Homework Set 5

Exercises; due Friday 10/2

E9. Calculate the shortest X-ray wavelengths than can be produced by an X-ray tube with accelerating voltage = 10 kV.

E10. The wavelengths of X-rays range from 10^{-12} to 10^{-8} m. Calculate the range of photon energies for X-rays.

E11. In 1912, Max Von Laue proposed to use a crystal as a diffraction grating for X-rays. The experiment was performed by Friedrich and Knipping. What crystal did they use?

Problems; due Monday 10/5

P22. The Collingwood X-ray tube was invented in 1913. An improvement, developed later and widely used today, is the *rotating anode X-ray tube*. Write a short essay, including a diagram, which explains the design of the rotating anode X-ray tube. (Be sure to explain why the anode rotates!)

P23. In a crystal of common salt (NaCl) one set of parallel atomic planes has spacing d = 0.282 nm. A monochromatic beam of X-rays produces a Bragg maximum when the glancing angle with respect to these planes is 7 degrees. Assume that this is the first-order maximum (n = 1).
(a) Calculate the wavelength of the X-rays.
(b) Calculate the minimum accelerating voltage in an X-ray tube to produce this wavelength.

P24. Look up the K_α X-ray emission lines for all the atoms from Z = 20 (Ca) to Z = 40 (Zr). Plot a graph of the photon energy versus atomic number Z. On the same graph, plot curves for the Bohr model prediction without screening, and the prediction for screening with $\delta \approx 1$. (Use computer graphics, e.g., Mathematica to make the graph; hand in both the program and graph.)

P25. Look up the electron energies for the inner electron orbitals, for a gold atom. Calculate, based on the energy levels, the wavelengths of the K_α, K_β, L_α and L_β X-ray emission lines of gold.