Kayla Pham
Physics 13SB-02
3/11/2024
Test Midterm 1

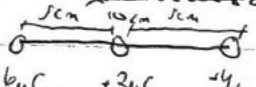
1.1) $C_{u\,wire} = 50g$

$$\frac{2.00\mu C}{1}\left|\frac{1C}{1\times10^{6}\mu C}\right. = 2\times10^{-6}C \qquad \frac{2\times10^{-6}C}{1}\left|\frac{1\,e^{-}}{1.6\times10^{-19}C}\right. = 1.25\times10^{13}\,e^{-}$$

$$\frac{50g}{1}\left|\frac{1\,mol\,Cu}{63.5g\,Cu}\right|\frac{6.02\times10^{23}\,atoms}{1\,mol} = 4.74\times10^{23}\,atoms$$

4.74×10^{23} atoms $\times 29$ protons $= \boxed{1.37\times10^{25}\,e^{-}}$

1.2)



$$\frac{5cm}{1}\left|\frac{1m}{100cm}\right. = 0.05m$$

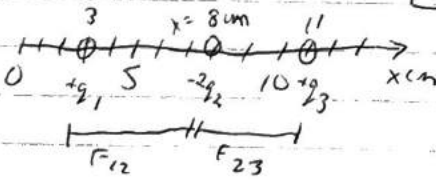
$K = 8.99\times10^{9}\,N\cdot m^2/C^2$

(a) $F_{1,2} = \frac{K|q_1q_2|}{r^2} = \frac{8.99\times10^{9}|6\times10^{-6}\times2\times10^{-6}|}{(0.05)^2} = \boxed{43.15N}$

(b) $F_{23} = \frac{8.99\times10^{9}|2\times10^{-6}\times4\times10^{-6}|}{(0.05)^2} = 28.77N$

$43.15N - 28.77N = \boxed{14.38N \text{ away from the charge } +6\mu C}$

1.3) (a)



F_{12} 8 − 3 $= \frac{5cm}{1}\left|\frac{1m}{100cm}\right. = 0.05m$

F_{23} 11 − 8 $= 3cm = 0.03m$

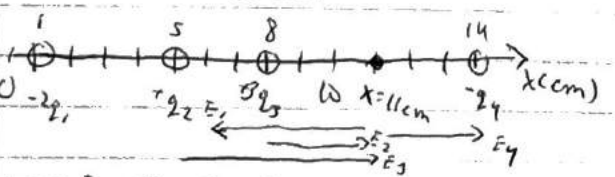
$$F_{12} = \frac{8.99\times10^{9}|1\times10^{-6}\times2\times10^{-6}|}{(0.05)^2} = \overset{7.19}{\cancel{12.79}}$$

$$F_{23} = \frac{8.99\times10^{9}|1\times10^{-6}\times2\times10^{-6}|}{(0.03)^2} = 19.98$$

~~19.98 − 12.79~~

$19.98 - 7.19 = \boxed{12.79N \text{ at } q_2}$

1.4)



$q = \frac{5.00nC}{1}\left|\frac{1\times10^{-9}C}{1nC}\right. = 5\times10^{-9}C$

E_2 11 − 5 $= 6cm = 0.06m$

E_3 11 − 8 $= 3cm = 0.03m$

E_4 14 − 11 $= 3cm = 0.03m$

E_1 11 − 1 $= 10cm = 0.1m$

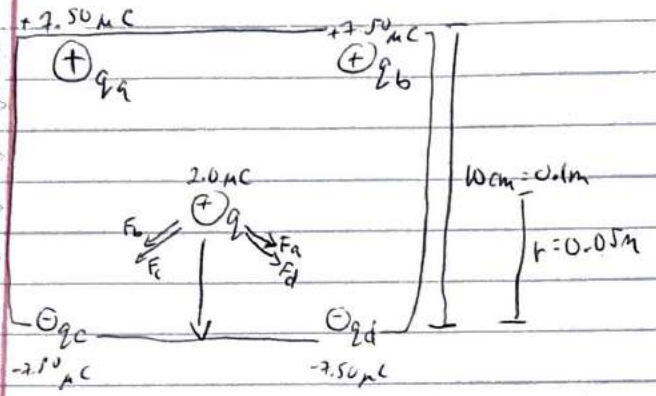
$E_T = E_2 + E_3 + E_4 - E_1$

$$E_T = \frac{K|Q|}{r^2} = k\left[\frac{E_2}{r_2^2} + \frac{E_3}{r_3^2} + \frac{E_4}{r_4^2} - \frac{E_1}{r_1^2}\right]$$

$$= 8.99\times10^{9}\left[\frac{(5\times10^{-9})}{(0.06)^2} + \frac{(3\times10^{-9})(3)}{(0.03)^2} + \frac{(5\times10^{-9})}{(0.03)^2} - \frac{(5\times10^{-9})(2)}{(0.1)^2}\right]$$

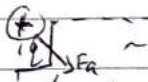
$\boxed{E_T = 2.03\times10^{5}\,N/C}$

1.5)



$$q = \frac{2.00\mu C \,/\, 1\times10^{-6} C}{1\mu C} = 2\times10^{-6} C$$

$$F_q = \frac{k\,/q_1 q_2/}{r^2} = \frac{8.99\times10^{9}\,/7.50\times10^{-6}\times2\times10^{-6}/}{(0.05)^2} = 26.97N$$



$F_a = 26.97\cos(45)$

$= 19.07\times4$

$= \boxed{76.3N \text{ on } q}$

1.6) (a) $V = \frac{40kV \,/ 1000V}{1kV} = 40000V$

$e = 1.6\times10^{-19} C$

$m = 9.1\times10^{-31} kg$

$\Delta PE = \Delta V q$

$= (40000V)(1.6\times10^{-19} C)$

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

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

$2KE = mv^2$

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

$= \sqrt{\frac{2(6.4\times10^{-15})}{9.1\times10^{-31}}}$

$\boxed{v = 1.2\times10^{8} m/s}$

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

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

$\frac{N\cdot\cancel{m}}{C\cdot\cancel{m}} = \frac{N}{C}$

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

1.7) $d = 4.00\text{cm} = 0.04\text{m}$ (a) $V = Ed$

$E = 7.5\times10^4 \text{ V/m}$ $= (7.5\times10^4 \text{ V/m})(0.04\text{m})$

$\boxed{V = 3\times10^3 \text{ V}}$

(b) $V = 0$ $V_1 = V + Ed$

$d = 0.01\text{m}$ $= 0 + (7.5\times10^4)(0.01)$

$\boxed{V_1 = 750 \text{ V}}$

(c) $V = 80.0\text{mV} \left|\frac{1\text{V}}{1000\text{mV}}\right. = 0.08\text{V}$ $V = Ed$ $E = \frac{V}{d} = \frac{(0.08)}{(9\times10^{-9})}$

$d = 9.00\text{nm} = 9\times10^{-9}\text{m}$

$\boxed{E = 8.89\times10^6 \text{ N/C}}$

1.8) $1\text{eV} = 1.6\times10^{-19}\text{J}$

$\frac{32.0\text{keV}}{1\text{keV}} \left|\frac{1000\text{eV}}{1\text{eV}}\right. \left|\frac{1.6\times10^{-19}\text{J}}{1\text{eV}}\right. = 5.12\times10^{-15}\text{J}$

$q = (1.6\times10^{-19}\text{C})2 = 3.2\times10^{-19}\text{C}$

$\Delta V = \frac{\Delta PE}{q} = \frac{5.12\times10^{-15}\text{J}}{3.2\times10^{-19}\text{C}} = 1.6\times10^4\text{V}$

$d = 0.02\text{m}$ $V = Ed \Rightarrow E = \frac{V}{d}$

$= \frac{(1.6\times10^4)}{0.02} = \boxed{8.0\times10^5 \frac{\text{V}}{\text{m}}}$

1.9) $1\text{eV} = 1.6\times10^{-19}\text{J}$

$\frac{5\text{MeV}}{1\text{MeV}} \left|\frac{1\times10^6\text{eV}}{1\text{eV}}\right. \left|\frac{1.6\times10^{-19}\text{J}}{1\text{eV}}\right. = 8\times10^{-13}\text{J}$

$q = (1.6\times10^{-19}\text{C})2 = 3.2\times10^{-19}\text{C}$

$\Delta V = \frac{\Delta PE}{q} = \frac{(8\times10^{-13})}{(3.2\times10^{-19})} = 2.5\times10^6\text{V}$

$r = \frac{KQ}{V} = \frac{8.99\times10^9(79\times1.6\times10^{-19})}{2.5\times10^6} = \boxed{4.55\times10^{-14}\text{m}}$

2.1) $V = 120\text{V}$ $C = \frac{Q}{V} = \frac{3\times10^{-6}}{120} = \boxed{2.5\times10^{-8}\text{F}}$

$q = \frac{3.0\mu\text{C}}{1\text{mC}} \left|\frac{1\times10^{-6}\text{C}}{1\text{mC}}\right. = 3\times10^{-6}\text{C}$

2.2) (a) $V = 9.0 \times 10^3 V$

$C = \frac{10.0 \mu F \mid 1 F}{1 \times 10^{-6} \mu F} = 10 \times 10^{-6} F$

$E = \frac{C \cdot V^2}{2} = \frac{(10 \times 10^{-6})(9.0 \times 10^3)^2}{2} = \boxed{405 J}$

(b) $Q = C \cdot V$

$= (10 \times 10^{-6})(9 \times 10^3) = \boxed{0.09 C}$

(c) $E = 40.0 J$

$C = \frac{8.0 \mu F \mid 1 F}{1 \times 10^6 \mu F} = 8 \times 10^{-6} F$

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

$2F_{cap} = CV^2$

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

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

d) $C = \frac{Q}{V}$ $Q = CV$

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

$\boxed{Q = 0.025 C}$

2.3) $V = 9.0 \times 10^3 V$

2.4) $d = 1.0\,mm$ $\quad R = \frac{\rho L}{A}$ $\quad A = \frac{\pi D^2}{4} = \frac{(3.14)(0.001)^2}{4}$

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

$\rho = 1.72 \times 10^{-8}$

$R = 2.0\,\Omega$ $\quad \rho L = RA$

$\frac{1.0\,mm}{1000\,mm} \left| \frac{1\,m}{} \right. = 0.001\,m$ $\quad L = \frac{RA}{\rho} = \frac{(2.0\,\Omega)(7.85 \times 10^{-7}\,m^2)}{1.72 \times 10^{-8}\,\Omega \cdot m}$

$L = 91.3\,m$

2.5) ~~$R = 3\,\Omega$~~ ~~$V = 3.0\,V$~~ ~~$I = \frac{\Delta V}{R} = \frac{3.0\,V}{3\,\Omega} = 1\,amp$~~

~~(b) $P = I^2 R$ $3\,\Omega$~~

(a) $V = 3.0\,V$ $\quad R_1 + R_2 = R_{tot}$

$R = 1\,k\Omega \left| \frac{1000\,\Omega}{1\,k\Omega} \right. = 1000\,\Omega + 3\,\Omega = 1003\,\Omega$

$I = \frac{V}{R} = \frac{3}{1003} = 0.003\,A$

(b) $P = \frac{V^2}{R} = \frac{(3.0)^2}{1000} = \frac{9}{1000} = 0.009\,W$

(c) $10\,min \left| \frac{60\,sec}{1\,min} \right. = 600\,sec$ $\quad I = \frac{\Delta Q}{\Delta t}$ $\quad Q = I\Delta t = (600)(0.003)$

$Q = 1.8\,C$

3.1) $R_1 = 10\,k\Omega$ $\quad R_2 = 5\,k\Omega$ $\quad R_{tot} = 2\,k\Omega$ $\quad R_3 = ?$

(a) $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$(\frac{1}{10}) + (\frac{1}{5}) = 0.3$

$R_{tot} = 0.3 + \frac{1}{R_3}$

$\frac{1}{2} \Rightarrow 0.5 = 0.3 + \frac{1}{R_3}$

$-0.3 \quad -0.3$

$R_3 = 0.2\,k\Omega$

(b) $\Delta V = 12\,V$ $\quad I = 2$ $\quad I = \frac{V}{R} = \frac{12}{2 \times 10^3}$

$R = \frac{2\,k\Omega \left| 1000\,\Omega \right.}{1\,k\Omega} = 2 \times 10^3\,\Omega$ $\quad I = 0.006\,A$

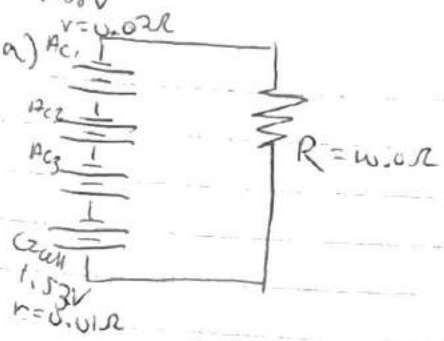
(c) $I_1 = \frac{V}{R_1} = \frac{12}{10 \times 10^3} = 0.0012\,A$

$I_2 = \frac{12}{5 \times 10^3} = 0.0024\,A$

$I_3 = \frac{12}{200} = 0.06\,A$

3.2)

3.3) 3.4)



(b) $I = \frac{V}{R} = \frac{3(1.58)+1.53}{3(0.02)+0.1+10}$

$\boxed{I = 0.617\,A}$

(c) $P = I^2 R$

$= (0.617)^2(10)$

$\boxed{P = 3.81\,W}$

(d) $P = 0.500\,W$ $\quad P = I^2 R$

$I^2 = \frac{P}{R}$

$I = \sqrt{\frac{0.5}{10}} = 0.2241\,A$

$I = \frac{V}{R} = \frac{3(1.58)+1.53}{3(0.02)+r+10} = 0.224$

$0.224 = \frac{6.27}{r+10.06}$

$r + 10.06 = \frac{6.27}{0.224}$

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

$\boxed{r = 18.0\,\Omega}$

3.4) $V = V_0(1 - e^{-(\frac{t}{RC})})$

$0.632 = 1 - e^{-(\frac{t}{RC})}$

$e^{-(\frac{t}{RC})} = 1 - 0.632$

$\ln(e^{-\frac{t}{RC}}) = \ln(0.368)$

$-\frac{t}{RC} = -0.9997$

$\frac{t}{RC} = 1$

$t = RC$

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

$\boxed{R = 33.3\times10^6\,\Omega}$

3.5) $\tau = \frac{1.0\times10^{-2}\,ms}{1\,ms} \,/\, \frac{1\times10^{-6}\,s}{1\,ms} = 1\times10^{-4}\,s$

$R = \frac{1k\Omega}{1k\Omega} \,/\, \frac{1\times10^3\,\Omega}{1k\Omega} = 1\times10^3\,\Omega$

$\tau = R \cdot C$

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

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

4.1)

Case	V dir	B dir	F dir
(a)	$-\hat{j}$	$\hat{k}$	$\hat{i}$
(b)	$\hat{j}$	$\hat{i}$	$\hat{k}$
(c)	$\hat{i}$	$-\hat{k}$	$-\hat{j}$

$\hat{i}$ = right

$\hat{j}$ = up

$\hat{k}$ = out

4.2) $F = qvB\sin\theta$

$F = 1.4\times10^{-16}\,N$

$q = 1.6\times10^{-19}\,C$

$v = 4.0\times10^{3}\,m/s$

$B = 1.25\,T$

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

$\sin\theta = \frac{(1.4\times10^{-16})}{(1.6\times10^{-19})(4.0\times10^{3})(1.25)}$

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

$\theta = 10.1°$ or $180 - 10.1 = 169.9°$

4.3) (a) $\frac{mv^2}{r} = qvB\sin\theta$

$m = 2.66\times10^{-26}$

$v = 5.0\times10^{6}\,m/s$

$B = 1.20\,T$

$r = 0.231\,m$

$\theta = 90° \perp$

$q = \frac{mv}{rB\sin\theta}$

$= \frac{(2.66\times10^{-26})(5.0\times10^{6}\,m/s)}{(0.231)(1.20)(\sin(90))}$

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

(b) $\frac{q}{e} = \frac{4.80\times10^{-19}\,C}{1.6\times10^{-19}\,C} = \frac{4.8}{1.6} = 3.0$

(c) This is because atoms can't be represented as an integer and can't be cut up into fractions.

(d) $r_{1,8} = \frac{m_{1,8}v_{1,8}}{q_{1,8}B}$

$B = 1.20\,T$

$m_{16} = 2.66\times10^{-26}$

$m_{18} = ?$

$v = 5.0\times10^{6}\,m/s$

$\frac{16}{18} = \frac{2.66\times10^{-26}}{x}$

$16x = (2.66\times10^{-26})(18)$

$x = 2.99\times10^{-26}$

$r_{18} = \frac{(2.99\times10^{-26})(5\times10^{6})}{(1.6\times10^{-19})(1.20)}$

$r_{18} = 0.78\,m$

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

$I = 100\,A$

$l = 25.0\,cm = 0.25\,m$

$B = 2.0\,T$

$\theta = 90° \perp$

$F = (100)(0.25)(2.0)(\sin 90)$

$F = 50.0\,N$

4.5) $\tau = NIAB\sin\theta$

$B = ?$

$N = 200$

$I = 25.0\,A$

$A = 20.0\,cm = (0.2\,m)^2 = 0.04\,m^2$

$\theta = 90°$

$T = 300\,N\cdot m$

$$B = \frac{\tau}{NIA\sin\theta} = \frac{300}{(200)(25)(0.04)(\sin 90)}$$

$$\boxed{B = 1.50\,T}$$

4.6)

Case	B dir
(a)	$-\hat{k}$
(b)	$-\hat{i}$
(c)	$\hat{i}$

4.7) $I = \frac{P}{V}$

$P = 450\,MW \left| \frac{10^6\,W}{1\,MW} \right. = 450\times10^6\,W$

$\mu_0 = 4\pi\times10^{-7}$

$V = 300000$

$$I = \frac{450\times10^6}{300000} = 1500$$

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi\times10^{-7})(1500)}{2(\pi)(20)}$$

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

4.8)