Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 711606N **Date: 16-01-2013**

Subject Name: Energy and Mass Integration

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)** Discuss the effect of minimum temperature driving force, ΔT_m for design of heat exchanger network. **05**

(b) Justify the statement: "Pinch design approach assures design with minimum utility requirements". **05**

(c) Justify the statement: "Adding cycles can save work required for refrigeration." **04**

Q.2 **(a)** Draw TQ diagrams for (i) side strippers and (ii) multi-effect distillation and explain how both concepts increases thermodynamic efficiency. **08**

(b) Explain the step-by-step procedure to estimate the optimum value of ΔT. **06**

OR

(b) The following streams exist at and just above the pinch point for a heat exchanger network synthesis problem. Propose all possible configurations, which correspond to matches that split the fewest streams. **06**

Stream	*FCp*
H1	10
H2	6
C1	9
C2	3

Q.3 Determine the minimum utility consumption for the hot and cold streams given below using LP transshipment formulation. **14**

Stream	FCp (MW/K)	T_{in} (°C)	T_{out} (°C)
H1	1.3	400	110
H2	2.2	360	120
C1	1.6	160	400
C2	1.8	110	360

Use ΔT_{min} = 10 ºC

Write a model for minimum utility cost if H1 and C2 are not allowed to exchange heat for the above Heat Exchanger Network Synthesis (HENS) problem.

OR

Q.3 **(a)** Explain minimum umber of mass exchangers by breaking mass loops with example. **07**

(b) Determine the minimum utility consumption for the hot and cold streams given below using ΔT_{min} = 10 ºC. **07**

Stream	T_{in} ºC	T_{out} ºC	FC_p kW/ºC
C1	60	180	3

C2	30	100	2
H1	180	40	2
H2	150	40	4

Q.4 For the Heat Exchanger Network Synthesis (HENS) problem following stream information is available: **14**

Stream	FCp (kW/°C)	T_{in} (°C)	T_{out} (°C)
H1	1.60	100	420
H2	3.27	200	310
H3	2.60	200	420
C1	2.80	440	150
C2	2.38	500	300

Draw Composite Curve and find out pinch point for ΔT_{min} = 10 ºC.
Estimate the fewest number of heat exchangers needed if heat is not allowed to flow through pinch.

OR

Q.4 **(a)** Explain the composite curve method for computation of minimum usage of external mass-separating agent to determine minimum operating cost of mass integration with example of H_2S removal from sour cock oven gas. **07**

(b) Determine minimum utility targets and formulate MILP problem for the minimum number of exchanger units. **07**

Stream	FCp (kW/°C)	T_{in} (°C)	T_{out} (°C)
H1	1.5	100	430
H2	3.0	150	350
C1	2.5	450	150
C2	2.0	500	300

Q.5 **(a)** Explain: How inter-cooling, inter-heating and preheating of feed increases possibility of energy integration in distillation? **07**

(b) Explain Heat Pumping, Vapor Recompression and Reboiler Flashing configurations for distillation columns. **07**

OR

Q.5 **(a)** Given the flow and composition for the top product, list out the steps for method of plotting inter-cooling and inter-heating temperature curve and explain the use of those curves. **07**

(b) A co-polymerization plant uses benzene solvent. Benzene must be recovered from its gaseous waste stream. Two lean streams in the process, an additive stream and a catalytic solution, are potential process MSAs. Organic oil, which can be regenerated by flash separation, is the external MSA. The stream data are as under: **07**

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

In the given concentration ranges following equilibrium equations apply:

Additives: $y = 0.25x$,

Catalytic solution: $y = 0.5x$,

Organic oil: $y = 0.1x$

Show how to utilize the process MSAs and minimize the amount of the external MSA required to remove benzene from the waste rich stream.
Use Δx_{min} = 0.0001.

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