Midterm

Mason Lebby

Electric Charge and Electric Fields

1) a) $E_c = 2.00\times10^{-3}\ V/m$ at 1mm or 0.001m

E_c at 5mm (0.005m) is ?

$E_c = \frac{kq}{r^2}$ $\quad \frac{E_c r^2}{k} = q = \frac{(2.00\times10^{-3})(0.001)^2}{(9\times10^9)}$ $\quad q = 2.22\times10^{-19}$ $\quad \cancel{q = 5.56\times10^{-18}}$

$E_c = \frac{kq}{r^2}$ $\quad E_c = \cancel{\frac{(9\times10^9)(5.56\times10^{-18})}{(0.005)^2}}$ $\quad E_c = \frac{(9\times10^9)(2.22\times10^{-19})}{(0.005)^2} = \boxed{8\times10^{-5}\ V/m \text{ at } 5mm}$

b) $E_c = 8.00\times10^{-3}\ V/m$ $\quad q = 1\mu C$ $\qquad E_c = ?$ when $q = 3\mu C$

$E_c = \frac{kq}{r^2} \rightarrow E_c = \frac{k3q}{r^2}$ $\qquad$ charge is 3 times greater so E_c is 3 times greater

$(8\times10^{-3})\times3 = \boxed{24.0\times10^{-3}\ V/m}$

2) Given: mass $= 4\times10^{-16}$ kg $\quad E = 6131.25\ N/C$

a) $F = qE$ $\quad F = mg$ (weight) $\rightarrow mg = qE$ $\quad q = \frac{mg}{E}$ $\quad q = \frac{(4\times10^{-16})(9.8)}{6131.25}$

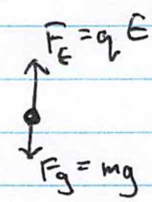
$q = 6.39\times10^{-19}$

q = # of electrons(n) x charge of electron(e) $\qquad q = ne$

$\frac{q}{e} = n = \frac{6.39\times10^{-19}}{1.6\times10^{-19}}$ $\qquad e = 1.6\times10^{-19}$ $\qquad n = 3.996$ $\qquad \boxed{n = 4 \text{ electrons}}$

b) one e^- removed

$q - e = q_2 = 6.39\times10^{-19} - 1.6\times10^{-19} = 4.79\times10^{-19}$



$F_{Net} = F_g - F_E = ma$ $\qquad a = \frac{F_g - F_E}{m}$ $\qquad a = \frac{mg - qE}{m}$

$a = \frac{(4\times10^{-16})(9.8) - (4.79\times10^{-19})(6131.25)}{4\times10^{-16}}$ $\qquad \boxed{a = 2.45\ m/s^2 \text{ downwards}}$

Potential Energy and Voltage, Capacitance

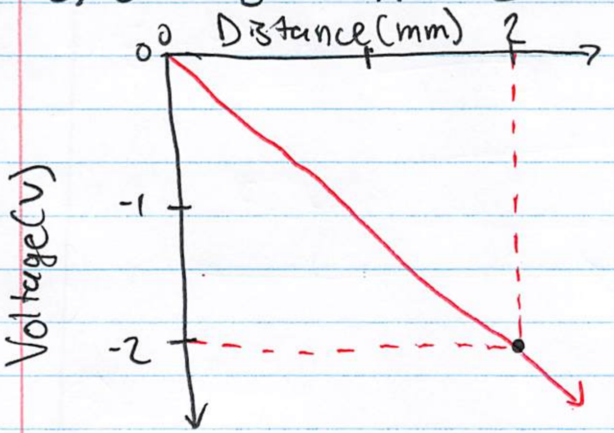
1) Given: $\Delta V = 4kV$ $H = +1q_e$ $He = +2q_e$ $1J = 6.242\times10^{18} eV$

a) $U = qV$ $U_{tot} = KE_{tot} \rightarrow KE = qV$

hydrogen $KE = (1.6\times10^{-19})(4\times10^{3}) = 6.4\times10^{-16} J \times \frac{6.242\times10^{18} eV}{1J} = \boxed{3995 eV}$ hydrogen

helium $KE = 2(1.6\times10^{-19})(4\times10^{-3}) = 12.8\times10^{-16} J \times \frac{6.242\times10^{18} eV}{1J} = \boxed{7990 eV}$ helium

2) Given $E = 1kV/m$ $\Delta x = 2mm$



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

m (slope) = $-1000 V/m$
or
$-1 V/mm$

y-intercept is zero. when distance is zero, voltage is zero ($V = E\Delta x$)

b) $E = -\frac{\Delta V}{\Delta x} = -\frac{(4\times10^{3})}{(5\times10^{-2})}$

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

3) a) $C = \frac{\epsilon_0 A}{d}$ $\epsilon_0 = 8.85\times10^{-12}$ $A = 1cm^2 \times \frac{1m}{100cm} \times \frac{1m}{100cm} = 1\times10^{-4} m^2$

$C = \frac{(8.85\times10^{-12})(1\times10^{-4})}{2\times10^{-3}} = \boxed{4.425\times10^{-13} F}$

b) $Energy = \frac{1}{2}CV^2 = \frac{1}{2}(4.425\times10^{-13})(5^2) = \boxed{5.53\times10^{-12} J}$

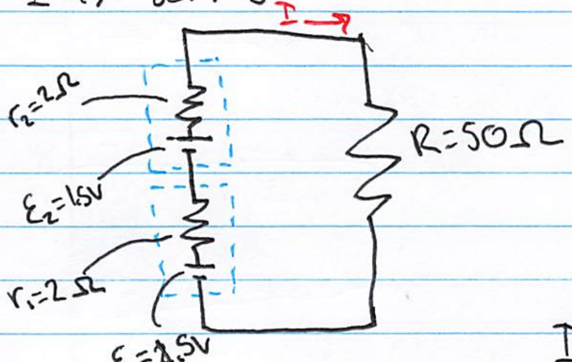
4) $C_{tot} = C_1 + C_2$ in parallel $\frac{1}{C_{tot}} = \frac{1}{C_1} + \frac{1}{C_2}$ in series

to store more energy we should add the other capacitor in parallel.

$\boxed{\text{parallel}}$

Current, Resistance, and DC circuits

1 a) series



$\mathcal{E}_1+\mathcal{E}_2+\ldots=0$

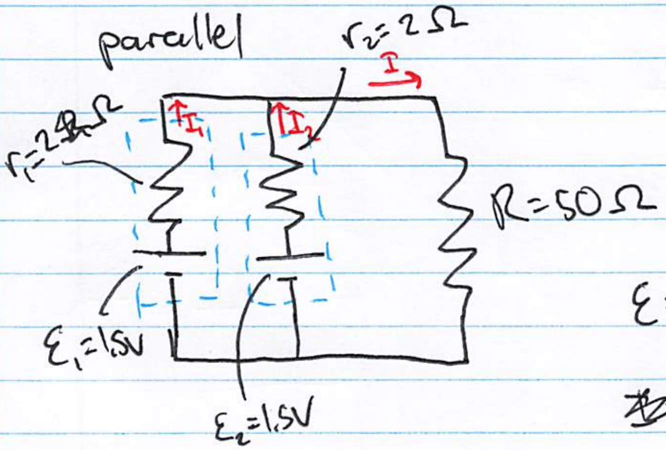
$\mathcal{E}_1-Ir_1-Ir_2-IR+\mathcal{E}_2=0$

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

$\mathcal{E}_1+\mathcal{E}_2=I(r_1+r_2+R)$

$$I=\frac{\mathcal{E}_1+\mathcal{E}_2}{r_1+r_2+R}=\frac{1.5+1.5}{2+2+50}=\boxed{55.6\,mA \text{ series}}$$

parallel



$\cancel{I_1+I_2=I}$

$I_1+I_2=I$

$\mathcal{E}=1.5V$ because batteries are in parallel

$I=\frac{V}{R}$ $\quad I=\frac{1.5}{50}=30\,mA$

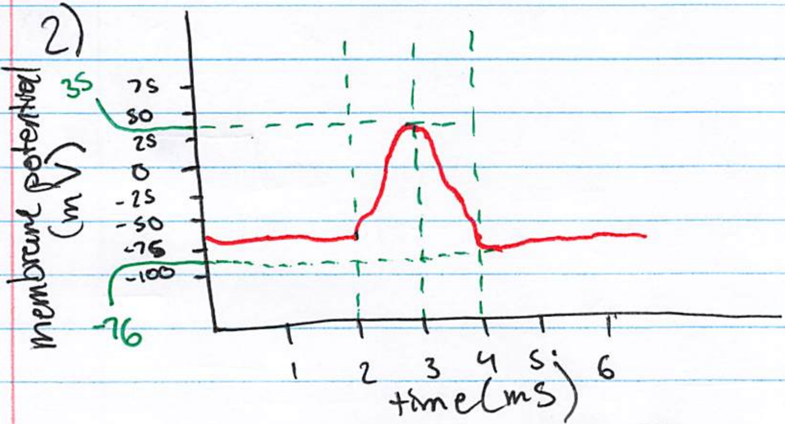
b) series $P=IV$ $\quad P=(55.6\times10^{-3})(3)=\boxed{166.8\,mW}$

$V_{tot}=V_1+V_2$

parallel $P=IV$ $\quad P=(30\times10^{-3})(1.5)=\boxed{45\,mW}$

$V_{tot}=1.5V$

2)



a) pulse width ≈ ~~2ms~~ $\boxed{2\,ms}$

b) top peak = 35 mV
bottom peak = -76 mV

$35-(-76)$

$35+76 = \boxed{111\,mV}$