Avery Turner

20/20

yay!

Physics Mid Term

Electric Charge & Electric fields

1) a)

$E = \frac{1}{4\pi\epsilon_0}\left(\frac{q}{r^2}\right)$

$E = 2\times10^{-3}$

$r = 1mm$

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

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

at 5mm :

$E = \frac{1}{4\pi\epsilon_0}\frac{q}{(5\times10^{-3})^2}$

$= 2\times10^{-3}\times10^{-6}\left(\frac{1}{25\times10^{-6}}\right)$

$= 0.08\times10^{-3}$

$E = \boxed{8\times10^{-5}\ \frac{V}{m}}$ ✓

b) $E = \frac{1}{4\pi\epsilon_0}\frac{3q}{r^2}$

I think you mean 10^{-3}

$E = 8\times10^{3}\times 3q$

$\boxed{E = 24\times10^{3}\ \frac{V}{m}}$ ✓

Electric field is 3 times bigger and due to Scaling problem we multiply 8×10^{3} by 3.

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2) $m = 4\times10^{-16}kg$

a) $E = 6131.25\ N/C$

$q = \frac{mg}{E} = \frac{4\times10^{-16}\times9.8}{6131.25}$

$= 6.39\times10^{-19}$

$\frac{q}{e} = \frac{ne}{e} \rightarrow n = \frac{q}{e}$

$\boxed{n = 4\ \text{electrons}}$ ✓

b) $q' = \frac{mg}{E} - e \rightarrow \frac{(4\times10^{-16})(9.8)}{6131.25} + 1.6\times10^{-19} \rightarrow 4.79\times10^{-19}$ electrostatic force

$Fe\uparrow$

$Fg\downarrow$

$Fe = q'E = (4.79\times10^{-19})(6131.2) \rightarrow 2.939\times10^{-15}$

mass of drop $= 4\times10^{-16}$ kg

$Fg = mg \rightarrow (4\times10^{-16})(9.8) = \boxed{3.92\times10^{-15}\ N}$ gravitational force

$a = \frac{Fg - Fe}{m} \rightarrow \frac{3.92\times10^{-13} - 2.939\times10^{-15}}{4\times10^{-16}}$

acceleration

$a = \boxed{2.45\ m/s^2}$ ✓ well done

downwards ✓

☆ Potential Energy and Voltage, Capacitors ☆

1) a) $KE = qV$

$q = 1.6 \times 10^{-19}$

$kV = 4 \times 10^{3} \rightarrow V = 4 \times 10^{3}$

$KE_{hydrogens} = (1.6 \times 10^{-19})(4 \times 10^{3})$

$= 6.4 \times 10^{-16}\,J \times 6.242 \times 10^{16}$ (conversion)

$= \boxed{3994.5\ eV}$ 4 keV

eV are easier

$KE_{He} = 2 \times 10^{-19} \times (4 \times 10^{3})$

$= 12.8 \times 10^{-16}\,J \times 6.242 \times 10^{18}$ (conversion)

8 keV $= \boxed{7990\ eV} \rightarrow \boxed{\text{Total eV} = 11984.5}$

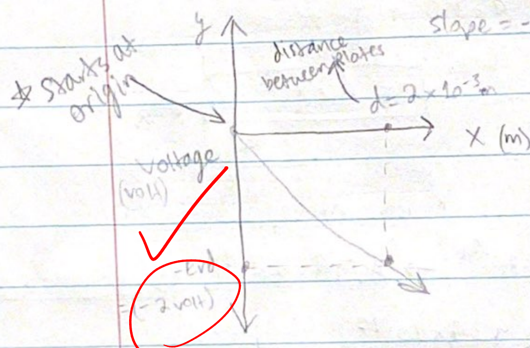
b) $E = -\frac{\Delta V}{\Delta x} \rightarrow E = \frac{4 \times 10^{3}}{5 \times 10^{-2}} = \boxed{8 \times 10^{4}\ V/m}$

$\Delta x = 5cm \rightarrow 5 \times 10^{-2}\,m$

$\Delta V = 4 \times 10^{3}$

2) $E = -\frac{dv}{dx}$ or $V = -E \times X$

$E = 1000\ V/m$



slope = -1000 V/m

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

☆ when distance is zero → voltage does not exist

☆ can't divide by 0

3) a) $C = \frac{\varepsilon_0 A}{d}$

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

$A = km^2 = \frac{1m}{100cm} \times \frac{1m}{100cm} = 10^{-4}\,m^2$

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

$= \boxed{4.425 \times 10^{-13}\,F}$

b) $\text{Energy} = \frac{1}{2}CV^2$

$= \frac{1}{2}(4.425 \times 10^{-13})(5^2)$

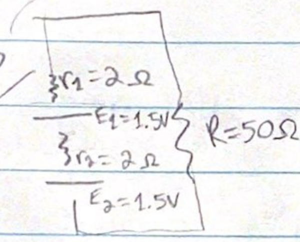
$= 2.2 \times 10^{-13}\ (25)$

$= \boxed{5.53 \times 10^{-12}\,J}$

A) We should connect the identical capacitor in parallel because it will allow a system to store more energy or have more capacitance by $C_{Tot} = C_1 + C_2$ while in series is $C_{Tot} = \frac{1}{C_1} + \frac{1}{C_2}$.

☆ Current, Resistance, and DC circuits ☆

1) a) Series



$I = ?$

$E_1 + E_2 + E_3 + \dots = 0$

$E_1 - Ir_1 - Ir_2 - IR + E_2 = 0$

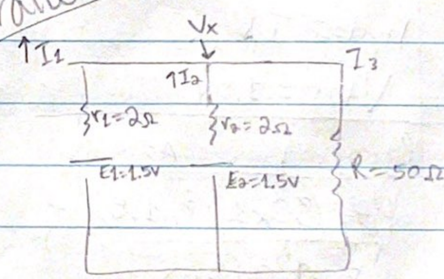
$E_1 + E_2 = I(r_1 + r_2 + R)$

$I = \frac{E_1 + E_2}{r_1 + r_2 + R}$

$\frac{1.5 + 1.5}{2 + 2 + 50} = \frac{3}{54} = 0.055\,A$ $\times 1000$

$\boxed{\text{Series } I = 55.6\,mA}$

Parallel



batteries are parallel → E = 1.5V

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

$\boxed{I = 30\,mA}$

1) b) Power Consumption → Series

$P = IV$

$V_{tot} = V_1 + V_2$

$= 1.5 + 1.5$

$V_{tot} = 3$

$P = (55.6 \times 10^{-3})(3)$

$= 0.1668 \times 1000$

$\boxed{P = 166.8\ mW}$ ✓

Power Consumption → Parallel

$P = IV$

$V_{tot} = 1.5V$

excellent

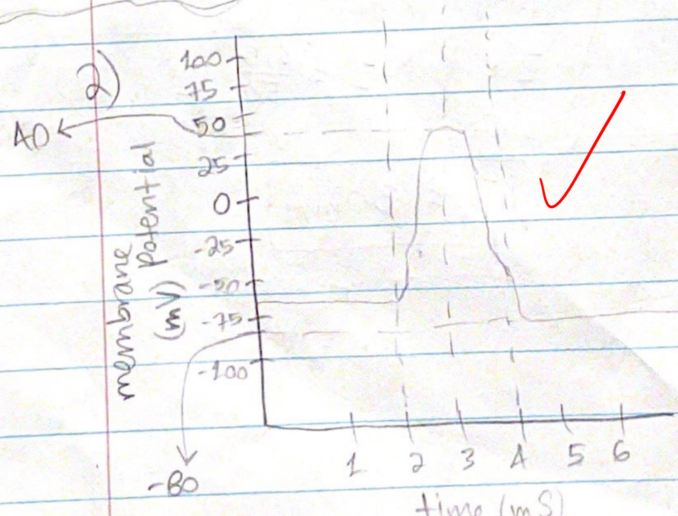
$P = (30 \times 10^{-3})(1.5)$

$= 0.045 \times 1000$

$\boxed{P = 45mW}$ ✓

c) Checked on PhET DC ✓ ✓

2)



✓

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

b) highest peak = 40mV

lowest peak = -80mV

40 - (-80)

40 + 80 = $\boxed{120mV}$