Midterm 1 3/11/24

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1. Unit 0

1) 50g ball copper, Net charge 2. μC $Cu \rightarrow 29$ proton, 63.5 A mass

$2\,\mu C \times \frac{1\,C}{10^6\,\mu C} \times \frac{1\text{ proton}}{1.6\times10^{-19}\,C} = 1.25\times10^{13}$ protons.

↳ Also means $1.25\times10^{13}\,e^-$ removed.

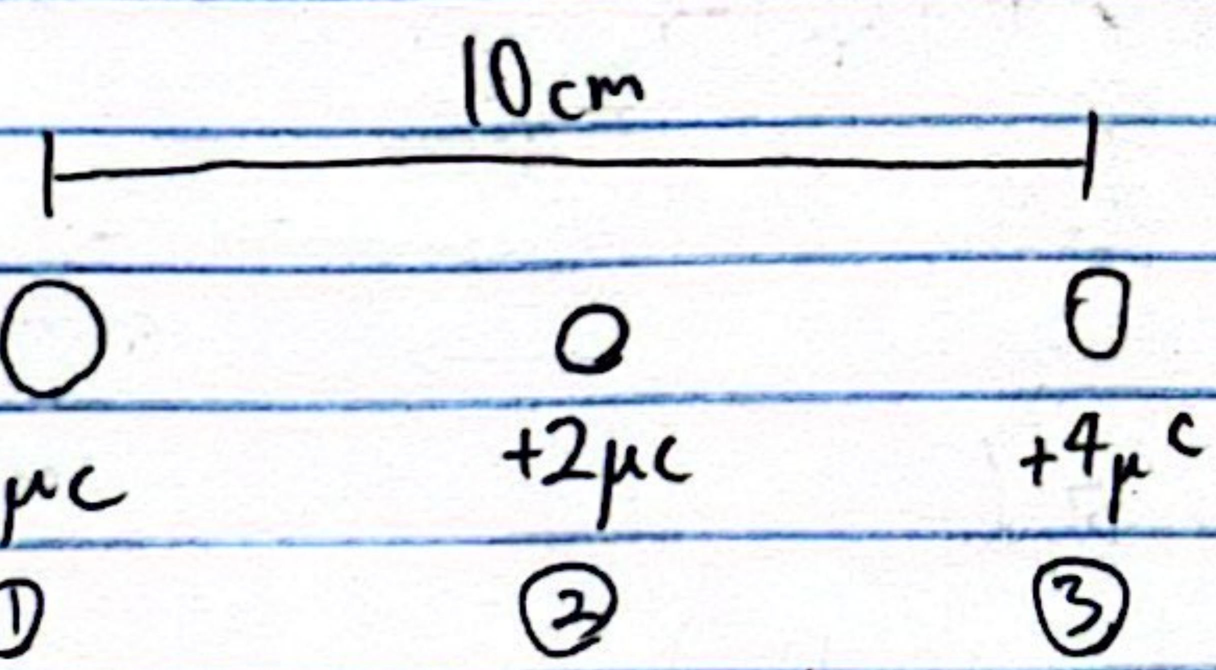
Total # of $e^- = 50g \times \frac{1\text{mol}}{63.5g} \times \frac{6.02\times10^{23}}{1\text{mol}}$

$= 4.74\times10^{23}$ ~~atoms of Cu~~ $\times \frac{29\text{ proton}}{\cancel{1\text{ atoms of Cu}}}$

$= 1.37\times10^{25}$ proton $= 1.37\times10^{25}\,e^-$

$\frac{1.25\times10^{13}\,e^-}{1.37\times10^{25}\,e^-} = \underline{9.09\times10^{-13}}$

2) a)



$F_{1,2} = \frac{k|q_1q_2|}{r^2}$

$= \frac{8.99\times10^9|6\times10^{-6}\times2\times10^{-6}|}{0.05^2}$

$= \underline{43.152N}$

$F_{2,3} = \frac{k|q_2q_3|}{r^2}$

$= \frac{8.99\times10^9|2\times10^{-6}\times4\times10^{-6}|}{0.05^2}$

$= \underline{28.768N}$

Net F

$\Sigma F = F_{1,2} - F_{2,3}$

$= 43.152 - 28.768$

$= \underline{14.4N}$

b) Force is pointing AWAY from +6μC charge.

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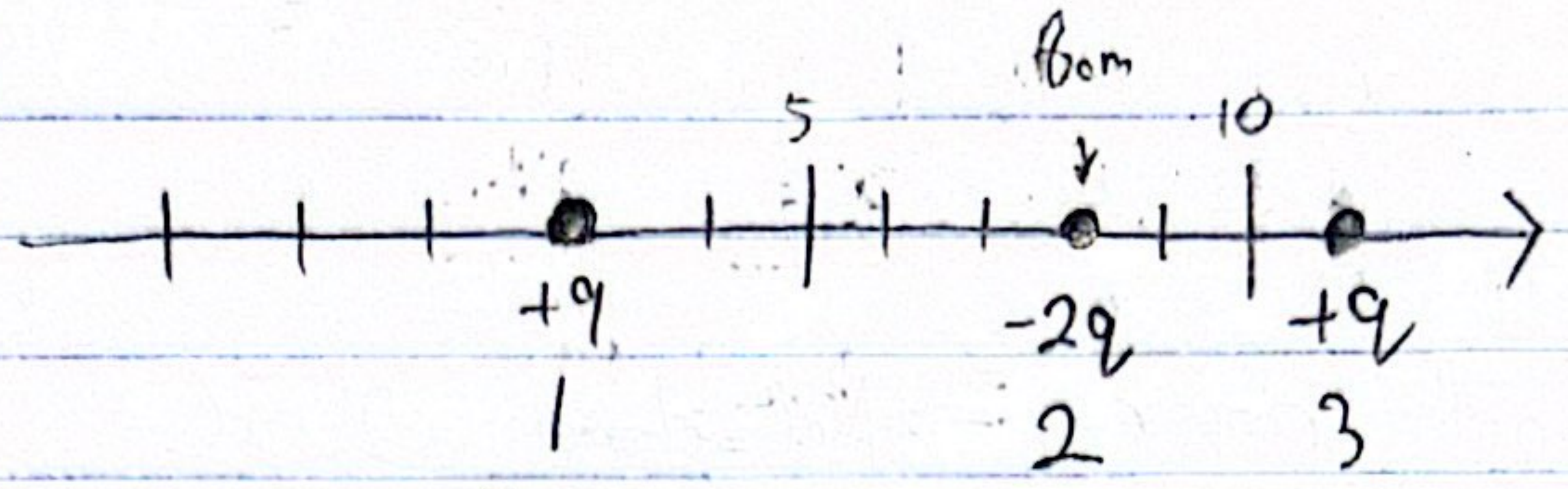
3)



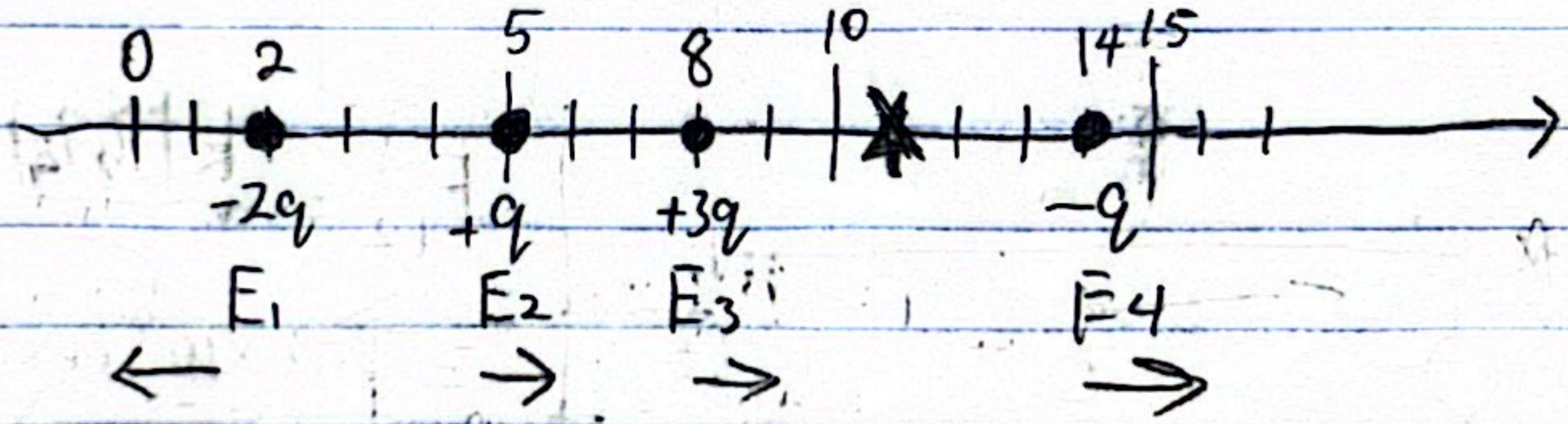
$$\Sigma F_2 = F_{3,2} - F_{1,2}$$

$$= \frac{k|q_3 q_2|}{r_{3,2}^2} - \frac{k|q_1 q_2|}{r_{1,2}^2}$$

$$= \frac{8.99\times10^9 |1\times10^{-6} \times 2\times10^{-6}|}{0.03^2} - \frac{8.99\times10^9 |1\times10^{-6} \times 2\times10^{-6}|}{0.05^2}$$

$= \underline{12.8\,N}$ on Positive direction.

4)



$$E_T = E_2 + E_3 + E_4 - E_1$$

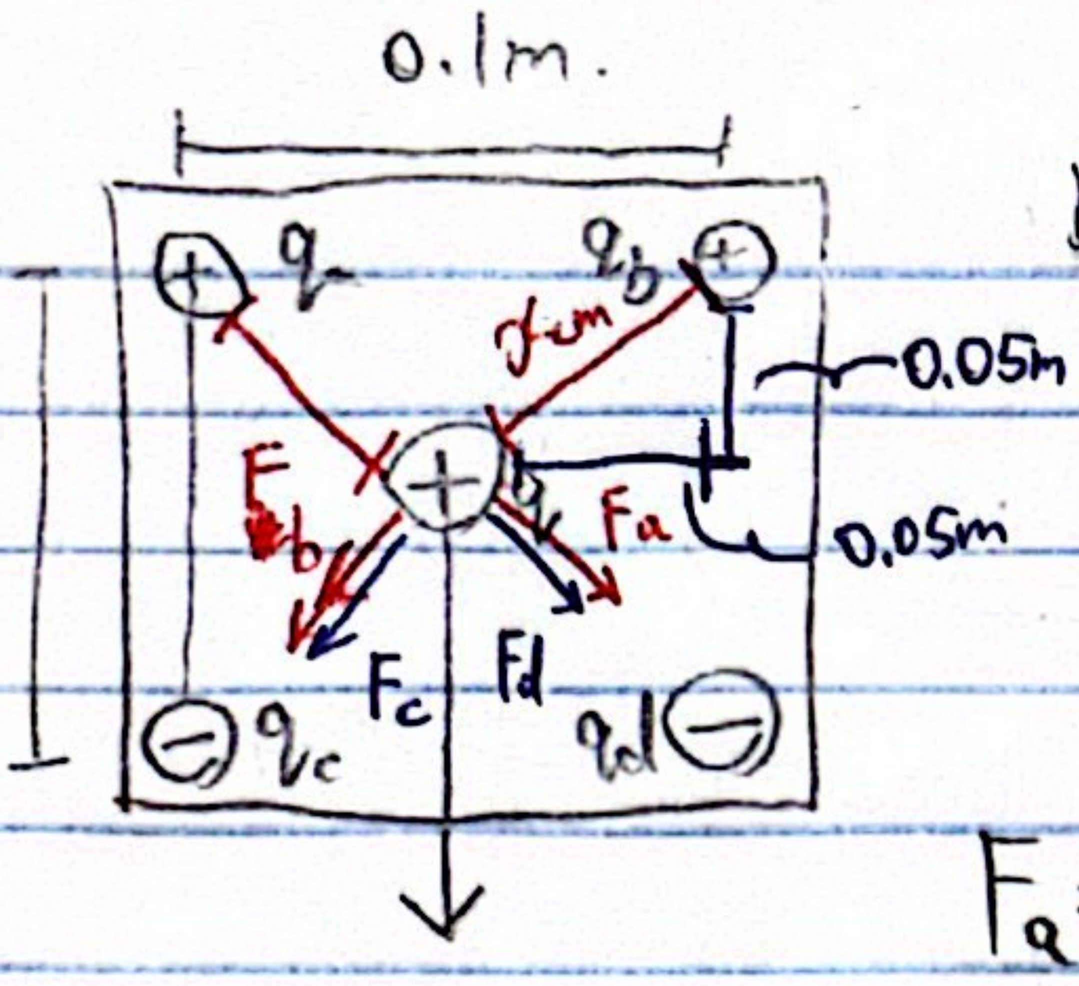
$$k\left[\frac{|q_2|}{r_2^2} + \frac{|q_3|}{r_3^2} + \frac{|q_4|}{r_4^2} - \frac{|q_1|}{r_1^2}\right]$$

$$= k\left[\frac{5\times10^{-9}}{0.06^2} + \frac{1.5\times10^{-8}}{0.03^2} + \frac{5\times10^{-9}}{0.03^2} - \frac{1\times10^{-8}}{0.1^2}\right]$$

$$= 8.99\times10^9 \left(2.26\times10^{-5}\right)$$

$$\underline{E_T = 2.03\times10^5 \ N/C}$$

5)



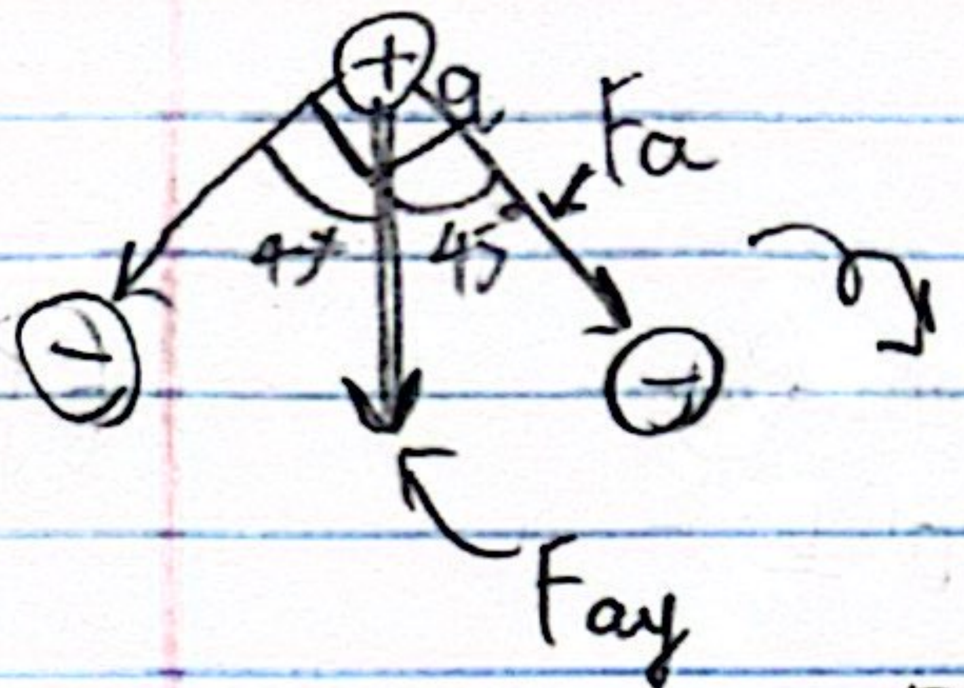
b) $\sqrt{x_{cm}^2} = \sqrt{0.05^2+0.05^2}$

$x = 0.0707m$

$$F = \frac{k|q_1 q_2|}{r^2}$$

$$F_a = \frac{8.99\times10^9(7.5\times10^{-6}\times2\times10^{-6})}{(0.0707)^2}$$

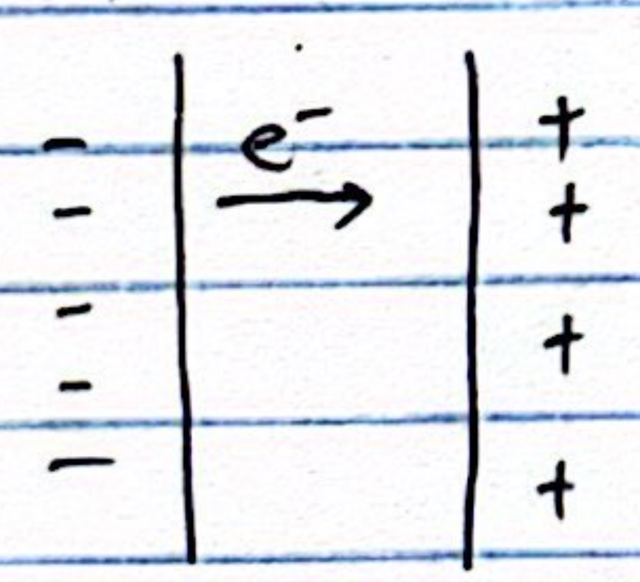
$$F_a = 26.97N$$



$$F_{ay} = 26.97N\cos(45)$$
$$= 19.07N$$

$$F_T = (F_{ay})4$$
$$= 76.28$$

6) a)



$\Delta V = 40kV$
$= 40{,}000V$

$$\Delta V = \frac{\Delta PE}{q_{e^-}}$$

$$40{,}000 = \frac{\Delta PE}{1.6\times10^{-19}}$$

$$\Delta PE = 6.4\times10^{-15}J$$

$KE = 6.4\times10^{-15}J$

$KE = \frac{1}{2}mv^2$

$$\sqrt{\frac{2KE}{m}} = v$$

$$v = \sqrt{\frac{2(6.4\times10^{-15})}{9.11\times10^{-31}}}$$
$$= 1.18\times10^8 m/s$$

b) $\frac{V}{m} = \frac{N}{C}$

$V = \frac{E}{q} = \frac{J}{C}$

$\frac{\frac{J}{C}}{m} = \frac{N}{C}$

$\frac{J}{cm} = \frac{N}{C}$

Work formula

$W = F\cdot d$

$J = N\cdot m$

$\frac{Nm}{Cm} = \frac{N}{C}$

$\frac{N}{C} = \frac{N}{C}$

$\therefore \frac{V}{m} = \frac{N}{C}$

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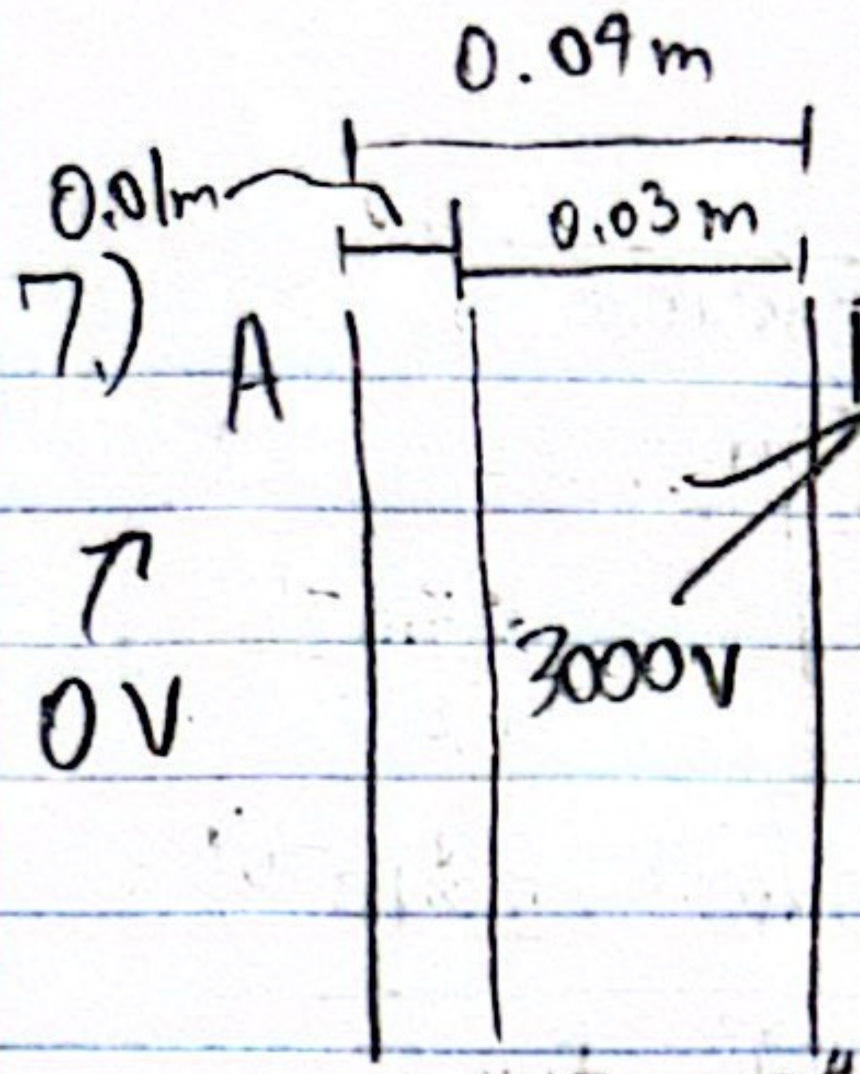


a)

$V_{AB} = Ed$

$= 7.5\times10^{4}(0.04)$

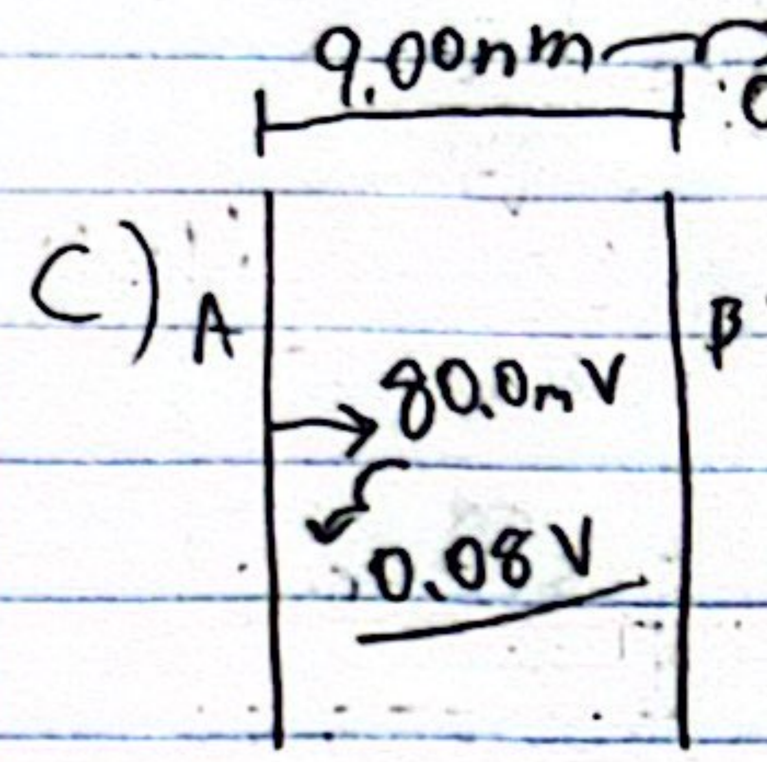
$\underline{\underline{V_{AB} = 3{,}000\,V}}$

b) Distance is $\frac{1}{4}$ of original

$E = 7.5\times10^{4}\,\frac{V}{m}$

$V = \frac{1}{4}(3000)$

$\underline{\underline{= 750\,V}}$



$V_{AB} = Ed$

$E = \frac{V_{AB}}{d}$

$= \frac{0.08}{9\times10^{-9}}$

$\underline{\underline{E = 8.89\times10^{6}\,\frac{V}{m}}}$

8) Doubly charged $= q = 2(1.6\times10^{-19}\,C)$

$\underline{= 3.2\times10^{-19}\,C}$

$E = 32.\cancel{keV}\times\frac{1000\cancel{eV}}{1\cancel{keV}}\times\frac{1.6\times10^{-19}J}{1\cancel{eV}}$

$E = \underline{5.12\times10^{-15}J} = \underline{\Delta PE}$

$\Delta V = \frac{\Delta PE}{q}$

$= \frac{5.12\times10^{-15}J}{3.2\times10^{-19}C}$

$\underline{= 1.6\times10^{4}V}$

$V_{AB} = Ed$

$E = \frac{V}{d}$

$E = \frac{1.6\times10^{4}}{0.02}$

$\underline{\underline{= 8\times10^{5}\,\frac{V}{m}}}$

9) Charge of Gold

$\hookrightarrow 79 \times 1.6 \times 10^{-19} = \underline{1.264 \times 10^{-17} C}$

Doubly α particle $= 2(1.6 \times 10^{-19})$

$q = \underline{3.2 \times 10^{-19} C}$

$E = 5\,\cancel{MeV} \times \frac{10^6\,\cancel{eV}}{1\,\cancel{MeV}} \times \frac{1.6 \times 10^{-19} J}{1\,\cancel{eV}}$

$= \underline{8 \times 10^{-13} J}$

$\Delta V = \frac{\Delta PE}{q}$

$= \frac{8 \times 10^{-13}}{3.2 \times 10^{-19}}$

$\Delta V = 2.5 \times 10^6 V$

$V = \frac{k q_\alpha}{r}$

$r = \frac{kq}{V}$

$r = \frac{8.99 \times 10^9 (1.264 \times 10^{-17})}{2.5 \times 10^6}$

$= \underline{\underline{4.55 \times 10^{-14} m}}$

2. Unit 1 !

1) $q = 3.00 \mu C = 3 \times 10^{-6} C$

$V = 120 V$

$C = \frac{q}{V}$

$C = \frac{3 \times 10^{-6}}{120}$

$\underline{\underline{C = 2.5 \times 10^{-8} F}}$

2) $C = 10 \mu F \Rightarrow 10 \times 10^{-6} F$

$V = 9.00 \times 10^3 V$

a) $E_{cap} = \frac{CV^2}{2}$

$E = \frac{10 \times 10^{-6} (9.00 \times 10^3)^2}{2}$

$= \underline{\underline{405 J}}$

b) $C = \frac{Q}{V}$

$Q = CV$

$Q = 10 \times 10^{-6} (9 \times 10^3)$

$= \underline{\underline{0.09 C}}$

c) $C = 8 \mu F = 8 \times 10^{-6} F$

$E = 40 J$

$E_{cap} = \frac{CV^2}{2}$

$V = \sqrt{\frac{2 E_c}{C}}$

$= \sqrt{\frac{2(40)}{8 \times 10^{-6}}}$

$= \underline{\underline{3.16 \times 10^3 V}}$

b) Charge (2)

$C = \frac{Q}{V}$

$Q = CV$

$= (8 \cdot 10^{-6}) 3.16 \times 10^3$

$\underline{\underline{q = 0.0253 C}}$

3. 4 Parallel.

a) $10\mu F = C_{Tot\,P}$

$C_p = C_1 + C_2 + C_3 + C_4$

$10\mu F = 4C$

$C = 2.5\mu F$

$Q = CV$

$= (2.5)(9.00 \times 10^3)$

$= 2.25 \times 10^4 \mu C$

b) To increase a capacitance by parallel arrangement. To increase total capacitance it is to either increase a parallel series or make bigger capacitor.

4. $d = 1.0mm \Rightarrow 0.001m$

$r = 2.0\Omega$, $20°C$

$A = \pi(0.0005)^2$

$= 7.85 \times 10^{-7} m^2$

$R = \rho \frac{L}{A}$

$L = \frac{RA}{\rho}$

$L = \frac{2 \cdot 7.85 \times 10^{-7}}{1.68 \times 10^{-8}}$

$= 93.45m$

5. a) $R_{Tot} = R_r + R_{LED}$

$= 1000\Omega + 3\Omega$

$= 1003\Omega$.

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

$= \frac{3V}{1003\Omega}$

$= 0.00299A$.

b) $P = I^2R$

$= (2.99 \times 10^{-3})^2 3$

$= 26.82 \times 10^{-6} W$

c) $T = 10min \Rightarrow 10 \times 60 \rightarrow 600s$.

$Q = It$

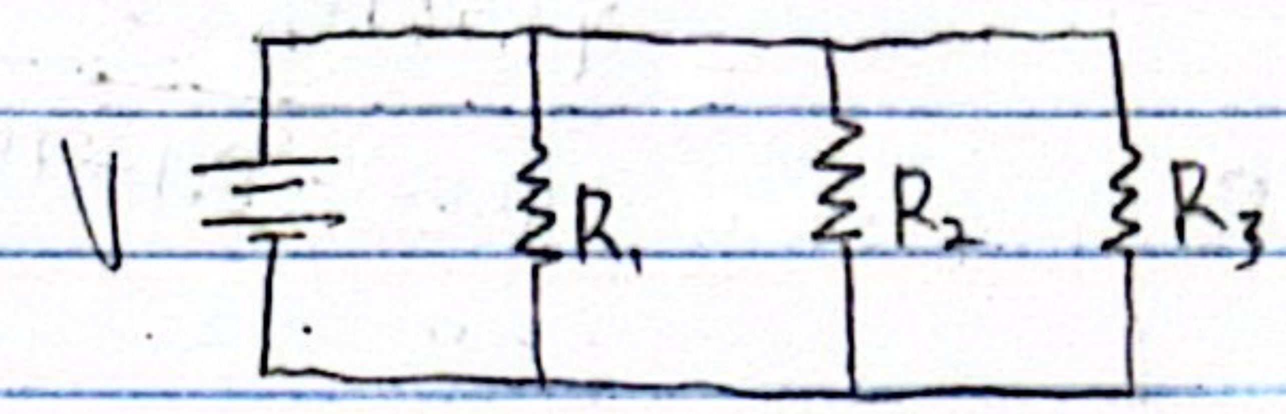
$= (2.99 \times 10^{-3}) 600$

$= 1.794 C$

3. Unit 2:

$R_{tot} = 2k\Omega$ (↑ $2000\,\Omega$)

1)



$10k\Omega \rightarrow 10000\,\Omega$ $\quad$ $5k\Omega \rightarrow 5000\,\Omega$

a) $R_3 = ?$

$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{2000} = \frac{1}{10000} + \frac{1}{5000} + \frac{1}{R_3}$$

$$\frac{1}{R_3} = \frac{5}{10000} - \frac{1}{10000} - \frac{2}{10000}$$

$$= \frac{2}{10000} = \frac{1}{5000}$$

$$\underline{\underline{R_3 = 5000\,\Omega}}$$

b) $I_{tot} = \frac{\Delta V}{R_{tot}}$

$$= \frac{12V}{2000}$$

$$\underline{\underline{= 0.006A}}$$

c) For R_1,

$$I_1 = \frac{\Delta V}{R_1} = \frac{12}{10000}$$

$$\underline{\underline{= 0.0012\,A}}$$

For R_2,

$$I_2 = \frac{\Delta V}{R_2} = \frac{12}{5000}$$

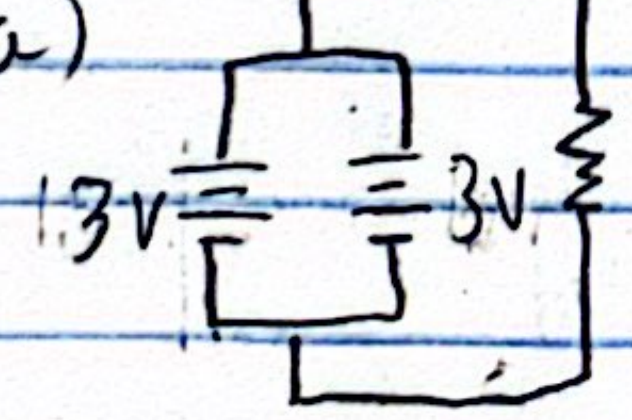
$$\underline{\underline{= 0.0024\,A}}$$

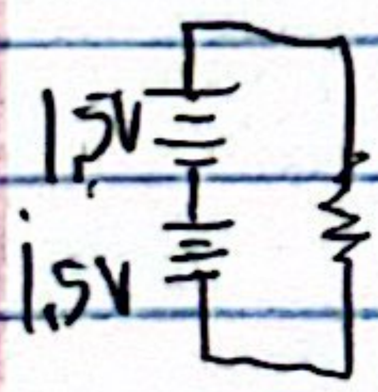
For R_3,

$$I_3 = \frac{\Delta V}{R_3} = \frac{12}{5000}$$

$$\underline{\underline{= 0.0024\,A}}$$

2) a)





Parallel: $\underline{\underline{3V}}$

$$P = VI$$

$$= V\left(\frac{V}{R}\right)$$

$$\underline{\underline{= 3W}}$$

Series: $1.5V + 1.5 = 3V$

$$P = V\left(\frac{V}{R}\right) = \underline{\underline{3W}}$$

b) Parallel:

$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{tot}} = \frac{1}{5} + \frac{1}{5}$$

$$R_{tot} = 2.5\,\Omega$$

$$P = V\left(\frac{V}{R}\right)$$

$$= 3\left(\frac{3}{2.5}\right)$$

$$\underline{\underline{P = 3.6\,W}}$$

Series: $R_{tot} = R_1 + R_2$

$$R_{tot} = 5 + 5$$

$$= 10\,\Omega$$

$$P = V\left(\frac{V}{R}\right)$$

$$= 3\left(\frac{3}{10}\right)$$

$$\underline{\underline{= 0.9\,W}}$$

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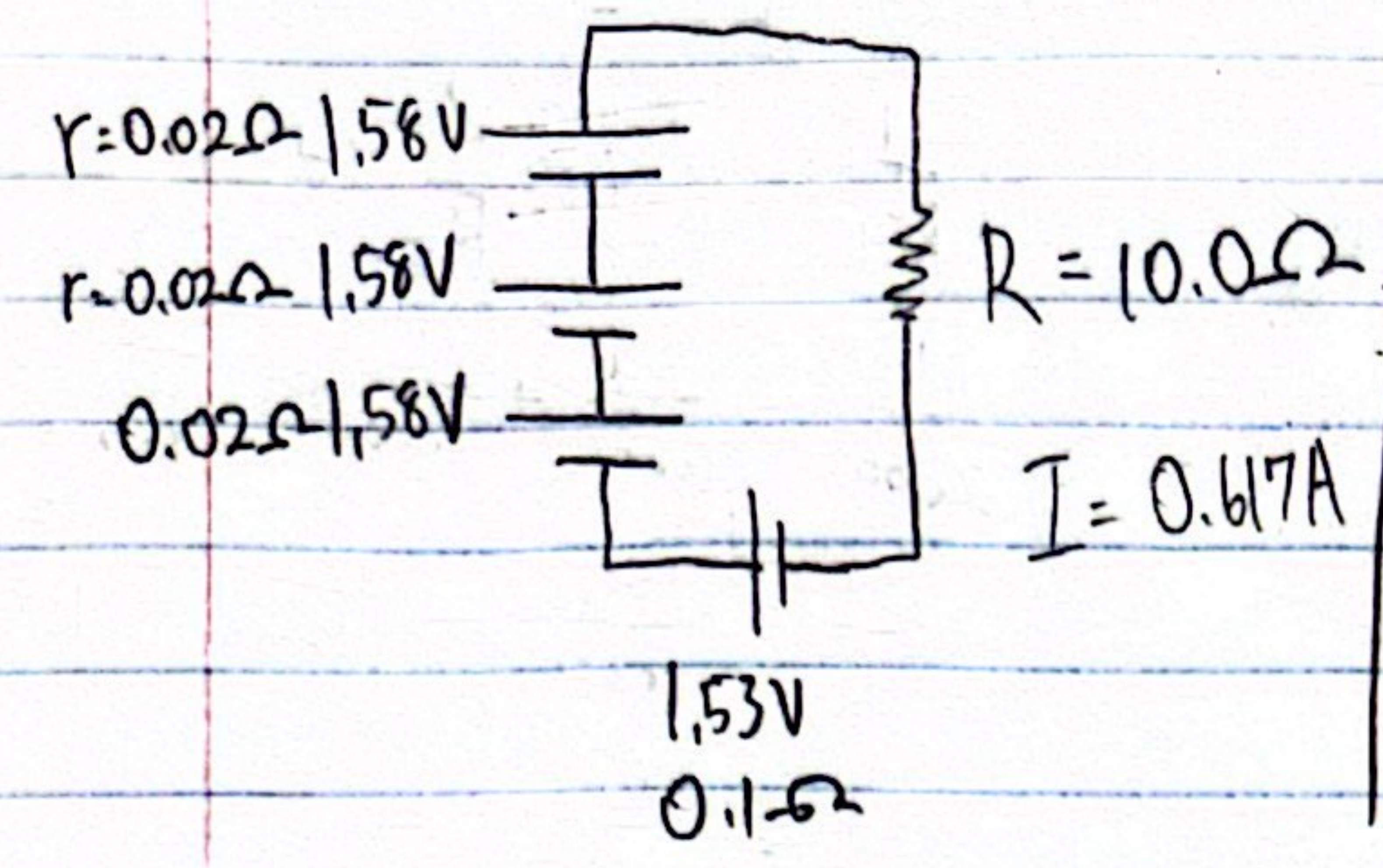
3) a)



b) $I_{tot} = \frac{V_{tot}}{R_{tot}}$

$= \frac{3(1.58)+1.53}{3(0.02)+0.1+10}$

$= \frac{6.27}{10.16}$

$I_{tot} = 0.617\,A$

c) $P_L = I_L^2 R_L$

$= (0.617)^2(10)$

$P_L = 3.81\ W$

d) $P_L = I^2 R_L$

$0.5 = I^2(10)$

$I^2 = \sqrt{\frac{0.5}{10}}$

$I = 0.22A$

$I_{tot} = \frac{V_{tot}}{R_{tot}}$

$0.22 = \frac{3(1.58)+1.53}{3(0.02)+r_d+10}$

$0.22 = \frac{6.27}{10.06+r_d}$

$r_d = \frac{6.27}{0.224} - 10.06$

$r_d = 18.0\ \Omega$

4) $\frac{72\ beats}{1\ min} \Rightarrow \frac{1\ min}{72\ beats} = 0.0139\ \frac{\cancel{min}}{beats} \times \frac{60s}{\cancel{1min}}$

$\tau = 0.833\ sec/beats$ $C = 25nF \Rightarrow 25\times10^{-9}$

$\tau = R\cdot C$

$R = \frac{\tau}{C}$

$R = \frac{0.833}{25\times10^{-9}}$

$R = 3.33\times10^{7}\ \Omega$

5) $\tau = 1\times10^{2} \times 10^{-6}$ $R = 1\times10^{3}\,\Omega$

$= 1\times10^{-4}$ sec

$\tau = RC$

$C = \frac{\tau}{R}$

$= \frac{1\times10^{-4}}{1\times10^{3}}$

$C = 1\times10^{-7}\,F$

4. Unit 3:

1)

Case	v direction	B direction	F direction
1	$-\hat{j}$	$\hat{k}$	$\hat{i}$
2	$\hat{j}$	$\hat{i}$	$\hat{k}$
3	$\hat{i}$	$-\hat{k}$	$-\hat{j}$
4			

$\hat{i}$: Right
$\hat{j}$: Up
$\hat{k}$: Out of Page

2) $F = qvB\sin(\theta)$

$\sin\theta = \frac{F}{qvB}$

$= \frac{1.4\times10^{-16}}{1.6\times10^{-16}(4\times10^{3})1.25}$

$\sin\theta = 0.175$

$\cancel{\sin^{-1}}(\cancel{\sin}\theta) = 0.175(\sin^{-1})$

$\theta = 10.1°, 169.9°$

3) a) $r = \frac{mV_T}{|q|B}$

$q = \frac{mV}{rB}$

$= \frac{2.66\times10^{-26}(5\times10^{6})}{0.231(1.2)}$

$= 4.80\times10^{-19}\,C$

b) $\frac{4.80\times10^{-19}\,\cancel{C}}{1.6\times10^{-19}\,\cancel{C}} = 3$

C) This can show that we have discrete charge values. This is based on physics.

d) $r = \frac{mv}{qB}$

Suppose q and B is same in O_{16} & O_{18}.

Same KE, which is $\frac{1}{2}mv^2 = qV$

If $\uparrow r = \frac{\uparrow m\,V}{qB}$ r is propotional to mass.

Hence, 16:18

$\frac{r_{18}}{r_{16}} = \sqrt{\frac{18}{16}}$

$r_{18} = \sqrt{1.125}\,r_{16}$

$l = 25cm \rightarrow 0.25m$

4) $F = I l B \sin\theta$

$= 100(0.25)\,2(\sin 90°)$

$= 50.N.$

5) $\tau = NIAB\sin\theta$ $\quad$ $20cm \Rightarrow 0.2m$

$B = \dfrac{\tau}{NIA\sin\theta}$

$= \dfrac{300}{200(25)(0.2)^2 \sin(90)}$ ← Perpendicular to loop.

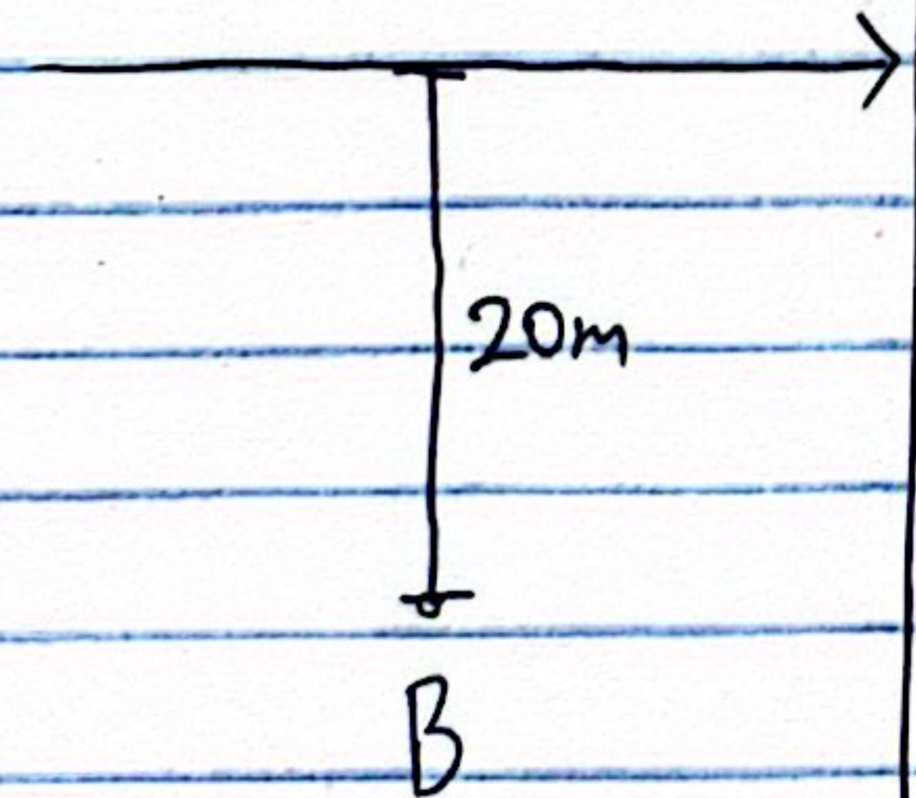
$\underline{\underline{B = 1.5T}}$

6)

Case	B direction
A	$\hat{k}$
B	$\hat{i}$
C	$-\hat{i}$

$\hat{i}$: Rigt
$\hat{j}$: Up
$\hat{k}$: Out of Page

7)



$\overset{450\times10^6}{P} = IV$

$I = \dfrac{P}{V}$

$= \dfrac{450\times10^6}{300{,}000}$

$I = 1500C$

$B = \dfrac{\mu_0 I}{2\pi r}$

$= \dfrac{4\pi\times10^{-7}(1500)}{2\pi(20)}$

$\underline{\underline{B = 1.5\times10^{-5}\,T}}$

8) a) $B = \frac{\mu_0 N I}{2\pi r}$

$1.0 = \frac{4\pi \times 10^{-7} N I}{10\pi}$

$NI = \frac{10}{4 \times 10^{-7}}$

$= 25 \times 10^6 A$

If running this on house wall supply. It can supply about 20 A.

$NI = 25 \times 10^6 A$

$N = \frac{25 \times 10^6 A}{I}$

$N = \frac{25 \times 10^6 A}{20}$

$= 1.25 \times 10^6$ of loops

which is not realistc. Seems like impossible to do in my house :(.

b) $f = \frac{qB}{2\pi m}$

$= \frac{1.6 \times 10^{-19}(1)}{2\pi \times 1.6 \times 10^{-27}}$

$= 15.3 \times 10^6 Hz$