PHY 3106, Fall 2017, Homework #5

due Thursday, Oct. 19, at 9:30 am (beginning of class)

1.) Use Faraday's law of electrolysis to find the weight of a coper atom. A current of 25.0 A flows through a solution of $CuSO_4$ for 2 hours. A) find the total charge and total number of electrons. B) The cathode is weighed before and after, and found to have gained 59.25 g. [Copper has two valence electrons.] How many copper atoms is this? [Hint: use the number of electrons from part A.] C) What is the mass of a single copper atom? D) what is the molar mass of copper?

2.) **Moving clocks run slow.** A beam of pions is produced at an accelerator, by scattering protons into a tungsten target. [Actually, all kinds of stuff is produced, and some of it is pions.] Pions decay ($e.g.,\ \pi^+ \rightarrow e^+ + \nu_e + \gamma$) with a half-life of $\tau_{1/2} = 2.60\times10^{-8}$ seconds. That means that in the rest frame of the pion, after one half-life, 50% of the pions is decayed, and after the second half-life, 50% of the remainder is decayed leaving only 25% of the original number of pions.

A series of magnets is used to select pions with a momentum of 4000 MeV/c. We want to calculate how far the pions travel before 50% of the pions have decayed.

A) Start by finding the relativistic factor, γ.
B) In the lab frame where the pions are seen to be moving, calculate the observed half-life.
C) We did not do much with relativistic velocities yet; Use equation 2.1, the given momentum, your calculated relativistic factor and the mass of 139.6 MeV/c^2 to find the pion velocity in the lab frame.
D) Now use the lab-frame velocity and lab-frame time to find how far the pion travels in the lab frame.

3.) Experimentally, the Rutherford scattering formula is only good up to an incident energy of 13.9 MeV for alpha particles incident on copper foils. A) Why do you think the formula stops describing the data? B) Use this information to estimate the nuclear size of copper. [You can assume the the copper nucleus is infinitely massive compared to the alpha particle and remains fixed in a head-on collision.]

4.) Use the Bohr model of the atom for this problem. A) Calculate the lowest 3 energies (i.e., most bound) for the electron in hydrogen. B) in the Bohr model, only certain velocities are allowed. Use equation 4.24 and 4.28 to find the velocity of the lowest 3 states.