (Ionizing an atom is the process of removing the electron from the atom.) (b) You tune your electron gun so that the electrons have an energy of $12.8\,eV$. These electrons then excite the hydrogen gas and you observe the emitted photons. What are the energies of the photons that can be emitted by the excited hydrogen atoms? (c) You now replace the electron beam with a photon beam. The photons in the beam are distributed between nearly zero and $12.8\,eV$. What are the energies of the photons that are absorbed from the beam?

6.S44. After careful experimental study, you have determined that a certain quantum system emits exactly three different photons: $1698\,nm$, $685\,nm$ and $488\,nm$. (a) What are the photon energies of the observed photons? What part of the electromagnetic spectrum do they occupy? (b) Propose two possible energy-level diagrams that could describe this system. (c) Propose an experiment that would allow you to distinguish between your two schemes.

6.S48. Consider an electron trapped in an infinite square well of width $0.1\,nm$. (a) What are the lowest four energy levels for the electron? (b) Assuming that all four of these levels are populated, what is the observed emission spectrum for this quantum system? (c) What size would our box need to be for the $n = 1$ to $n = 2$ transition in the box to match the same transition in the Hydrogen atom?