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Nice

PHSX 343: Assignment 12

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Problem 1

a) We can just use the $hf_{threshold} = \Phi$ and $f = \frac{c}{\lambda}$ to solve for all out values:

$$f_{threshold} = \frac{\Phi}{h} = \boxed{4.72 \times 10^{14} hz} \text{ and } \lambda_t = \frac{c}{f_t} = \boxed{635nm}$$

b) $eV_0 = hf - \Phi = \frac{hc}{\lambda} - \Phi$ where $\Phi = 1.95eV$, $hc = 1240eV \cdot nm$, and $\lambda = 300nm$.

$$\boxed{eV = 2.18eV}$$

Problem 2

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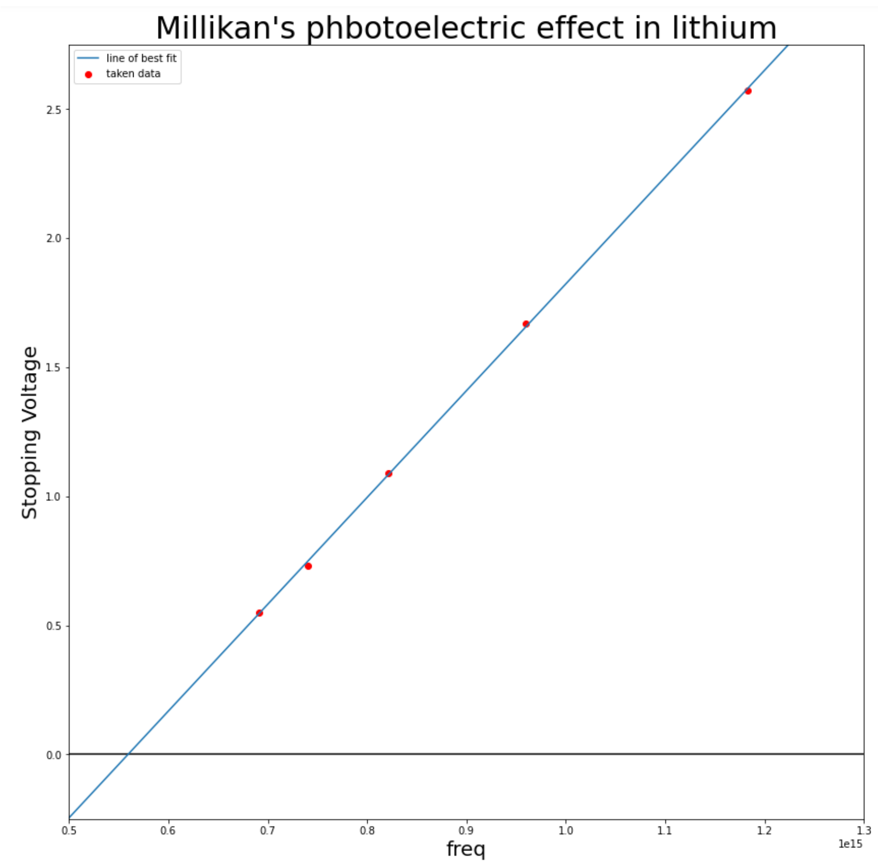
a) I plotted this with python, using the matplotlib.pyplot and numpy modules. the numpy modules allowed me to calculate the line of best fit exactly with what I gave it. Getting a rough estimate isn't hard by hand however; what you'd do is just just find the slope between the points and use point-intercept to find the intercept.



Where the line is given by $V = 4.137 \times 10^{-15} f - 2.315$. This equation is equivalent to saying $V = hf - \Phi$. So:

$$\boxed{h = 4.14 \times 10^{-15} eV \cdot s} \text{ and } \boxed{\Phi = 2.32eV}$$

The threshold frequency is given by the x-intercept.

$$0 = 4.137f - 2.315 \rightarrow f = \frac{2.135}{4.137 \times 10^{-15}} = \boxed{5.59 \times 10^{14} hz}$$

b) We are looking for when $hf \geq 4.14$eV. If we multiply the array of frequencies given by h, we get

$$[4.89, 3.97, 3.40, 3.06, 2.86]$$

Only the first value is greater than 4.14, so only the first wavelength has enough energy to cause emission of photo electrons. The question asks for the converse though, so all but the first wavelength would not cause emission.

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Problem 3

Using the outline of compton scattering from the lecture notes:

$$\lambda_2 = \lambda_1 + \frac{hc}{mc^2}(1 - cos(\theta)$$

Using the values that $\theta = \frac{115\pi}{180} = 2.007$, $\lambda_1 = \frac{E}{hc} = 0.0024nm$, $hc = 1240eV \cdot nm$, $m = 0.511\frac{MeV}{c^2}$: $\lambda_2 = 0.0059nm$. Recalculating this as the energy of the photon: $E_p = \frac{hc}{\lambda} = \boxed{0.211MeV}$. Now, using conservation of energy:

$$E_e = E_{p_i} + mc^2 - E_{p_f} = \frac{hc}{\lambda_1} + mc^2 - \frac{hc}{\lambda_2} = \boxed{0.811eV}$$

Now to find the direction, we can use the $-\frac{h}{\lambda_2}sin(\theta) = p_e sin(\phi)$ equation.

$$p_e = \sqrt{E^2 - (mc^2)^2} = 0.630\frac{MeV}{c}$$

$$\phi = sin^{-1}\Big(-\frac{hc}{\lambda_2 p_e}sin(\theta)\Big) = \boxed{-0.308} = -17.7^o$$

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Problem 4

First, to find what case gives us the maximum kinetic energy, let's set up the conservation of energy

$$E_\gamma + mc^2 = E_{\gamma_f} + E_{e_f} = E_{\gamma_f} + K + mc^2 \rightarrow E_\gamma = E_{\gamma_f} + K$$

So what is E_{γ_f}? $E_{\gamma_f} = \frac{hc}{\lambda_2} = \frac{hc}{\lambda_1 + \frac{hc}{mc^2}(1 - cos(\theta))}$. This value is minimized when $cos(\theta) = -1$ so the denominator in maximized. Obviously this is when $\theta = \pi$. So then:

$$K_{max} = E_\gamma - \frac{hc}{\lambda_1 + \frac{2hc}{mc^2}} = E_\gamma - \frac{E_\gamma}{1 + \frac{2E_\gamma}{mc^2}} = E_\gamma - \frac{E_\gamma mc^2}{mc^2 + 2E_\gamma}$$

$$K_{max} = \frac{E_\gamma mc^2 + 2E_\gamma^2 - E_\gamma mc^2}{2E_\gamma + mc^2} = \frac{2E_\gamma^2}{2E_\gamma + mc^2}$$