Thermodynamics 2 second exam 2013/2014

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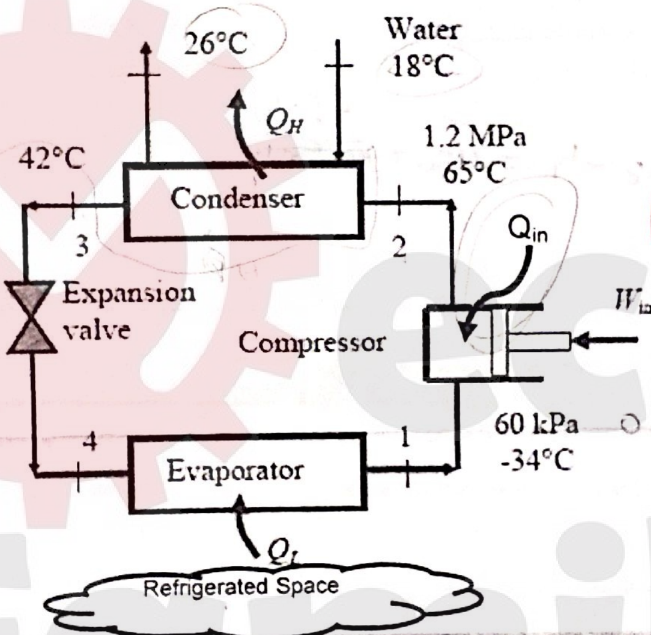
Question 1) A commercial refrigerator with refrigerant 134-a as the working fluid is used to keep the refrigerated space at -30 °C by rejecting its waste heat to a cooling water that enters the condenser at 18 °C at rate of 0.25 kg/s and leaves at 26 °C (as shown below). The refrigerant enters the condenser at 1.2 MPa and 65 °C and leaves at 42 °C. The inlet state of the compressor 60 kPa and -34 °C and during compression some heat is transferred to the refrigerant equals to 450 Watt from the surrounding.

1) Draw the T-S and P-h diagrams of the cycle.
2) Calculate refrigeration load.
3) Calculate the quality of the refrigerant at the evaporator inlet.
4) Calculate the COP of the cycle and compare with Carnot COP.
5) Calculate the mass flow rate of the refrigerant.
6) The exergy loss in the cycle (neglect the interface processes).
7) The second law efficiency of each component and the cycle as whole.



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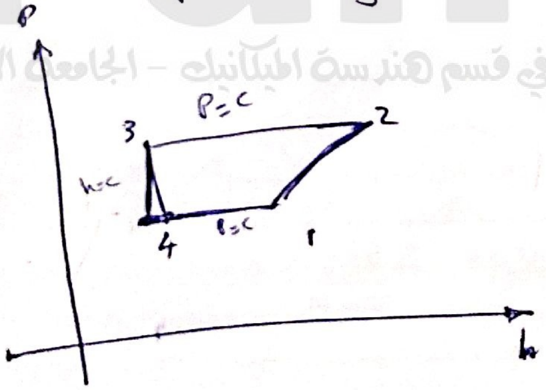
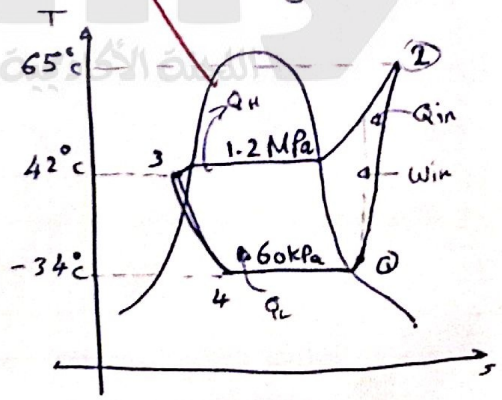
solution :-

1)

P-h diagram



T-s diagram



b) **Point 1** $P_1 = 60$ kPa, $T_1 = -34$ } $h_1 = 230.05$ kJ/kg, $s_1 = 0.9732$

Point 2 $P_2 = 1.2$ MPa, $T_2 = 65°c$ } $h_2 = 295.125$ kJ/kg, $s_2 = 0.9776$

Point 3 $P_3 = 1.2$ MPa, $T_3 = 43°c$ } $h_3 \approx 117.7$ kJ/kg, $s_3 \approx 0.423$

Point 4 $h_3 = h_4 \approx 117.7$ kJ/kg, $P_4 = 60$ kPa

$Q_L = h_1 - h_4 = 230.05 - 117.7 = 112.35$ kJ/kg

c) $h_4 = 117.7$ $\quad x = \frac{h_4 - h_f}{h_{fg}|_{60kPa}} = 0.508$

d) $Q_H = h_2 - h_3 = 295.125 - 117.7 = 177.425$ kJ/kg

~~$W_{net} = h_2 - h_1 = 295.125 - 230.05 = 65.075$~~

~~$COP_{ref} =$~~

$COP_{carnot} = \frac{T_L}{T_H - T_L} = \frac{243.15}{291.15 - 243.15} = 5.07$

$W_{net} = Q_H - Q_L = 177.42 - 112.35 = 65.07$

$COP_{ref} = \frac{Q_L}{W_{net}} = \frac{112.35}{65.07} = 1.7266$

$\eta_{II} = \frac{COP_{ref}}{COP_{carnot}} = \frac{1.726}{5.07} = 34\%$

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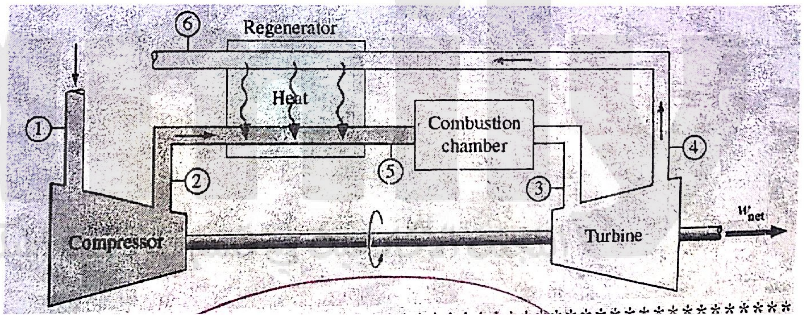
Question 2)

Helium is used as the working fluid in a Brayton cycle with regeneration. The pressure ratio of the cycle is 8, the compressor inlet temperature is 300 K, and the turbine inlet temperature is 1800 K. The effectiveness of the regenerator is 75 percent. The cycle produces net power output of 60 MW. Assuming both the compressor and the turbine have an isentropic efficiency of 100 %, determine :

1) The works IN and OUT, Heats IN and OUT.
2) The thermal efficiency
3) The required mass flow rate of helium.
4) The second law efficiency of the cycle,
5) The back-work ratio,
6) What are the other cycles used to improve the thermal efficiency of the Brayton cycle. Explain their effect.



Question 3)

A mixture of ideal gasses consists of ~~30%~~ 20 % H_2, ~~40%~~ 40 % He, ~~30%~~ 20 % N_2 and ~~20% C_2H_6~~ 20 C_2H_6 on volume basis. The mixture as shown in the figure below expands isentropically 5MPa and 600 C to 200 kPa. Calculate:

1) The total number of moles for the mixture (N_m),
2) The apparent molecular weight of the mixture (M_m),
3) The apparent gas constant for the mixture (R_m),
4) The apparent specific heat of the mixture at constant volume and constant pressure.
5) The work produced per unit mass of the mixture,

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~~suppose N_m = 100 kmol~~

By volume → y

$P_1 = 5$ MPa, $T = 600$ C

$P_2 = 200$ kPa

i	y_i	M_i	mf_i	y_iM_i	Cp_i	Cv_i	N_i
H_2	.20	2	0.03	0.4	14.307	10.183	20
He	.4	4	0.117	1.6	5.1926	3.1156	40
N_2	.2	28	0.412	5.6	1.039	0.743	20
C_2H_6	.2	30	0.441	6	1.7662	1.4897	20
	1			13.6			

$M_{mix} = \sum y_i M_i = 13.6$

$R_m = \frac{R_u}{M_{mix}} = \frac{8.314}{13.6} = 0.6113$ KJ/kg.

$mf_i = y_i \frac{M_i}{M_{mix}}$

$Cp_m = \sum mf_i \, cp_i = 0.03 * 14.307 + 0.117 * 5.1926 + 0.412 * 1$
$+ 0.441 * 1.7662$
$= 2.2437$ ~~= 1.802~~ $\frac{KJ}{kg.K}$

$Cv_m = \sum mf_i \, Cv_i = 0.03 * 10.183 + 0.117 * 3.1156 + 0.412 * 0.74$
$+ 0.441 * 1.4897$
$= 1.633 \frac{KJ}{Kg.K}$

$k_m = \frac{Cp_m}{Cv_m} = 1.374$