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Physics II
3/26/21

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Midterm Exam

Nice

1) Scaling problem

a) $E_C = 2.00 \times 10^{-3}$ V/m, distance = 1 mm

value of E_C @ 5 mm?

$$E_C = \frac{1}{4\pi E_0} \times \frac{q_1}{r^2}$$

$$2 \times 10^{-3} = \frac{1}{4\pi E_0} \times \frac{q_1}{(1 \times 10^{-3})^2}$$

$$2 \times 10^{-3} = \frac{q_1}{(4\pi E_0)(1 \times 10^{-3})^2}$$

$$\rightarrow (2 \times 10^{-3})(1 \times 10^{-6}) = \frac{q_1}{4\pi E_0}$$

$$\frac{q_1}{4\pi E_0} = 2 \times 10^{-3} \times 10^{-6}$$

$$E_C = \frac{q_1}{(4\pi E_0)(5 \times 10^{-3})^2}$$

r = 5 mm

$$E_C = \frac{q_1}{(4\pi E_0)(5 \times 10^{-6})^2}$$

$$E_C = \frac{2 \times 10^{-3} \times \cancel{10^{-6}}}{25 \times \cancel{10^{-6}}}$$

$$E_C = \frac{2}{25} \times 10^{-3}$$

$$= \boxed{0.08 \times 10^{-3} \frac{V}{C} \text{ or } 8 \times 10^{-5} \frac{V}{C}}$$

✓

b) 1 μC, $E_C = 8.00 \times 10^{-3}$ V/m

value of E_C @ 3 μC?

$$E_C = \frac{1}{4\pi E_0} \times \frac{q_1}{r^2}$$

$$8 \times 10^{-3} = \frac{1}{4\pi E_0} \times \frac{1 \times 10^{-6}}{r^2}$$

$$8 \times 10^{-3} = \frac{1 \times 10^{-6}}{4\pi E_0 r^2}$$

$$\frac{8 \times 10^{-3}}{1 \times 10^{-6}} = \frac{1}{4\pi E_0 r^2}$$

$$8 \times 10^{3} = \frac{1}{4\pi E_0 r^2}$$

$q_1 = 1$ μC, $E_C = 8 \times 10^{-3}$ V/C

$$E_C = \frac{1}{4\pi E_0} \times \frac{3 \times 10^{-6}}{r^2}$$

$$= 8 \times 10^{3} \times \frac{3 \times 10^{-6}}{r^2}$$

$$= \boxed{24 \times 10^{-3} \frac{N}{C}}$$

✓

2) mass = 4×10^{-16} kg, E - field = downward, value = 6131. 25 N/C

a) how many electrons?

$= \frac{4 \times 10^{-16}}{9.0 \times 10^{-31}}$

$= \boxed{4.40 \times 10^{14}}$

-1 neglects protons and neutrons, but I meant the excess $\bar{e}$... $4\bar{e}$

b) acceleration?

$q = NE$

$= (4.4 \times 10^{14})(1.6 \times 10^{-19})$

$= \boxed{7.03 \times 10^{-5} \text{ C}}$

$qE = ma$

$\frac{qE}{m} = a$

$a = \frac{qE}{m}$ ✓ (would have been right)

$= \frac{(7.03 \times 10^{-5} \cancel{C})(6131.25 \text{ N}/\cancel{C})}{4.0 \times 10^{-16} \text{ kg}}$

$= \boxed{1.08 \times 10^{15} \text{ m/sec}^2}$

3) Potential Energy & Voltage, Capacitors

1a) $\Delta V = 4$ kV ; hydrogen charge = $+1q_e$; helium charge = $+2q_e$

kinetic energy = qV

KE (hydrogen) = $(1.6 \times 10^{-19}) \times (4 \times 10^3)$ ✓

$= \boxed{6.4 \times 10^{-16} \text{ J}}$ ✓

KE (helium) = $2(1.6 \times 10^{-19})(4 \times 10^3)$ ✓

$= 2(6.4 \times 10^{-16})$

$= \boxed{12.8 \times 10^{-16} \text{ J}}$ ✓

1b) $\Delta x = 5$ cm

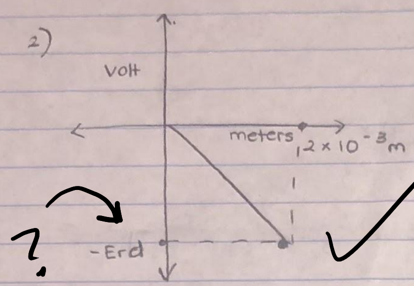
electric fieldvalue?

$E = \frac{\Delta V}{\Delta x}$

$= \frac{4 \times 10^3}{5 \times 10^{-2}}$ ✓

$= \boxed{8 \times 10^4 \text{ V/m or } 80{,}000 \text{ V/m}}$

2)



Y-intercept = 0 b/c the line is at the origin point, (0, 0).

3) $1\ cm^2$ = area

a) capacitance?

$$C = \frac{\epsilon_0 A}{d}$$

$$= \frac{(8.85 \times 10^{-12})(10^{-4})}{(2 \times 10^{-3})}$$

$$= \boxed{4.43 \times 10^{-13}\ F}$$

b) energy if voltage is 5V?

$$\text{energy} = \frac{1}{2} C V^2$$

$$= \frac{1}{2}(4.43 \times 10^{-13})(25)$$

$$= 12.5(4.43 \times 10^{-13})$$

$$= \boxed{55.38 \times 10^{-13}\ J}$$

4) we should connect an identical capacitor to the 1st in parallel b/c we can add up the capacitances.

$$C_{net} = C_1 + C_2$$

$$= 2C$$

↑ This is more capacitance in comparison to in series where $C_{net} = C/2$. Capacitance is getting halved.

4) Current, Resistance, & DC Circuits

1) $r_1 = r_2 = 2\Omega$

$\varepsilon_1 = \varepsilon_2 = 1.5V$

$R = 50\Omega$

4a) $-\varepsilon_2 + Ir_2 + Ir_1 - \varepsilon_1 + IR = 0$

$-1.5 + I(r_2 + r_1 + R) - 1.5 = 0$

$I(r_2 + r_1 + R) - 3 = 0$

$I(r_2 + r_1 + R) = 3$

$I = \frac{3}{r_1 + r_2 + R}$

$= \frac{3}{2 + 2 + 50}$

series

$= \frac{3}{54} = 0.0555 = \boxed{55.56 mA}$

$\frac{V_x - 1.5}{2}\frac{(25)}{(25)} + \frac{V_x - 1.5}{2}\frac{(25)}{(25)} + \frac{V_x}{50} = 0$

$\frac{25V_x - 37.5}{50} + \frac{25V_x - 37.5}{50} + \frac{V_x}{50} = 0$

$\frac{50V_x - 75 + V_x}{50} = 0$

$\frac{51V_x - 75}{50} = 0$

$51V_x - 75 = 0$

$51V_x = 75$

$\boxed{V_x = \frac{75}{51} \text{ or } 1.47 \text{ Volts}}$

$I_1 = \frac{1.5 - 1.47}{2\Omega} = 15mAmp$

$\boxed{30 mA}$ - parallel

$I_2 = \frac{1.5 - 1.47}{2} = 15mAmp$

4b) power consumption?

$P_{total} = P_{r_1} + P_{r_2} + P_R$ — series

$= I^2 r_1 + I^2 r_2 + I^2 R$

$= (55.56\ mA)^2 \times 2 + (55.56\ mA)^2\ 2 + (55.56 mA)^2\ 30$

$= 6.17 mW + 6.17 mW + 154.34\ mW$

$= \boxed{166.68\ mW}$

$P_R = 154.34\ mW$

parallel

$P_{total} = P_{r_1} + P_{r_2} + P_R$

$= I_1^2 r_1 + I_2^2 r_2 + I^2 R$

$= (15)^2\ 2 + (15)^2\ 2 + (30)^2 \times 50$

$= 450 + 450 + 45000$

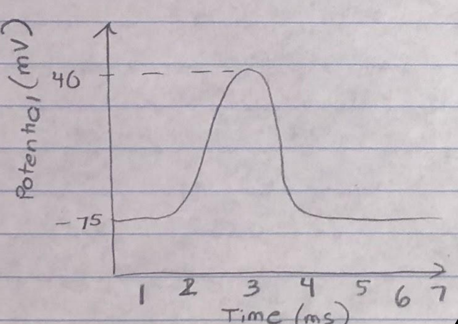
$= 0.45\ mW + 0.45 mW + 45 mW$

$= \boxed{45.9\ mW}$

$P_R = 45\ mW$

well done

2) Potential vs time



a) pulse width in milliseconds?

$\boxed{2\ ms}$

b) peak-to-peak voltage?

$= 40 - (-75)$

$= 40 + 75$

$= \boxed{115\ mV}$