PROCESS INTEGRATION
(CHEN 4232)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) In a chemical plant, the onion model design strategy starts
(a) with the core of the process (b) with the Heat exchanger Networking
(c) with the utilities (d) none of the above.

(ii) In Heat Exchanger Network synthesis it is possible to quantify targets for
(a) minimum utility consumption (b) minimum number of units
(c) minimum area (d) all of the above.

(iii) Process Integration
(a) changes the characteristics of the plant
(b) increases interaction in the plant
(c) both (a) and (b)
(d) none of the above.

(iv) Process Integration is motivated
(a) from economic benefit (b) from technical benefit
(c) both (a) and (b) (d) none of the above.

(v) The "pinch" signifies
(a) minimum energy requirement (b) maximum utility cost
(c) minimum exchanger area (d) minimum driving force.

(vi) Above the "pinch point", for MER network design
(a) utility cooling can be used (b) utility heating can be used
(c) both can be used (d) none can be used.

(vii) A numerical procedure for network design involving a single pinch is
(a) composite curve method (b) problem table algorithm
(c) grand composite curve method (d) supertargeting.

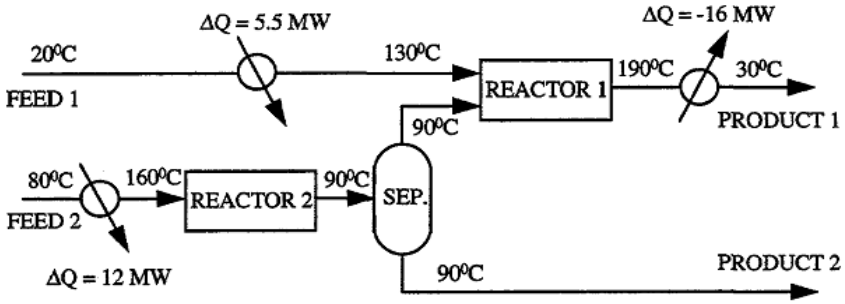
(viii) "Loop breaking" is a means of
(a) supertargeting (b) optimizing a network design
(c) designing a preliminary network (d) area targeting.

(ix) Heat and Power integration can be achieved by
(a) Distillation (b) Regeneration
(c) Cogeneration (d) Recuperation.

(x) The performance of a heat pump is expressed by its
(a) power requirement (b) COP
(c) inlet temperature only (c) exit temperature only.

Group- B

2. Consider the plant shown in figure below where decisions regarding reaction path, reactors and separation have been made. The process does not have any material recycles.



The two feed streams require heating and PRODUCT 1 requires cooling. Table 1 below gives the data necessary for considering heat recovery between these three streams. Note that the classification of hot and cold streams is based on whether a stream requires cooling or heating, it does not depend on temperature.

Table 1

Stream Name	Stream No.	T_S, ^0C	T_t, ^0C	C_P. MW / ^0C
PRODUCT I	Hot 1(H1)	190	30	0.10
FEED 2	Cold 1(C1)	80	160	0.15
FEED 1	Cold 2 (C2)	20	130	0.05

Suggest a possible Heat Exchanger Network for this system and hence suggest the complete process including the HEN to show how HEN may influence the dynamics of the overall plant. [(CO1)(Analysis/IOCQ)]
12

3. Discuss in details the Pinch design methods with detail discussion on Targeting, Synthesis and Optimization. [(CO1)(Analyse/IOCQ)]
12

Group - C

4. (a) What is the utility of drawing composite curves in pinch analysis?
[(CO1)(Analyse/IOCQ)]

(b) For the following data, plot the hot composite curve on a graph paper:

Table 2

Stream number	Stream type	CP (kW/°C)	T_S (°C)	T_T (°C)
1	Cold	2	20	135
2	Hot	3	170	60
3	Cold	4	80	140
4	Hot	1.5	150	30

[(CO1)(Apply/IOCQ)]

3 + 9 = 12

5. For the data given in Table 2, perform pinch analysis based on a ΔT_{min} of 10°C, by Problem Table Algorithm. Determine the total heating and cooling utility loads.

[(CO2)(Evaluate/HOCQ)]

12

Group – D

6. Discuss the utility of stream-splitting in pinch analysis. [(CO3)(Analyse/IOCQ)]

12

7. Discuss the methodology of handling "Threshold Problems" in exchanger networking.

[(CO3)(Analyse/IOCQ)]

12

Group - E

8. Enumerate a suitable MER network design method for a crude preheat train.

[(CO4)(Evaluate/HOCQ)]

12

9. Explain the process flow in an aromatics plant. [(CO4)(Analyse/IOCQ)]

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	0	75	25

Course Outcomes (CO):

After completing this course students will be able to:

1. Perform pinch analysis on a given Heat exchange system to identify non-optimal arrangements.
2. Design a Heat Exchanger Network (HEN) for a given heat exchange problem.
3. Analyze and optimize a HEN with respect to cost, energy requirement, area requirement etc.

4. Design energy-integrated process systems for distillation, chemical reaction, evaporation, refrigeration and cogeneration.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question