Name(s): PHY-222 (Fall 2017), 10/11/17

Homework Assignment #4

(*Due Date*: Thu, 10/19, 05:30 pm, in class; Show all your work for full/partial credit)

4.1 *Collision Kinematics* (cf. Quest. 4.9 in textbook) *(1 pt.)*
An electron ($m_e = 0.511\,MeV/c^2$) of kinetic energy $12.1\,eV$ collides inelastically with a Xenon atom ($m_{Xe} = 131.2u$). Explain why essentially all of the incoming electron's kinetic energy is available to ionize the Xenon atom.
(*hint*: energy-momentum conservation in a heavy-light collision)

4.2 *Rutherford Scattering* (cf. Probs. 4.8+9 in textbook) *(4 pts.)*
A beam of α particles of 7 MeV kinetic energy is directed on a thin gold foil (Au nuclei have a radius of $\sim 7\,fm$ and charge $+79e$; the density of gold is ρ_{Au}=19.3g/cm^3).

(a) If the rate of scattered α's under a 30° angle is 100 per minute, what is the rate at (i) 10° (ii) 50° (iii) 90° (iv) 170°?

(b) If the incident energy is doubled, what is the rate of deteced α's under a 90° angle?

(c) What is the minimal incident energy (in MeV) of α's to cause deviations from the Rutherford formula?
At what angles would you expect the deviations to first occur?

(d) If the original gold foil is replaced by an aluminum foil (ρ_{Al}=2.7g/cm^3, Z_{Al}=13) of identical thickness, what is the rate of scattered α's under 30°?

4.3 *Hydrogen Transitions* (cf. Quest. 3.11 in textbook) *(1 pts.)*
Consider 3 transitions of electronic orbits in hydrogen characterized by their initial (n_i) and final (n_f) quantum numbers as follows:
(i) n_i=1 and n_f=4 (ii) n_i=5 and n_f=3 (iii) n_i=3 and n_f=7.
Which transition involves the shortest wavelength and which transitions are absorption processes?

4.4 *Bohr Model of the Atom* (cf. Probs. 4.23+24 in textbook) *(4 pts.)*
A hydrogen model is initially at rest and in its third excited state (n_i=4).

(a) Calculate the radius of the orbit (in nm), as well as the electron's kinetic, potential and total energy (all in eV).

(b) The atom de-excites into the ground state. Calculate the wavelength of the emitted photon (in nm) as well as the recoil momentum (in eV/c) and kinetic energy (in eV) of the atom.
(*hint*: momentum conservation)