Physics Midterm

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2 - Electric Charge + Fields

1. a) $E = 2.0 \times 10^{-3}$ V/m ; $r = 1$ mm

$E = ?$; $r = 5$ mm

$$E = k \frac{q}{r^2}$$

$$E = k_2 \left(\frac{1}{25}\right) \Rightarrow \frac{2.0 \times 10^{-3}}{25} \approx \boxed{8.0 \times 10^{-5} \text{ V/m}}$$

b) $q = 1\mu C$ or $1 \times 10^{-6} C$

$E_c = 8.0 \times 10^{-3}$ V/m

value of E @ $q = 3\mu C$ or 3×10^{-6}

$$E = k \frac{q}{r^2}$$

$$E = \frac{k}{r^2}(3) \Rightarrow 8.0 \times 10^{-3}(3) \approx \boxed{2.4 \times 10^{-2} \text{ V/m}}$$

2. a) $m = 4 \times 10^{-16}$ kg

$E = 6131.25$ N/C down

$e^- ?$

$$E = \frac{\text{weight}}{\text{charge}} \Rightarrow 6131.25 = \frac{3.92 \times 10^{-15}}{\text{charge}?} \Rightarrow \text{charge} = 6.393 \times 10^{-19} C$$

$W = m \cdot g$

$W = (4 \times 10^{-16})(9.8) = 3.92 \times 10^{-15}$ kg

$$\# \text{ of } e^- = \frac{6.393 \times 10^{-19} C}{1.6 \times 10^{-19} C}$$

$$= 3.996 \approx \boxed{4 \text{ electrons}}$$

b) removal of $1e^-$

↳ charge $= (6.393 \times 10^{-19}) - (1.6 \times 10^{-19}) \approx 4.79 \times 10^{-19} C$

Acceleration: $a = \frac{E \cdot q}{m}$ $\quad a = \frac{(6131.25 \text{ N/C})(4.79 \times 10^{-19} C)}{4 \times 10^{-16} \text{ kg}} \Rightarrow \boxed{a = 7.34 \text{ m/s}^2}$

3. Potential Energy, Voltage + Capacitors

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

$H = +1qe$

$He = +2qe$

$$\Delta U = q \Delta V$$

$$\Delta U = (3qe)(4000V) = 12,000 \text{ eV} \approx \boxed{12 \text{ ekV}}$$

b) $\Delta x = 5$ cm

$$E = \frac{\Delta V}{\Delta x} \Rightarrow E = \frac{4000V}{0.05m} = 80,000 \text{ V/m} \approx \boxed{8.0 \times 10^4 \text{ V/m}}$$

2. $E = 1kV/m$

$\Delta x = 2$ mm

$\Delta V = \frac{1 \times 10^3 V/m}{2 \times 10^{-3} m} = 0.5 V$
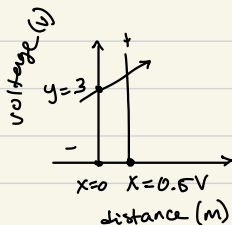
$F(x) = mx + b$

$V(x) = Ex + b \Rightarrow 5.0 = (1 \times 10^3)(2 \times 10^3) + b$

$= 5 - 2 = b \Rightarrow \boxed{b = 3}$

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

$A = 1cm^2 \approx 1 \times 10^{-4} m^2$

$d = 2mm \approx 2 \times 10^{-3} m$

$$C = \frac{(8.85 \times 10^{-12})(10^{-4} m^2)}{(2 \times 10^{-3} m)} = \frac{8.85 \times 10^{-13}}{2} = \boxed{4.42 \times 10^{-13} C}$$

b.) $V = 5V$

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$U = \frac{1}{2}(4.42 \times 10^{-13} C)(5V)$

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

$= \boxed{1.105 \times 10^{-12} \text{ J}}$

4. To store more energy for the same voltage (capacitance), an identical capacitor should be placed in __parallel.__

↪ $C_{tot} \text{ (in parallel)} = C_1 + C_2 + C_n \ldots$

$C_{tot} \text{ (in series)} = \left(\frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_n} \ldots \right)^{-1}$

4 - Current, Resistance, & DC Circuits

1. a) Current through R?

In series: $I_{total} = I_1 = I_2 = I_3$

$I = \frac{V}{R_{total}} = \frac{3V}{54\Omega} = \underline{0.06 A}$

I is same across all resistors, so current through R is $\boxed{0.06 A}$

In parallel: V = same across all resistors.

$I_R = \frac{V}{R} \Rightarrow \frac{1.5V}{50\Omega} = 0.03 A$

Since V is the same across all resistors, then $V = 1.5 V$ (volts are not additive in parallel), then I_R is $\boxed{0.03 A}$

$\frac{1}{R} = \frac{1}{2} + \frac{1}{2} + \frac{1}{50} = 0.98$

b.) Power consumption?

In series: $P = I^2 R$

$P = (0.06)^2 (54)$

$\boxed{P = 0.194 W}$

In Parallel: $P = I^2 R \rightarrow$

$P = (0.03)^2 (0.98\Omega)$

$\boxed{P = 8.8 \times 10^{-4} W}$

c.) Checked & found to be correct.

2. a) Pulse width:

$3 ms - 5 ms \approx \boxed{3 ms}$

b.) Peak to peak voltage:

$35 mV - (-75 mV) = \boxed{110 mV}$