-5

1. Carnot developed the cycle comprised of four processes shown in the figures below.

a. Use the boxes to describe the **key** descriptors of the processes and draw the process on the TS diagram. (hint: Processes 1-2 and 3-4 are isentropic)

b. Start with the equation $\delta q = C_v dT + \frac{RT}{v} dv$. Apply it to the four processes in the Carnot cycle to show that $\left(\frac{q_H}{q_L}\right)_{rev} = \frac{T_H}{T_L}$.

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$q_H - q_L = C_v(T_H - T_L) + RT \ln \frac{V_2}{V_1}$

Process 1-2: $\int \delta q = \int C_v dT + \int \frac{RT}{V} dv$

$q_H - q_L = C_v(T_H - T_L) + RT \ln \frac{V_2}{V_1}$

$q_H - q_L = RT$

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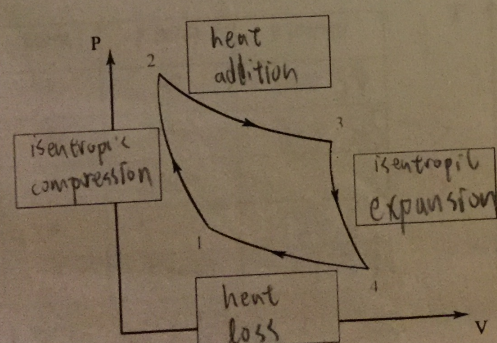
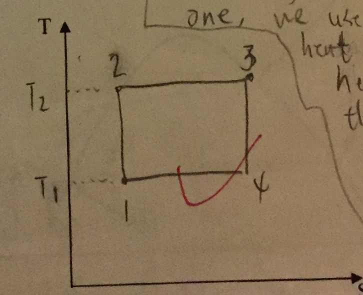
c. Comment on the difference between using q and T in calculating thermal efficiency.

① $- \eta_{th,carn} = 1 - \frac{T_L}{T_H}$

-5 ② $- \eta_{th,carn} = 1 - \frac{Q_L}{Q_H}$

From the equation we can see that first ① uses T_L and ~~T_H which is from the environment~~ (i.e. boiler or condenser). For the second one, we use the actual heat addition and heat loss to the system, is some case the ② will be more accurat



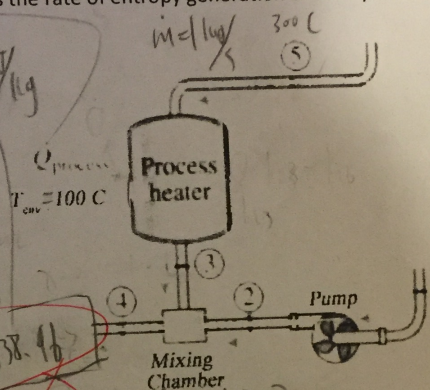


(50)

2. Focus on one small part of a cogeneration vapor power cycle system, shown in the device-pipe diagram below:

The pump operates between 50 kPa and 5 MPa with an isentropic efficiency of 80%. The inlet of the process heater (state 5) is at 300 C. Both the inlet of the pump (state 1) and the outlet of the ideal mixing chamber (state 4) is at saturated liquid state. The mass flow rate through both the pump and the process heater is 1 kg/s.

a. Fill in the missing properties of each state in the below table. (Please show how you get all the values to receive credit)
b. Show the processes on the T-s diagram. (Label all the states and connect them with lines representing the correct processes)
c. What is the rate of process heat generation?
d. What is the rate of entropy generation of this system?



1: h_f @ 50 kPa = 340.54 kJ/kg

2: $\eta = \frac{h_{2s} - h_1}{h_{2a} - h_1}$

$h_{2a} = \frac{h_{2s} - h_1}{\eta} + h_1$

$= \frac{338.96 - 340.54}{0.8} + 340.54$

$s_1 = s_2 = 1.0912$, $h_{2s} \approx 338.96$

$P_5 = P_2 = P_3 = 5000$ kPa

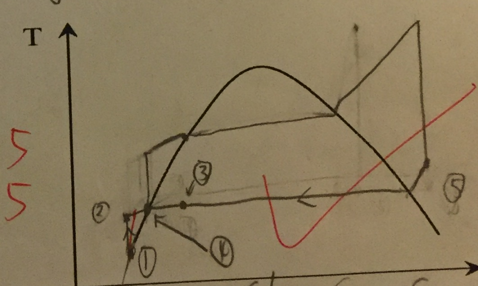
$P_5 = 5000$ kPa, $T_5 = 300$ °C → $h_5 = 2925.7$

④ $P_4 = 5000$ kPa, $x_4 = 0$ → h_4

$T_3 = 300$ °C, $P = 5000$ kPa

State	P [kPa]	h [kJ/kg]
1	50	340.54
2	5000	338.565
3	5000	
4	5000	1154.5
5	5000	2925.7

−5
−5



(c) $\dot{Q} = \dot{m}(h_3 - h_5)$
$= 1 \cdot (h_3 - 2925.7)$

(d) $\Delta S_{sys} = S_{in} - S_{out} + S$

$S_{gen} = \frac{-\dot{Q}}{T_3} + \dot{m}_4 s_4$

-5

$-\frac{Q}{T_3} + 1($