Name_____

Physics 121 Quiz #3, October 7, 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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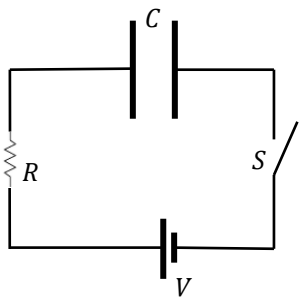
A cylindrical capacitor is made of two concentric metal plates. The inner plate is $50cm$ long and has a radius of $r_{inner} = 4cm$, while the outer plate is $50cm$ long and has a radius of $r_{outer} = 20cm$.

1. What is the capacitance of the system?

$$C = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{r_{outer}}{r_{inner}}\right)} = \frac{2\pi \times 8.85 \times 10^{-12}\frac{C^2}{Nm^2} \times 0.5m}{\ln\left(\frac{20cm}{4cm}\right)} = 1.73 \times 10^{-11}F$$

2. Suppose that the cylindrical capacitor was connected to a $V = 100V$ battery, a $R = 100000\Omega$ resistor and a switch S, as shown on the right. The switch is initially open, and the capacitor is initially uncharged. When the capacitor is fully charged, what is the maximum magnitude of charge that would appear on the plates?



$$Q_{max} = CV_{max} = 1.73 \times 10^{-11}F \times 100V = 1.73 \times 10^{-9}C$$

3. How much current is flowing in the circuit at a time $t = 0.5\mu s$?

$$I = \frac{dQ}{dt} = \frac{d}{dt}\left(Q_{max} - Q_{max}e^{-\frac{t}{RC}}\right) = \frac{Q_{max}}{RC}e^{-\frac{t}{RC}} = \frac{1.73 \times 10^{-9}C}{100000\Omega \times 1.73 \times 10^{-11}F}e^{-\frac{0.5\times10^{-6}s}{1\times10^{5}\Omega\times1.73\times10^{-11}F}}$$

$$I = 0.00075A = 0.75mA$$

4. What is the potential difference across the capacitor at a time $t = 0.5\mu s$?

$$V = V_{max}\left(1 - e^{-\frac{t}{RC}}\right) = 100V \times \left(1 - e^{-\frac{0.5\times10^{-6}s}{1\times10^{5}\Omega\times1.73\times10^{-11}F}}\right) = 25.1V$$

5. What is the potential difference across the resistor at a time $t = 0.5\mu s$?

Method 1: $V = V_R + V_C \rightarrow V_R = V - V_C = 100V - 25.1V = 74.9V$

Method 2: $V = IR = \frac{Q_{max}}{C}e^{-\frac{t}{RC}} = 100V \times e^{-\frac{0.5\times10^{-6}s}{1\times10^{5}\Omega\times1.73\times10^{-11}F}} = 74.9V$