

Question one (25 marks)

a) $r = 4 \Omega$ $V = 12V$

$$\mathcal{E} = I(r + R)$$

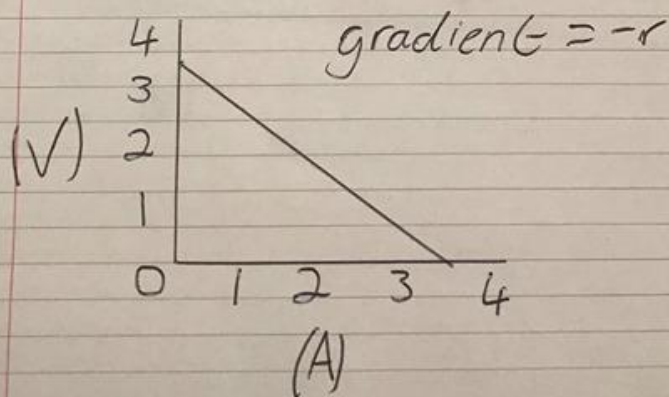
$$I = \frac{\mathcal{E}}{(r + R)} \quad I = \frac{12}{(4 + 8)}$$

$$\underline{I = 1A}$$

~~W~~ ~~W~~ $P = I^2 R$ $P = 1^2 \times 8$

$$\underline{P = 8W}$$

b)



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

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

~~100 x 10^-3 m~~ $\frac{100 \times (7.85 \times 10^{-9})}{9.81 \times 10^{-8}}$

$$\underline{= 0.08002m}$$

C) ii)

$$R = 100 \Omega$$

$$t = 0^\circ \text{C}$$

$$\rho = 9.81 \times 10^{-8} \Omega \text{m at } 0^\circ \text{C}$$

$$d = 0.1 \text{ mm}$$

$$R = \frac{\rho L}{A} \therefore \frac{\rho A}{L} = L \therefore \frac{\rho \pi d^2}{4} = L$$

$$\frac{100 \times \pi (0.1)^2 \times 10^{-3}}{4}$$

$$\frac{\quad}{9.81 \times 10^{-8}} = 8.006097486 \text{ m}$$

$$L = 8.01 \text{ m}$$

$$\text{ii) } V = \frac{\pi d^2}{4} \times L$$

$$V = \frac{\pi (0.1 \times 10^{-3})^2}{4} \times 8.006097486$$

~~$$V = 6.287974261 \times 10^{-8} \text{ m}^3$$~~

$$V = 6.287974261 \times 10^{-8} \text{ m}^3$$

C) iii.

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$\text{Density} = 21.45 \times 10^3 \text{ kg m}^{-3}$$

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

$$\text{mass} = 21.45 \times 10^3 \times 6.287974261 \times 10^{-8} \text{ m}$$

$$\text{mass} = 1.35 \times 10^{-3} \text{ kg}$$

$$1.35 \times 10^{-3} \times 10000$$

$$\text{£13.5}$$

C) IV

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

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

$$9.81 \times 10^{-8} \times 7.5 \times 10^1$$

$$A = \frac{7.3575 \times 10^{-8}}{125}$$

$$A = \frac{2.1886 \times 10^{-9}}{5.886 \times 10^{-10}}$$

$$\text{Thickness} = \frac{A}{3.5 \times 10^{-6}}$$

$$5.886 \times 10^{-10}$$

$$\frac{5.886 \times 10^{-10}}{3.5 \times 10^{-6}}$$

$$= 1.682$$

d)

$$(i) R = 3.5 \Omega$$

$$L = 1 \text{ km} = 1000 \text{ m}$$

$$d = 7.4 \text{ mm} = 7.4 \times 10^{-3} \text{ m}$$

$$A = \frac{\pi d^2}{4}$$

$$A = \pi \times (7.4 \times 10^{-3})^2 = 4.30 \times 10^{-5} \text{ m}^2$$

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

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

$$\frac{3.3 \times 4.3 \times 10^{-5}}{1000}$$

$$= 1.42 \times 10^{-7} \Omega \text{ m}$$

Question 1

d)

(ii) Aluminium wire has a lower resistivity compared to steel wire. ~~Alum wire has lower resistance~~ Because steel has a higher resistance.

steel

$$R = 3.3 \Omega$$

$$P = \frac{V^2}{R} = \frac{75^2}{3.3}$$

$$P = \underline{32.4 \text{ kW}}$$

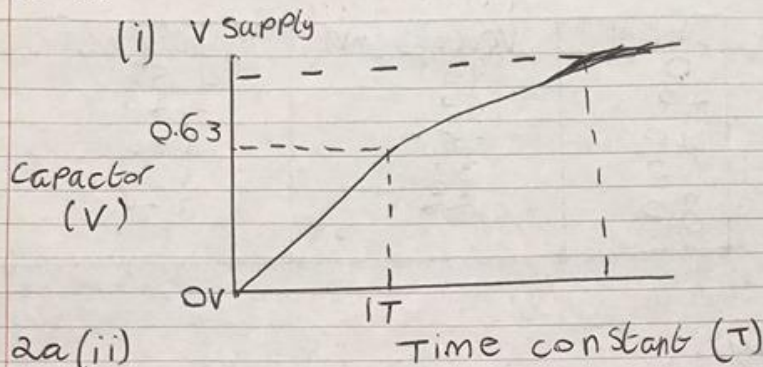
Aluminium

$$R = \frac{1.1}{6} = 0.182 \Omega$$

$$P = \frac{75^2}{0.182} = \underline{30.7 \text{ kW}}$$

Question 2 Page 1

2a



2a(ii)

As the capacitance moves because of the diagram, the capacitor changes by using $C = \frac{Q}{V}$. When the V value of the capacitor ~~alters~~ changes therefore the value of charge ~~travels~~ through the resistor.

2b ~~answer~~ $C = \frac{Q}{V}$

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

$$V = 95 \text{ mV} = 0.095 \text{ V}$$

$$Q = C \times V = 0.22 \times 0.095$$

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

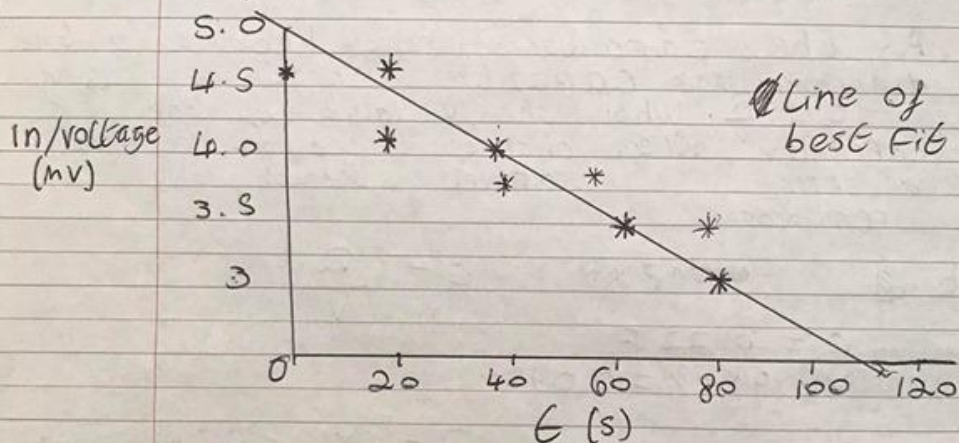
2b ~~the~~ The capacitor is giving out to a
(i) high level of resistance.

Question 2 page 2

2b (ii)

Time (s)	Voltage (mV)	ln/voltage (mv)
0	95	4.55
20	67	4.20
40	46	3.83
60	33	3.50
80	22	3.09

2b (iii)



2b (iv)

The graph shows a negative line due to the relationship between ln/voltage and time.

2b (v) $95 \text{ mV} \times 0.37 = 35$

$\therefore \ln 35 = 3.5$

~~3.55~~ $\rightarrow 605$
Time con R_C

$R = \frac{60}{0.22} = 273 \Omega$

Second voltmeter resistance = 273Ω

Question 3

Tank A	Tank B
3 kg	2.7 kg
1.6 MPa	1.2 MPa
$x_1 = 0.4$	120°C
R-134a	R-134a

$$m_1 = 3 \text{ kg}, m_2 = 2.7 \text{ kg}$$

$$p_1 = 1.6 \text{ MPa}, p_2 = 1.2 \text{ MPa}$$

$$x_1 = 0.4, T_2 = 120^\circ\text{C}$$

$$\textcircled{1} [h_{f1} = 135.93 \text{ kJ/kg}, (h_{fg})_1 = 141.93 \text{ kJ/kg}]$$

$$\rightarrow \text{For } \{p_1 = 1.6 \text{ MPa}\}$$

$$\textcircled{2} \text{ For } p_2 = 1.2 \text{ MPa and } T \text{ superheated} = 120^\circ\text{C}$$

$$h_2 = 354.11 \text{ kJ/kg}$$

$$h_1 = x_1(h_{fg}) + h_{f1} = 0.4 \times 141.93 + 135.93$$

$$h_1 = 192.702 \text{ kJ/kg}$$

Question 3 continued

putting values of u_1 and u_2
in eq (c) r)

$$(3 \times 0.0056132) + (2.7 \times 0.0246228) \\ = 5.7 \times u_3$$

$$\frac{0.0816552}{5.7} = u_3$$

$$u_3 = 0.01432$$

$$0.01432 \text{ m}^3/\text{kg}$$

Pressure of mixture, $P_3 = 900 \text{ kPa}$

From A-12 and A-13 tables

$$\text{At } P = 900 \text{ kPa}, u_{f3} = 0.000858 \text{ m}^3/\text{kg}$$

$$(u_g)_3 = 0.022683 \text{ m}^3/\text{kg}$$

$$\therefore u_3 = (v_f)_3 + x_3(v_g - v_f)_3$$

$$0.01432 = 0.000858 + x_3(0.021825)$$

$$x_3 = 0.6168$$

$$x_3 = 0.617$$

d.

Applying mass equilibrium and energy equilibrium conditions

$$(a) m_1 + m_2 = m_3$$

$$3 + 2.7 = m_3$$

$$m_3 = 5.7 \text{ kg}$$

$$(b) m_1 h_1 + m_2 h_2 = m_3 h_3 + Q_{\text{loss}}$$

are closed system

$$(u=0, \Delta KE=0, \Delta PE=0)$$

$$(c) v_1 + v_2 = v_3$$

$$m_1 u_1 + m_2 u_2 = m_3 u_3$$

From tables A-12 and A-13

For Tank A

$$P_1 = 1.6 \text{ MPa}$$

$$x = 0.4$$

$$v_1 = 0.0056132 \text{ m}^3/\text{kg}$$

For Tank B

$$u_2 = 0.024228 \text{ m}^3/\text{kg}$$

Question 3 Page 3

~~Q3~~ The quality of refrigerant R-134a

(I) after mixing is wet vapour
of dryness Fraction ($x = 0.617$) Ans

~~Q4~~

At $P = 900 \text{ kPa}$

and $x = 0.617$

(II) $h_3 = (h_f)_3 + x_3 (h_{fg})_3$

$$h_3 = 101.61 + 0.617(167.66)$$

$$h_3 = 205.05 \text{ kJ/kg}$$

Applying values of h_1 , h_2 and h_3

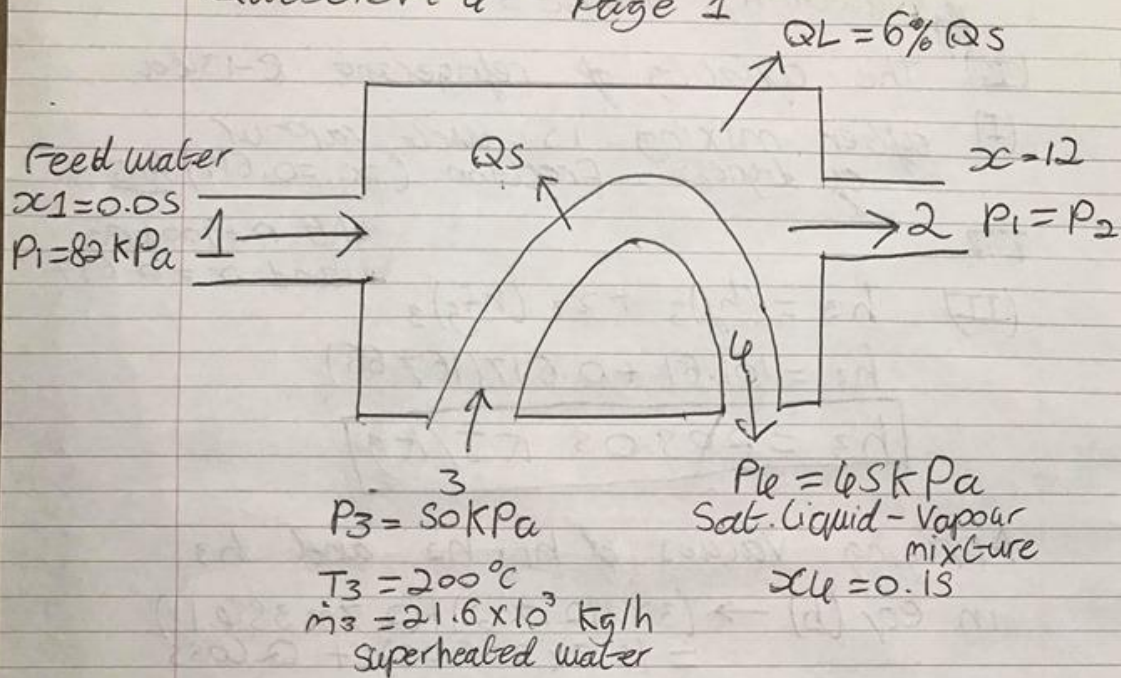
in eq (b) $\rightarrow (3 \times 192.702) + (2.7 \times 356.11)$
 $= (5.7 \times 205.05) + Q_{\text{loss}}$

$$Q_{\text{loss}} = 1536.203 - 1168.785$$

$$Q_{\text{loss}} = 365.418 \text{ kJ}$$

Ans

Question 4 Page 1



① System = total heat

Mass balance: $\dot{m}_1 = \dot{m}_2$; $\dot{m}_3 = \dot{m}_4$

Energy balance:

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

mass balance: $\dot{m}_1 = \dot{m}_2$

Energy balance: $Q_L + Q_s = \dot{m}_2 h_2 - \dot{m}_1 h_1$

System: Feed water tank

mass balance: $\dot{m}_3 = \dot{m}_4$

energy balance: $Q_s = \dot{m}_4 h_4 - \dot{m}_3 h_3$

System: Steam pipe

Question 6 Page 2

a) $\dot{Q}_s = ?$

$h_3 \begin{cases} T_3 = 200^\circ\text{C} \\ P_3 = 45 \text{ kPa} \end{cases}$

$h_4 \begin{cases} P_4 = 45 \text{ kPa} \\ x_4 = 0.15 \end{cases}$

Using Table A-5

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

ΔkPa

$\begin{pmatrix} 40 \\ 45 \end{pmatrix}$
SO

Δh_{fg}

$\begin{pmatrix} 2318.4 \\ 2306.7 \end{pmatrix}$

difference 10
step 5

13.7
 Δh_{fg}

$5 \times 13.7 = 10 \Delta h_{fg}$

$\Delta h_{fg} = 6.85$

$\frac{5 \times 13.7}{10} = \Delta h_{fg}$

$h_{fg} = 2318.4 - \Delta h_{fg} = 2318.4 - 6.85 = 2311.55 \text{ kJ/kg}$

ΔkPa

$\begin{pmatrix} 40 \\ 45 \end{pmatrix}$
SO

Δh_f

$\begin{pmatrix} 317.62 \\ 360.86 \end{pmatrix}$

10
5

22.92

Δh_f

$5 \times 22.92 = 10 \Delta h_f$
 $5 \times 22.92 = \Delta h_f = 11.46$

$h_f = 317.62 + \Delta h_f = 317.62 + 11.46 = 329.08 \text{ kJ/kg}$

Question 4 Page 3

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

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

$$h_4 = 675.8125 \text{ kJ/kg}$$

System: Steam pipe

$$\dot{Q}_s = \dot{m}_4 h_4 - \dot{m}_3 h_3$$

Using Table A-6

$$h_3 = 2877.8 \text{ kJ/kg}$$

$$\dot{Q}_s = (6)(675.8125) - (6)(2877.8)$$

$$\dot{Q}_s = 4054.875 - 17266.8$$

$$\dot{Q}_s = -13211.925 \text{ kJ/s}$$

$$\dot{Q}_s = 13211.925 \text{ kJ/s}$$

b) mass flow of Feed water

system: total heat exchanger

$$\text{mass balance: } \dot{m}_1 = \dot{m}_2 \rightarrow \dot{m}_w$$

$$\dot{m}_3 = \dot{m}_4$$

$$\text{Energy balance: } Q_T = (\dot{m}_2 h_2 + \dot{m}_4 h_4) - (\dot{m}_1 h_1 + \dot{m}_3 h_3)$$

Question 4 Page 4

(h₂) h_{fg} using table A-S

ΔkPa

Δh_{fg}

(75
82
↓100)

(2278.0
h_{fg}
2287.5)

$$\begin{array}{rcl} 25 & \times & 20.5 \\ 7 & \times & \Delta h_{fg} \end{array} \quad \begin{array}{l} 7 \times 20.5 = 25 \Delta h_{fg} \\ \frac{7 \times 20.5}{25} = \Delta h_{fg} \end{array}$$

$$\Delta h_{fg} = 5.74$$

$$h_{fg} = 2278 - 5.74 = 2272.26 \text{ kJ/kg}$$

(h_f)

ΔkPa

Δh_f

(75
82
↓100)

(384.46
Δh_f
417.51)

$$\begin{array}{rcl} 25 & \times & 33.07 \\ 7 & \times & \Delta h_f \end{array}$$

$$33.07 \times 7 = 25 h_f$$

$$\frac{33.07 \times 7}{25} = \Delta h_f$$

$$9.2596 = \Delta h_f$$

$$h_f = 384.46 + 9.2596 = 393.6996 \text{ kJ/kg}$$

Question 6 Page 5

(h₂)

$$h_2 = h_f + x \cdot h_{fg}$$

$$x_2 = 0.12$$

$$h_2 = 395.6996 + 0.12 \times 2272.26$$

$$h_2 = 666.3708 \text{ kJ/kg}$$

(h₁)

$$h_1 = h_f + x \cdot h_{fg}$$

$$x_1 = 0.05$$

$$h_1 = 395.6996 + 0.05 \times 2272.26$$

$$h_1 = 507.3126 \text{ kJ/kg}$$

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

$$\dot{Q}_T = 13211.925 + 6\%$$

$$\dot{Q}_T = 13211.925 \times 1.06 = 14004.6405 \text{ kJ/s}$$

$$\dot{m}_3 = \dot{m}_4 = 6 \text{ kg/s}$$

$$h_1 = 507.3126 \text{ kJ/kg}, h_2 = 666.3708 \text{ kJ/kg}$$

$$h_3 = 2877.8 \text{ kJ/kg}, h_4 = 675.8125 \text{ kJ/kg}$$

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

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

$$\dot{Q}_T = \dot{m}_w (h_2 - h_1) + \dot{m}_4 h_4 - \dot{m}_3 h_3$$

$$\dot{Q}_T = -\dot{m}_4 h_4 + \dot{m}_3 h_3 = \dot{m}_w (h_2 - h_1)$$

$$14004.6405 - (6 \times 675.8125) + (6 \times 2877.8) =$$

$$27216.5655 = \dot{m}_w (666.3708 - 507.3126)$$

$$27216.5655 = \dot{m}_w (159.0582)$$

$$\frac{27216.5655}{159.0582}$$

$$\dot{m}_w = 171.11 \text{ kg/s}$$