Physics 222 – Test 3 – Spring 2010

One-page reminder sheet allowed. *Show all work – no credit given if work not shown!* Note that $\hbar = 1.06 \times 10^{-34}$ J s, $c = 3 \times 10^8$ m s^{-1}, 1 eV $= 10^{-3}$ KeV $= 10^{-6}$ MeV $= 10^{-9}$ GeV $= 1.6 \times 10^{-19}$ J. The mass of the proton, neutron, and electron are 938.280 MeV, 939.573 MeV, and 0.511 MeV, and the binding energy of the deuteron is 2.22 MeV.

1. Determine the minimum energy (in MeV) an electron needs to probe the structure of an atomic nucleus (of order 5×10^{-15} m in radius). Hint: Is the electron likely to be hyper-relativistic? If so, what is the relationship between its momentum and energy?

2. Determine the atomic numbers of the first two noble gases (i. e., closed shells) if the electron had spin 3/2.

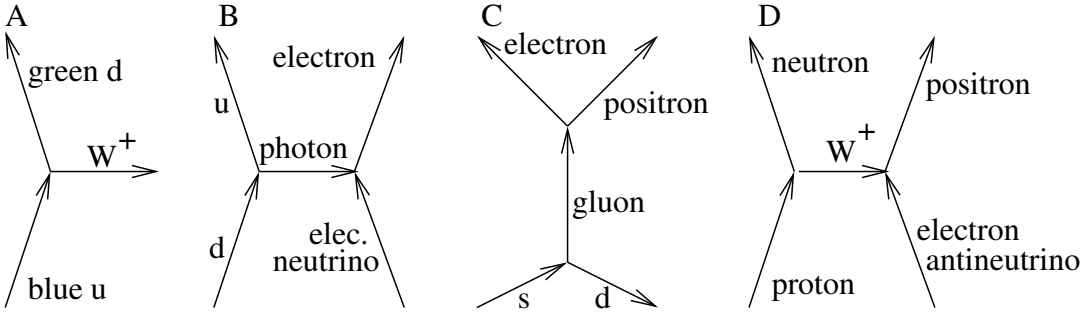
3. Given that the energies an electron can take on in a hydrogen atom are $E_n = -E_0/n^2$ where $n = 1, 2, 3, ...$ and $E_0 = 13.6$ eV, calculate all possible frequencies of photons emitted by hydrogen atoms starting with the electron in the $n = 3$ state. Note that the atom may decay immediately into the ground state, emitting only one photon, or it may decay into a succession of intermediate states, emitting a photon at each step down to a lower energy level.

4. A positive kaon ($u\bar{s}$) decays into a positive pion ($u\bar{d}$) and a neutral pion ($u\bar{u}$ or $d\bar{d}$)

   (a) Draw a picture of how this decay works at the quark level.

   (b) Does this decay occur via the strong or the weak interaction? Explain.

5. For each of the interactions (A-D) below, determine what, if anything, is wrong with it. (There may be multiple problems!)



6. The simplest fusion reaction is two protons colliding to form a deuteron (isotope of hydrogen with $A = 2$) and some other stuff.

   (a) What particles make up the "other stuff"?

   (b) Compute the energy released in this reaction.