PHYSICS 1320

MIDTERM #2

PROBLEM #1

A) $\rho = 1.68\times10^{-8}\ \Omega\cdot m$

$d = 0.002052 m \Rightarrow r = 0.001026 m$

$\Rightarrow A = \pi r^2 = 3.307 * 10^{-6}\ m^2$

$R = \rho \frac{L}{A} = 1.68\times10^{-8}\ \Omega\cdot m \left(\frac{20 m}{3.307\times10^{-6}\ m^2}\right)$

$\boxed{R = 0.102\ \Omega}$

B) $\rho = 2.65\times10^{-8}\ \Omega\cdot m$

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

$= 2.68\times10^{-8}\ \Omega\cdot m \left(\frac{20 m}{0.102\ \Omega}\right)$

$= 5.2\times10^{-6}\ m^2$

$d = 2 * \sqrt{\frac{5.2\times10^{-6} m^2}{\pi}}$

$\boxed{d = 2.57 mm}$

C) $R_{EQ} = 100\Omega + 0.102\Omega$

$= 100.102\ \Omega$

$I = V/R = \frac{12 V}{100.102\ \Omega} = 0.1199 A$

$P = VI = I^2 R$

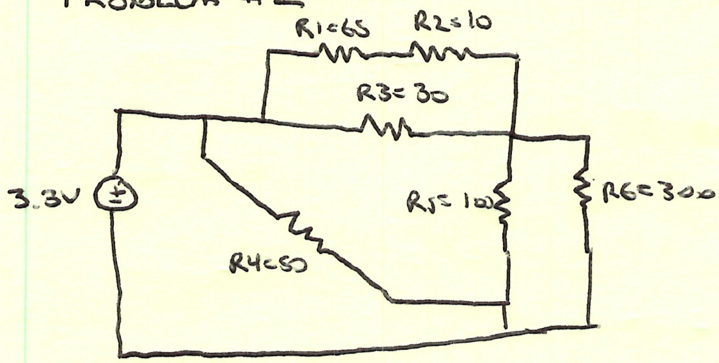
$= (0.1199 A)^2 (0.102\ \Omega)$

$= 0.00147$

$\boxed{P = 1.47 mW}$

D) $\boxed{\text{HEAT}}$

PROBLEM #2



R_1 and R_2 in series

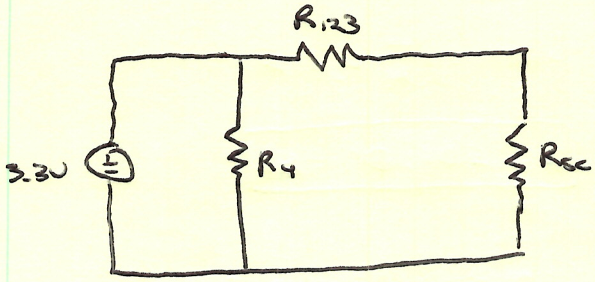
$R_{12} = 75\,\Omega$

$R_{12} \parallel R_3$ in parallel

$$R_{123} = \frac{1}{\frac{1}{75} + \frac{1}{30}} = 21.4\,\Omega$$

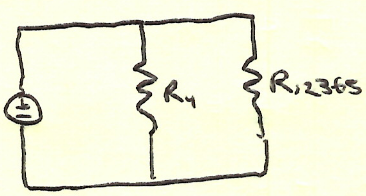
R_5 and R_6 in ~~series~~ parallel

$$R_{56} = \frac{1}{\frac{1}{100} + \frac{1}{300}} = 75$$



R_{123} and R_{56} in series

$R_{12356} = 96.4\,\Omega$



$R_4 \parallel R_{12356}$

$$R_{EQ} = \frac{1}{\frac{1}{50} + \frac{1}{96.4}}$$

$R_{EQ} = 32.9\,\Omega$

A) $I = \dfrac{V}{R_{EQ}} = \dfrac{3.3V}{32.9\,\Omega}$

$\boxed{I = 0.1\,A}$

B) $V = V_4 = V_{12356} = 3.3V$

$I_{12356} = \dfrac{3.3V}{96.4\,\Omega} = 0.034A$

$V_{123} = I_{12356} R_{123} = (0.034A)(21.4\,\Omega)$
$= .73V$

$I_{12} = \dfrac{V_{123}}{R_{12}} = \left(\dfrac{0.73V}{75\,\Omega}\right) = 0.0097A$

$V_2 = I_{12} R_2 = (0.0097A)(10\,\Omega)$

$\boxed{\cancel{V_2 = 97mV}}$

$\boxed{V = 97mV}$

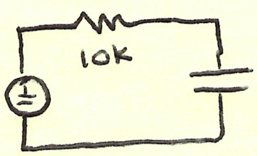
C) $V_{56} = I_{12356} R_{56}$
$= (0.034A)(75\,\Omega)$
$= 2.55V$

$I_6 = \dfrac{V_{56}}{R_6}$
$= \dfrac{2.55V}{300\,\Omega}$

$\boxed{I_6 = 8.5mA}$

PROBLEM #3

CHARGING ($5 < t < 14$)



$C_{EQ} = C_1 \| C_2 = 300\mu F$

$\tau = R_1 C_{EQ} = (10k\Omega)(300\mu F) = 3s$

A) t_1 = time since switch to charging $\quad t = 11s \Rightarrow \boxed{t_1 = 6s}$

$q(t) = Q_F(1 - e^{-t/\tau})$

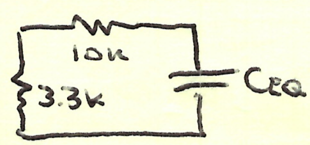
$Q_F = C_{EQ}V = (300\mu F)(12V) = 0.0036\,C$

$q(t_1) = (0.0036\,C)(1 - e^{-6/3})$

$= (0.0036\,C)(0.865)$

$\boxed{q(t_1) = 0.00311\,C}$

DISCHARGING



$C_{EQ} = 300\mu F$

$R_{EQ} = R_1 + R_2 = 13.3k\Omega$

$\tau = R_{EQ}C_{EQ} = 4s$

t_2 = time since discharg $\quad t = 20 \rightarrow \boxed{t_2 = 6s}$

$q(t) = Q_i e^{-t_2/\tau}$

$Q_i = q(t=14) = (0.0036\,C)(1 - e^{-9/3})$

$= 0.00335\,C$

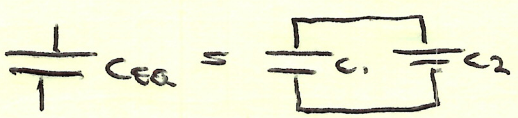
$q(t_2) = (0.00335\,C)(e^{-6/4})$

$= 7.47 \times 10^{-4}\,C$

At $t_2 = 6s$:

$C_{EQ} \Rightarrow V_{EQ} = \frac{q(t_2)}{C_{EQ}} = 2.49V$

GIVEN:



$V_{EQ} = V_1 = V_2$

$q_{C_2}(t_2) = V_{EQ} \cdot C_2 = (2.49V)(120\mu F)$

$\boxed{q_{C_2}(t_2) = 2.99 \times 10^{-4}\,C}$

PROBLEM 4

$$\vec{F} = q\vec{v} \times \vec{B}$$

$$\vec{B} = 2.73\,\hat{k}\ T$$

A) $\vec{v} = -4.2\,\hat{j}\ \text{m/s}$

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

$$\vec{F} = (-1.6\times10^{-19}\,C)(-4.2\,\tfrac{m}{s}\,\hat{j}) \times (2.73\,T)\,\hat{k}$$

$$= (-1.6\times10^{-19}\,C)(-4.2\,\tfrac{m}{s})(2.73\,T)(+\hat{i})$$

$$\boxed{\vec{F} = +1.83\times10^{-18}\ N\ \hat{i}}$$

B) $\vec{v} = -8.98\,\hat{k}\ \text{m/s}$

$-\hat{k}\times\hat{k} = \emptyset$

$$\boxed{\vec{F} = \emptyset}$$

C) $\vec{v} = (-3\hat{i} + 4\hat{j} - 5\hat{k})\ \text{m/s}$

$q = 3.2\times10^{-19}\ C$

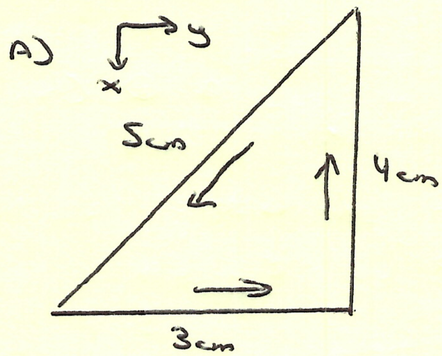
$$\vec{F} = (3.2\times10^{-19}\,C)\left[(-3\,\tfrac{m}{s})\,\hat{i}\times 2.73\,T\,\hat{k} + (4\,\tfrac{m}{s})\,\hat{j}\times 2.73\,\hat{k} + \emptyset\right]$$

$$= (3.2\times10^{-19}\,C)\left[(-8.19)(-\hat{j}) + (10.92)(\hat{i})\right]\tfrac{m}{s}$$

$$\boxed{\vec{F} = 3.49\times10^{-18}\ N\ \hat{i} + 2.62\times10^{-18}\ N\ \hat{j}}$$

PROBLEM #5

A)



$\Theta = \emptyset$

$\vec{l}_1 = 0.04\,m\,(-\hat{i})$

$\vec{l}_2 = 0.04\,m\,(\hat{i}) + (0.03m)(-\hat{j})$

$\vec{l}_3 = 0.03m\,(+\hat{j})$

$B = 80\,mT\,(\hat{j})$ $\qquad I = 5A$

$\vec{F}_1 = I\,\vec{l}_1 \times \vec{B}$

$= (5A)(0.04m)(-\hat{i}) \times (0.08T)(\hat{j})$

$\boxed{\vec{F}_1 = 0.016\,N\,(-\hat{k})}$

$\vec{F}_2 = I\,\vec{l}_2 \times \vec{B}$

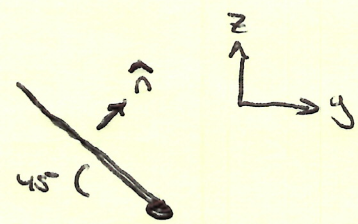
$= (5A)\left[0.04(\hat{i}) + (0.03)(-\hat{j}) \times 0.08\,\hat{j}\right]$

$= (5A)(0.04\,m)(0.08T)\,\hat{k} + \emptyset$

$\boxed{\vec{F}_2 = 0.016\,N(\hat{k})}$

$\boxed{\vec{F}_3 = \emptyset}$ $\qquad \hat{j} \times \hat{j} = 0$

B) $\vec{\mu} = I A\,\hat{n}$



$A = \frac{1}{2}(0.04m)(0.03)m$

$A = 0.0006\,m^2$

$\hat{n} = \sin\Theta\,\hat{j} + \cos\Theta\,\hat{k}$

$= \frac{1}{\sqrt{2}}(\hat{j} + \hat{k})$

$\vec{\mu} = \frac{(5A)(0.0006\,m^2)}{\sqrt{2}}(\hat{j} + \hat{k})$

$\boxed{\vec{\mu} = (0.0021\,\hat{j} + 0.0021\,\hat{k})\,(A \cdot m^2)}$

c) $\vec{\tau} = \vec{\mu} \times \vec{B}$

$= (0.0021\,Am^2)\,\hat{k} \times (0.08T)(\hat{j})$

$\boxed{\vec{\tau} = -1.68 \times 10^{-4}\,\hat{i}}$

PROBLEM #6

A) The velocity selector allows particles with the velocity where $\vec{F}_E$ and $\vec{F}_B$ are equal and opposite to pass through. All other particle velocities are deflected either right or left

B) $v = \frac{E}{B} = \frac{12{,}500 \text{ V/m}}{0.01 \text{ T}}$

$\boxed{v = 1.25\times10^{6} \text{ m/s}}$

c) $R = \frac{mv}{qB_0}$

$m = \frac{qB_0R}{v}$

$m_1 = \frac{(1.6\times10^{-19} \text{ C})(1.404 \text{ T})(0.1291 \text{ m})}{1.25\times10^{6} \text{ m/s}}$

$\boxed{m_1 = 2.32\times10^{-26} \text{ kg}}$

$m_2 = \frac{(1.6\times10^{-19} \text{ C})(1.404 \text{ T})(0.1475 \text{ m})}{1.25\times10^{6} \text{ m/s}}$

$\boxed{m_2 = 2.65\times10^{-26} \text{ kg}}$

D) 1 Amu = 1.66×10^{-27} kg

PARTICLE 1: $m_1 = \frac{2.32\times10^{-26} \text{ kg}}{1.66\times10^{-27} \text{ kg/Amu}} = 14$ Amu $\Rightarrow$ NITROGEN

PARTICLE 2: $m_2 = \frac{2.65\times10^{-26} \text{ kg}}{1.66\times10^{-27} \text{ kg/Amu}} = 16$ Amu $\Rightarrow$ OXYGEN

$\boxed{\text{GAS} \Rightarrow \text{NO} \quad \text{Nitrous Oxide}}$

EXTRA CREDIT

A) 1 HORSE CAN EXERT 14.9 horsepower

B) 14.9 hp × 745.7 W/hp = 11,110 W

5 min = $\frac{1}{12}$ hr

$\boxed{\text{Energy} = P \times \text{time} = 0.925 \text{ kWh}}$

or 3.33×10^{9} J