

Question One

a)

$$\mathcal{E} = 12 \text{ V}$$
$$r = 6 \, \Omega$$
$$R = 10 \, \Omega$$

~~$P = I V$~~

~~$P = \frac{V}{R} V$~~

~~$P = \frac{V^2}{R}$~~

~~$P = \frac{12^2}{6+10}$~~

~~$P = 9 \text{ W}$~~

$$V = I R$$

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

$$\frac{12}{10+6} = 0.75 \text{ A}$$

$$P = I^2 R$$

$$P = (0.75)^2 (10)$$

$$P = 5.63 \text{ W}$$

b)

$$\mathcal{E} = V + I r$$
$$V = \mathcal{E} - I r$$

~~$y = mx + c$~~

$$y = c + mx$$

$$V = 0$$

$$I = 0$$

~~$0 = 12 + I(6)$~~

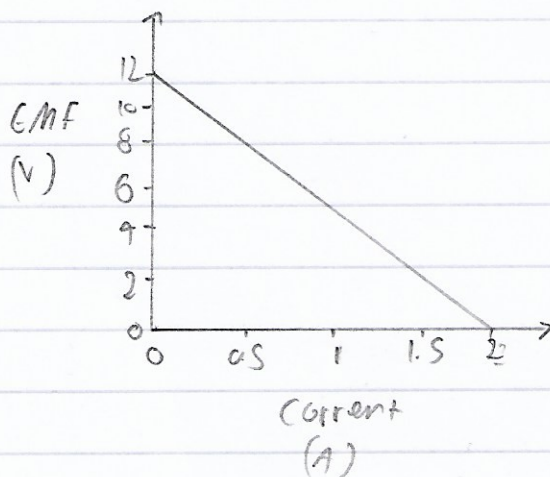
$$0 = 12 - I(6)$$

$$\frac{-12}{-6} = I$$

$$I = 2 \text{ A}$$

~~$V = 12 - 0(6)$~~

$$V = 12$$



$$c) P = \frac{V^2}{R}$$

$$P_{\max} = \frac{12^2}{6+6}$$

$$P_{\max} = 12 \text{ W}$$

load resistance that should be used is 6Ω as maximum power occurs when load resistance is equal to internal resistance of battery.

$$i) R = 100 \Omega$$

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

$$d = 0.05 \text{ mm}$$

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

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

$$A = \pi r^2$$

$$A = \pi \left(\frac{5 \times 10^{-5}}{2} \right)^2$$

$$A = 1.963 \times 10^{-9} \text{ m}^2$$

$$RA = \rho L$$

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

$$L = \frac{(100)(1.963 \times 10^{-9})}{9.81 \times 10^{-8}}$$

$$L = 2.001 \text{ m}$$

$$\boxed{L = 2 \text{ m}}$$

$$ii) V = A \cdot L$$

$$V = (1.963 \times 10^{-9})(2)$$

$$V = 3.926 \times 10^{-9} \text{ m}^3$$

$$\boxed{V = 3.93 \times 10^{-9} \text{ m}^3}$$

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

$$\approx 10000 \text{ kg}^{-1}$$

$$(21.45 \times 10^3)(3.926 \times 10^{-9}) = 8.421 \times 10^{-5} \text{ kg}$$

$$\cancel{(21.45)} \cancel{(3.926)} = \cancel{(21.45)} \cancel{(3.926 \times 10^{-9})} = \cancel{8.421 \times 10^{-5} \text{ kg}}$$

$$(1000) / (8.421 \times 10^{-8}) =$$

$$(10000) (8.421 \times 10^{-5}) = 0.842$$

$$\text{cost} = \pounds 0.84$$

iv) $R = 100 \Omega$

$$\text{width} = 4 \times 10^{-9} \text{ cm}$$

$$= 4 \times 10^{-6} \text{ m}$$

$$l = 81 \text{ cm}$$

$$= 0.81 \text{ m}$$

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

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

$$A = \frac{(9.81 \times 10^{-8}) (0.81)}{100}$$

$$A = 7.9461 \times 10^{-10} \text{ m}^2$$

$$7.9461 \times 10^{-10} = (4 \times 10^{-6}) x$$

$$x = \frac{7.9461 \times 10^{-10}}{4 \times 10^{-6}}$$

$$x = 1.987 \times 10^{-4}$$

~~$$x = 1.987$$~~

$$x = 1.99 \times 10^{-4} \text{ m}$$

v) $V = (7.9461 \times 10^{-10}) (0.81)$

$$V = 6.436 \times 10^{-10} \text{ m}^3$$

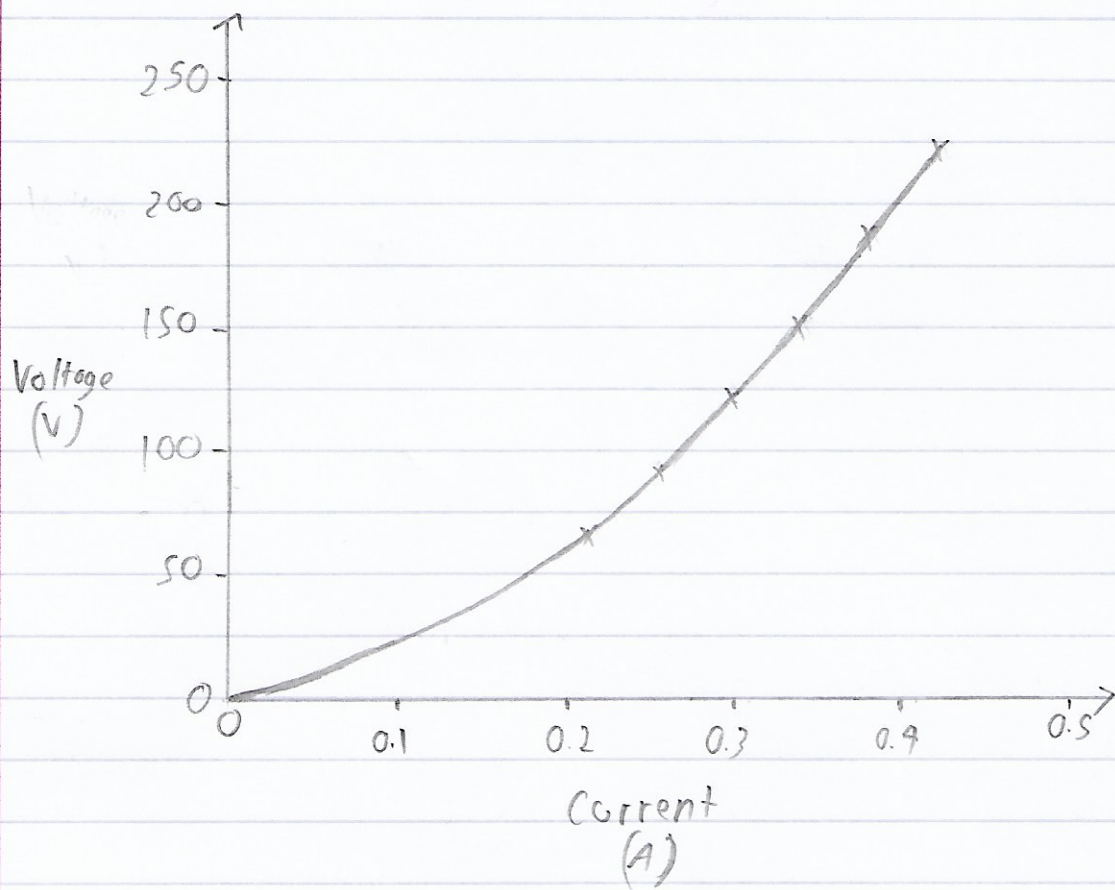
$$(21.45 \times 10^3) (6.436 \times 10^{-10}) = 1.381 \times 10^{-5} \text{ kg}$$

$$(10000) (1.381 \times 10^{-5}) = 0.138$$

~~$$\text{cost} = \pounds 0.14$$~~

$$\text{cost} = \pounds 0.14$$

vi)



The trend is an exponential increase. The resistance of the filament increases exponentially as well.

Question Two

a)

$$i) \quad w = \frac{1}{2} QV \quad Q = 10 \times 10^{-6} \quad V = 8 \times 10^3$$

$$w = \frac{1}{2} (10 \times 10^{-6}) (8 \times 10^3)$$

$$\boxed{w = 0.04 \text{ J}}$$

ii)

$$C = 10 \times 10^{-6} \text{ F}$$

$$I = 200 \times 10^{-6} \text{ A}$$

$$V = 2 \times 10^3 \text{ V}$$

$$t = ?$$

$$V = \frac{I \cdot t}{C}$$

$$VC = It$$

$$\frac{VC}{I} = t$$

$$t = \frac{(2 \times 10^3)(10 \times 10^{-6})}{200 \times 10^{-6}}$$

$$\boxed{t = 100 \text{ s}}$$

b)

$$C_x = 1000 \times 10^{-6} \text{ F}$$

$$C_y = 100 \times 10^{-6} \text{ F}$$

$$Q = CV$$

$$w = \frac{1}{2} CV^2$$

$$Q_x = (1000 \times 10^{-6}) V$$

$$Q_y = (100 \times 10^{-6}) V$$

$$w_x = \frac{1}{2} (1000 \times 10^{-6}) V^2$$

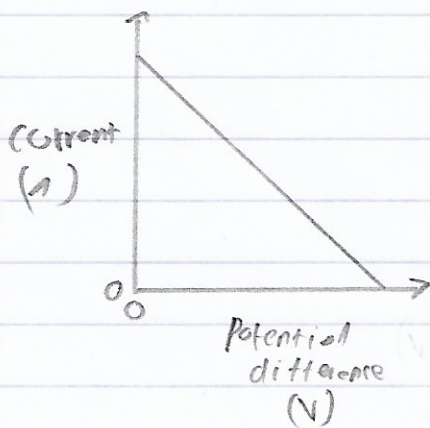
$$w_y = \frac{1}{2} (100 \times 10^{-6}) V^2$$

$$\frac{Q_x}{Q_y} = \frac{(1000 \times 10^{-6}) V}{(100 \times 10^{-6}) V} = 10$$

$$\frac{w_x}{w_y} = \frac{\frac{1}{2} (1000 \times 10^{-6}) V^2}{\frac{1}{2} (100 \times 10^{-6}) V^2} = 10$$

Answer D

c)
i)



ii)

$$I = I_0 e^{-\frac{t}{RC}}$$

$$\frac{I}{I_0} = e^{-\frac{t}{RC}}$$

$$\ln \frac{I}{I_0} = \ln e^{-\frac{t}{RC}}$$

$$\ln \frac{I}{I_0} = -\frac{t}{RC}$$

$$\ln I - \ln I_0 = -\frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{1}{RC} t$$

iii)

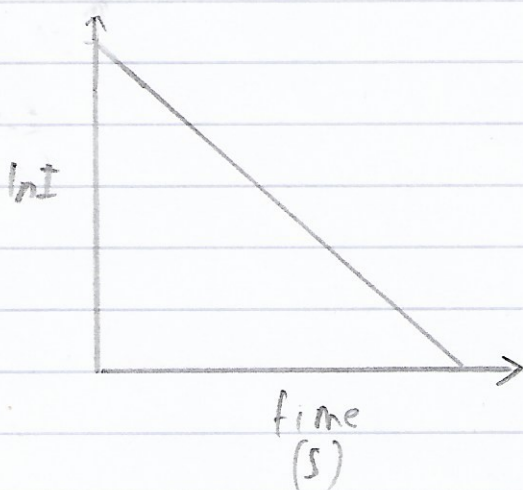
$$a = \ln I_0$$

~~$$b = -\frac{1}{RC}$$~~

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$$b = -\frac{1}{RC}$$

iv)



Question Three

a) $V_1 = 0.52 \text{ m}^3$ $V_2 = 0.2 \text{ m}^3$
 $P_1 = 1.5 \times 10^5 \text{ Pa}$ $P_2 = 5 \text{ bar}$
 $T_1 = 85^\circ\text{C}$ $= 5 \times 10^5 \text{ Pa}$
 $= 358 \text{ K}$

$$P \frac{V}{m} = RT$$

$$R = 0.2598$$

$$PV = mRT$$

$$\frac{P_1 V_1}{R T_1} = m_1$$
$$m_1 = \frac{(1.5 \times 10^5)(0.52)}{(0.2598)(358)}$$

$$m_1 = 0.839 \text{ kg}$$

$$m = 0.84 \text{ kg}$$

b) $P_1 V_1^n = P_2 V_2^n$

$$(1.5 \times 10^5)(0.52)^n = (5 \times 10^5)(0.2)^n$$

$$\frac{1.5 \times 10^5}{5 \times 10^5} = \frac{0.2^n}{0.52^n}$$

$$\log\left(\frac{1.5 \times 10^5}{5 \times 10^5}\right) = \log\left(\frac{0.2^n}{0.52^n}\right)$$

$$\log\left(\frac{1.5 \times 10^5}{5 \times 10^5}\right) = \log 0.2^n - \log 0.52^n$$

$$\log\left(\frac{1.5 \times 10^5}{5 \times 10^5}\right) = n \log 0.2 - n \log 0.52$$

$$\log\left(\frac{1.5 \times 10^5}{5 \times 10^5}\right) = n(\log 0.2 - \log 0.52)$$

$$\frac{\log\left(\frac{1.5 \times 10^5}{5 \times 10^5}\right)}{\log 0.2 - \log 0.52} = n$$

$$n = 1.26$$

as $n = k$ the process is Isentropic

c) ~~$\Delta u = q - w$~~

$$\Delta u = c_v \cdot \Delta T$$

$$c_v = 0.658$$

$$\frac{p_1 v_1}{T_1} = \frac{p_2 v_2}{T_2}$$

$$\frac{(1.5 \times 10^5)(0.52)}{358} = \frac{(5 \times 10^5)(0.2)}{T_2}$$

$$T_2 = \frac{(5 \times 10^5)(0.2)}{\frac{(1.5 \times 10^5)(0.52)}{358}}$$

$$T_2 = 458.974 \text{ K}$$

$$\Delta u = (0.658)(458.974 - 358)$$

$$\Delta u = 66.44 \text{ kJ kg}^{-1}$$

$$66.44(0.839) = 55.743 \text{ kJ}$$

$$\boxed{\Delta u = 55.74 \text{ kJ}}$$

d) $W_b = \frac{p_2 v_2 - p_1 v_1}{1-n}$

$$W_b = \frac{(5 \times 10^5)(0.2) - (1.5 \times 10^5)(0.52)}{1-1.26}$$

$$W_b = -84.615 \text{ kJ}$$

$$\Delta u = q - w$$

$$55.743 = q - (-84.615)$$

$$q = -84.615 + 55.743$$

$$q = -28.872$$

$$\boxed{q = -28.87 \text{ kJ}}$$

Question Four

a) $\boxed{T_2 = 179.88^\circ\text{C}}$ From table A-5

$$T_4 = T_2 - 10^\circ\text{C}$$

$$T_4 = 179.88 - 10$$

$$\boxed{T_4 = 169.88^\circ\text{C}}$$

b) $\frac{5}{100} Q_i = \dot{m}_4 h_4 - \dot{m}_3 h_3$

$$h_4 = h_f + x h_{fg}$$

T	h_f	h_{fg}	
165	697.24	2065.6	from table A-4
169.88	?	?	
170	719.08	2048.8	

$$169.88 - 165 = 4.88^\circ\text{C}$$

$$719.08 - 697.24 = 21.84$$

$$2065.6 - 2048.8 = 16.8$$

~~8~~

$$\begin{array}{r} 5 \times 21.84 \\ 4.88 \times y \\ y = \frac{(4.88)(21.84)}{5} \end{array}$$

$$y = 21.31584$$

$$h_f = 697.24 + 21.31584$$

$$h_f = 718.56 \text{ kJ kg}^{-1}$$

$$\begin{array}{r} 5 \times 16.8 \\ 4.88 \times z \\ z = \frac{(4.88)(16.8)}{5} \end{array}$$

$$\cancel{z = 13.7088}$$

$$z = 16.3968$$

$$h_{fg} = 2065.6 - 16.3968$$

$$h_{fg} = 2049.20 \text{ kJ kg}^{-1}$$

$$h_4 = 718.56 + 0.23(2049.20)$$

$$h_4 = 1189.876 \text{ kJ kg}^{-1}$$

$$h_3 = h_f + \lambda h_{fg}$$

$$\begin{aligned} h_f &= 209.34 \text{ kJ kg}^{-1} \\ h_{fg} &= 2382.0 \text{ kJ kg}^{-1} \end{aligned} \quad \left. \begin{array}{l} \text{from table A-4} \end{array} \right\}$$

$$\begin{aligned} h_3 &= 209.34 + 0.2(2382.0) \\ h_3 &= 685.74 \text{ kJ kg}^{-1} \end{aligned}$$

$$Q_i - Q_f = \dot{m}_4 h_4 = \dot{m}_3 h_3$$

$$Q_i - \frac{1}{100} Q_i = \dot{m}_4 h_4 - \dot{m}_3 h_3$$

$$\begin{aligned} \cancel{0.459 Q_i} \quad 0.95 Q_i &= 5(1189.876) - 5(685.74) \\ Q_i &= \frac{2520.68}{0.95} \end{aligned}$$

$$Q_i = 2653.347 \text{ kJ}$$

$$\boxed{Q_i = 2653.35 \text{ kJ}}$$

c)

$$\dot{m}_s = ?$$

$$h_1 = 2828.3 \text{ kJ kg}^{-1}$$

$$h_2 = 762.51 \text{ kJ kg}^{-1}$$

$$\frac{Q_i}{\dot{m}_s} = h_2 - h_1$$

$$\cancel{\frac{Q_i}{\dot{m}_s} = 762.51 - 2828.3}$$

$$\frac{2653.35}{\dot{m}_s} = 762.51 - 2828.3$$

$$\dot{m}_s = \frac{2653.35}{762.51 - 2828.3}$$

$$\dot{m}_s = -1.284 \text{ kg s}^{-1}$$

$$\boxed{\dot{m}_s = -1.28 \text{ kg s}^{-1}}$$