Name_____

Physics 111 Quiz #3, February 4, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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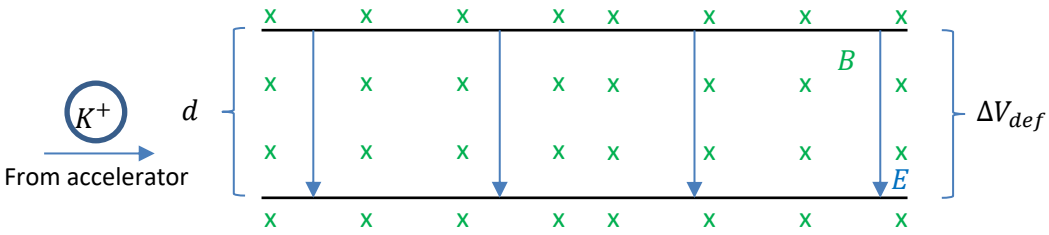
1. Potassium has 3 naturally occurring isotopes ($^{39}_{19}K, {}^{40}_{19}K, \& {}^{41}_{19}K$). $^{40}_{19}K$ is radioactive and is sometimes considered an impurity that needs to be removed from experiments. One way to determine the presence of (and possibly remove this impurity) is by mass spectrometry. Suppose that singly charged $^{40}_{19}K^{+}$ ions are accelerated through a potential difference $\Delta V_{acc} = -1000V$. What is the speed of one of these ions if $m_{^{40}_{19}K^{+}} = 39.963999u$?

$$W = -q\Delta V_{acc} = -(+e)(-V) = eV = \Delta K = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19}C \times 1000V}{39.963999u \times \frac{1.66 \times 10^{-27}kg}{1u}}} = 6.95 \times 10^4 \frac{m}{s}$$

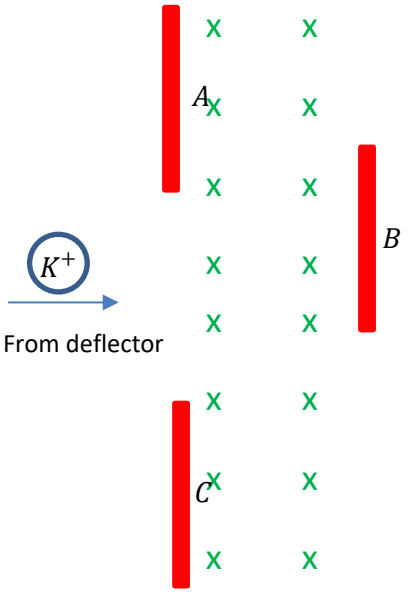
2. After the ions are accelerated, they pass through a region of space containing crossed electric and magnetic fields, as shown below. What value would you need to set for the deflecting potential (ΔV_{def}) if the ions go undeflected through this region of space. Assume that the separation between the plates and the uniform magnetic field are given by $d = 3cm$ and $B = 2T$ respectively.



$$F_B - F_E = ma_y = 0 \rightarrow F_E = F_B \rightarrow eE = evB \rightarrow E = vB$$

$$-\frac{\Delta V_{def}}{\Delta y} = E = vB \rightarrow \Delta V_{def} = -vdB = -6.95 \times 10^4 \frac{m}{s} \times 0.03m \times 2T = 4170V$$

3. At the end of the deflecting region, the ions enter a region of space where only the uniform magnetic field exists. Explain fully, which detector, A, B, or C will the ions strike and why.



After the ions leave the deflection region only the magnetic force remains. And by since the ions experience an upward initial force and by the right-hand rule, the potassium ions will strike the detector A.

4. What is the orbital radius of the ions in the magnetic field only region of space?

$$F = evB = m\frac{v^2}{R} \rightarrow R = \frac{mv}{eB} = \frac{39.963999u \times \frac{1.66\times10^{-27}kg}{1u} \times 6.95 \times 10^4\frac{m}{s}}{1.6 \times 10^{-19}C \times 2T} = 0.014mm = 1.4cm$$

5. How long does it take the ion to strike the detector you chose in part 3?

$$v = \frac{\pi R}{T} \rightarrow T = \frac{\pi R}{v} = \frac{\pi \times 0.014m}{6.95 \times 10^4\frac{m}{s}} = 6.51 \times 10^{-7}s$$