

GUJARAT TECHNOLOGICAL UNIVERSITY
ME - SEMESTER- 3 (NEW) • EXAMINATION – WINTER - 2023

Subject Code: 3731606**Date: 02 Dec 2023****Subject Name: Advance Chemical Process Synthesis****Time: 10:30 AM TO 01:00 PM****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

- Q.1 (a)** Briefly describe the role of computers in product and process design. **07**
(b) Justify the statement “No heat should pass across the pinch for the minimum utility consumption design” with suitable diagram. **07**

- Q.2 (a)** Explain how Underwood’s method can be used for finding the best distillation sequence for multicomponent mixtures. **07**
(b) Explain the step wise procedure for construction of attainable region. **07**

OR

- (b)** Write a short note on geometric concepts for reactor attainable region. **07**
Q.3 (a) Consider a plant consisting of two stages that manufactures two products A and B. Demands are 500000 kg/year for A and 300000 kg/year for B and the production time considered is 6000 hr. The production schedule is single product campaigns and length of production cycle is 1000 hr. Perform the sizing of vessels for the plant. Data for Processing time, size factors and cleanup times are as follows: **07**

Product	Processing times (hr)		Size Factors (m ³ /kg roduct)	
	Stage 1	Stage 2	Stage 1	Stage 2
A	8	3	0.08	0.05
B	6	3	0.09	0.04
Cleanup Times: 4 hrs for A to B and B to A				

- (b)** Explain in detail the significance of Grand Composite Curve for integration of other equipment with the background process. **07**

OR

- Q.3 (a)** Explain overlapping and non-overlapping operations in batch scheduling. Also describe how placing of parallel units can be beneficial in a batch plant. **07**
(b) For the stream data given below, design a Heat Exchange Network (HEN) when the minimum utility consumptions are $Q_H = 2360$ kW and $Q_C = 1860$ kW at pinch temperatures 150 and 160 K. **07**

Stream	T _{in} , K	T _{out} , K	FC _p , kW/K
H1	180	40	20
H2	160	40	40
C1	60	220	30
C2	30	180	22

- Q.4 (a)** For a multi-component mixture consisting of 10 products, calculate the number of possible sequences of distillation column for separation of individual products. Explain how marginal vapor rate method can be used for finding the best distillation sequence for multicomponent mixtures. **07**

- (b) Determine the pinch point and minimum utility requirements for the given stream data using Hohmann Lockhart Composite Curve (HCC). Take $\Delta T_{\min} = 20$ K. 07

Stream	T _{in} , K	T _{out} , K	FC _p , kW/K
H1	525	300	2
H2	500	375	4
H3	475	300	3
C1	275	500	6

OR

- Q.4 (a) A feed mixture consists of four alcohols labeled as A, B, C, and D with a total flow of 9.75 mol/s. The individual flow rates of A, B, C and D in the feed are 1.05, 0.5, 1.2 and 7 mol/s respectively, and relative volatilities are 3.4, 2.5, 2 and 1 respectively. The information about marginal vapor flows estimated for non-key species are given in the table below. Find the best and third-best distillation sequences and also sketch both the sequences. 07

	A	B	C	D
A/B	--	--	2.53	3.59
B/C	3.11	--	--	5.6
C/D	1.88	1.25	--	--

- (b) Determine the minimum utility consumption for the hot and cold streams given below using Grand Composite Curve method. Take $\Delta T_{\min} = 10$ K. 07

Stream	T _{in} , K	T _{out} , K	FC _p , kW/K
H1	480	250	2
H2	430	180	3
C1	100	400	2.5
C2	150	360	2.5
C3	200	400	2.5

- Q.5 (a) Mass exchanger network is to be designed for removal of H₂S from sour coke oven gas (a mixture of H₂, CH₄, CO, N₂, NH₃, CO₂ and H₂S). It is proposed to remove H₂S and send it to a unit to convert it to sulfur. The conversion is incomplete in that unit and hence tail gases must be sent for H₂S removal. Adsorption is to be used for H₂S removal using aqueous ammonia or chilled methanol as MSA (Mass Separating Agent). 07

Stream	F (kg/s)	y ^s or x ^s	y ^t or x ^t
Coke oven gas	0.9	0.0700	0.0005
Tail gases	0.1	0.0510	0.0003
Aq. NH ₃	2.3	0.0008	0.0310
Methanol	Unlimited	0.0001	0.0035

Equilibrium data is given by $y = 1.45x$ for aqueous ammonia and $y = 0.26x$ for chilled methanol. Find out pinch point and minimum amounts of external MSA.

- (b) Define makespan and cycle time for batch processes. Explain various policies with example. 07

OR

- Q.5 (a) Products A and B are produced in the same plant via batch operations. Plant needs to produce the same number of batches of each product using ABAB... sequence and processing times are given in Table below: 07

Product	Stage 1	Stage 2	Stage 3
A	6 hr	4 hr	3 hr
B	3 hr	2 hr	1 hr

Draw Gantt charts and also identify cycle times for each of the following transfer policies: 1. Zero-Wait transfer 2. No intermediate storage 3. Unlimited intermediate storage

- (b)** Explain the procedure of Concentration-Interval (CI) method for finding the pinch point and minimum amount of External Mass Separating agent for Mass Exchange Network Synthesis. **07**
