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20/20

Electric Charge and Electric Fields

1. (a) $E_c = 2.00\times10^{-3}$ V/m @ 1 mm

$E_c = ?$ @ 5 mm

$E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$

$2.00\times10^{-3} = \frac{1}{4\pi\epsilon_0}\frac{q}{(1\times10^{-3})^2}$

$2.00\times10^{-3}\cdot 1\times10^{-6} = \frac{q}{4\pi\epsilon_0}$

$2.00\times10^{-3}\cdot 1\times10^{-6}\cdot\frac{1}{(5\times10^{-3})^2}$

$2.00\times10^{-3}\cdot 1\times10^{-6}\cdot\frac{1}{25\times10^{-6}}$

$\boxed{= 8\times10^{-5}\ \text{V/m}}$

nice work

(b) $1\ \mu C \rightarrow E_c = 8.00\times10^{-3}$ V/m

$3\ \mu C \rightarrow E_c = ?$

$(8.00\times10^{-3})(3)$

$= 0.024$

$\boxed{= 2.4\times10^{-2}\ \text{V/m}}$

2. (a) drop mass $= 4\times10^{-16}$ kg

E-field $= 6131.25$ N/C

$q = \frac{mg}{E} \Rightarrow \frac{(4\times10^{-16})(9.8)}{6131.25}$

$= \frac{6.39347604\times10^{-19}}{1.6\times10^{-19}}$

$= 3.99\ldots$

$\boxed{\approx 4 \text{ electrons on the drops}}$

(b) $(4\times10^{-16})(9.8)$

$= F_g = 3.92\times10^{-15}$ N

$(6.39\times10^{-19}) - (1.6\times10^{-19}) = 4.79\times10^{-19}$

$= F_e = (4.79\times10^{-19})\cdot 6131.25 = 2.939\times10^{-15}$

$a = \frac{F_g - F_e}{m} \Rightarrow \frac{(3.92\times10^{-15}) - (2.939\times10^{-15})}{(4\times10^{-16})}$

$= 2.4525$

$\boxed{a \simeq 2.45\ \text{m/s}^2}$

(acceleration of droplet)

Potential Energy and Voltage, Capacitors

1. (a) $\Delta V = 4$ kV

$H = +1q_e \quad He = +2q_e$

$KE_H = (1.6\times10^{-19})(4.0\times10^3)$

$= 6.4\times10^{-16}\ \text{J} \times \frac{6.242\times10^{18}\ \text{eV}}{1\ \text{J}}$

$= 3994.88$

$KE_H \cong 3995$ eV — electron volts

you can just say 4 keV

$KE_{He} = (2)(1.6\times10^{-19})(4.0\times10^3)$

$= 1.28\times10^{-15}\ \text{J} \times \frac{6.242\times10^{18}\ \text{eV}}{1\ \text{J}}$

$= 7989.76$

$KE_{He} \simeq 7990$ eV

$KE_{tot} = 3995 + 7990$

$\boxed{KE_{total} = 11{,}985\ \text{eV}}$

(b) $\Delta x = 5$ cm

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

$= \frac{4\ \text{kV}}{5\ \text{cm}} = \frac{4\times10^3\ \text{V}}{5\times10^{-2}\ \text{m}}$

$= -80{,}000$ V/m

$\boxed{E = -8\times10^4\ \text{V/m}}$

2. E-field $= 1$ kV/m $\rightarrow 1000$ V/m $=$ slope

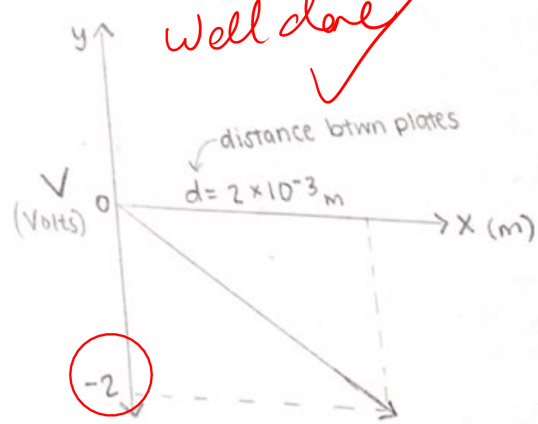
$\Delta x = 2$ mm $\rightarrow 2\times10^{-3}$ m

y-intercept $= ?$

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

Slope $= -1000$ V/m

well done



$\boxed{\text{y-intercept} = \text{zero}}$

3. (a) area $= 1\,cm^2 = 10^{-4}$ m

Capacitance$_{sys}$ = ?

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

$$C = \frac{\varepsilon_0 A}{d} \Rightarrow \frac{(8.85\times10^{-12})(10^{-4})}{2\times10^{-3}}$$

$= 4.425 \times 10^{-13}$

$\boxed{\text{Capacitance}_{sys} \cong 4.43 \times 10^{-13}\ F}$

(b) if voltage = 5 V

Energy = $\frac{1}{2}CV^2$

$= 0.5(4.425\times10^{-13})(5)^2$

$= 5.531 \times 10^{-12}$

$\boxed{\text{Energy} \cong 5.5 \times 10^{-12}\ J}$

4.

= If we want more capacitance, then we should connect an identical capacitor to the first in Parallel. The series would be C/2 whereas the parallel would be added so it would make sense for it to be in parallel if the goal is more capacitance.

Current, Resistance, and DC Circuits

1. (a) Serial Case

$-\varepsilon_2 + Ir_2 + Ir_1 - \varepsilon_1 + IR = 0$

$$I = \frac{3V}{r_1+r_2+R} \Rightarrow \frac{3}{2+2+50} \Rightarrow \frac{3}{54} = 55.\overline{5}$$

$\boxed{I = 55.6\ mA}$

Parallel Case

$I = \frac{V}{R}$

$I = \frac{1.5}{50}$

$\boxed{I = 30\ mA}$

(b) Serial Case Power Consumption

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

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

$= (55.56)^2(2) + (55.56)^2(2) + (55.56)^2(50)$

$= 6173.8 + 6173.8 + 154345.68$

$= 166693.33$ W

$\boxed{P_{total} = 166.7\ mW}$ *PR = 154.3 mW

Parallel Case Power Consumption

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

$= I_1^2 R_1 + I_1^2 R_2 + I^2 R$

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

$= 450 + 450 + 45000$

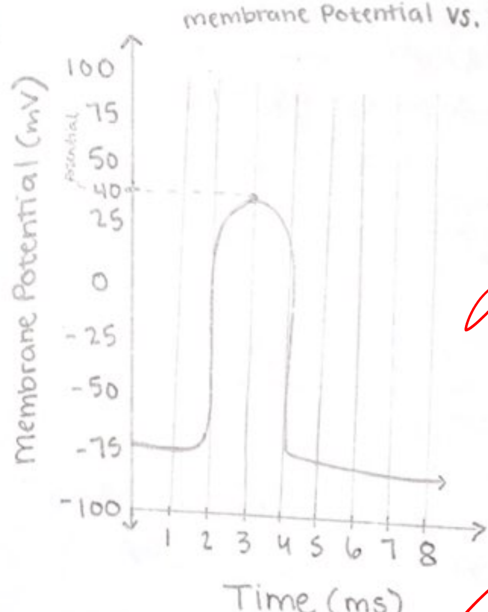
$= 45{,}900$ W

$\boxed{P_{total} = 45.9\ mW}$ *PR = 45 mW

(c) PHET CHECK

$\boxed{= \text{correct}}$

2. membrane Potential vs. Time



2 ms

(a) Pulse width = $\boxed{2\ ms}$

(b) Peak to Peak Voltage

= 40 − (−75)

= 40 + 75

$\boxed{= 115\ mV}$

nice