

# Eng Sci 2

## Assignment

Q1

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

$$V = 12$$

$$R = 4\Omega$$

$$I = \frac{V}{R} = \frac{12}{4} = 3A$$

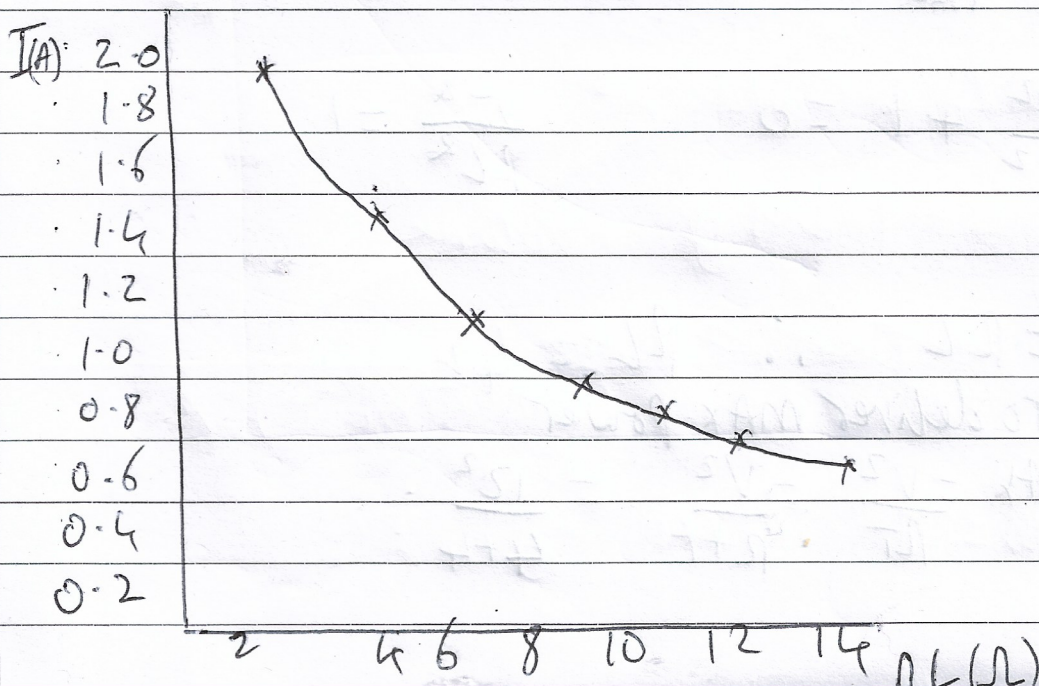
$$8\Omega \text{ Load}$$

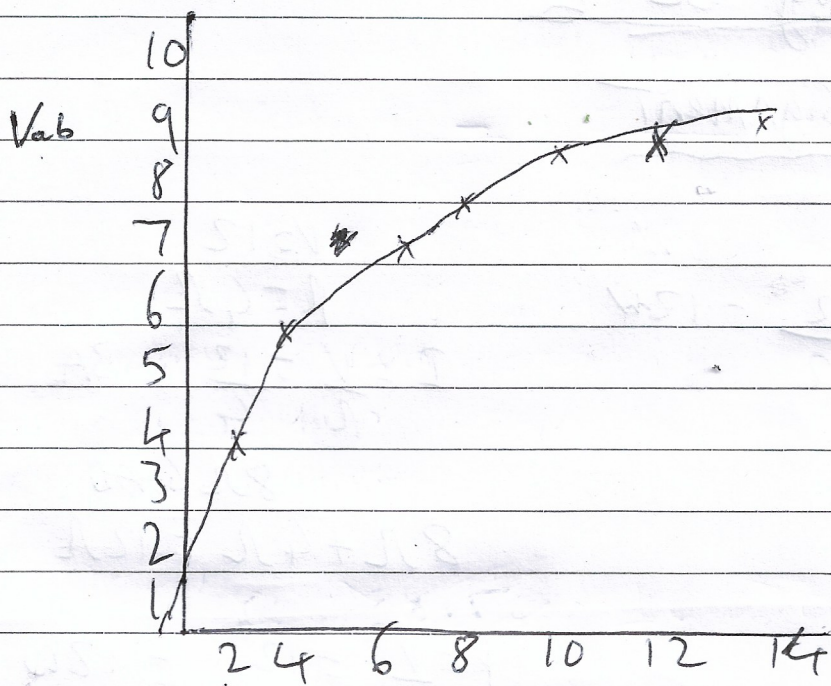
$$8\Omega + 4\Omega = 12\Omega$$

$$P = \frac{V^2}{R} = \frac{12^2}{12} = 12W$$

b)

| $R_L (\Omega)$ | $R_T (4\Omega)$ | $I_T \frac{V}{R_T}$ | $V_{ab}$ |
|----------------|-----------------|---------------------|----------|
| 2              | 6               | 2 A                 | 4V       |
| 4              | 8               | 1.5 A               | 6V       |
| 6              | 10              | 1.2 A               | 7.2V     |
| 8              | 12              | 1 A                 | 8V       |
| 10             | 14              | 0.85 A              | 8.5V     |
| 12             | 16              | 0.75 A              | 9V       |
| 14             | 18              | 0.66 A              | 9.24V    |





C,  $V = IR \Rightarrow V = IR_T$   
 where  $R_T = (R_L + R)$

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

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

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

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

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

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

To deliver MAX 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/

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

$$R = 100 \Omega$$

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

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

$$d = 25 \Rightarrow r = \frac{d}{2} = 5 \times 10^{-5}$$

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

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

$$L = 8.006 m$$

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

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

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

$$iii) \text{ MASS} = \text{Density} \times \text{Volume} \quad \text{density of Platinum} = 21.45 \times 10^3 \text{ kg/m}^3$$

$$= (21.45 \times 10^3) (6.288 \times 10^{-8}) \quad \text{cost of } \frac{1}{10,000} \text{ per kg}$$

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

$$\text{cost} = (\text{cost per kg}) (\text{MASS})$$

$$= (10 \times 10^3) (1.349 \times 10^{-3}) = \text{£}13.49$$

C/  
iv)

$$\text{Resistance} = \frac{PL}{wT} = \frac{PL}{A}$$

$\rho$  = resistivity

$t$  = thickness of resistor

$L$  = length of resistor

$w$  = width of resistor

$$R = \frac{PL}{wT} \Rightarrow \frac{Rw}{PL} = \frac{1}{t} \Rightarrow t = \frac{PL}{Rw}$$

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

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

v/  $\text{Volume} = (L)(w)(t) = V$

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

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

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

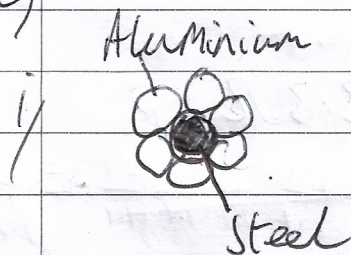
~~$$= (21.45 \times 10^3) (4.415 \times 10^{-10})$$~~

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

$$\text{MASS} = 9.471 \times 10^{-6} \text{ kg}$$

$$\begin{aligned}
 \text{Cost} &= \text{Cost per kg} \times \text{Mass} \\
 &= (10 \times 10^3) (9.471 \times 10^{-6}) \\
 &= \cancel{\text{£}} 0.0947 = 9.5p
 \end{aligned}$$

d,



Cross  
section of cable

1 km of steel wire has 3.3  $\Omega$   
 steel wire diameter = 7.4 mm  $\Rightarrow d = 2r$   
 steel wire radius = 3.7 mm

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

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

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

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

$$\rho = 1.4619 \times 10^{-7} \Omega \text{ m}$$

- ii) Aluminium HAS more conductivity than steel which allows for a higher flow of current. The steel cable has a higher resistance than aluminium. As a result the current flow is decreased. The aluminium has a greater area in the cross section diagram, this will decrease the amount of total current passing through the steel wire.

$$\text{Resistance of } \del{steel} \text{ Steel} \Rightarrow 3.3 \Omega = R_s$$

$$\text{Resistance of Aluminium} \Rightarrow \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} + \frac{1}{1.1} = \frac{1}{R_A}$$

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

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

$$\frac{1}{3.3} = \frac{1}{R_T} = 3.3 \Omega$$

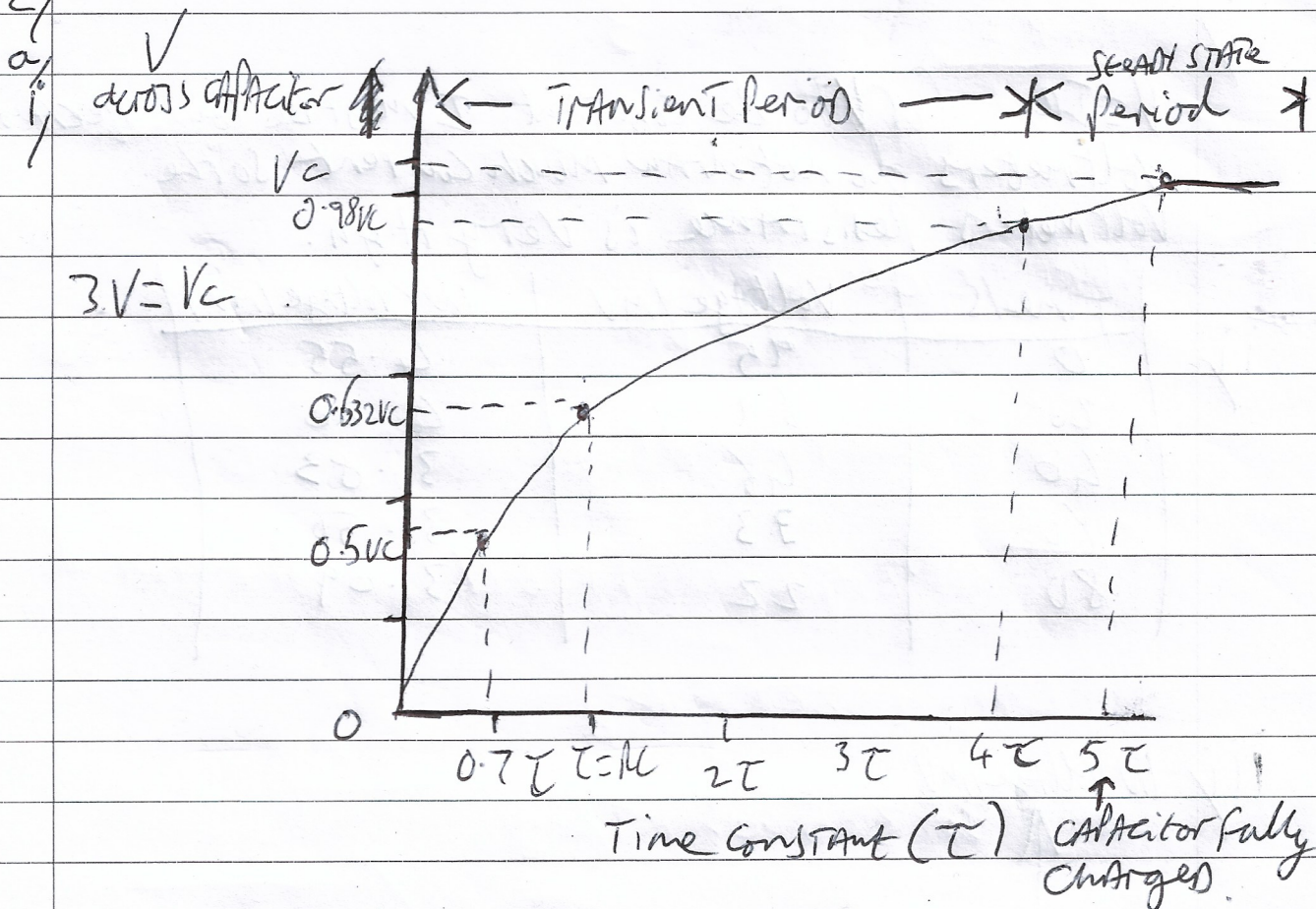
$$\frac{1}{0.183} + \frac{1}{3.3} = \frac{1}{R_T}$$

$$R_T = 0.173 \Omega$$

$$\frac{R_T}{R_{\text{steel}}} = \text{Percentage} \quad \frac{0.173}{0.183} = 95\%$$

$$d) \frac{(75)^2}{0.173} = 32.5 \times 10^3 \text{ W}$$

Q2/



- i/ Movement of the diaphragm causes a potential difference across R because if there was no movement it would not create charge in C therefore no signal across R. By moving the diaphragm C will change as well as V, as  $V = IR$  then  $V + IR$  must remain constant so change at R will cause V to change. C changes then Q changes since Q flows through R  $V = IR$  signal is created at R.

$$b, Q = CV$$

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

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

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

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

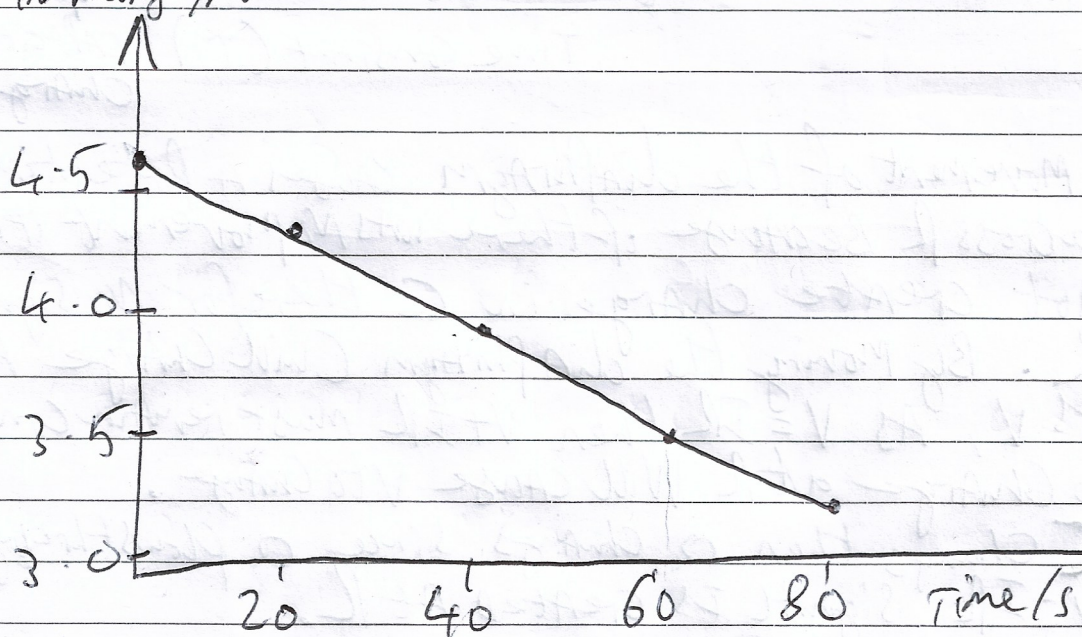
i/

$V = IR$  for  $V$  to be constant  $I$  must be low because voltmeters do not draw much current so the voltmeters resistance is very high.

ii

| Time/s | Voltage/mV | IN (Voltage/mV) |
|--------|------------|-----------------|
| 0      | 95         | 4.55            |
| 20     | 67         | 4.20            |
| 40     | 46         | 3.83            |
| 60     | 33         | 3.50            |
| 80     | 22         | 3.09            |

ii IN Voltage/mV



iv) log of exponential function shows as a straight line graph  $y = mx + c$ . The graph shows a negative gradient as it decreases.

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

~~At~~ At the point  $V = V_0/e$  then time  $= \tau$

$$e = 2.718$$

$$\ln V_0 = 4.55$$

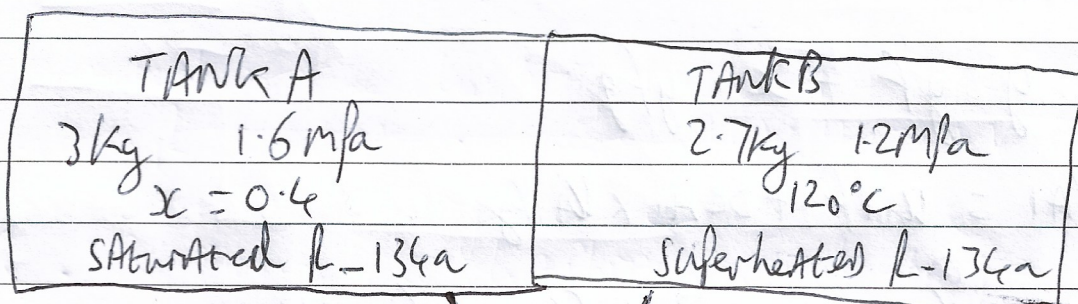
$$V_0 = 95 \text{ mV} \quad V = \frac{95}{2.718} = 34.95 \text{ mV}$$

at  $V = 34.95 \text{ mV}$  gradient on graph  $t = 54.79 \text{ s}$

At this point  $t = RC$

$$C = 0.22 \text{ F} \quad \frac{54.79}{0.22} = R = 249.05 \Omega$$

Q3,



$$\Delta u = Q - W$$

$$(W = KE = PE = 0)$$

$$\Delta (u_A + u_B) = Q$$

$$\Delta u_A + \Delta u_B = Q$$

$$(u_{A2} - u_{A1}) + (u_{B2} - u_{B1}) = Q$$

State 1 - 25 mAtank

Tank A

$$x = 0.4 \quad 1.6 \text{ mPa} \quad \text{saturated}$$

$$u_{A1} = 0.00094 \text{ m}^3/\text{kg} \quad u_{A1} = 134.43 \text{ kJ/kg}$$

$$v_{A1} = 0.012123 \text{ m}^3/\text{kg} \quad u_{A1} = 124.04 \text{ kJ/kg}$$

Tank B

$$1.2 \text{ mPa} \quad 120^\circ\text{C} \quad \text{superheated}$$

$$v_{B1} = 0.024228 \text{ m}^3/\text{kg}$$

$$u_{B1} = 325.03 \text{ kJ/kg}$$

$$y = y_f + x \cdot y_{fg}$$

$$v_{A1} = u_{A1f} + x_{A1} \cdot u_{A1fg}$$

$$v_{A1} = (0.00094) + (0.4 \times (0.012123 - 0.00094))$$

$$v_{A1} = 5.413 \times 10^{-3} \text{ m}^3/\text{kg}$$

$$u_{A1} = u_{A1f} + x_{A1} \cdot u_{A1fg}$$

$$= 134.43 + (0.4 \times 124.04)$$

$$u_{A1} = 184.05 \text{ kJ/kg}$$

State 2

$$V_2 = V_A + V_B$$

$$V = m v$$

$$V_2 = m_A v_A + m_B v_B$$

$$V_2 = (3 \times 0.012123) + (2.7 \times 5.413 \times 10^{-3})$$

$$V_2 = (0.036369) + (0.0146151) = 0.051 \text{ m}^3$$

$$m_2 = m_A + m_B = 3 + 2.7 = 5.7 \text{ kg}$$

Specific Volume  $v_2$  At State 2

$$v_2 = \frac{V_2}{m_2} = \frac{0.051}{5.7} = 8.947 \times 10^{-3} \text{ m}^3/\text{kg} \\ = 0.008947 \text{ m}^3/\text{kg}$$

$$p_2 = 900 \text{ kPa}$$

$$v_{2g} = 0.022683 \text{ m}^3/\text{kg}$$

$$T_{\text{sat}} = 35.51^\circ \text{C}$$

$$v_{2f} = 0.0008580 \text{ m}^3/\text{kg}$$

$$u_{2f} = 100.83 \text{ kJ/kg}$$

$$V_2 = v_{2f} + x_2 \cdot v_{2fg}$$

$$\frac{v_2 - v_{2f}}{v_{2fg}} = x_2 \quad (\text{Quality of steam})$$

$$\frac{V_2 - V_{2f}}{V_{2g} - V_{2f}} = x_2 = \frac{(8.947 \times 10^{-3}) - (0.858 \times 10^{-3})}{(2.2683 \times 10^{-2}) - (0.858 \times 10^{-3})}$$

$$x_2 = \frac{8.089 \times 10^{-3}}{22.1825 \times 10^{-3}}$$

$$x_2 = 0.3647$$

$$u_2 = u_{2f} + x_2 \cdot u_{2fg}$$

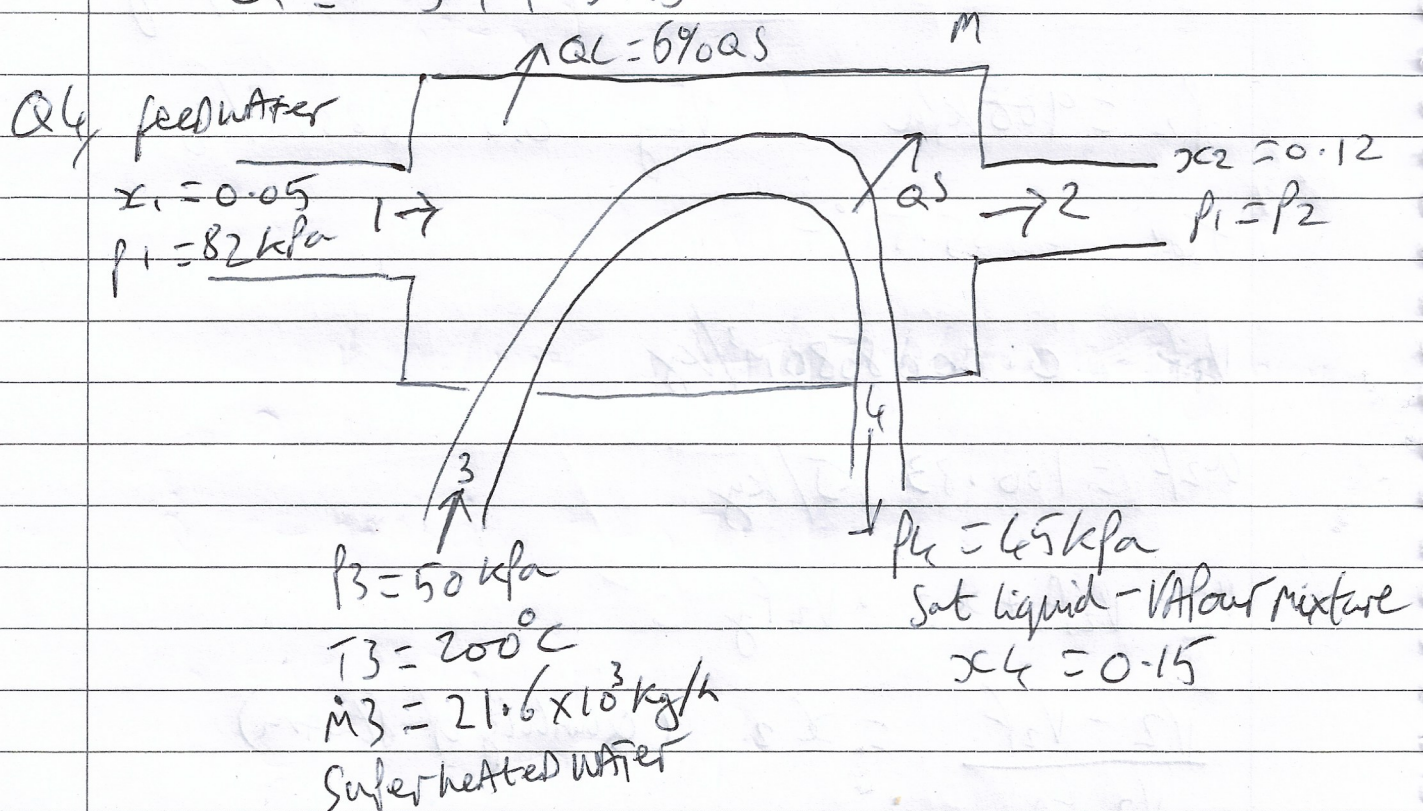
$$u_2 = 100.83 + (0.3647 \times 14801) = u_2 = 154.81 \text{ kJ/kg}$$

$$u_{A2} - u_{A1} + u_{B2} - u_{B1} = Q \quad u_{A2} = u_{B2}$$

$$M_A(u_{A2} - u_{A1}) + M_B(u_{B2} - u_{B1}) = Q$$

$$3(154.81 - 184.05) + 2.7(154.81 - 325.03) = Q$$

$$Q = -547.3 \text{ kJ}$$



free - open

MASS BALANCE

$$\sum \dot{M}_{in} = \sum \dot{M}_{out}$$

$$\dot{M}_1 = \dot{M}_2 = \dot{M}_4$$

$$\dot{M}_3 = \frac{21.6 \times 10^3}{3600} = 6 \text{ kg s}^{-1}$$

$$\dot{M}_3 = \dot{M}_4 = \dot{M}_5$$

$$M(h + \frac{1}{2}C^2 + gz) = Mh + \frac{1}{2}mC^2 + mgz$$

Energy BALANCE

$$(KE = PE = 0)$$

$$\dot{Q} - \dot{W} = \sum \text{out } \dot{M} (\cancel{\Delta KE} + \cancel{\Delta PE} + \Delta h) - \sum \text{in } \dot{M} (\cancel{\Delta KE} + \cancel{\Delta PE} + \Delta h)$$

$$\dot{Q} = \dot{M}_{\text{out}} h_{\text{out}} - \dot{M}_{\text{in}} h_{\text{in}} = (\dot{M}_2 h_2 + \dot{M}_4 h_4) - (\dot{M}_1 h_1 + \dot{M}_3 h_3)$$

$$\dot{Q} = (\dot{M}_w h_2 + \dot{M}_s h_4) - (\dot{M}_w h_1 + \dot{M}_s h_3)$$

$$\dot{Q} = \dot{M}_w (h_2 - h_1) + \dot{M}_s (h_4 - h_3)$$

Pipe System

MASS BALANCE

$$\dot{M}_1 = \dot{M}_2 = \dot{M}_w$$

Energy BALANCE

$$\dot{Q}_1 - \dot{W} = \dot{M} (\cancel{\Delta KE} + \cancel{\Delta PE} + \Delta h)$$

$$\dot{Q} + \dot{M}_w (h_1 - h_2) = \dot{M}_s (h_4 - h_3)$$

$$\dot{Q} + \dot{M}_w (h_1 - h_2) = \dot{M}_s (h_4 - h_3)$$

$$\Delta h = c \Delta T \quad \Delta h = h_4 - h_3 \quad \Rightarrow \Delta T = T_4 - T_3$$

$$\dot{Q} + \dot{m}_w (h_1 - h_2) = \dot{m}_s (c_p T_4 - c_p T_3)$$

$$\dot{Q} + \dot{m}_w (h_1 - h_2) = \dot{m}_s \cdot c_p T_4 - \dot{m}_s \cdot c_p T_3$$

$$h = h_f + x \cdot h_{fg}$$

TABLE A5 for 82 kPa

$$h_f = 393.7 \quad h_{fg} = 2272.26$$

$$h_1 = 393.7 + (0.05 \times 2272.26) = 507.31 \text{ kJ/kg}$$

$$h_2 = 393.7 + (0.12 \times 2272.26) = 666.37 \text{ kJ/kg}$$

$$\dot{Q}_s = \dot{m}_s h_2 - \dot{m}_w h_1$$

$$= \dot{m}_s (h_2 - h_1)$$

$$= 6 (666.37 - 507.31)$$

$$\dot{Q}_s = 954.36 \text{ kJ/s}$$

the heat exchanger is poorly insulated ~~losing~~ losing 6%

$$\dot{Q} = -0.06 \dot{Q}_s = -57.44 \text{ kJ/s}$$

$$h = h_f + x \cdot h_{fg}$$

TABLE A5 for 45 kPa

$$h_f = 329.08 \quad h_{fg} = 2311.55$$

$$h_4 = 329.08 + (0.15 \times 2311.55)$$

$$= 675.81 \text{ kJ/kg}$$

$$\dot{Q} = \dot{m}_w (h_2 - h_1) + \dot{m}_s (h_4 - h_3)$$

$$\frac{\dot{Q} - \dot{m}_s (h_4 - h_3)}{(h_2 - h_1)} = \dot{m}_w$$

from A6  $p_3 = 50 \text{ kPa} \therefore h_3 = 2877.8 \text{ kJ/kg}$   
 $T_3 = 200^\circ\text{C}$

$$\dot{m}_w = \frac{-57.44 - 6(675.81 - 2877.8)}{(666.37 - 507.31)}$$

$$\dot{m}_w = \frac{13154.5}{159.06} = 82.7 \text{ kg/s}$$