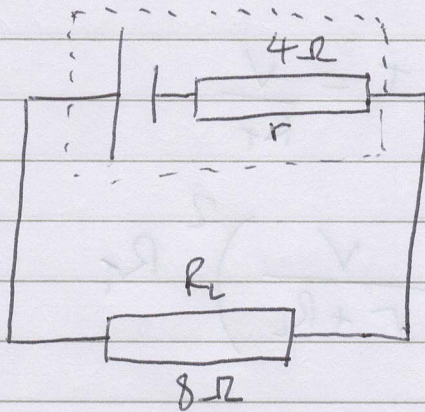


ASSIGNMENT - QUESTION ONE

a)



$$R_T = R_L + 4\Omega$$

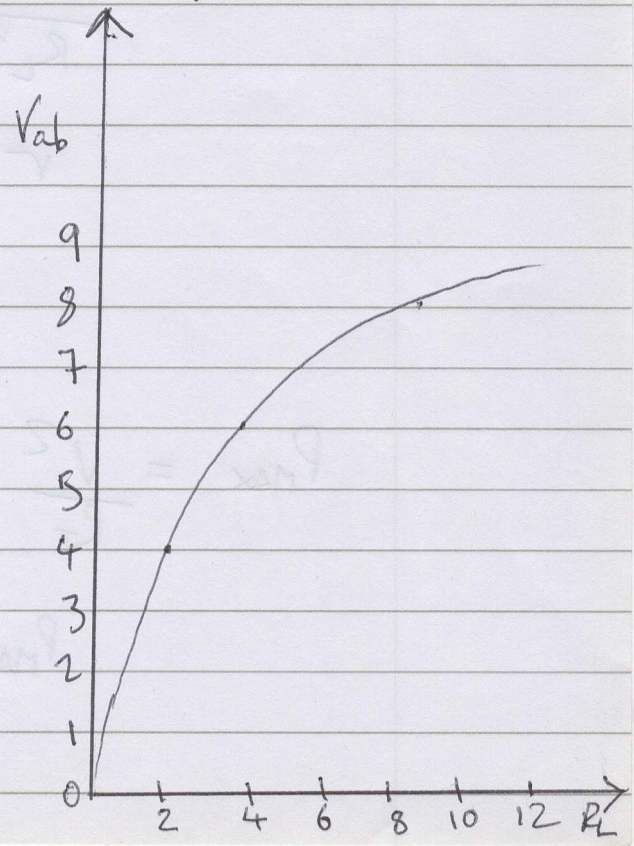
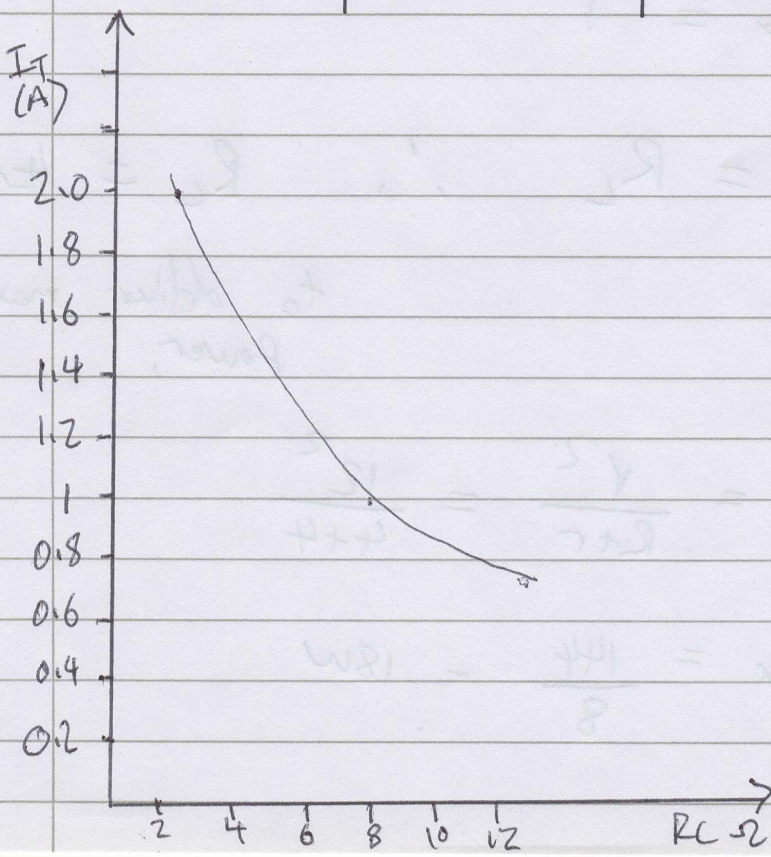
$$R_T = 4\Omega + 8\Omega = 12\Omega$$

$$I = \frac{V}{R} = \frac{12}{12} = 1A$$

$$P = I^2 R_T \Rightarrow P = \frac{V^2}{R_T} = 12W$$

b)

R_L	$R_T = R_L + r$	$I_T = \frac{V}{R_T}$	$V_{ab}(I \times R_L)$
2Ω	6	2	4
4Ω	8	1.5	6
6Ω	10	1.2	7.2
8Ω	12	1	8
10Ω	14	0.86	8.6
12Ω	16	0.75	9
14Ω	18	0.67	9.38



$$c) \quad V = IR \Rightarrow V = IR_T \quad \text{where } R_T = (R_L + r)$$

$$I = \frac{V}{r + R_L} \quad \therefore \quad I = \frac{V}{R_T}$$

$$P = IV = I^2 R_T = \left(\frac{V}{r + R_L} \right)^2 R_T$$

$$P = \frac{V^2}{\frac{r^2}{R_L} + 2r + R_L}$$

$$\frac{d}{dR_L} \left(\frac{r^2}{R_L} + 2r + R_L \right) = 0$$

$$-\frac{r^2}{R_L^2} + 1 = 0$$

$$\frac{r^2}{R_L^2} = 1$$

$$r = R_L \quad \therefore \quad R_L = 4\Omega$$

to deliver maximum power,

$$P_{\max} = \frac{V^2}{R_T} = \frac{V^2}{R + r} = \frac{12^2}{4 + 4}$$

$$P_{\max} = \frac{144}{8} = 18W$$

$$c) i) R = \frac{\rho L}{A}$$

$$R = 100 \Omega$$

$$\rho = 9.81 \times 10^{-8} \Omega m$$

$$A = \pi r^2 \quad d = 0.1 mm = 1 \times 10^{-4} m$$

$$d = 2r \Rightarrow r = \frac{d}{2} = 5 \times 10^{-5}$$

$$A = \pi (5 \times 10^{-5})^2 = 7.854 \times 10^{-9} m^2$$

$$\frac{RA}{\rho} = L = \frac{100 \times 7.854 \times 10^{-9}}{9.81 \times 10^{-8}}$$

$$L = 8.006 m$$

$$ii) V = \pi r^2 L \Rightarrow V = AL$$

$$V = 7.854 \times 10^{-9} \times 8.006$$

$$V = 6.288 \times 10^{-8} m^3$$

$$iii) \text{ density of platinum} = 21.45 \times 10^3 kg m^{-3}$$

platinum costs £10K per Kg

$$\text{Mass} = \text{Density} \times \text{Volume}$$

$$= (21.45 \times 10^3) \times (6.288 \times 10^{-8})$$

$$\text{Mass} = 1.349 \times 10^{-3} kg = 1.349 g$$

$$\text{Specific Cost} = (\text{cost per Kg}) \times (\text{Mass})$$

$$= (10 \times 10^3) \times (1.349 \times 10^{-3})$$

$$= £13.49$$

$$c)iv) \text{ Resistance} = \frac{PL}{wt} = \frac{PL}{A}$$

P = resistivity L = length of resistor
 w = width of resistor t = thickness of resistor

$$R = \frac{PL}{wt} \Rightarrow \frac{RW}{PL} = \frac{1}{t} \Rightarrow t = \frac{PL}{RW}$$

$$t = \frac{(9.81 \times 10^{-8}) \times (0.75)}{(125) \times (3.5 \times 10^{-6})}$$

$$t = \frac{7.3575 \times 10^{-8}}{4.375 \times 10^{-4}} = 1.682 \times 10^{-4} \text{ m}$$

$$= 0.1682 \text{ mm}$$

$$v) \text{ Volume} = Lwt = v$$

$$v = (3.5 \times 10^{-6}) \times (0.75) \times (1.682 \times 10^{-4})$$

$$= 4.415 \times 10^{-10} \text{ m}^3$$

$$\text{Mass} = \text{Density} \times \text{volume}$$

$$= (21.45 \times 10^3) \times (4.415 \times 10^{-10})$$

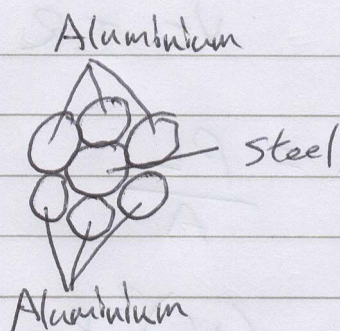
$$\text{Mass} = 9.471 \times 10^{-6} \text{ Kg}$$

$$\text{Specific cost} = \text{cost per Kg} \times \text{mass}$$

$$= (10 \times 10^3) \times (9.471 \times 10^{-6})$$

$$= £0.0947 = 9.5p$$

d) i)



Cross-section
of cable

1 Km of steel wire has 3.3Ω resistance
 steel wire diameter $= 7.4 \text{ mm} \Rightarrow d = 2r$
 steel wire radius $= 3.7 \text{ mm}$

$$\text{Area of cable} = \pi (3.7 \times 10^{-3})^2$$

$$A = 4.301 \times 10^{-5} \text{ m}^2$$

$$R = \frac{PL}{A} \Rightarrow P = \frac{RA}{L}$$

$$P = \frac{(3.3) \times (4.301 \times 10^{-5})}{1000} \Rightarrow \frac{\Omega \times \text{m}^2}{\text{m}}$$

$$P = 1.419 \times 10^{-7} \Omega \text{ m}$$

ii) The Aluminium is more conductive than steel and so allows a higher current flow. The steel cable also has a higher resistance than aluminium which results in a decreased current flow. In the cross-sectional picture, it appears as if the aluminium wire occupies a greater area. This will also decrease the percentage of total current passing through the steel wire.

d) ii) Resistance of steel $\Rightarrow 3.3 \Omega = R_s$

Resistance of Aluminium $\Rightarrow$

$$R_A = \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} = \frac{1}{R_A}$$

$$\Rightarrow 6 \times \left(\frac{1}{1.1} \right) = \frac{1}{R_A} \Rightarrow R_A = 0.183 \Omega$$

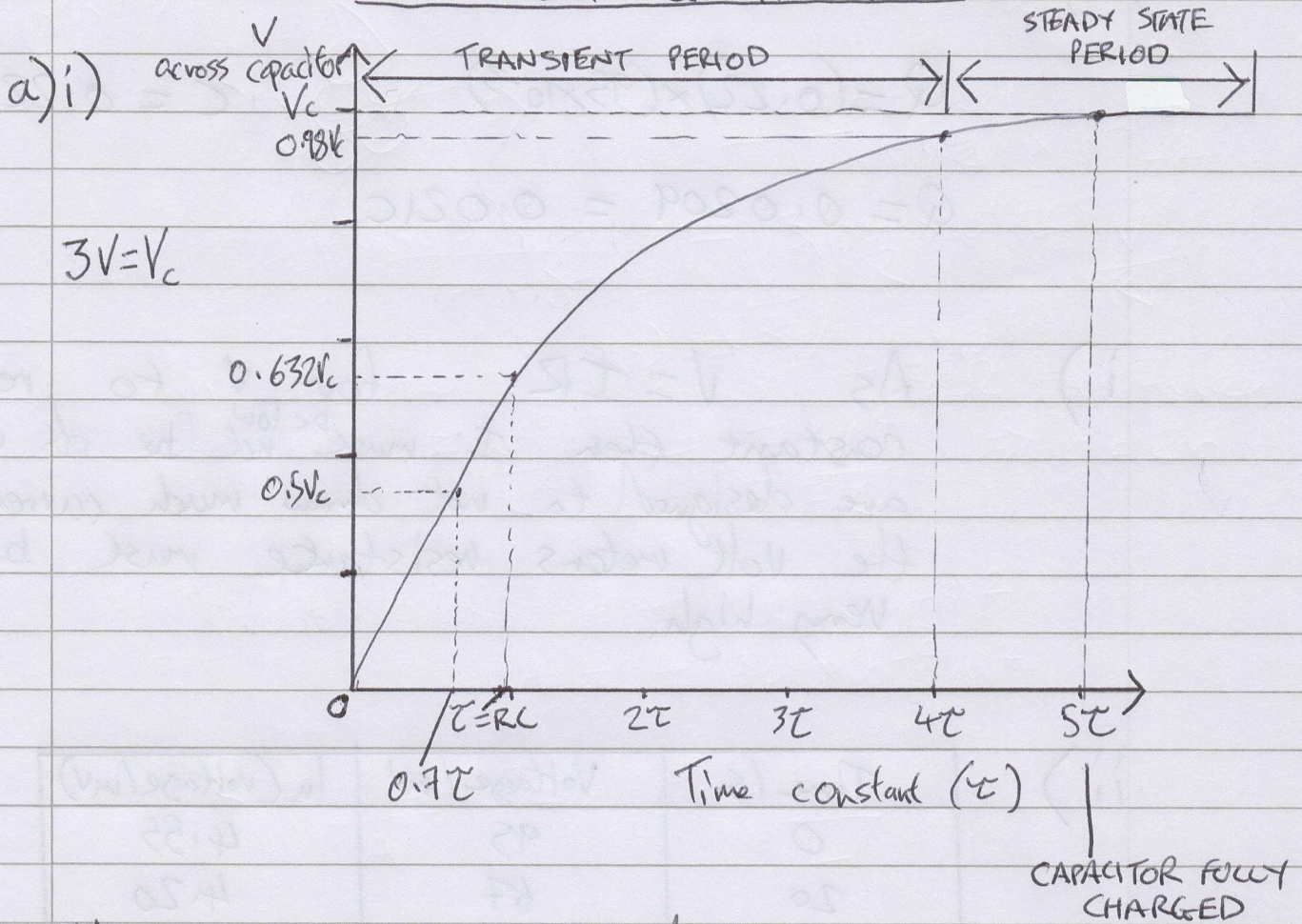
$$\frac{1}{3.3} + \left(6 \times \left(\frac{1}{1.1} \right) \right) = \frac{1}{R_T} \Rightarrow R_T = 0.17368$$

$$R_T = 0.174 \Omega$$

Steel therefore has a much higher resistance across the cable than Aluminium, which results in decreased current flow across the steel

$$\begin{aligned} \text{d) iii) } P &= \frac{V^2}{R} = \frac{(72)^2}{0.174} = 32327.6 \text{ W} \\ &= 32.3 \text{ kW} \end{aligned}$$

ASSIGNMENT - QUESTION TWO



- ii) Movement of the diaphragm causes a potential difference across R as no movement would not create a change in C and then there would be no signal across R . By moving the diaphragm, C changes and then V also changes. As $V = IR$ then $V + IR$ must remain constant so change at R would cause a change to V (p.d.). Also as C changes then Q would change, since Q flows through R then, because $V = IR$ a signal would be created at R .

b)

$$Q = CV$$

$$95 \text{ mV} = 95 \times 10^{-3}$$

$$Q = (0.22) \times (95 \times 10^{-3})$$

$$C = 0.22 \text{ F}$$

$$Q = 0.0209 = 0.021 \text{ C}$$

i)

As $V = IR$ for V to remain constant then I must be low as voltmeters are designed to not draw much current and the voltmeters resistance must be very high.

ii)

Time / s	Voltage / mV	$\ln(\text{Voltage / mV})$
0	95	4.55
20	67	4.20
40	46	3.83
60	33	3.50
80	22	3.09

 $\ln(\text{Voltage / mV})$

4.5

4.0

3.5

3.0

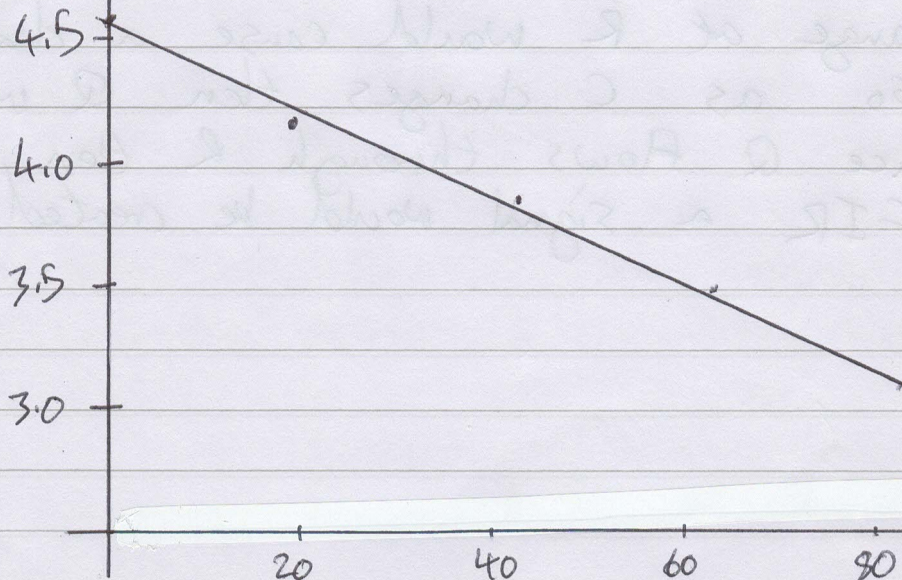
20

40

60

80

Time / s



b) iv) A log of an exponential function would show as a straight line graph of the type $y = mx + c$. The graph has a negative gradient as it is decreasing.

v) V_0 = Voltage at $t=0$ $\ln V = \ln V_0 - \frac{t}{RC}$

At the point $V = V_0 / e$ then Time = τ

$$e = 2.718$$

$$\ln V_0 = 4.55$$

$$V_0 = 95 \text{ mV}$$

$$V = \frac{95}{2.718} = 34.95 \text{ mV}$$

At $V = 34.95 \text{ mV}$ from gradient/graph
 $t = 54.79 \text{ s}$

At this point $t = RC$

$$C = 0.22 \text{ F}$$

$$\frac{54.79}{0.22} = R = 249.05 \Omega$$