Name_____

Physics 111 Quiz #2, January 21, 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. Suppose that a particle accelerator is constructed out of two parallel metal plates. The plates are circular with a diameter $0.5m$, are separated by a distance $2m$, and a vacuum ($\kappa = 1$) exists between the plates. What is the capacitance of this system?

   $C = \frac{\kappa\varepsilon_0 A}{d} = \frac{1\times 8.85\times 10^{-12}\frac{C^2}{Nm^2}\times\pi(0.25m)^2}{2m} = 8.7\times 10^{-13}F$

2. Suppose that a potential difference of $2.2MV$ was placed across the plates. What is the magnitude and direction of the electric field between the plates?

   $E = -\frac{\Delta V}{\Delta x} \rightarrow |E| = \left|-\frac{\Delta V}{\Delta x}\right| = \frac{2.2\times 10^6 V}{2m} = 1.1\times 10^6\frac{V}{m}$ and points from the positive towards the negative plate.

3. What charge was on a plate of this capacitor?

   $Q = CV = 8.7\times 10^{-13}F\times 2.2\times 10^6 V = 1.9\times 10^{-6}C = 1.9\mu C$

   Or $E = \frac{Q}{\varepsilon_0 A} \rightarrow Q = \varepsilon_0 AE = 8.85\times 10^{-12}\frac{C^2}{Nm^2}\times\pi(0.25m)^2\times 1.1\times 10^6\frac{V}{m} = 1.9\times 10^{-6}C = 1.9\mu C$

4. How much energy is stored in the electric fields of the capacitor?

$$U_e = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{Q^2}{2C} \rightarrow U_e = \frac{1}{2}CV^2 = \frac{1}{2} \times 8.7 \times 10^{-13}F \times (2.2 \times 10^6 V)^2 = 2.1J$$

5. Suppose that a helium ion ($_2^4He^{+2}$) was accelerated from rest through this accelerator. What would the speed of the helium ion be when it exited the accelerator?

$$W = -q\Delta V = \Delta K = \frac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{2W}{m}};\ W = -(2e)(-2.2 \times 10^6 V) = 2.2 \times 10^6 eV$$

$$v = \sqrt{\frac{2 \times 2.2 \times 10^6 eV \times \frac{1.6 \times 1010^{-19} J}{1eV}}{4 \times 1.67 \times 10^{-27} kg}} = 1.03 \times 10^7 \frac{m}{s}$$