

B.Tech. (Chemical Engineering) Eighth Semester (C.B.S.)  
**Elective - III : Chemical Process Synthesis and Design**

P. Pages : 2

Time : Three Hours

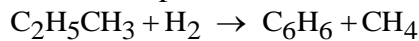


NIR/KW/18/3810

Max. Marks : 80

- Notes :
1. All questions carry marks as indicated.
  2. Solve **any five** questions.
  3. Due credit will be given to neatness and adequate dimensions.
  4. Assume suitable data whenever necessary.
  5. Diagrams and chemical equations should be given whenever necessary.
  6. Use of non programmable calculator is permitted.

1. a) Define steps involved in chemical process design & integration with onion model. 8  
b) What is retrofitting of a plant. Explain with suitable example. 8
2. a) Benzene is to be produced from toluene according to the reaction 8



some of the benzene formed undergoes a number of secondary reactions in series to unwanted by products that can be characterized by the reaction to diphenyl, according to the reaction  $2\text{C}_6\text{H}_6 \rightleftharpoons \text{C}_{12}\text{H}_{10} + \text{H}_2$

The compositions of the reactor feed and effluents streams are as follows:

Components	Inlet flow rate Kmol/hr	Outlet flow rate Kmol/hr
H <sub>2</sub>	1858	1583
CH <sub>4</sub>	804	1083
C <sub>6</sub> H <sub>6</sub>	13	282
C <sub>2</sub> H <sub>5</sub> – CH <sub>3</sub>	372	93
C <sub>12</sub> H <sub>10</sub>	00	04

Calculate the conversion, selectivity and reactor yield with respect to the

- i) Toluene feed
- ii) Hydrogen feed

- b) Discuss the various types of reaction systems in details. 8
3. a) Discuss the heterogeneous azeotropic distillation sequence with the help of suitable example and necessary diagrams. 8  
b) Discuss the heat integration characteristics of evaporators with appropriate placement to improve heat integration. 8

4. The stream data for a process are given in the following table. Steam is available between 180° and 179°C and cooling water between 20 and 40°C. for  $\Delta T_{\min} = 10^\circ\text{C}$ , the minimum hot and cold utility duties are 7 MW and 4 MW respectively. The pinch is at 90°C on the hot streams and 80°C on the cold streams. 16

Stream		T <sub>s</sub> (°C)	T <sub>T</sub> (°C)	Steam heat duty (MW)
No.	Type			
1.	Hot	150	50	-20
2.	Hot	170	40	-13
3.	Cold	50	120	21
4.	Cold	80	110	15

- a) Calculate the targets for the minimum number of units for maximum energy recovery.
- b) Develop two alternative maximum energy recovery designs, keeping units to a minimum.

5. a) Vapour flowrate in kmol/hr for each task for the separation of a four component mixture are 8

A/BCD	100	B/CD	90	A/B	70
AB/CD	120	BC/D	250	B/C	100
ABC/D	240	A/BC	130	C/D	220
		AB/C	140		

Determine the best distillation sequence for minimum total vapour flowrate.

- b) Develop a network super structure for the separation of a mixture of five components (A-B-C-D-E) into relatively pure products using simple tasks. 8
6. a) Discuss the heat integration of Heat pump. 8
- b) Discuss the pinch technology for Heat recovery with example. 8
7. a) A storage tank with a vent to be filled at 25°C with a mixture containing benzene with a mole fraction of 0.2 and toluene with a mole fraction of 0.8. Estimate the concentration of benzene and toluene in the tank vent: 8
  - a) at 25°C
  - b) Corrected to standard conditions of 0°C and 1 atm

Assume that the mixture of benzene and toluene obeys Raoult's Law and the molar mass in kilograms occupies 22.4 m<sup>3</sup> in the vapor phase at standard conditions. The molar masses of benzene and toluene are 78 and 92 respectively. The vapor pressures of benzene and toluene at 25° C are 0.126 bar and 0.0376 bar respectively.
- b) Write a short note on Inherent safety from fire, explosion & toxic release. 8
8. a) Discuss the problem table algorithm with suitable diagrams. 8

Chlorobenzene is manufactured by the reaction between benzene and chlorine. A number of secondary reactions occur to form undesired byproducts.

$$\text{C}_6\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_6\text{H}_5\text{Cl} + \text{HCl}$$

$$\text{C}_6\text{H}_5\text{Cl} + \text{Cl}_2 \rightarrow \text{C}_6\text{H}_4\text{Cl}_2 + \text{HCl}$$

$$\text{C}_6\text{H}_4\text{Cl}_2 + \text{Cl}_2 \rightarrow \text{C}_6\text{H}_3\text{Cl}_3 + \text{HCl}$$

make an initial choice of reactor type.
- b) Discuss different issues that must be addressed for reactor design. 8

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