Name_____

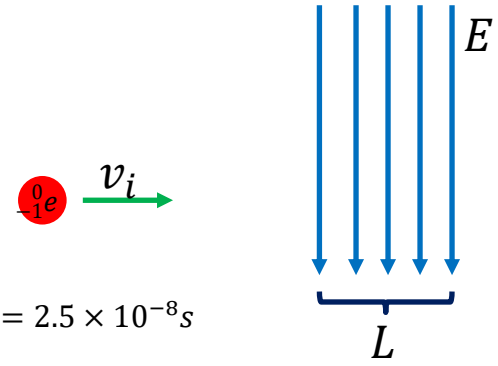
Physics 111 Quiz #2, September 16, 2024

*Please show all work, thoughts and/or reasoning to receive partial credit. The quiz is worth 10 points total, and all parts may not be of equal weight.*

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

_____

1. An electron, traveling horizontally at a speed $v_i = 4 \times 10^6 \frac{m}{s}$, encounters a region of uniform electric field. The electric field has a strength $E = 800 \frac{N}{C}$ and is directed vertically down as shown below. The electric field spans a horizontal distance $L = 10cm$. How long does the electron spend in the electric field?




$$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \rightarrow L = v_i t \rightarrow t = \frac{L}{v_i} = \frac{0.1m}{4 \times 10^6 \frac{m}{s}} = 2.5 \times 10^{-8} s$$

2. What is the vertical displacement of the electron in the electric field?

$$y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 = \frac{1}{2}\left(\frac{F}{m}\right)t^2 = \frac{1}{2}\left(\frac{(-e)(-E)}{m}\right)t^2$$

$$y_f = \frac{1}{2}\left(\frac{1.6 \times 10^{-19} C \times 800 \frac{N}{C}}{9.11 \times 10^{-31} kg}\right)(2.5 \times 10^{-8} s)^2 = 0.044m$$

3. How much work (in Joules) was done on the electron by the electric field?

$W = F\Delta y = qE\Delta y = (-e)(-E)\Delta y = 1.6 \times 10^{-19}C \times 800\frac{N}{C} \times 0.044m = 5.6 \times 10^{-18}J$

4. With what speed does the electron leave the electric field?

$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \rightarrow v_f = \sqrt{\frac{2W}{m} + v_i^2}$

$v_f = \sqrt{\frac{2 \times 5.6 \times 10^{-18}J}{9.11 \times 10^{-31}kg} + \left(4 \times 10^6\frac{m}{s}\right)^2} = 5.3 \times 10^6\frac{m}{s}$

Or, $v_{fx} = v_{ix} = 4 \times 10^6\frac{m}{s}$ and $v_{fy} = a_y t = \left(\frac{1.6\times10^{-19}C\times800\frac{N}{C}}{9.11\times10^{-31}kg}\right) \times 2.5 \times 10^{-8}s = 3.5 \times 10^6\frac{m}{s}$

so that $v_f = \sqrt{v_{fx}^2 + v_{fy}^2} = \sqrt{(4)^2 + (3.5)^2} \times 10^6\frac{m}{s} = 5.3 \times 10^6\frac{m}{s}$

5. Through what potential difference (voltage) was the electron accelerated when moving through the electric field?

$E = -\frac{\Delta V}{\Delta y} \rightarrow \Delta V = -E\Delta y = -\left(-800\frac{N}{C}\right) \times 0.044m = 35V$

Or

$W = -q\Delta V = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \rightarrow \Delta V = \frac{m}{2e}\left(v_f^2 - v_i^2\right)$

$\Delta V = \frac{9.11 \times 10^{-31}kg}{2 \times 1.6 \times 10^{-19}C}\left(\left(5.3 \times 10^6\frac{m}{s}\right)^2 - \left(4 \times 10^6\frac{m}{s}\right)^2\right) = 34.4V$