Name ... Univ No :

24

Q1) Based on your understanding of the course answer the following (10 Marks)

8

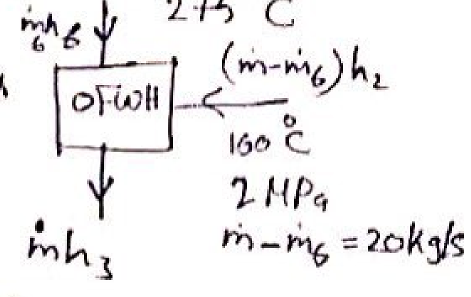
1. An open feed water heater used in regenerative Ranking cycle receives bleeded steam from the turbine at 2 MPa and 275 °C to heat the feed water from the condenser at 100 °C, 2 MPa and rate of 20 kg/s. The exit of the OFWH is saturated liquid. Calculate the mass flow rate of the bleeded steam. Show calculation steps. ↓ 2 MPa

take the OFWH as control volume

$\dot m_6 h_6 + (\dot m - \dot m_6) h_2 = \dot m h_3$

$y h_6 + (1-y) h_2 = h_3$

$\frac{\dot m_6}{\dot m} = y = \frac{h_3 - h_2}{h_6 - h_2}$



State 6 is superheated at 2 MPa

T = 275 °C — T = 250 °C h = 2903.3 KJ/kg

T = 300 h = 3024.2 KJ/kg

$h_6 = 2963.75$ KJ/kg

$h_2 \doteq h_{f@100°C} = 419.17$ KJ/kg

$h_3 = 908.47$ KJ/kg

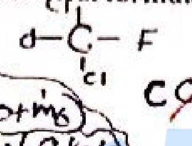
$y = 0.19$

$\dot m_6 = 0.19 \dot m = 0.19(20 + \dot m_6)$

$\dot m = 20 + \dot m_6$ $\boxed{\dot m_6 = 4.69\ kg/s}$

2. Write down the chemical formula for the following refrigerants

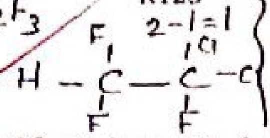
R11 1-1=0



CCl_3F

R123 2-1=1

$C_2HCl_2F_3$



3. Why and in which device cooling water is required for in Ammonia absorption refrigeration cycle?

in the absorber, in order to dissolve NH_3 into H_2O the absorber must be cooled. (because it is an exotherim reaction)

4. What is the function of rectifier in Ammonia absorption cycle? What is the difference between it and flash chamber in regeneration cycle?

the rectifier seperates H_2O from NH_3 and allow NH_3 to enter the condenser and returns H_2O to the generator

flash chamber is used for separation in liquids but rectifier is used for gases

5. State TWO problems with Carnot refrigerator cycle?

① the inlet of the compressor is wet mixture. compressors can't deal with wet mixture

② the inlet of the turbine is saturated liquid. the turbine cannot allow the liquid to expand largely (in order to cool the liquid because liquids are incompressible)

2

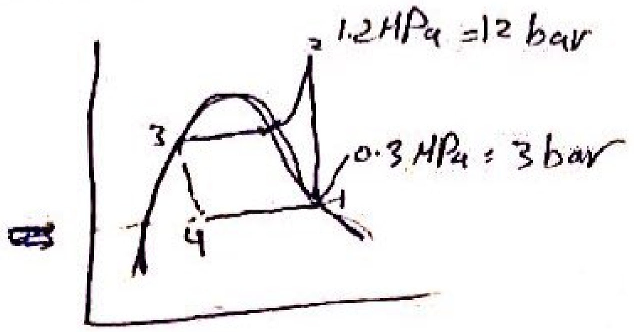
6. Consider a heat pump that operates on the ideal vapor compression refrigeration cycle with R-134a as the working fluid flowing at rate 0.193 kg/s between the pressure limits of 0.3 and 1.2 MPa. Using the P-H chart find :

The enthalpies at all points: h1 = 300 KJ/Kg h2 = 328 KJ/Kg h3 = 165 KJ/Kg h4 = 165 KJ/Kg

The quality of the mixture at the evaporator inlet is nearly = 32 %

The heating load for this cycle is = kW = 8.94 Tonnes

The coefficient of performance is =



$\dot m_R (h_2 - h_3)$

$0.193\,(328 - 165)$

31.459 KW

$31.459\,\frac{KJ}{s} \cdot \frac{60\,s}{1\,min}$

$211\ \frac{KJ}{min}$

Q2) Based on Gas Mixture Chapter answer the following

A mixture of ideal gases consists of 4 kg of Nitrogen (N_2) and 6 kg of Carbon Dioxide (CO_2) at a pressure of 0.1 MPa and a temperature of 25°C.
Find :
(i) The mass and mole fraction of each constituent (m_{fi} and y_i).
(ii) The molecular weight of the mixture (M_{mix}).
(iii) The gas constant of the mixture (R_{mix}).
(iv) The partial pressure for each component (P_i).
(v) The volume and density of the mixture, and
(vi) The c_p and c_v of the mixture.
(vii) If the mixture is heated at constant volume to 50°C, find the changes in internal energy and entropy of the mixture.
(viii) If the mixture is compressed adiabatically to 0.25 MPa find the final temperature and work done.
++

Q3) Based on Refrigeration cycles' Chapter answer the following

A vapor-compression refrigeration system circulates Refrigerant 134a at a rate of 6 kg/min. The refrigerant enters the compressor at -10 °C, 1.4 bar, and exits at 7 bar. The isentropic compressor efficiency is 67%. There are no appreciable pressure drops as the refrigerant flows through the condenser and evaporator.
The refrigerant leaves the condenser at 7 bar, 24 °C. Ignoring heat transfer between the compressor and its surroundings, determine
(a) The coefficient of performance and its theoretical maximum value.
(b) The refrigerating capacity, in tons. (Define the word "Tonne" of refrigeration)
(c) The rates of exergy destruction in the compressor and expansion valve, in kW.
(d) The second law efficiency of the cycle.
(e) The cost of running this cycle for one month, 8 hours per day with electricity cost 0.8 JD/kW-hr.
Take To = 21 °C, Po = 1 bar.

Name : Univ No :

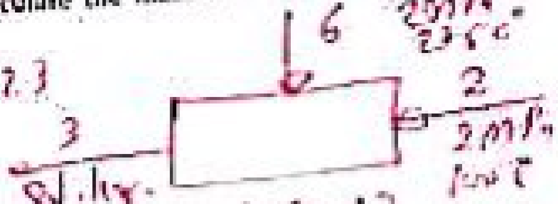
Q1) Based on your understanding of the course answer the following (10 Marks)

1 An open feed water heater used in regenerative Rankine cycle receives bleeded steam from the turbine at 2 MPa and 275 °C to heat the feed water from the condenser at 100 °C 2 MPa and rate of 20 kg/s. The exit of the OFWH is saturated liquid. Calculate the mass flow rate of the bleeded steam. Show calculation steps.

1

$$Y = \frac{h_3 - h_2}{h_6 - h_2} = 0.1923$$

$$\boxed{\dot{m}_6 = 3.845 \text{ kg/s}}$$



$h_2 = 419.17$
$h_3 = 908.47$ kJ/kg
$h_6 = 2963.75$

2. Write down the chemical formula for the following refrigerants

R11 CCl_3F R123 $C_2HCl_2F_3$

1

3. Why and in which device cooling water is required for in Ammonia absorption refrigeration cycle?

1 Absorber to dissolve NH_3 in water.

4. What is the function of rectifier in Ammonia absorption cycle? What is the difference between it and flash chamber in regeneration cycle?

1 Rectifier → removes NH_3 & H_2O ~~vapor~~ liquid H_2O vapor before pump!
Flash chamber → ?/

5 State TWO problems with Carnot refrigerator cycle?

2 Check books

6 Consider a heat pump that operates on the ideal vapor compression refrigeration cycle with R-134a as the working fluid flowing at rate 0.193 kg/s between the pressure limits of 0.8 and 1.2 MPa. Using the P-H chart find :

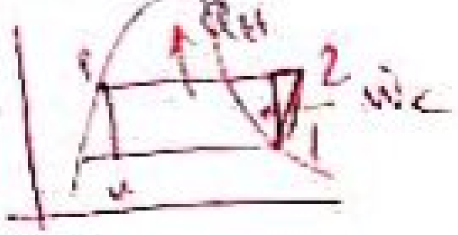
4

The enthalpies at all points: h1 = 203 h2 = 330 h3 = 106 h4 = 106

The quality of the mixture at the evaporator inlet is nearly 30%

The heating load for this cycle is 43.81 kW = Tons 17.055

The coefficient of performance is = 6.441



$1 \text{ ton} = 211 \frac{kJ}{min}$

$? = 2663.4$

$\dot{Q}_H = 31.845 \text{ kW}$

Q2) $P_{mix} = 100\,kPa$, $T_{mix} = 25\,°C$

(1)

	m	M	N_i	mf_i	y_i	C_p	$mf_i \cdot C_{p_i}$
N_2	4	28	0.14285	0.4	0.5116	1.0039	
CO_2	6	44	0.13636	0.6	0.48113	0.846	
Σ	10 kg		0.27922	1	≈ 1		

$N = \frac{m}{M}$, $R_{mix} = \frac{R_u}{M_{mix}} = \sum mf_i \cdot R_i$

(2) $M_{mix} = \frac{m_{mix}}{N_{mix}} = 35.814 \frac{kg}{kmol}$

(3) $R_{mix} = 0.23214 \frac{kJ}{kg \cdot K}$ $\quad R_{CO_2} = 0.1889$

(4) $\frac{P_i}{P_{tot}} = y_i \Rightarrow P_{CO_2} = 48.113\,kPa$ $\quad R_{N_2} = 0.2968$

$P_{N_2} = 51.16\,kPa$

(5) $C_{p_{mix}} = \sum mf_i \cdot C_{p_i} = 0.9232 \frac{kJ}{kg \cdot K}$

$\therefore C_{v_{mix}} = -R_{mix} + C_{p_{mix}} = 0.69106$

$K_{mix} = (C_p / C_v)_{mix} = 1.336$

(6) $(PV = mRT)_{mix} \Rightarrow V_{mix} = \frac{m_{mix} R_{mix} T_{mix}}{P_{mix}}$

$= \frac{N_{mix} R_u T_{mix}}{P_{mix}}$

$= 6.928\,m^3$

(7) $Q_{in} = m_{mix} C_{v_{mix}} \Delta T$

$= 172.765\,kJ$

(8) ΔU $\Delta S = m C_v \ln \frac{T_2}{T_1} + m R \ln \frac{V_2}{V_1}$ $\quad \rho_{mix} = \frac{m_{mix}}{V_{mix}} =$

$= 0.55809 \frac{kJ}{K}$ $\quad 1.4455 \frac{kg}{m^3}$

(9) $T_2 = T_1 (P_2/P_1)^{\frac{k-1}{k}} \Rightarrow T_2 = 375.23\,K$, $W = m C_v \Delta T = 530$

b) $\dot{Q}_L = \dot{m}_R(h_1 - h_4) = 16.138$ kW

$= 4.6$ Tonn

c) $\dot{X}_{dest,1-2} = \dot{m}_R T_0 (s_2 - s_1)$

$= 0.14294(1.02 - 0.97291)$

$= \underline{\underline{1.4 \text{ kW}}}$

$\dot{X}_{dest,3-4} = \dot{m}_R T_0 (s_4 - s_3)$

$= 0.14294(0.38473 - 0.31915)$

$= \underline{\underline{0.555 \text{ kW}}}$

d) $\eta_{II} = \dfrac{COP_R}{COP_{rev}} = \dfrac{3.104}{5.6} * 100\%$

$= 55.5\%$

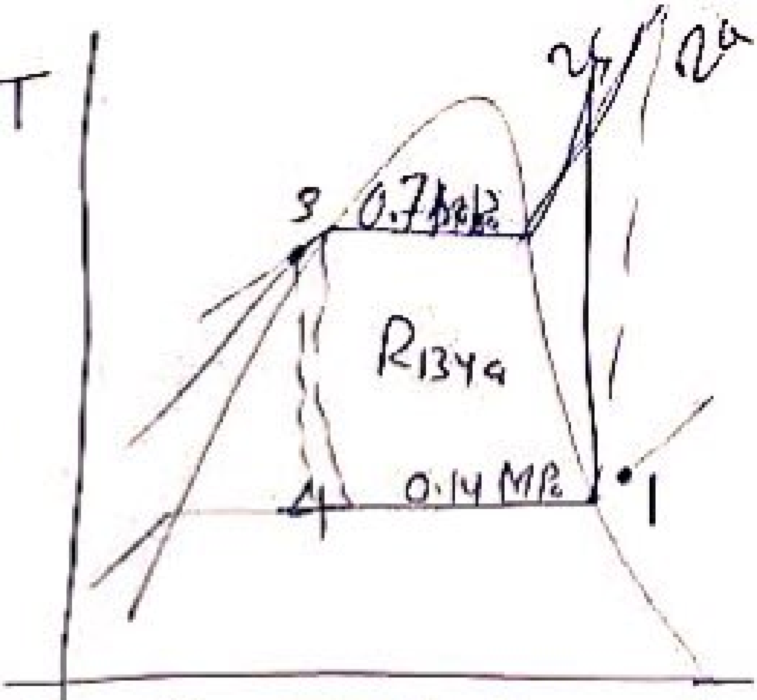
e) $\dot{X}_{\dot{Q}_L} = 2.5245$

Cost = time * tariff * W_{in}

$= 8 \frac{hrs}{day} * 30 \frac{day}{mon} * 0.8 \frac{JD}{kW \cdot h} * 5.183$ kW

$= 998.4$ JD/month

Q3) $\dot{m}_R = 6$ kg/min $= 0.1$ kg/s



1) $-10°C$, 1.4 bar $= 0.14$ MPa

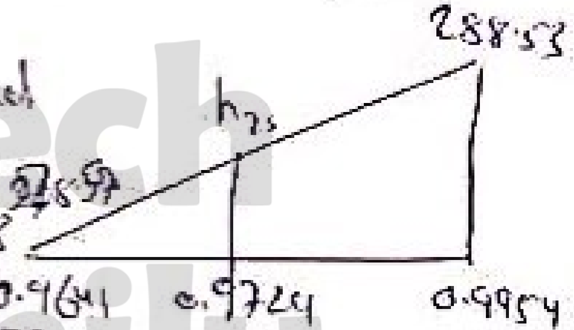
Superheated.

$h_1 = 246.36 \ \frac{kJ}{kg}$

$s_1 = 0.9724 \ \frac{kJ}{kgK}$

2) $\eta_c = 67\%$, $s_{2s} = s_1$, $P_2 = 0.7$ MPa $\Rightarrow h_{2s} = 281.189$

$\therefore h_{2a} = 298.343$, $s_{2a} = 1.02 \ \frac{kJ}{kgK}$



3) 7 bar, $24°C$ Subcooled

0.7 MPa

$\therefore h_3 = h_{f@24°C} = 84.98$

$s_3 = s_{f@24°C} = 0.31958$

4) $h_4 = h_3 = 84.98$

$= h_f + x_4 h_{fg}$

$\therefore x_4 = 0.273$

$s_4 = s_f + x_4 s_{fg} = 0.338473$

A) $COP_R = \dfrac{h_1 - h_4}{h_{2a} - h_1} = \underline{\underline{3.104}}$

$T_L = 254.23$

$T_H = 299.69$

$COP_{max} = \dfrac{T_L}{T_H - T_L} = \dfrac{-18.77 + 273}{26.69 - (-18.77)} = \underline{\underline{5.592}}$

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