PHYS 2604
Assignment #6

Given: Thursday, November 5, 2009
Due: Thursday, November 12, 2009 **in class**

1. Derive the following relation for a) the recoil kinetic energy, T', of the electron and b) its recoil angle, ϕ, in Compton scattering.

   a) $T' = E_\gamma \frac{\left(\frac{E_\gamma}{mc^2}\right)(1-cos\theta)}{\left[1+\left(\frac{E_\gamma}{mc^2}\right)(1-cos\theta)\right]}$

   b) $cot\phi = \left(1 + \left(\frac{E_\gamma}{mc^2}\right)\right) tan\left(\frac{\theta}{2}\right)$

   Note that in question 51 of Chapter 3 of Thornton and Rex another relation for the recoil kinetic energy is given, in terms of the wavelength shift of the photon. It can also be useful.

2. A cosmic ray photon is scattered through 90° by an electron that is initially at rest. The wavelength of the scattered photon is twice that of the incident photon. Find the frequency of the incident photon and the recoil angle (ϕ) of the electron.

3. In Compton scattering of a photon from an electron at rest, at what scattering angle of the photon (θ) is the recoil kinetic energy of the electron minimum? At what θ is it maximum? What energy of photons are needed to produce a maximum recoil kinetic energy of electron (initially at rest) of 30 keV?

4. The Rutherford model of the atom could explain the large angle scattering of α particles because it led to very large electric fields (and consequently forces) compared to the Thomson model. In the Thomson model, the positive charge of the atom is distributed through a sphere of the same size as the atom itself.

   According to the Thomson model, the positive charge in a gold atom ($Z = 79$) is distributed within an atomic radius of about 1.8 $\dot{A}$.

   In Rutherford's model of the gold atom, the positive charge is confined to a sphere of radius 8 fm, where 1 $fm = 10^{-15}\ m$.

   What is the ratio of the maximum electric field in the Rutherford model to that in the Thomson model?

   Ignore the effect of electrons in your calculations.

Over……

5. A beam of α particles with fixed kinetic energy is incident normally on a piece of gold foil.

a) If 1000 α particles per minute are detected at an angle of $20°$ from the beam direction, what will be the rate of detection at an angle of $90°$?

b) If the kinetic energy of the incident α particles is doubled, what will be the rate of detection at $20°$?

c) If the original α particles were incident on a copper foil of the same thickness, what would be the rate of detection at $20°$?

The density of copper is $8.9\ g/cm^3$ while that of gold is $19.3\ g/cm^3$. Copper has $Z = 29$ while gold has $Z = 79$. The atomic masses of copper and gold are $62.93\ g/mole$ and $196.97\ g/mole$, respectively.