Seat No.: ________ *Enrolment No.*___________

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER • 2014

Subject code: 2711606 **Date: 12-01-2015**

Subject Name: Energy and Mass Integration (EMI)

Time: 02:30 pm - 05:00 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)** A co-polymerization plant uses benzene as a solvent. Benzene is to be recovered from its gaseous waste stream. Two lean steams in the process, an additive stream and a catalytic solution, are potential process MSAs. Organic oil, which can be regenerated using flash separation, is the external MSA. The stream data is as follows **09**

Stream	F (kmol/s)	y^s or x^s	y^t or x^t
R_1 (Off-gas)	0.2	0.0020	0.0001
L_1 (Additives)	0.08	0.003	0.006
L2 (Catalytic sol)	0.05	0.002	0.004
L_3 (Organic oil)	Unlimited	0.0008	0.0100

The equilibrium relation for Additives is : $y = 0.25x$, for Catalytic solution is : $y = 0.5x$ and for Organic oil is : $y = 0.1x$.

(a) Show how to utilize the process MSAs to minimize the amount of the external MSA required to recover benzene from gaseous waste stream. Use æx_{min} = 0.0002.

(b) Design the MEN.

(b) Write step by step procedure to find out optimum value of æT_{min} for heat exchanger network synthesis problem. **05**

Q.2 **(a)** Justify: ñNo heat should pass across the pinch for the minimum utility designò **05**

(b) Determine minimum utility targets using LP method. (æT_{min} = 10 ºC) **09**

	FCp (kW/°C)	T_{in} (°C)	T_{out} (°C)
H1	3.60	100	430
H2	3.27	180	350
C1	2.80	440	150
C2	1.38	520	300
C3	3.36	390	150

OR

(b) Mass exchanger network is to be designed for removal of H_2S from sour coke oven gas, which is a mixture of H_2, CH_4, CO, N_2, NH_3, CO_2 and H_2S. it is proposed to remove H_2S and sent it to a unit to convert it to sulfur. The conversion is incomplete in that unit hence tail gases must be sent for H_2S removal. Adsorption is to be used for H_2S removal using aqueous ammonia or chilled methanol as MSA. **09**

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

Equilibriums data is $y=1.45x$ for aqueous ammonia and $y=0.26x$ chilled methanol.
Find out pinch point and minimum amounts MSE.

Q.3 To explore the possibilities for energy integration before designing a column we need to prepare inter-cooling and inter-heating curve for de-propanizer. Explain the step by step procedure to plot it for a mixture of five hydrocarbons in the series, C_2 to C_6 in feed. The feed contains C_2-3, C_3-20, C_4-37, C_5-35, and C_6-5 lb moles/hr. The column is to be designed for splitting C_3/C_4. It is expected that more than1 % C_4 should not go in top product, no C_5 and C_6 in top product. There should not be C_2 in bottom product, maximum 1.5% of C_3 can be allowed in bottom product. Write all the working equations along with algorithm using Antoine constants for vapor pressure calculation. **14**
(Vapor Pressure = 10^(A + B / (t°C + C)) psia)

Component	A	B	C
C2	5.0120015	-823.03103	328.18
C3 lk	4.3742477	-587.76681	248.90
C4hk	3.8201853	-367.50819	153.30
C5	4.0537542	-539.73661	169.60
C6	4.0165587	-545.39181	141.15

OR

Q.3 Find out pinch point and minimum utilities for the following network if H1 and C3 are not permitted to exchange heat. Use æT_{min} = 10 °C. **14**

	Fcp (MW/K)	Tin (°K)	Tout (°K)
H1	2.376	590	400
H2	1.577	471	200
H3	1.320	533	150
C1	1.600	200	400
C2	1.600	100	430
C3	4.128	300	400
C4	2.624	150	280

Q.4 **(a)** Justify with suitable example that adding cycles can save work required for refrigeration. **05**

(b) Formulate MILP problem for the minimum number of exchanger units for the hot and cold streams given below. Use æT_{min} = 20 °C. **09**

Stream	Fcp (MW/K)	T_{in} (°C)	T_{out} (°C)
H1	1.3	400	110
H2	2.2	340	120
C1	1.6	160	400
C2	1.8	110	260

OR

Q.4 **(a)** Explain the analogy of Heat Exchanger Network Synthesis and Mass Exchanger Network Synthesis. **05**

(b) Explain Multi effect Distillation. Discuss benefits and limitations of multi-effect distillation. With a case study data compare it with conventional column. **09**

Q.5 **(a)** Explain Composite Curve (HCC and GCC) and discuss role of them for HENS. **07**

(b) Compare Sequential and Simultaneous Heat Exchanger Network Synthesis approaches. **07**

OR

Q.5 **(a)** Can stream splitting reduce number of Exchanger units for HENS? Justify your answer. **05**

(b) Explain TQ diagram for side strippers and side enriches and compare it with TQ diagram of conventional equivalent sequential separation. **09**

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