

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.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Process Integration:
 - (a) Is limited to the design of new plants.
 - (b) May involve design of new plants as well as retrofit design.
 - (c) Is involved only in operation.
 - (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) Process Integration is primarily based on
 - (a) Mass balance
 - (b) Heat balance
 - (c) Pinch Concept
 - (d) None of the above
- (iv) A well designed plant generally gives an opportunity for how much annual energy cost reduction?
 - (a) >50%
 - (b) 40-50%
 - (c) 20-30%
 - (d) upto 10%
- (v) 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
- (vi) A plot of the Temperature vs the net heat flow in each interval of the PTA is called
 - (a) Grand Composite curve
 - (b) Hot Composite curve
 - (c) Cold Composite curve
 - (d) Threshold curve

- (vii) If the pinch temperature boundary is at 75°C in a PTA for $\Delta T_{\min} = 10^\circ\text{C}$, the pinch temperatures for the hot and cold streams are
 (a) 70°C, 80°C (b) 85°C, 75°C
 (c) 80°C, 70°C (d) 75°C, 85°C
- (viii) An example of a hot utility is
 (a) Chilled water (b) Cooling water
 (c) Condensing steam (d) Chilled brine
- (ix) For power generation, the most suitable type of steam is
 (a) High pressure steam (b) Medium Pressure steam
 (c) Low pressure steam (d) Ultra high pressure steam
- (x) In a heat engine, the exhaust steam from the turbine is sent to a
 (a) Heat Exchanger (b) Boiler
 (c) Compressor (d) Steam Trap

Fill in the blanks with the correct word

- (xi) A superstructure in process integration includes all Process _____.
- (xii) The full form of GCC is _____.
- (xiii) The heat exchanger area _____ with $\Delta T_{\min}$.
- (xiv) Chilled water generally has a temperature of _____.
- (xv) Temperature cross can be avoided by increasing the number of _____ in series.

Group - B

2. (a) Explain in details the concepts of Process Integration in general and with respect to Chemical Engineering in particular. [[C01](Remember/LOCQ)]
 (b) State the common assumption of any process design. [[C01](Remember/LOCQ)]
 (c) Explain the main advantage of process integration over the analytical approach. [[C01](Remember/LOCQ)]
8 + 2 + 2 = 12

3. (a) Between the Composite curves method and problem table algorithm method, which one is more advantageous? Justify your thoughts. [[C01](Evaluate/HOCQ)]
 (b) Define the following terms:
 (i) Superstructure
 (ii) HEN. [[C01](Remember/LOCQ)]
8 + (2 + 2) = 12

Group - C

4. (a) Consider a system where A and B react to form two products C and D. The feed to the reactor is to be preheated before the reaction, which takes place at 500°C and 5 atm pressure. The product stream (along with the unreacted B) is to be separated by distillation at 250°C and 1.5atm pressure, which gives C as the top

product and a mixture of B and D as the bottoms. Develop the process flow diagram of the system, implementing heat integration wherever possible.

[[C02,4](Create/HOCQ)]

- (b) What is Energy targeting?

[[C01,3](Remember/LOCQ)]

10 + 2 = 12

5. (a) Prepare the Problem Table Algorithm for the following stream data:

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

Take a $\Delta T_{\min} = 20^{\circ}\text{C}$.

[[C01](Apply/IOCQ)]

- (b) Calculate the hot and cold utility requirements and the pinch temperatures for the hot and cold streams, for part (a).

[[C01,2](Apply/IOCQ)]

8 + 4 = 12

Group - D

6. (a) What is the utility of stream splitting?

[[C03](Analyse/IOCQ)]

- (b) Write the algorithm for stream splitting below the pinch.

[[C03](Remember/LOCQ)]

6 + 6 = 12

7. (a) What is meant by temperature cross? How can it be avoided in heat exchanger networking?

[[C03](Analyse/IOCQ)]

- (b) Write the algorithm for stream splitting above the pinch.

[[C03](Remember/LOCQ)]

(3 + 3) + 6 = 12

Group - E

8. (a) If a heat engine operates between a High temperature source at 450 K and a low temperature sink at 300 K, what is the efficiency of the engine considering it to be completely reversible?

[[C04](Apply/IOCQ)]

- (b) What is the significance of the COP of a heat pump?

[[C04](Analyse/IOCQ)]

6 + 6 = 12

9. (a) What are the functions of heat recovery steam generators and economizers?

[[C04](Analyse/IOCQ)]

- (b) A MER network is not always the network of choice in a chemical process plant. Justify.

[[C04](Evaluate/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.25	43.75	25

