Seat No.

King Mongkut's University of Technology Thonburi
Final examination of semester 2/2013

CHE 452 ChE Plant Design   4th-year ChE students (Regular and International)
Thursday 8th May 2014   1:00 pm-4:00 pm

Instructions: (Please read them carefully.)

1) This examination paper consists of 5 questions with 13 pages in total. The full score is 100.
2) *Answer all questions in this paper*. If you require additional space to answer, please continue on the back of each answer sheet.
3) This is an *open-book examination*. Students are allowed to bring any document into the examination room.
4) Only scientific calculator complying with the university's regulation is allowed during the examination.

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Important notes:

- **Once completing your examination paper, please ask for permission from your proctor to leave the room.**
- **Students are not allowed to take any examination paper out of the room.**
- **Any cheating during the examination will not be tolerated. The maximum penalty is dismissal from university.**

Examiner: Asst. Prof. Dr. Bunyaphat Suphanit
Tel: 9222

No.	Scores (100)
1 (15)	
2 (35)	
3 (20)	
4 (15)	
5 (15)	
Total	

This paper was evaluated and approved by the ChE Dept.

(Assoc. Prof. Dr. Piyabutr Wanichpongpan)
Head of Chemical Engineering Dept.

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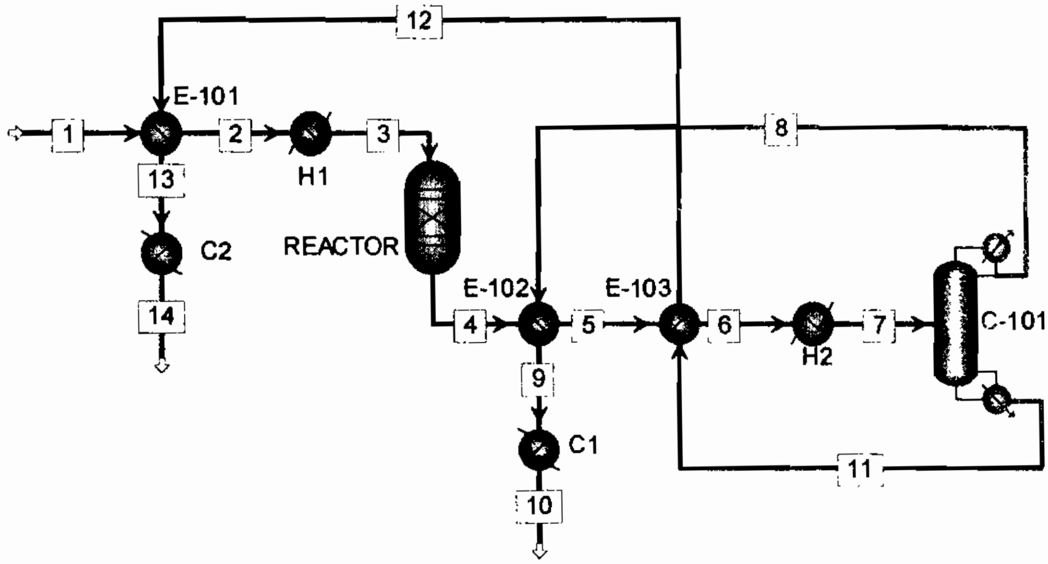
1) From the given flowsheet, calculate the missing temperatures and heat loads in the data table. Determine all hot and cold stream data, and fill in the stream data table (Table 1). (15 points)



Data given are as follows:

Location	Temp.(°C)
1	
2	70
3	160
4	120
5	150
6	
7	260
8	180
9	138.75
10	20
11	280
12	
13	
14	60

Exchanger	Heat load (kW)
E-101	2,500
E-102	1,650
E-103	
H1	4,500
H2	2,750
C1	
C2	800

Heat loads of condenser and reboilers are not taken into accounted.

Table 1 : Stream data

Stream	Supply Temp (°C)	Target Temp (°C)	CP (kW/°C)	ΔH (kW)
Feed				
Reactor Effluent				
Distillate				
Bottom product				

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2) From the given stream data below,

Table 2: Stream data

Stream	Supply Temp (^oC)	Target Temp (^oC)	CP (kW/^oC)
H1	327	40	10
H2	220	160	16
H3	220	60	6
H4	160	45	40
C1	100	300	10
C2	35	164	7
C3	85	138	35
C4	60	170	6
C5	140	300	20

If ΔT_{min} = 10 ^oC, use problem table algorithm to determine:

a) Pinch interval temperature. (T_{Pinch})
b) The minimum hot and cold utility requirement (Q_{Hmin}, Q_{Cmin}) (use Table 3)
c) Draw Grand Composite Curve (GCC) on the provided chart.
d) If the available utilities are flue gas at 400^{o}C, HP steam at 250^{o}C and CW operating between 30-40^{o}C, show all utility lines on the GCC.

(35 points)

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Table 3 : Surplus/Deficit in each interval temperature

	Interval	ΔT (°C)	ΣCP_H (kW/°C)	ΣCP_C (kW/°C)	ΣCP_H - ΣCP_C	ΔH (kW)

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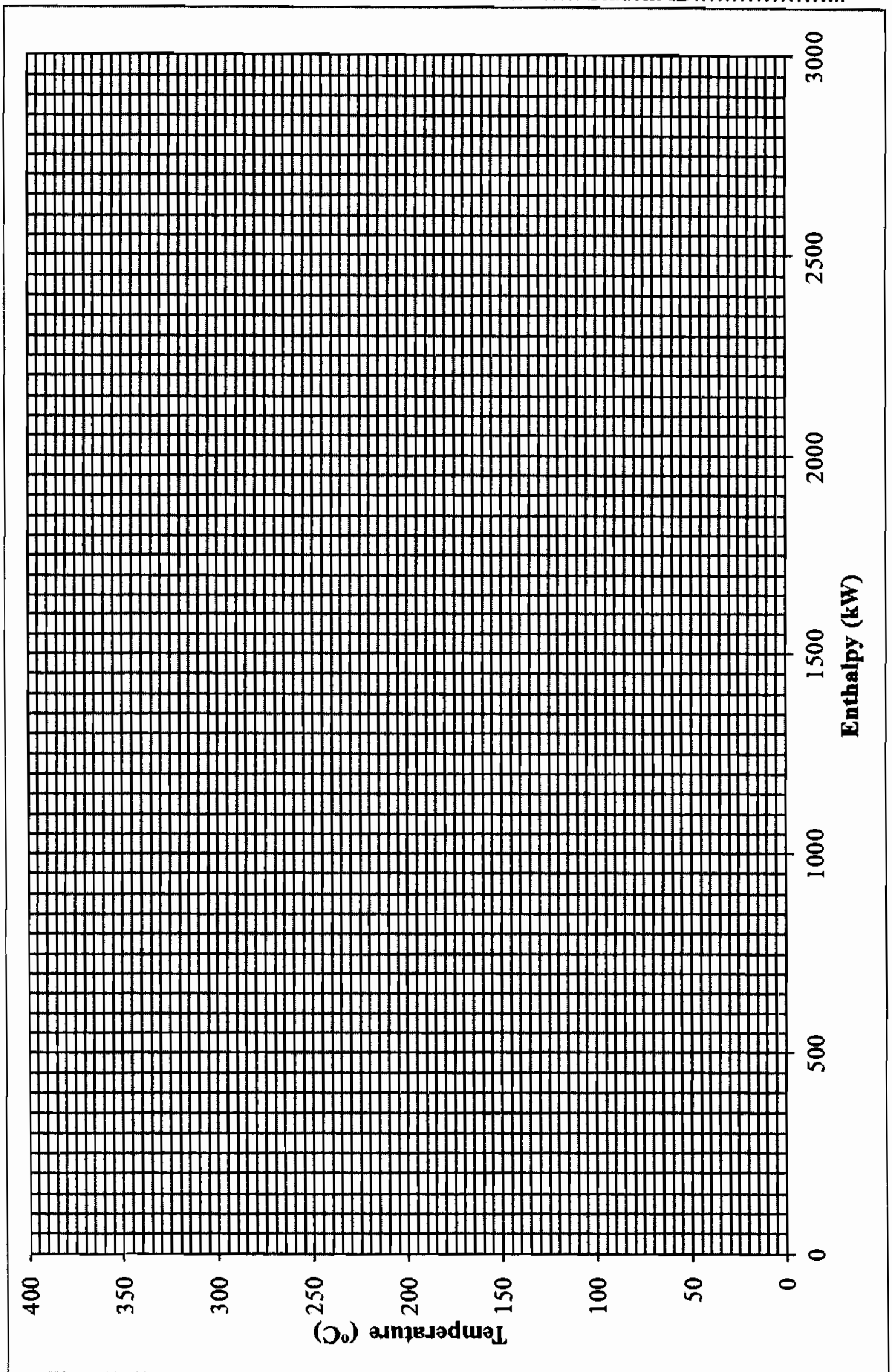
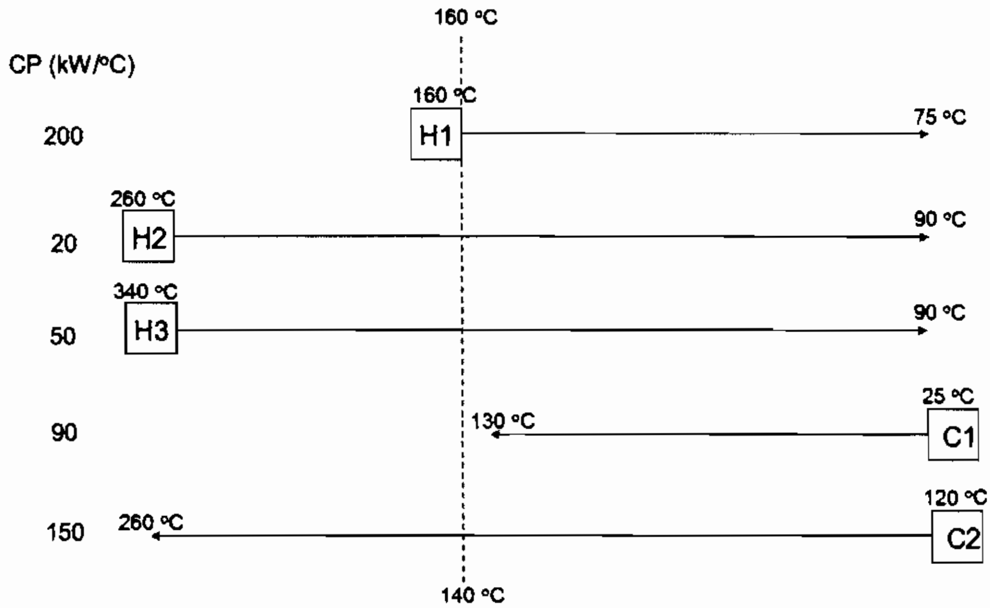


3) From the given grid diagram with ΔT_{min} of 20°C, design an MER network which can achieve Q_{Hmin} of 7,000 kW and Q_{Cmin} of 9,450 kW. Describe each hot-and-cold stream matching step and display all inlet and outlet temperatures of all heat exchangers on the grid diagram.

Please show your resulting MER network on next page. (20 points)



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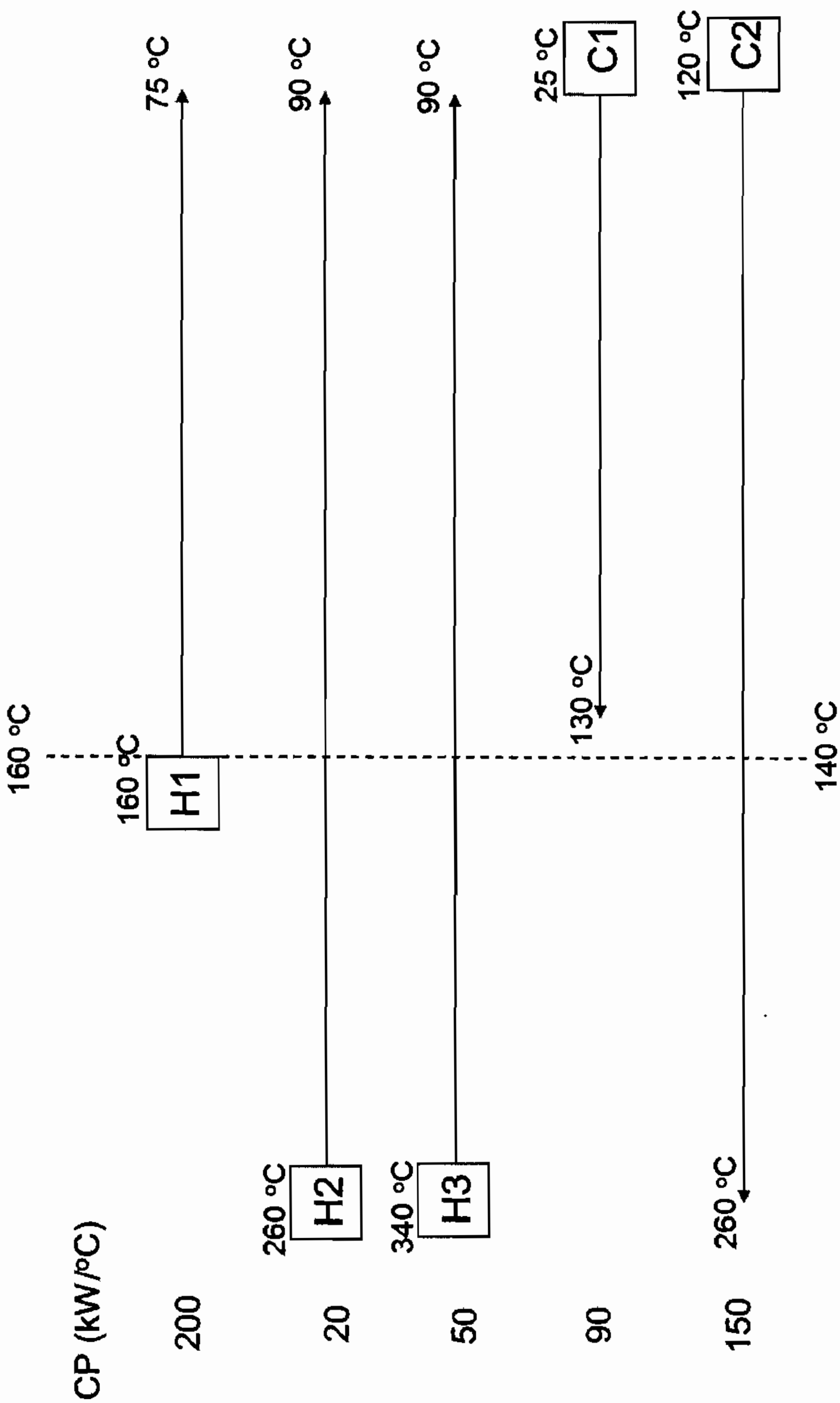
Answer sheet for question 3)



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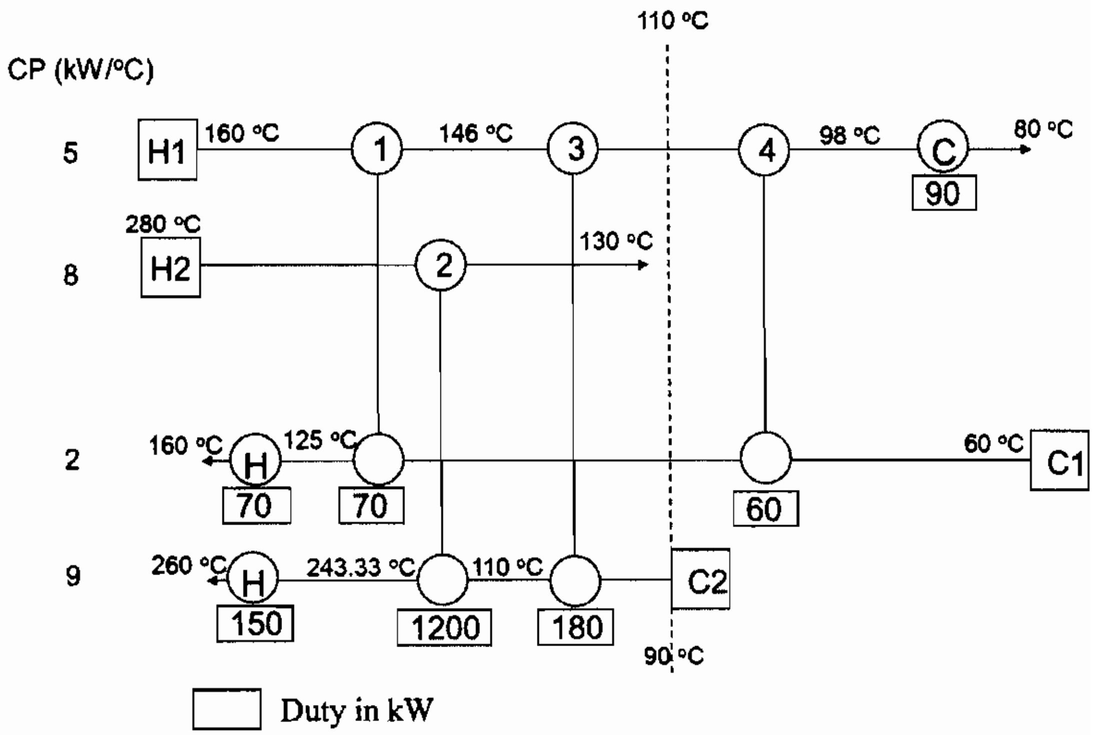
4) From the given heat exchanger network,



a) What is the maximum number of exchangers that can be removed from this network? Please give a brief reason to support your answer.
b) Show the existing loops in this MER network on the grid diagram.
c) Remove <u>only one recovery exchanger</u> (No. 1, 2, 3, or 4) while still maintaining ΔTmin at 20°C.
d) Determine the increase in hot utility when compared to Q_{Hmin}.

Show your results on next pages.

(15 points)

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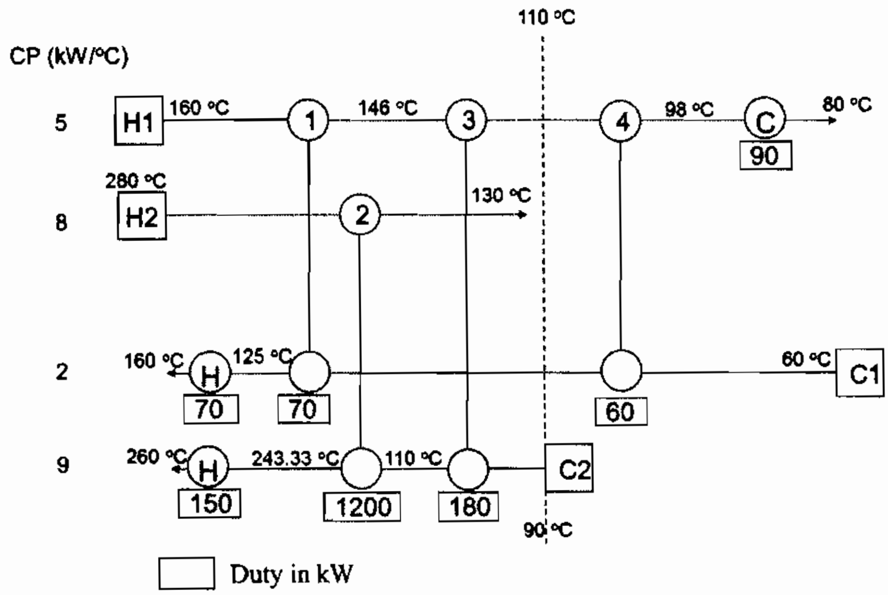
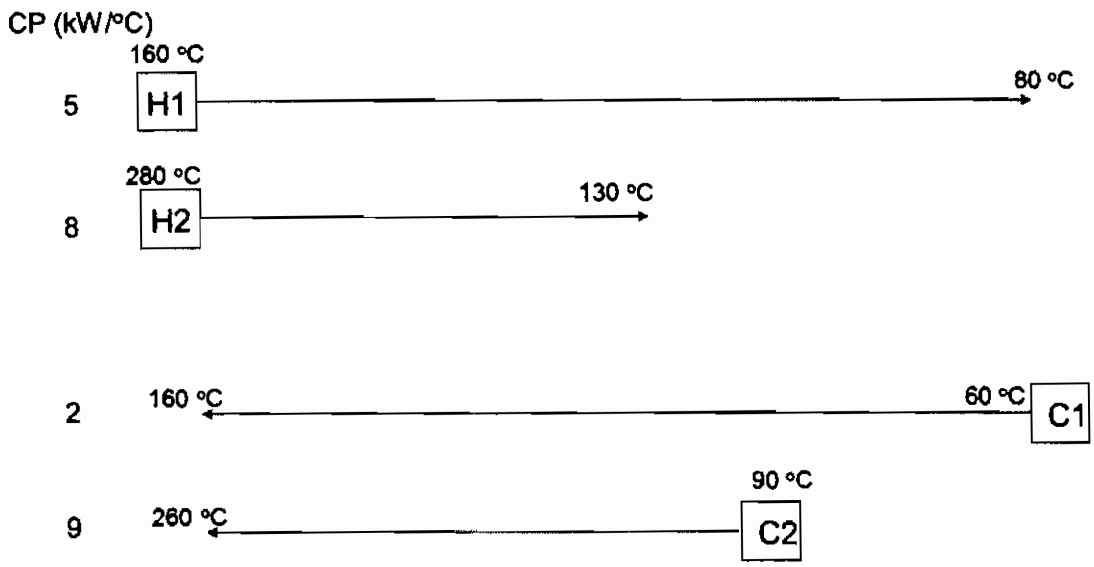
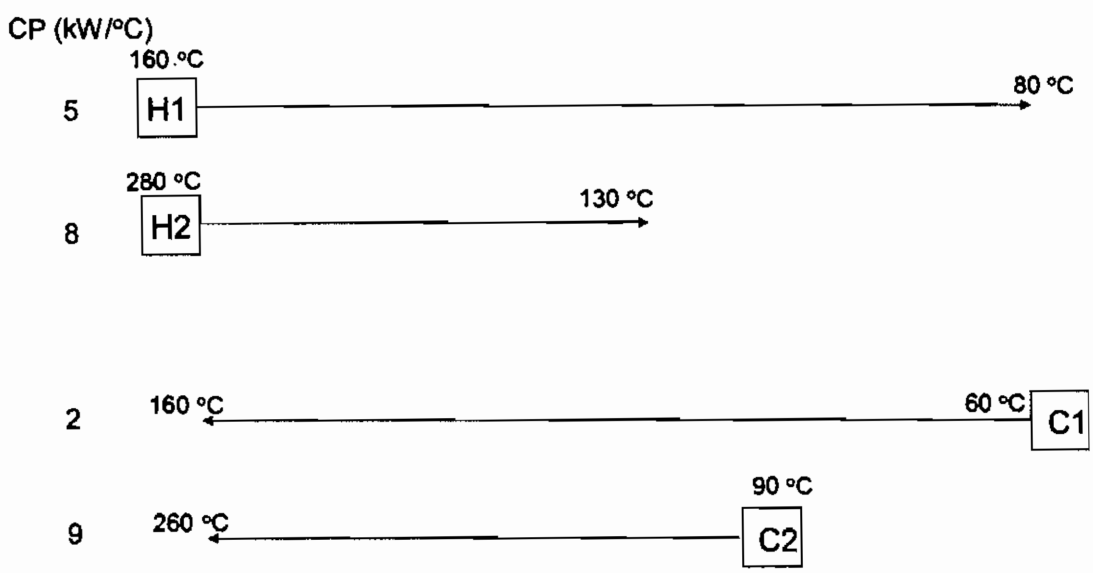
Answer sheet for question 4)







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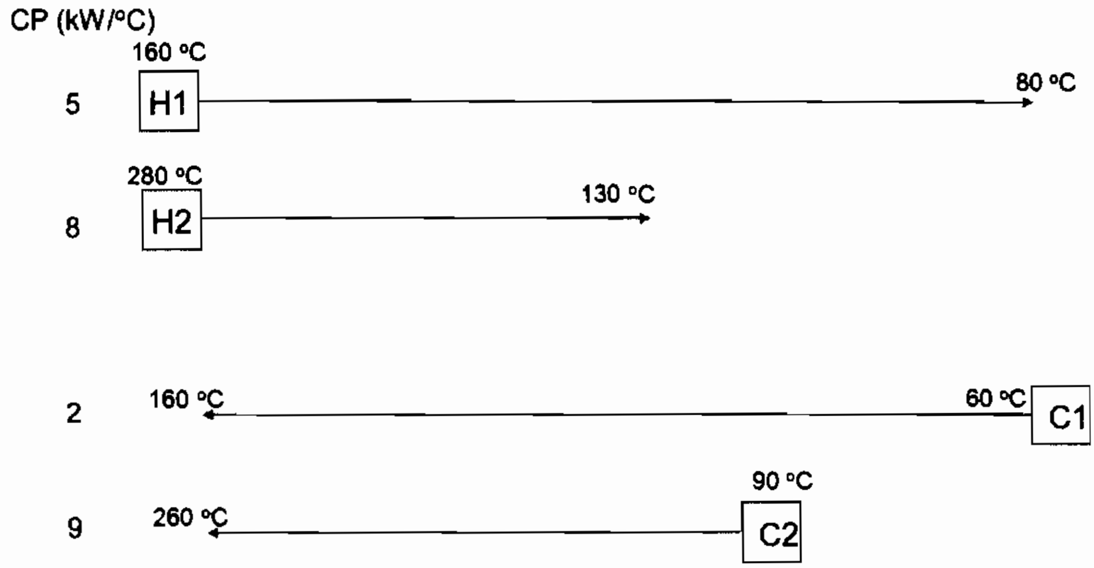

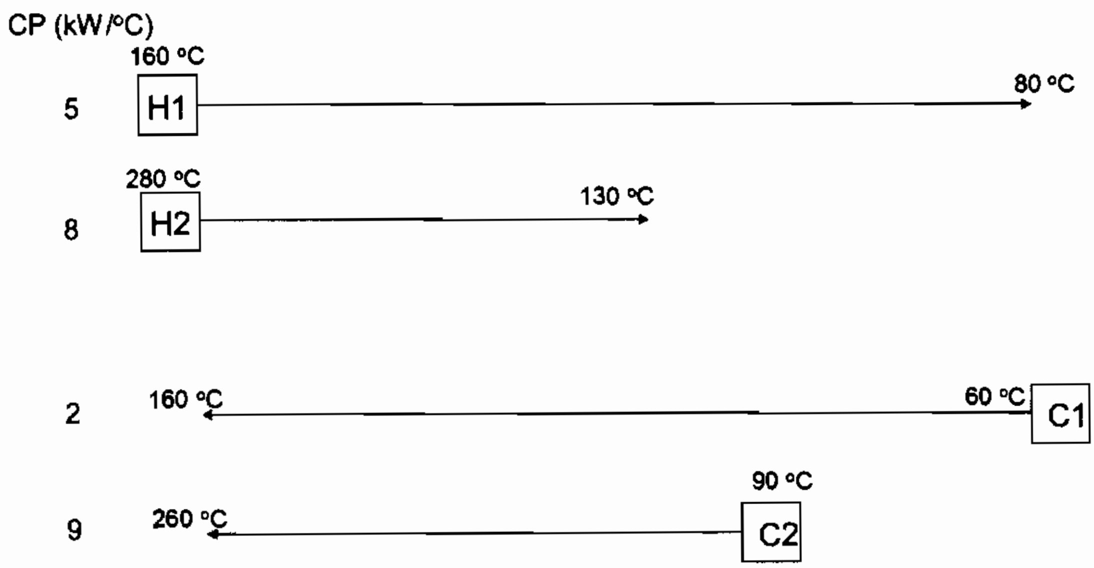

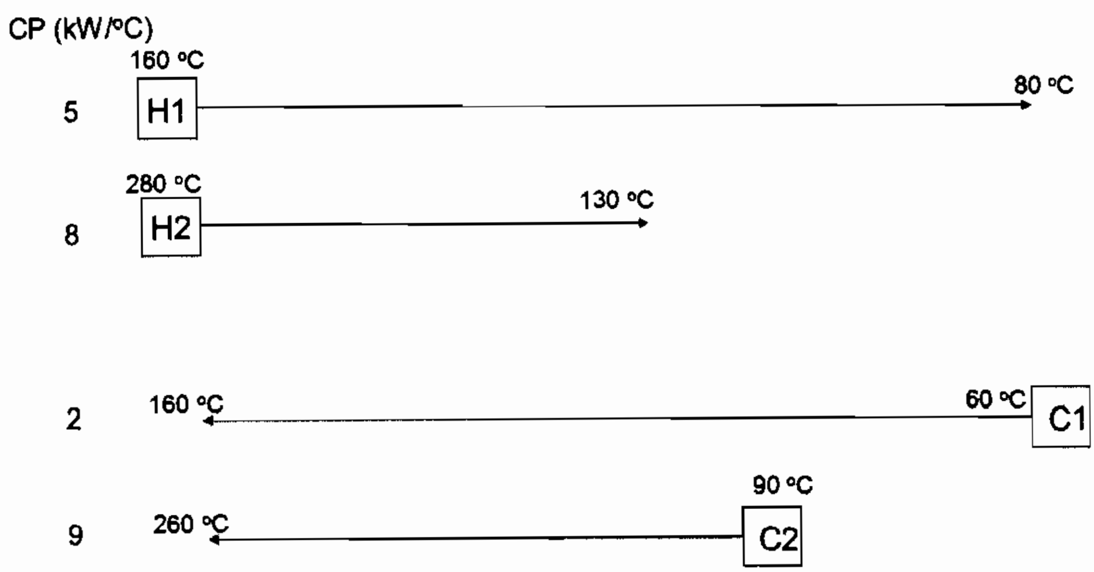

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5) Determine the optimum conversion of an isothermal plug-flow reactor with reaction A→B which is first-order. The separation between reactant and product is assumed to be cost-free. The unconverted reactant cannot be recycled. The total cost of the process involves the economic trade-offs between the raw material cost and the reactor cost as written below.

$$TAC\ (\$/yr) = C_F F_F + C_{VR} V_R / T$$

The production rate is related to the feed rate by

$$P = F_F X$$

Where X is conversion,
V_R is reactor volume (m^3).

(15 points)

Given information:
Density of feed (ρ) = 1,100 kg/m^3
Production rate (P) = 10,000,000 kg/yr
Feed cost (C_F) = \$5/kg
Reactor cost (C_{VR}) = \$100,000/m^3
Rate constant (k) = 0.0001 h^{-1}
Operating hours per year = 8,000 hrs.
Equipment life time (T) = 10 yrs.
Assume no interest rate.