*Name*___________________________
PIXE Homework #3 - Physics 100
Union College Fall 2024

1. Suppose that your x-ray detector had an energy resolution of $\Delta E = 0.5keV$, would it be able to separate the K_a lines for platinum($^{195}_{78}Pt$) and gold($^{197}_{79}Au$)? An energy resolution means that anything smaller than this value ($0.5keV$), and I won't be able to distinguish the lines as separate from each other. In other words, the lines will overlap. Suppose that you had an x-ray energy spectrum (a graph of the intensity of x-rays versus their energy, as was shown in homework 2) would you be able to tell the K_a line of platinum from the K_a line of gold?

   $\Delta E = 0.5keV$ corresponds to $\Delta E = 500eV$. I need to determine the K_a energies for platinum and gold. They are $66832eV$ and $68804eV$ respectively using the x-ray energy table. The difference in their energies is $1972eV = 1.972keV$ and thus since they are separated by more than $500eV$, I'd see them as separate peaks.

2. Starting with the fact that an emitted x-ray has an energy given by $E = hf$, show that the Moseley's law for a K_a radiative transition may be expressed as

   $\sqrt{f} = \sqrt{\frac{3}{4}\left(\frac{13.6eV}{h}\right)}(Z-1)$ where *f* is the x-ray frequency.

   $$E_n = -13.6eV(Z-1)^2\left[\frac{1}{n_{upper}^2} - \frac{1}{n_{lower}^2}\right] = hf \rightarrow f = -\frac{13.6eV(Z-1)^2}{h}\left[\frac{1}{n_{upper}^2} - \frac{1}{n_{lower}^2}\right] \rightarrow$$

   $$f = \frac{-13.6eV(Z-1)^2}{h} \times \left(\frac{1}{2^2} - \frac{1}{1^2}\right) = \frac{3}{4} \times \frac{13.6eV(Z-1)^2}{h}$$

   $$\sqrt{f} = \sqrt{\frac{3}{4} \times \frac{13.6eV}{h}}(Z-1)$$

3. Suppose that you did not have a source of protons in which to perform a PIXE experiment. Rather, you had a source of alpha particles (or helium nuclei.) Describe how you could use the alpha particles to do materials identification of an unknown target material. In particular describe the HIXE (which stands for Helium Induced X-ray Emission spectroscopy) process and what the energy formula for the emitted x-rays might look like.

   HIXE stands for helium induced x-ray emission spectroscopy. This is a technique whereby a high-energy helium nucleus (an alpha particle) interacts with a target nucleus ejecting an electron from an inner atomic orbital of the target atom. An electron from a higher atomic orbital de-excites to the vacancy in the lower atomic orbital with an emission of an x-ray photon. The energy of the photon is *characteristic of the atomic nucleus. The process of using alpha particles would be identical to using protons in the process. As for the "energy formula" the energy formula that we developed in class we obtained by adding together the kinetic and potential energies of an electron in a given orbit. The formula only involves a electron transitioning between two atomic orbitals. It does not reference the incident particle that created the vacancy in the inner atomic orbital. Therefore the energy formula will be exactly the same for HIXE as for PIXE.*