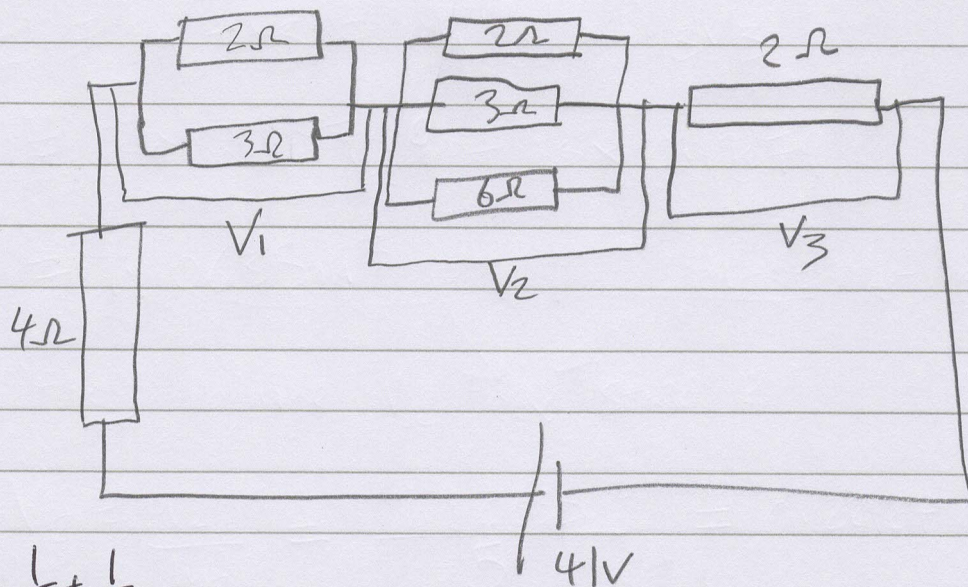


①

M4X00386 - ENGINEERING SCIENCE 2

1) i)



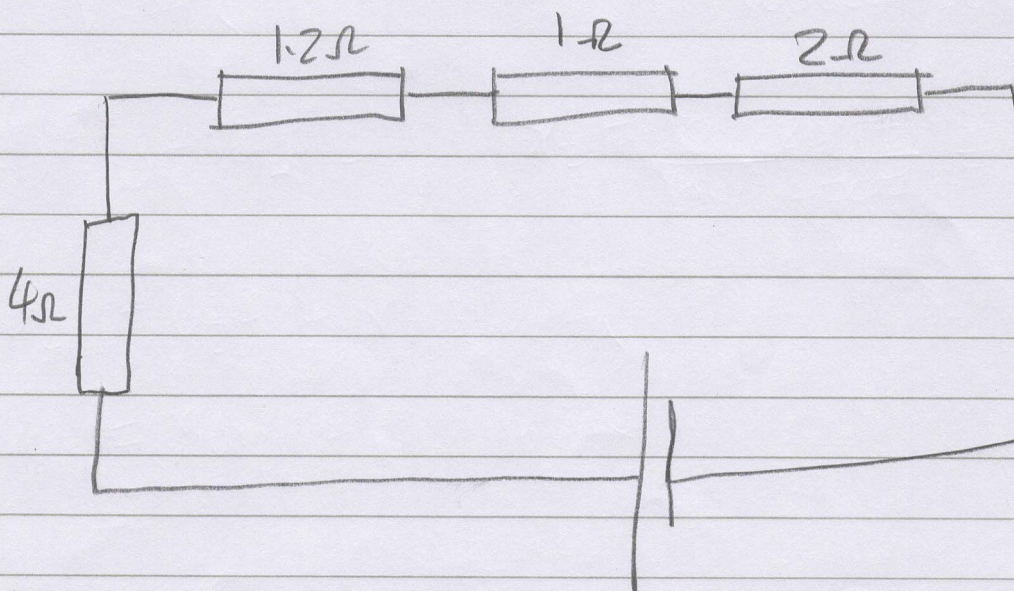
parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \dots$

Across $V_1 \Rightarrow \frac{1}{R_{V_1}} = \frac{1}{2} + \frac{1}{3} \Rightarrow R_{V_1} = \frac{1}{0.8\bar{3}} = 1.2\Omega$

Across $V_2 \Rightarrow \frac{1}{R_{V_2}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{1}{1} = 1\Omega$

Across $V_3 \Rightarrow R = 2\Omega$

Redrawn:



②

i) i) Series $R_T = R_1 + R_2$

$$R_T = 4 + 1.2 + 1 + 2 = 8.2 \Omega$$

i) ii) $V = IR$ $V = 41V$

$$R = 8.2 \Omega$$

$$\frac{V}{R} = I \Rightarrow \frac{41}{8.2} = 5A$$

i) iii) At $V_1 \Rightarrow R_{V_1} = 1.2 \Omega$

Current same in all parts of series circuit $I = 5A$

$$V_1 = 5 \times 1.2 = 6V$$

At $V_2 \Rightarrow R_{V_2} = 1 \Omega$

$$V_2 = 5 \times 1 = 5V$$

At $V_3 \Rightarrow R_{V_3} = 2 \Omega$

$$V_3 = 5 \times 2 = 10V$$

i) iv) Current same in all parts of series circuit
So $I = 5A$ @ 4Ω resistor

In parallel $I = I_1 + I_2 + I_3 \therefore I_3 = \frac{V}{R_3}$

@ $V_2 = 5V$ and $R_3 = 6 \Omega$ $I = \frac{5}{6} = 0.833A$

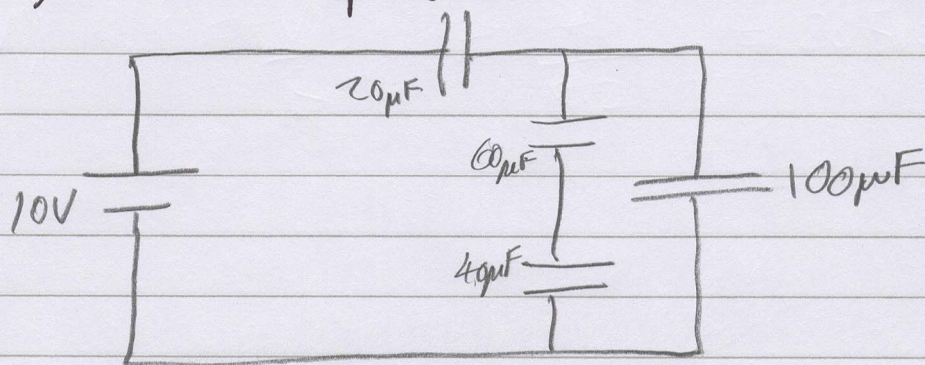
at 6Ω resistor

③

$$1) v) \quad P = \frac{V^2}{R} = \frac{41^2}{8.2} = 205W$$

(4)

2) i) Total capacitance



In series $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

In parallel $C_T = C_1 + C_2 + C_3$

$$\frac{1}{C_{64}} = \cancel{\frac{1}{60 \times 10}} + \frac{1}{60} + \frac{1}{40} \Rightarrow C_{64} = 24 \mu F$$

$$C_{T_{64+100}} = 24 \mu F + 100 \mu F = 124 \mu F$$

$$C_T = \frac{1}{\frac{1}{124} + \frac{1}{20}} = 17.22 \mu F$$

ii) charge $Q = CV = 17.22 \times 10^{-6} \times 10$
 $= 1.722 \times 10^{-4} C$

$$Q = 0.172 \times 10^{-3} C$$

⑤

2) iii) V across $20\mu F$

$$V_{20} = \frac{Q}{C_{20}} = \frac{0.172 \times 10^{-3}}{20 \times 10^{-6}} = 8.6V$$

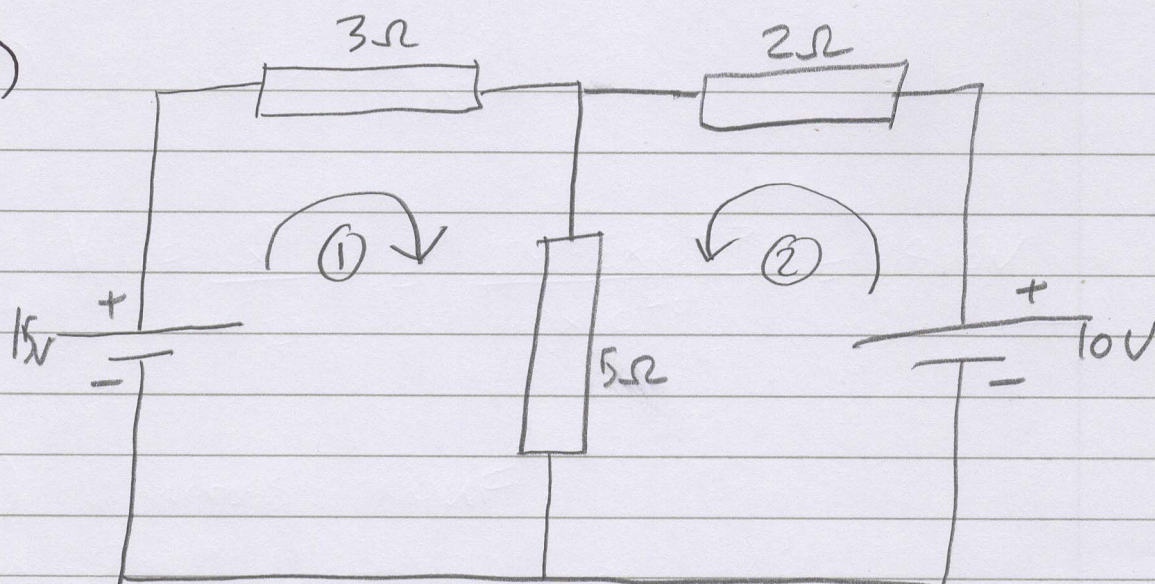
iv) V across $100\mu F$

$$Q_{100} = C_{100} V \Rightarrow V = \frac{Q_{100}}{C_{100}} = \frac{0.172 \times 10^{-3}}{100 \times 10^{-6}} = V$$

$$V = 1.72V$$

⑥

3) a)



$$\textcircled{1} \quad 3I_1 + 5(I_1 + I_2) + 15 = 0$$

$$8I_1 + 5I_2 = -15$$

$$\textcircled{2} \quad 2I_2 + 5(I_1 + I_2) + 10 = 0$$

$$5I_1 + 7I_2 = -10$$

Simultaneous equations

$$\times 5 \quad 8I_1 + 5I_2 = -15 \quad \textcircled{1}$$

$$\times 8 \quad 5I_1 + 7I_2 = -10 \quad \textcircled{2}$$

↓

$$- \quad 40I_1 + 25I_2 = -75$$

$$40I_1 + 56I_2 = -80$$

↓

$$-31I_2 = 5$$

$$I_2 = \frac{5}{-31} = -0.161 \text{ A}$$

Substitute

$$5I_1 + (7 \times -0.161) = -10$$

$$5I_1 = -10 - 1.27$$

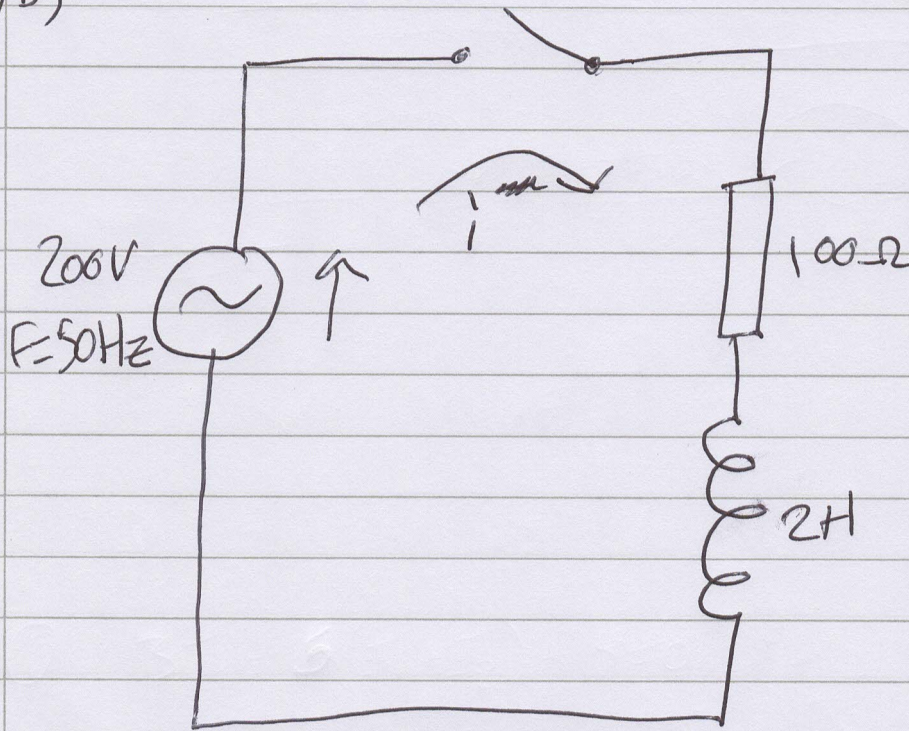
$$I_1 = \frac{-11.27}{5} = -2.25 \text{ A}$$

At 5Ω current $I = I_1 + I_2 \Rightarrow I = (-2.25 + (-0.161))$

$$I_{@5\Omega} = -2.411 \text{ A}$$

⑦

3) b)



$$\begin{aligned} \text{i)} \quad X_L &= 2\pi fL \\ &= 2\pi \times 50 \times 2 \end{aligned}$$

$$X_L = 628.31 \Omega$$

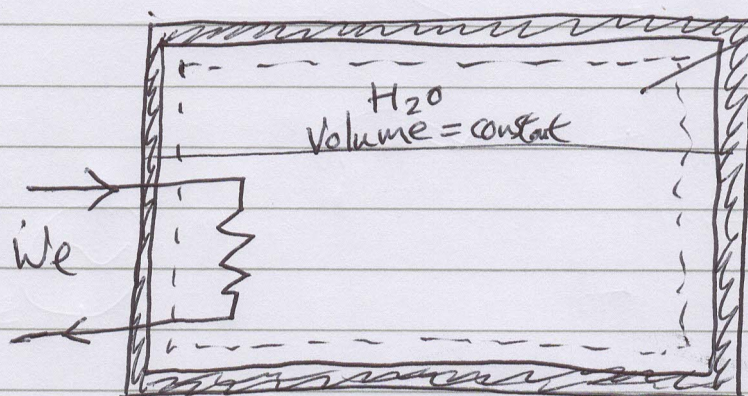
$$\begin{aligned} \text{ii)} \quad Z &= \sqrt{R^2 + X_L^2} \\ &= \sqrt{(100)^2 + (628.31)^2} \end{aligned}$$

$$Z = 636.22 \Omega$$

$$\text{iii)} \quad I = \frac{V}{Z} = \frac{200}{636.22} = 0.314 \text{ A}$$

(8)

4. i)



$\dot{m} = 5 \text{ kg}$
Sat. liq. vap.

$x_1 = 0.35721$
 $P_1 = 100 \text{ kPa}$
 $x_2 = 1$

$$P = W_e = IV = 8 \times 110 = 880 = W_e$$

Knowing $V = \text{constant}$, determine final pressure

$$\Delta U = Q - W$$

$$KE \approx PE \approx 0$$

$$W_e = VI\Delta t$$

$$y = y_F + x \cdot y_{Fg}$$

$$V_{Fg} = V_g - V_F$$

Table A-5

$$E_{in} - E_{out} = \Delta E_{\text{system}}$$

The tank is the system

For constant volume

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\Delta U_A + \Delta U_B = Q$$

$$Q = 0$$

$$Q = U_{A2} - U_{A1} + U_{B2} - U_{B1}$$

①

4) from table A-5 $P_1 = 100 \text{ kPa}$

$$V_g = 1.6941 \text{ m}^3/\text{kg}$$

$$V_f = 0.001043 \text{ m}^3/\text{kg}$$

$$\begin{aligned} V_{fg} &= 1.6941 - 0.001043 \\ &= 1.693 \text{ m}^3/\text{kg} \end{aligned}$$

$$V_1 = V_2 = V$$

$$V_1 = V_f + x \cdot (V_{fg})$$

$$V_1 = 0.001043 + 0.35721 (1.693)$$

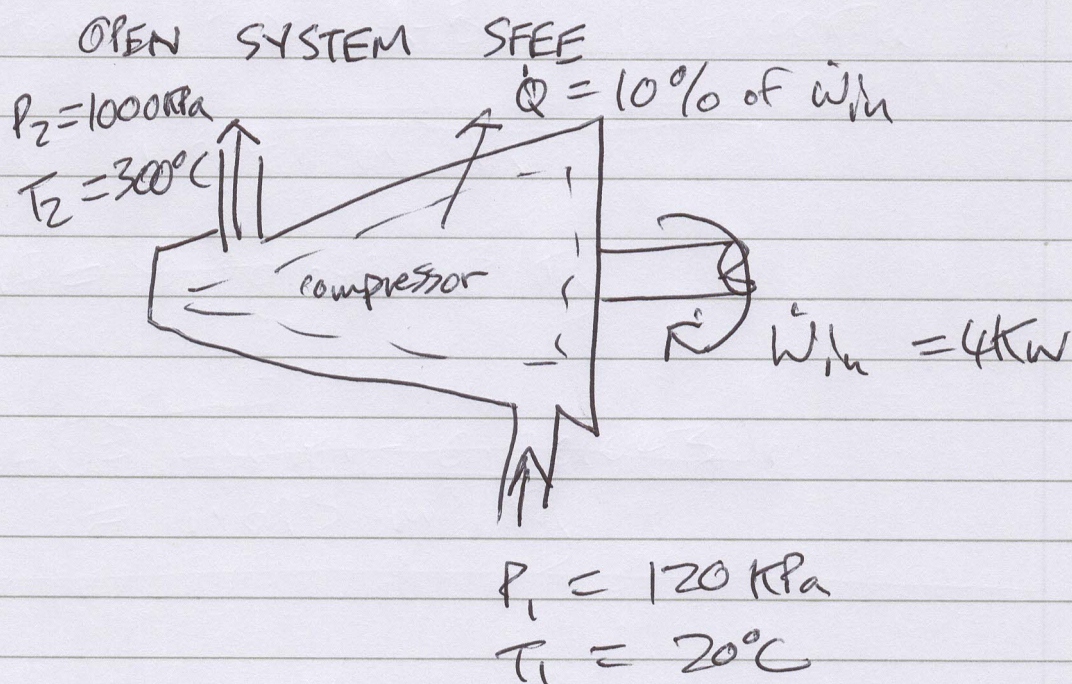
$$V_1 = 0.6058 \text{ m}^3/\text{kg}$$

$$\dot{V}_2 = \frac{V_2}{m_2} =$$

$$V_2 = 0.6058$$

$$V_2 = V_f$$

(10) 5)



* Text says 100 kPa Diagram says 1000 kPa *
 * using 1000 kPa *

$$\dot{m}_1 = \dot{m}_2 = \dot{m}$$

Table A-2

$$KE \approx PE \approx 0$$

Air : $R = 0.287 \text{ kJ/kg} \cdot \text{K}$
 $C_p = 1.005 \text{ kJ/kg} \cdot \text{K}$
 $C_v = 0.718 \text{ kJ/kg} \cdot \text{K}$

Ideal gas $pV = nRT$

$$\dot{W} = \dot{m} (h_{out} - h_{in})$$

$$\dot{W} = C_p (T_1 - T_2) = 1.005 (300 - 20)$$

$$\dot{W} = 281.4 \text{ W}$$

(11)

$$\frac{\dot{W}}{\dot{m}} = w$$

$$\dot{W} = \dot{W}_{in} = 4 \text{ kW} = 4 \times 10^3 \text{ W}$$

$$\frac{\dot{W}}{w} = \dot{m} \quad \text{as power } \dot{W} = w \dot{m}$$

$$\frac{4 \times 10^3}{281.4} = 14.21 \text{ kg/s}$$

ii) find V_1 and V_2

$$V_1 = \frac{P_1}{T_1}$$

$$V_2 = \frac{P_2}{T_2}$$

$$\frac{P_1}{T_1} = \frac{120 \times 10^3}{(20 + 273)} = 409.5$$

$$\frac{P_2}{T_2} = \frac{1000 \times 10^3}{(300 + 273)} = \frac{1000}{(300 + 273)} = 1.74 \text{ m}^3/\text{s}$$

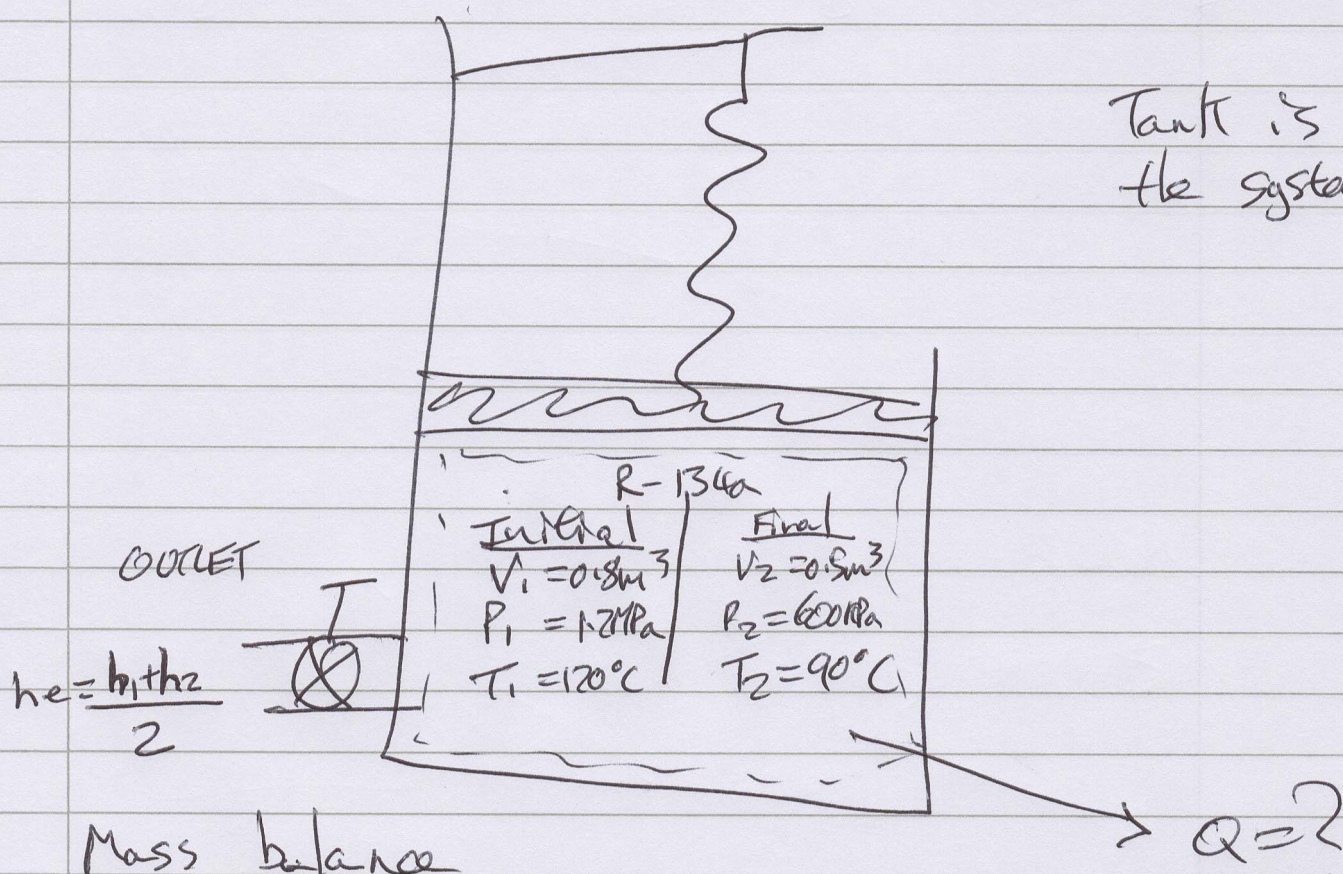
$$\frac{P_1}{T_1} = \frac{120}{(20 + 273)} = 0.4096 \text{ m}^3/\text{s}$$

(12)

6)

Open system / Unsteady flow process

Tank is the system



Mass balance

$$m_i - m_e = (m_2 - m_1)_{\text{system}}$$

$$m_i = m_2 \quad \text{Since } m_e = m_1 = 0$$

Energy balance

$$Q - W = \sum_{\text{out}} m h - \sum_{\text{in}} m h + (m_2 u_2 - m_1 u_1)_{\text{system}}$$

$$0 = -m_1 h_1 + m_2 u_2$$

$$Q \approx W \approx KE \approx PE \approx 0$$

$$u_2 - u_1 = C_v (T_2 - T_1)$$

$$h_2 - h_1 = C_p (T_2 - T_1)$$

$$u_2 = C_v T_2$$

$$h_1 = C_p T_1$$

(13)

$$W_b = \frac{1.2 \times 10^3 + 600}{2} (0.8 - 0.5)$$

$$= \frac{1.8 \times 10^3}{2} (0.8 - 0.5)$$

$$W_b = 270 \text{ W} = \dot{W}$$

$$\frac{\dot{W}}{\dot{m}} = W$$

$$W = C_p (T_1 - T_2)$$

$$C_p = 1.23 \text{ kJ/Kg K}$$

R134a

$$\frac{\dot{W}}{W} = \dot{m}$$

$$W = 1.23 (120 - 90)$$

$$= 36.9$$

$$\dot{m} = \frac{270}{36.9} = 7.317 \text{ Kg/s}$$