PROCESS INTEGRATION
(CHEN 4232)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Process Integration is motivated
(a) From economic benefit (b) From technical benefit
(c) Both (a) and (b) (d) None of the above

(ii) Major tasks that have a major impact on the overall properties of a plant are the selection of
(a) Reaction path and reactor(s) (b) Recycle and separation network
(c) Heat exchanger network and utilities (d) All of the above

(iii) If the hot utility load increases by 30 kW for a total heat exchange of 350 kW, the heat exchange possible now is
(a) 330 Kw (b) 320 kW (c) 380 kW (d) 300 kW

(iv) Temperature shifting is done by shifting the temperature interval values by
(a) ΔT_{min} (b) $\Delta T_{min}/2$ (c) $\Delta T_{min}/3$ (d) $2\ \Delta T_{min}$

(v) The overlapping region of the hot and cold composite curves represents
(a) The hot utility requirement
(b) The theoretical maximum amount of heat exchange possible
(c) The cold utility requirement
(d) The heat exchange possible at a particular ΔT_{min}

(vi) If one of the heat exchanging streams is a highly viscous liquid, then for a ΔT_{min} of 10°C, its ΔT_{cont} should be
(a) 5°C (b) 4°C
(c) >5°C (d) It does not depend on liquid viscosity

(vii) Above the pinch, the number criteria for stream matching is
(a) $N_{Hot} = N_{Cold}$ (b) $N_{Hot} > N_{Cold}$
(c) $N_{Hot} < N_{Cold}$ (d) $N_{Hot} \leq N_{Cold}$

(viii) A closed path through a heat exchanger network is called a
(a) Circuit (b) Path
(c) Stream (d) Loop

(ix) If the temperature difference between the low temperature heat source and the high temperature heat sink decreases, the COP of the heat pump
(a) Decreases (b) Increases
(c) Remains same (d) Decreases, then increases

(x) The integration of a gas turbine with a steam turbine for generating power is called
(a) Linde Cycle (b) IGCC
(c) Rankine Cycle (d) Otto Cycle

Fill in the blanks with the correct word

(xi) In a chemical plant, the onion model design strategy starts with the _____of the process.

(xii) The pinch design method consists of three stages, targeting, synthesis and _____.

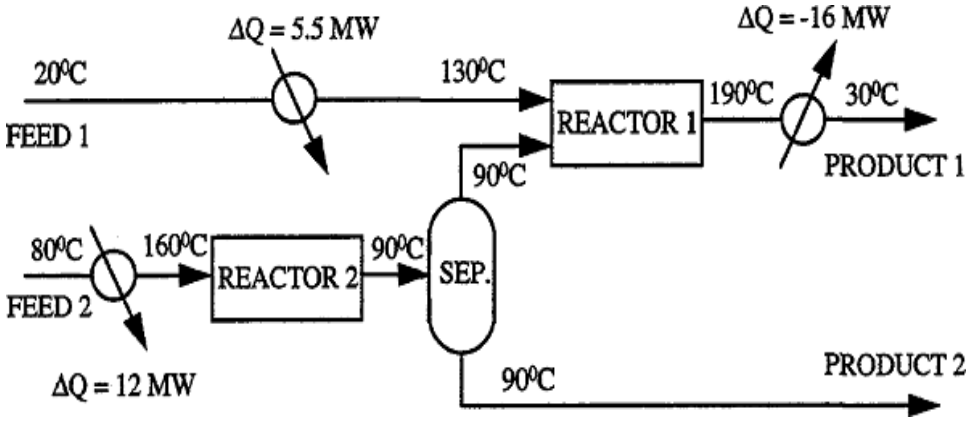
(xiii) The number criteria is generally fulfilled by _____ splitting.

(xiv) The full form of CHP is _____.

(xv) IGCC stands for _____.

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 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.

Stream Name	Stream No.	TS, ^{0}C	Tt, ^{0}C	CP. MW / ^{0}C
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 HEN for the system and hence suggest the complete process including the HEN to show how HEN may influence the dynamics of the overall plant.

[(CO2)(Apply/IOCQ)]

12

3. (a) Explain briefly how the concept of onion diagram is used in chemical engineering design. *[(CO1,2)(Understand/LOCQ)]*

(b) Discuss briefly the following two methods used for solving pinch systems
(i) Composite curves method
(ii) Problem table method. *[(CO1)(Remember/LOCQ)]*

4 + (4 + 4) = 12

Group - C

4. (a) What is the utility of a Composite curve? *[(CO1)(Understand/LOCQ)]*

(b) Prepare the Problem Table Algorithm for the following stream data:

Table 1

Stream No	Capacity (kW/K)	T_s (°C)	T_t (°C)
1	2	25	140
2	3	175	65
3	5	75	145
4	1.8	150	25

Take a ΔT_{min} = 10°C. *[(CO1)(Apply/IOCQ)]*

4 + 8 = 12

5. (a) Increase in the value of ΔT_{min} results in a reduction of the heat exchange possible between the hot and cold streams. Justify this, especially given that ΔT_{min} is the driving force for heat exchange and increasing it should favour the heat exchange, but it doesn't. *[(CO3)(Analyse/IOCQ)]*

(b) Where should the cold utilities be placed in a grand composite curve and why? *[(CO3)(Analyse/IOCQ)]*

5 + 7 = 12

Group - D

6. (a) Device the MER Network for the following problem, with a ΔT_{min} = 10°C :

Table 2

Stream No	Capacity (kW/K)	T_s (°C)	T_t (°C)
1	2	25	140
2	3.5	175	65
3	5	75	145
4	2.5	150	25

[(CO2)(Create/HOCQ)]

(b) Is there a loop within the network? If so, identify it. *[(CO3)(Analyse/IOCQ)]*

9 + 3 = 12

7. (a) In case of multiple available utilities, how do we select among the different utilities? *[(CO3)(Analyse/IOCQ)]*

(b) Between high pressure steam and low pressure steam, which one is selected for power generation and why? *[(CO3,4)(Analyse/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) How can energy integration be achieved in a Crude oil distillation system? Explain with a PFD. *[(CO4)(Evaluat/HOCQ)]*

   (b) What is the basic principle of IGCC? *[(CO4)(Understand/LOCQ)]*

8 + 4 = 12

9. (a) An irreversible heat engine extracts heat from a hot source at a rate of 100 kW and rejects heat to a cold sink at the rate of 50 kW. The work output from the engine is used to drive a reversible heat pump working between 17°C and 75°C. What is the rate at which the heat pump delivers heat to the high temperature sink? *[(CO4)(Apply/IOCQ)]*

   (b) Comment on the energy integration in an absorption-desorption system. *[(CO4)(Evaluate/HOCQ)]*

8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.17	48.96	21.87