Physics Midterm

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$\frac{19}{20}$

Well done

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1. a) $\mathcal{E}_c = \frac{Kq}{r^2}$ $K = 9 \cdot 10^9\ N{\cdot}m^2 C^{-2}$ q = charge $r = 1mm$

$2 \cdot 10^{-3} = \frac{(9 \cdot 10^9)q}{(10^{-3})^2} \Longrightarrow q = \frac{2 \cdot 10^{-3}(10^{-3})^2}{9 \cdot 10^9} \Longrightarrow 2.22 \cdot 10^{-19} C$

$\mathcal{E}_c$ @ $r = 5mm = 5 \cdot 10^{-3} m$

$\mathcal{E}_c = \frac{Kq}{r^2} = \frac{(9 \cdot 10^9)(2.22 \cdot 10^{-19})}{(5 \cdot 10^3)^2}\ V/m \Longrightarrow \underline{8 \cdot 10^{-5}\ V/m}$ ✓

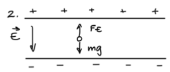
b) $\mathcal{E}_c = 8 \cdot 10^{-3}\ V/m$ $q = 1 \mu C$ $K = 9 \cdot 10^9\ n{\cdot}m^2 c^{-2}$ r = dist.

$r^2 = \frac{Kq}{\mathcal{E}_c} \Longrightarrow r = \sqrt{\frac{Kq}{\mathcal{E}_c}} \Longrightarrow r = \sqrt{\frac{(9 \cdot 10^9) \cdot 1 \cdot 10^{-6}}{8 \cdot 10^{-3}}}\ m.$

$\Longrightarrow 1060.66\ m.$

$q = 3mC = 3 \cdot 10^{-6} C \rightsquigarrow \mathcal{E}_c = \frac{kq}{r^2} \Longrightarrow \frac{9 \cdot 10^9 \cdot 3 \cdot 10^{-6}}{(1060.66)^2}$

$\Longrightarrow \underline{24 \cdot 10^{-3}\ V/m}$ ✓

2. 

$\mathcal{E} = 6131.25\ N/C$

$m = 4 \cdot 10^{-16}\ Kg$

$g = 9.81\ m/s^2$

a) $F_\mathcal{E} = mg \Longrightarrow q\mathcal{E} = mg \Longrightarrow q = \frac{mg}{\mathcal{E}} = \frac{4 \cdot 10^{-16} \cdot 9.81}{6131.25}$

$= 0.0064 \cdot 10^{-16} = 6.4 \cdot 10^{-19} C \Longrightarrow \frac{6.4 \cdot 10^{-19}}{1.6 \cdot 10^{-19}} = \underline{4}$ ✓

b) $q_0 = (4-1) \cdot 1.6 \cdot 10^{-19} C = 4.8 \cdot 10^{-19} C$

a↓ ↑$q_0\mathcal{E}$ ↓mg $mg - q_0\mathcal{E} = ma \Longrightarrow a = \frac{mg - q_0\mathcal{E}}{m}$

$= \frac{(4 \cdot 10^{-16} \cdot 9.81) - (4.8 \cdot 10^{-19} \cdot 6131.25)}{4 \cdot 10^{-16}}$

$= \frac{(39.24 \cdot 10^{-16}) - (29.43 \cdot 10^{-16})}{4 \cdot 10^{-16}} = \underline{2.4525\ m/s^2}$ ✓

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1. a) $KE = q(\Delta v)$ Hydrogen = $q = e$ Helium = $q = 2e$

$KE_H = 1.602 \cdot 10^{-19} \cdot 4000 J = \underline{6.408 \cdot 10^{-16} J}$ ✓

$KE_{He} = 2 \cdot 1.602 \cdot 10^{-19} \cdot 4000 J = \underline{12.816 \cdot 10^{-16} J}$

b) $E = \left|\frac{\Delta v}{\Delta x}\right| = \frac{4000}{0.05} = 8000\ V/m$ OR $8 \cdot 10^4\ V/m$ ✓

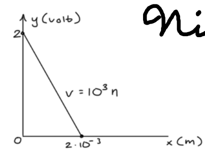
2. $E = 1\ KV/m$ $E = 1 \cdot 10^3\ V/m$ $d = 2mm = 2 \cdot 10^{-3} m$ $E = \frac{\Delta v}{x}$

$10^3 = \frac{\Delta v}{x}$ $\Delta v = 10^3 x$

Assume voltage @ negative plate = 0 $\Delta v = 10^3 x n$ $v - 0 = 10^3 n$

$v = 10^3 n$

@ positive plate :



Nice!

3. a) Capacitance (C) = $\frac{\mathcal{E}_0 A}{d}$

$C = \frac{(8.85 \cdot 10^{-12}\ c^2/n{\cdot}m^2)(1 \cdot 10^{-4} m^2)}{2 \cdot 10^{-3} m} = 4.425 \cdot 10^{-13} F = 0.4425\ pF$ ✓

b) Energy in C

$U_C = \frac{1}{2} CV^2 = \frac{1}{2}(4.425 \cdot 10^{-13} F)(5V)^2 = 5.53 \cdot 10^{-12} J$ ✓

4. $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{C_2 + C_1}{C_1 + C_2}$ $C_1 = C_2 = C \Longrightarrow C_{eq} = \frac{C \cdot C}{C + C} = \frac{C}{2} = 0.5C$ ✓

$U = \frac{1}{2} C_{eq} V^2$ In parallel : $C_{eq} = C_1 + C_2 = C_1 + C_2$ $C_{eq} = 2C \rightsquigarrow$ capacitance ↑

$U = \frac{1}{2} C_{eq} V^2 \rightsquigarrow$ energy stored ↑ $\Longrightarrow$ Identical capacitor must be connected in parallel with first capacitor

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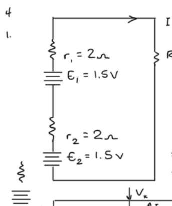
1.



$-\mathcal{E}_2 + Ir_2 + Ir_1 - \mathcal{E}_1 + IR = 0$

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

$I = \frac{3V}{r_1 + r_2 + R} = \frac{3}{2 + 2 + 50} = \frac{3}{54}$ ✓

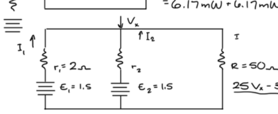
$= 55.56\ mA$

$\boxed{-1}$

$P_{TOTAL} = P_{r_1} + P_{r_2} + P_R \Longrightarrow I^2 r_1 + I^2 r_2 + I^2 R$

$= (55.56mA)^2 \cdot 2 + (55.56mA)^2 \cdot 2 + (55.56mA)^2 \cdot 50$

$= 6.17mW + 6.17mW + 154.34mW = \underline{777.51mW}$



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

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

$51V_x = 75 \Longrightarrow V_x = 1.47$ Volts

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

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

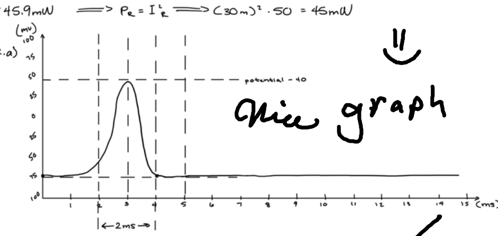
$I = I_1 + I_2 = 15mAmp + 15mAmp = \underline{30mAmp}$

$P_{TOTAL} = P_{r_1} + P_{r_2} + P_R \Longrightarrow I_1^2 r_1 + I_2^2 r_2 + I^2 R$

$= (15mAmp)^2 \cdot 2 + (15mAmp)^2 \cdot 2 + (30mAmp)^2 \cdot 50 = 0.45mW + 0.45mW + 45mW$

$= 45.9mW \Longrightarrow P_R = I^2 R \Longrightarrow (30m)^2 \cdot 50 = 45mW$

2.a)



:)

Nice graph

Pulse width = 2ms

b) $= 40 - (-75) \Longrightarrow 40 + 75 = 115 \Longrightarrow V_{p-p} = 115mV$ ✓