Assignment #4

1. a) $\frac{8\times10^{-6}C}{\pi(10^{-3}m)(10^{-3}m)} = 2.546\ C/m^2$

b) $(\text{Electron density})(3\times10^{8})(1.6\times10^{-19}) = 8\times10^{-6}$

$\text{Electron density} = \frac{8\times10^{-6}}{(3\times10^{8})(1.6\times10^{-19})}$

$= 166666.67\ \text{electrons}/m^2$

c) $\frac{8\times10^{-6}}{1.6\times10^{-19}} = 5\times10^{-13}$ electrons per second.

$\frac{6.023\times10^{23}}{5\times10^{-13}} = 1.2046\times10^{10}$ seconds

2. $R = \frac{\rho L}{A}$ $\quad V = LA$

$R_1 = \frac{\rho\, 3L}{(A/3)} = \frac{\rho\, 9L}{A} = 9R$

3. $R = \rho_{cu}\frac{L}{A_{cu}}$ $\quad R = \rho_{Al}\frac{L}{A_{Al}}$

$= \rho_{cu}\frac{L}{\pi(r_{cu})^2}$ $\quad = \rho_{Al}\frac{L}{\pi(r_{Al})^2}$

$\frac{\pi r^2 R}{\pi R} = \frac{\frac{\rho L}{\cancel{\pi r^2}}}{\pi R} \cdot \cancel{\pi r^2}$

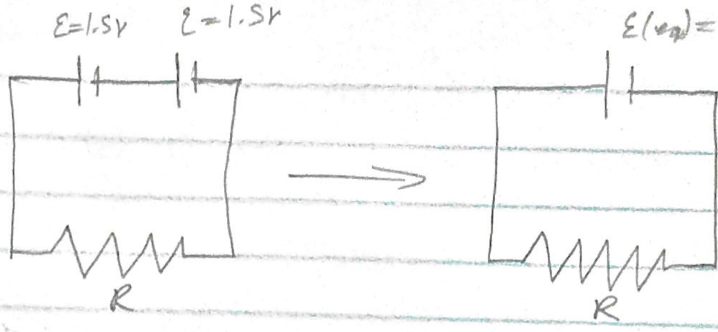
$\sqrt{r^2} = \sqrt{\frac{\rho L}{\pi R}}$

$r = \sqrt{\frac{\rho L}{\pi R}}$

$\frac{r_{Al}}{r_{cl}} = \frac{\sqrt{\frac{\rho_{Al} L}{\pi R}}}{\sqrt{\frac{\rho_{cu} L}{\pi R}}} = \frac{\sqrt{2.82\times10^{-8}\Omega}}{\sqrt{1.7\times10^{-8}\Omega}}$

$r_{Al} : r_{cl} = 1.3$

4. a)



$$P = \frac{\mathcal{E}_{eq}^2}{R} = 0.53\,W$$

b) $E = P t_{seconds} = (0.53)(5.1)(3600) = 9700\,J$

c) $P_R' = \frac{P_0}{2}$

$$I_f^2 R = \frac{1}{2}\frac{(\mathcal{E}_{eq})^2}{R}$$

$$\Rightarrow \left(\frac{\mathcal{E}_{eq}}{r+R}\right)^2 R = \frac{(\mathcal{E}_{eq})^2}{2R}$$

$$\Rightarrow \frac{1}{(r+R)^2} = \frac{1}{2R^2}$$

$$\Rightarrow r = (\sqrt{2} - 1)R$$

$$= 7.04\,\Omega$$

5. a) $V_1 = (I_2)(R_2) = (3.00)(4.00) = 12.00V$

$\frac{V}{R_1} = I_1 = \frac{12.00V}{3.00V} = 4.00A$

$R_3 = I_1 + I_2 = I_3 = 4.00 + 6.00 = 10A$

b) Voltage drop across $R_3 = V_3 = I_3(R_3)$
$= (10.00)(3.00)$
$= 30V$

Battery emf $= V_3 + V_2 = 30V + 12V$
$= 42V$

6. $(3 \parallel 6) + (12 \parallel 4)$ is the equivalent resistance.
$= 2 + 3 = 5$
So, total $I = \frac{60}{5} = 12A$

7. a) ① $I_R = I_4 + I_4 + I_{E_1}$
② $I_{E_1} = I_{E_2} + I_3$
③ $I_{E_3} = I_6 + I_R$

Subing 2 into 3 we get

$I_{E_1} = I_6 + I_R + I_3$

We can further sub this result into 1 and obtain

$\therefore I_R = I_4 + I_6 + I_R + I_3 = I_3 = -(I_4 + I_6) = -8.00A$

Which mean that the current is going the opposite direction relative to the assumed one.

b) To find the unknown emf we apply the loop rule and obtain.

$\mathcal{E}_2 = -i_3 R_3 + i_6 R_6 = (8.00 \times 3.00 + 5.00 \times 6.00)\,V = 54.00$

$\mathcal{E}_1 = -i_3 R_3 + i_4 R_4 = (8.00 \times 3.00 + 3.00 \times 4.00)\,V = 36.00\,V$

c) Applying the loop rule to the uppermost rule we get

$$i_R R = \mathcal{E}_2 - \mathcal{E}_1 \Rightarrow R = \frac{\mathcal{E}_2 - \mathcal{E}_1}{i_R} = \frac{54.00 - 36.00}{2.00}\,\Omega$$

$$= 9.00\,\Omega$$

8. a) $C15 \| C20 = 35\,uF = 35 \times 10^{-6}\,F$

$R30 + R45 = 75\,\Omega$

$$V = V_0 \times e^{(-t/RC)}$$

$$10\,V = 45\,V \times e^{(-t/(75)(35 \times 10^{-6}))}$$

$$\frac{10\,V}{45\,V} = e^{(-t/(75)(35 \times 10^{-6}))}$$

$$\ln(0.222222) = -t/((75)(35 \times 10^{-6}))$$

$$(-1.5041)((75)(35 \times 10^{-6})) = -t$$

$t = 0.003948262$ seconds

$= 3.948262$ milliseconds

b) $\frac{10\,V}{75\,\Omega} = 0.133333$ Ampere $= 133.333$ milliAmpere