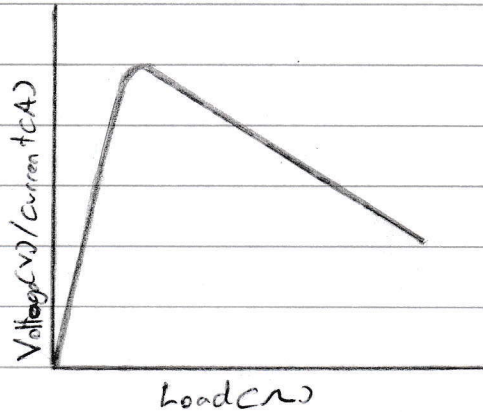


Question One

Harry Rivers

a) $P = \frac{V^2}{R} = \frac{12^2}{8} = 18W$

b



c) $V_{peak} = I_{peak} \times R_{load}$

i) $L = \frac{BA}{P} = \frac{100 \times CTI \times (0.1 \times 10^{-3})^2 \times 41}{0.81 \times 10^{-8}} = 8m$

ii) $V = \pi r^2 L = \pi \times (0.05 \times 10^{-3})^2 \times 8 = 6.3 \times 10^{-8} m^3$

iii) $21.45 \times 10^3 \times 6.3 \times 10^{-8} = 1.35 \times 10^{-3} kg$
 $1.35 \times 10^{-3} \times 10,000 = £13.50$

iv) $Volume = \pi \times (0.05 \times 10^{-3})^2 \times 75 \times 10^{-2} = 5.89 \times 10^{-9} m^3$

$$0.00035 \times 10^{-2} \times 75 \times 10^{-2} = 2.625 \times 10^{-6}$$

$$Thickness = \frac{5.89 \times 10^{-9}}{2.625 \times 10^{-6}} = 2.24 \times 10^{-3} m$$

v) $2.24 \times 10^{-3} \times 10,000 = £22.4$

d

$$i \quad P = \frac{RA}{L} \quad \frac{3.3 \times (\pi \times 0.0074^2 \div 4)}{1 \times 10^3} = 141.9 \mu m$$

ii

ii the steel wire has a higher resistance compared to the which means less current can go through

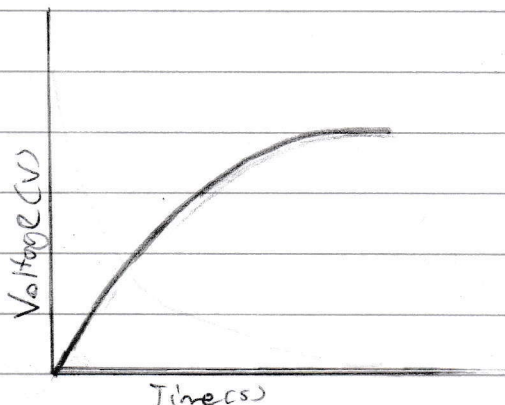
iii

$$iii \quad \frac{75^2}{3.3} = 1704.5 W$$

3

Question two

a.



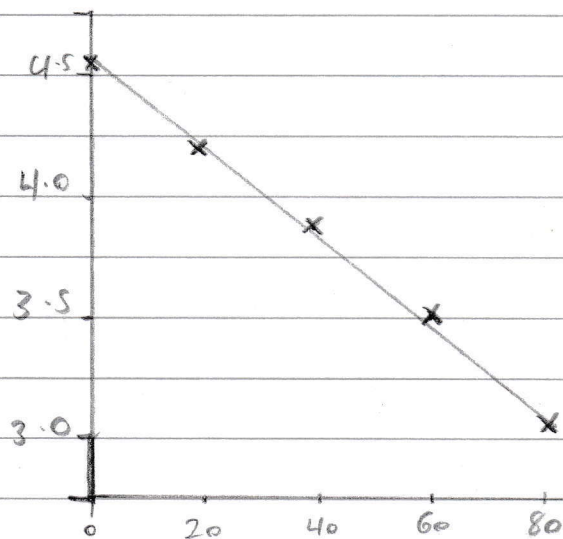
ii) Movement of the plates causes the capacitor to charge. When this happens it allows current to flow around the circuit causing a potential difference across R

i) $Q = CV \quad 0.22 \times 95 \times 10^{-3} = 0.021C$

iv) The voltmeter could be damaged or wired up incorrectly

V	Time	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

V.



vii) As the voltage decreases the voltage decreases as well but at a faster rate. This can be seen as the gap between values increases

viii) $V = V_0 e^{-t/RC}$

$$V = V_0 e^{-\frac{t}{RC}}$$

$$\log V - \log V_0 = -\frac{t}{RC}$$

$$R \log V - \log V_0 = -\frac{t}{C}$$

$$R = \frac{-t}{\log V - \log V_0} \times C$$

$$\frac{-20}{\log(0.67) - \log(0.95)} \times 0.22$$

$$= 260 \Omega$$

$$(\ln(0.67) - \ln(0.95)) \times 0.22$$

Question 3

a) Tank A

$$T_{\text{emp}} = 57.88^\circ\text{C}$$

$$m_{\text{vapor}} = 258.47$$

$$m_{\text{total}} = 258.47 + 124.04 + 134.43 \\ = 516.94$$

$$x = \frac{258.47}{516.94} = 0.5$$

50% is gas

50% is liquid

Tank B

$$T_{\text{emp}} = 120^\circ\text{C}$$

$$m_{\text{vapor}} = 354.11$$

$$m_{\text{total}} = 354.11 + 325.03 + 1.1394 \\ = 680.27$$

$$x = \frac{354.11}{680.27} = 0.52$$

52% is gas

48% is liquid

b)

$$W = 0$$

Q = heat transfer

$$\Delta U = 57.88 - 0$$

$$\Delta U = 120 - 0$$

state ①

A	B
m_A	m_B
U_{A1}	U_{A2}

state ②

U_2
$m_A + m_B$

Tank A

$$P_A = 1.6 \text{ MPa}$$

$$T_A = 57.85^\circ\text{C}$$

$$\left. \begin{array}{l} V_{\text{specific}} \\ \text{Volume} = 0.012123 - 0.00094000 = 0.011183 \text{ m}^3/\text{kg} \\ u = 258.47 \text{ kJ/kg} \end{array} \right\}$$

Tank B

$$P_B = 1.2 \text{ MPa}$$

$$T_B = 120^\circ\text{C}$$

$$T_{\text{sat}}(46.29)$$

$$V_2 = 0.024228$$

$$U_2 = 680.27 \times 354.11 + (0.52 \times 354.11 + 680.27) = 707.9$$

6
Total volume

$$\begin{aligned} V &= V_A + V_B = m_A v_1 + m_B v_2 \\ &= (3 \times 0.011183) + (2.7 \times 0.024228) \\ &= 0.098 \text{ m}^3 \end{aligned}$$

$$\text{Total mass} = 3 + 2.7 = 5.7 \text{ kg}$$

$$\text{Final Volume} = \frac{0.098}{5.7} = 0.017 \text{ m}^3/\text{kg}$$

$$\left. \begin{aligned} P_2 &= 1.2 \text{ MPa} \\ U_2 &= 0.017 \text{ m}^3/\text{kg} \end{aligned} \right\} x_{22} = \frac{v_2 - v_f}{v_g - v_f} = \frac{0.017 - 0.00094}{0.011183} = 1.454$$

$$\begin{aligned} U_{A2} &= 258.47 + (1002.86 \times 0.44 \times 516.94) = 1002.86 \times 465.25 \\ U_{A1} &= 516.94 \end{aligned}$$

$$U_{B2} = 707.9$$

$$U_{B1} = 680.27$$

$$\begin{aligned} Q_{\text{out}} &= \Delta U_A + \Delta U_B [m(U_2 - U_1)]_A + [m(U_2 - U_1)]_B \\ &= 3 \times (1002.86 - 516.94) + 2.7 \times (707.9 - 680.27) \\ &= 1532.36 \text{ kJ} \end{aligned}$$

Question 4

System	Mass Balance	Energy balance
Pipe	$\dot{m}_3 = \dot{m}_4$ $= \dot{m}_P$	$\dot{Q}_S = \dot{m}_4 \times h_4 - \dot{m}_3 \times h_3$ $= \dot{m}_P (h_4 - h_3)$
Tank	$\dot{m}_1 = \dot{m}_2$ $= \dot{m}_T$	$\dot{Q}_L + \dot{Q}_S = \dot{m}_2 h_2 - \dot{m}_1 h_1$
entire heat exchanger	$\dot{m}_3 = \dot{m}_4$ and $\dot{m}_1 = \dot{m}_2$	$\dot{Q}_L = \dot{m}_2 h_2 + \dot{m}_4 h_4 - (\dot{m}_1 h_1 + \dot{m}_3 h_3)$

a) Steam $c_p = 1.8723$

mass flow rate $= 21.6 \times 10^3 \text{ kg/hr} \div 60 = 360 \text{ kg/sec}$

$$\dot{Q} = \dot{m}g + \frac{\dot{m}}{2} v^2 + \dot{m}c_p$$

$$\dot{Q} = (360 \times 9.81) + \frac{360}{2} + (360 \times 1.8723)$$

$$\dot{Q} = 4385.6 \text{ W}$$

b)

$$h_3 = 2877.8 \quad h_4 = 2636.1 \quad h_1 \text{ and } h_2 = 2662.4$$

$$\dot{Q} - \dot{W} = \sum_{in} \dot{m} \left(h + \frac{1}{2} v^2 + g \cdot z \right) - \sum_{out} \dot{m} \left(h + \frac{1}{2} v^2 + g \cdot z \right)$$

$$\dot{Q}_L = \dot{m}_2 h_2 + \dot{m}_4 h_4 - (\dot{m}_1 h_1 + \dot{m}_3 h_3)$$

$$\dot{Q}_L = 2662.4 + \frac{21.6 \times 10^3}{3600} \times 2636.1 - (2662.4 + 2877.8 \times \frac{21.6 \times 10^3}{3600})$$

$$47.6 \text{ MW}$$

$$\dot{Q} = \sum_{in} \dot{m} (h) - \sum_{out} \dot{m} (h)$$

$$Q + \dot{m}_{out} \times h = \dot{m}_{in} h$$

$$\dot{m}_{out} = \frac{\dot{m}_{in} h_{in} - Q}{h_{out}}$$

$$= \frac{21.6 \times 10^3 \times 2877.8 - 417.6 \times 10^6}{2636.1}$$

$$= 5.5 \times 10^3 \text{ kg/hr}$$