PHYS 2604
Assignment #8

Given: Thursday, November 19, 2009
Due: Tuesday, December 1, 2009 **in class**

1. An x-ray tube with a copper target is operated at a potential difference of $25\ kV$. The glancing angle (θ in our discussion of Bragg scattering) for first order constructive interference with a NaCl crystal for the Cu K^{α} line is found to be $15.8°$. The planar spacing of NaCl is $0.282\ nm$.

   Find the wavelength of that K^{α} line.

   What is the short wavelength limit for this x-ray tube? (Hint: Recall the mechanism of the inverse photoelectric effect and the resulting Duane-Hunt rule for x-ray tubes.) Find the first order glancing angle (θ) for photons at the short wavelength limit.

2. This is #5-7 of Thornton and Rex. Transmission electron microscopes that use high energy electrons accelerated over a range from 40 to 100 kV are employed in many areas including the study of biological samples (like a virus) and nanoscience research. What would be the spatial limitation for this range of electrons? (It is often true that resolution is limited by the optics of the lens system, not by the intrinsic limitation due to the de Broglie wavelength.)

3. This is similar to Thornton and Rex #5-19. In an electron scattering experiment, an intense reflected beam is found at $\phi = 28°$ for a crystal with an interatomic distance of $0.23\ nm$. What is the lattice spacing of the planes responsible for the scattering? Assuming this is first order diffraction, what are the wavelength, momentum, total energy and kinetic energy of the incident electrons. (Use multiples of eV and eV/c for your energy and momentum units.)

4. This is similar to Thornton and Rex #5-43. An atom in an excited state of energy $4.5\ eV$ emits a photon and ends up in the ground state. The lifetime of the excited state is $1.0 \times 10^{-13}\ s$.

   a) What is the energy uncertainty of the emitted photon?

   b) What is the uncertainty ratio $\Delta\nu/\nu$ of the photon?

5. This is Thornton and Rex #5-46. Calculate the de Broglie wavelength of a $5.5\ MeV\ \alpha$ particle emitted from an ^{241}Am nucleus. Could this particle exist inside that nucleus? (Hint: To answer that question, use the diameter of the nucleus as $\Delta x = 1.6 \times 10^{-14}\ m$ and find the minimum kinetic energy (nonrelativistic calculation is okay) allowed within that distance according to the (one dimensional) uncertainty principle.)