CBCS SCHEME

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18CH742

Seventh Semester B.E. Degree Examination, July/August 2022
Chemical Process Integration

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Write notes on:
(i) Process analysis and process synthesis
(ii) Process integration and different activities of process integration. **(10 Marks)**

b. Consider a process with six sinks and five sources, for the data given below fresh water is used in sinks and it is desired to replace as much fresh water as possible using direct recycle of the process sources. Determine the target for minimum usage of fresh water and water discharge after direct recycle by graphical approach. Justify the results obtained.

Sink	Flow rate (ton/hr)	Max inlet conc (ppm)
1	120	0
2	80	50
3	80	50
4	140	140
5	80	170
6	195	240

Source	Flow rate (ton/hr)	Max inlet conc (ppm)
1	120	100
2	80	140
3	140	180
4	80	230
5	195	250

(10 Marks)

OR

2 a. Explain the traditional approach of practice in industry and their limitations. **(10 Marks)**

b. Determine by the source sink mapping minimum requirement of fresh and wastage of the hydrogen in the given process for the following data. Justify the result obtained and percentage of recovery of fresh and wastage.

Sink data	Flow (L/min)	Max con (%)
1	620	7
2	415	20
3	1800	25
4	140	25
5	346	27
6	457	30

Source data	Flow (L/min)	Max con (%)
1	2495	20
2	180	21
3	554	22
4	720	24

(10 Marks)

Module-2

3 a. Explain the general procedures step by step, the plot of mass pinch diagram and enumerate on the design rules of the pinch. **(10 Marks)**

b. The following data for rich and lean stream are given below, obtain the pinch point by graphical method and what is the excess load of process MSAs and load of extend MSAs. The equilibrium data for the pollutant in two process MSAs are given as $y = 0.25x_1$ and $y = 0.50\, x_2$ with 0.001 minimum allowable composition.

Stream	Flow rate (kg/s)	Supply composition (ppm)	Target composition (ppm)
R_1	0.2	0.0020	0.0001
S_1	0.08	0.003	0.006
S_2	0.05	0.002	0.004

(10 Marks)

OR

4 a. Explain the process of screening of multiple MSAs without the process MSAs. **(10 Marks)**

b. The following data for rich and lean stream are given below, obtain the pinch point by graphical method and what is the excess load of process MSAs and load of extend MSAs. The equilibrium data for the pollutant in two process MSAs are given as $y = 1x_1$ and $y = 2x_2$ with 300 ppm and 200 ppm minimum allowable composition.

Stream	Flow rate (kg/s)	Supply Comp (ppm)	Target Comp (ppm)
R_1	0.1	1200	100
S_1	0.1	500	700
S_2	0.3	200	350

(10 Marks)

Module-3

5 a. Explain the importance of mass integration and pinch point, and how minimum allowable composition have an impact on the cost of whole process. **(10 Marks)**

b. The following data for rich and lean streams are given below, obtain the pinch point by algebraic method and what is the excess load of process MSAs and load of extend MSAs. The equilibrium data for the pollutant in two process MSAs are given as $y = 0.25\, x_1$ and $y = 0.50\, x_2$ with 0.001 minimum allowable composition.

Stream	Flow rate (kg/s)	Supply composition (ppm)	Target composition (ppm)
R_1	2.0	0.030	0.005
R_2	3.0	0.010	0.001
S_1	17.0	0.007	0.009
S_2	1.0	0.005	0.015

(10 Marks)

OR

6 a. Explain in general the algebraic procedures to obtain the pinch point between source and sink. **(10 Marks)**

b. Use the algebraic approach, to obtain pinch point and justify the results.

Stream	Flow rate (kg-mole/s)	Supply Comp (mole fraction)	Target comp. (mole fraction)	M	E
R_1	0.2	0.002	0.0001		
S_1	0.08	0.003	0.006	0.25	0.001
S_2	0.05	0.002	0.004	0.50	0.001

(10 Marks)

Module-4

7 a. Enumerate on heat engines and heat pump with a neat sketch and placing heat engines and heat pump in what position of cascade diagram is beneficial. **(10 Marks)**

b. The hot and cold stream data stream data are given below. Design the HEN system for the following data assuming ΔT_m as 20°C by algebraic techniques. Justify the results obtained and find the percentage recovery.

Stream	FR × CP (KW/°C)	Supply Temp (°C)	Target Temp (°C)
H_1	40	10	120
H_2	85	15	5
H_3	45	15	110
C_1	45	80	20
C_2	10	75	25
C_3	50	85	5
C_4	10	120	45

(10 Marks)

OR

8 a. Explain the cogeneration technique considering any industrial example. **(10 Marks)**

b. Using the following data, obtain thermal pinch point, cooling and heating utility using the algebraic technique. Construct a GCC curve to screen out the hot utilities required among the available stream. Available for services are two heating utilities a high pressure steam at 140°C and very high pressure stream at 165°C. Justify the results obtained using $\Delta T = 10°C$.

Stream	Flow rate (KW/°C)	Supply Temp (°C)	Target Temp (°C)
H_1	3	170	60
H_2	2	150	30
C_1	2.25	20	135
C_2	4.25	80	140

(10 Marks)

Module-5

9 a. Explain the cost optimization of ΔT, and effect of the ΔT in heat integration. **(10 Marks)**

b. With the help of mathematical equations, explain the synthesis of HEN system in a typical industry. **(10 Marks)**

OR

10 a. Write the mathematical technique for the synthesis of MEN system and its applications. **(10 Marks)**

b. Enumerate on the cost optimization of minimum allowable composition and what is the impact of trading between operating line and equilibrium line. **(10 Marks)**

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