Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER II (NEW) – • EXAMINATION – SUMMER 2016

Subject Code: 2723012 Date: 31/05/2016

Subject Name: Advance 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 The process in Figure below is being designed to remove H_2S from sour coke oven gas (COG), which is a mixture of H_2, CH_4, CO, N_2, NH_3, CO_2, and H_2S. The removal is necessary because H_2S is corrosive and becomes the pollutant SO_2 when the gas is combusted. It is proposed to remove the H_2S and send itto a Claus unit to convert it to sulphur. However, because the conversion of the H_2S is incomplete, the tail gases must be recycled for H_2S removal. Distillation to remove the H_2S is not feasible, but absorption is feasible. Thus, it is proposed to design a MEN based on absorption. One possible MSA is aqueous ammonia, noting that ammonia is already present in the COG and that the flow rate and composition of the recycle stream are specified before the HEN is designed. An alternative MSA is chilled methanol ,which is an external MSA. Both ammonia and chilled methanol are to be considered as possible absorbents for the removal of H_2S from the COG and the tail gas. As shown in Figure below, the rich absorbent streams are regenerated by stripping to recover the acid gases, which are sent to the Claus unit. 14

To begin the development of the MEN, the sour COG and the tail gases are not mixed, and absorption can utilize ammonia, methanol, or both. Mass transfer in all mass exchangers is from the gas phase to the liquid phase.

The specifications for the rich and lean streams are as follows, where compositions, y for gases and $x$for liquids, are in mass fractions, F is the stream mass flow rate, and n is the mass flow rate of H_2Stransferred to or from the stream:

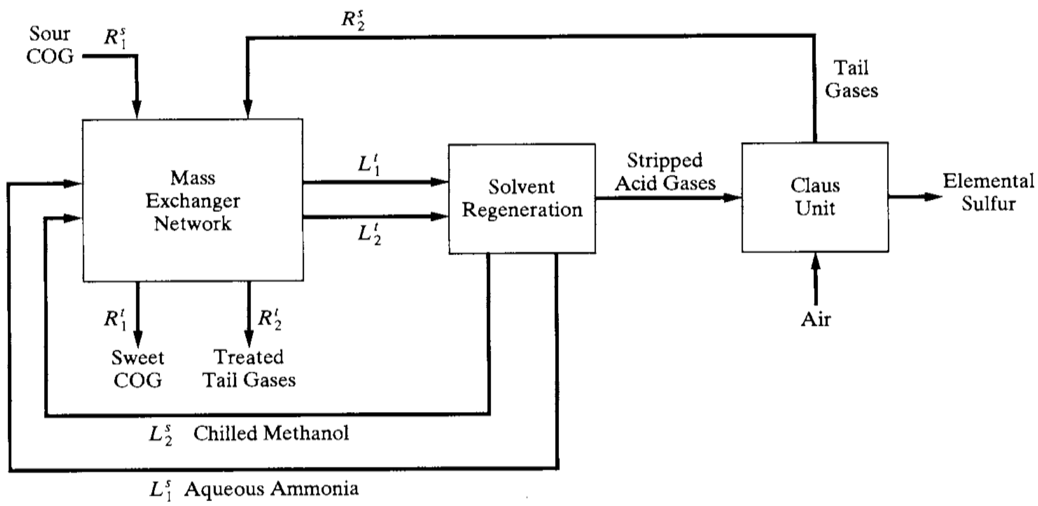
Stream	y^s or x^s	y^t or x^t	$F\ (kg/s)$	$n\ (kg/s)$
R1 (COG)	0.0700	0.0005	0.9	0.06255
R2 (Tail Gases)	0.0510	0.0003	0.1	0.00507
L1(Aq. NH_3)	0.0008	0.0310	2.3	0.06946
L2 (Methanol)	0.0001	0.0035	Unlimited	Unlimited

Note that the flow rate of aqueous ammonia is limited, but chilled methanol is considered to be available in unlimited amounts. Note, also that the total amount of H_2S to be transferred to the absorbent(s) is0.06255 + 0.00507 = 0.06762 kg/s. This is less than the capacity of the aqueous ammonia. However, as in heat exchange, where a driving force is necessary to transfer the heat, mass exchange also requires a driving force and, at this point in the synthesis, it is not known whether sufficient mass-transfer driving forces exist to utilize the capacity of the aqueous ammonia. If not, then the use of chilled methanol must be considered. All conditions in the above specifications table are considered to be dilute in the solute, H_2S. Therefore, stream flow rates are assumed constant and at the expected operating conditions of temperature and pressure, the following linear equilibrium equations apply:

Aqueous ammonia (1),$y = m_1 x = 1.45x$

Chilled methanol (2), $y = m_2 x = 0.26x$

For concentrated solutes, it is preferable to use solute-free flow rates and the mass ratios of solute to solute-free solvent.



At this stage in process synthesis, it is desired to determine, by the CI method, the minimum amount of chilled methanol required for a MEN involving these four streams, noting that it may be possible to eliminate the need for chilled methanol. Matched the COG and lean gas streams with the aqueous ammonia stream. $\Delta x_{min} = 0.0001$

1) Rank order the source and target mass fraction
2) Prepare a cascade of composition interval
3) Summarize solute load to be added or removed

Draw a Pinch decomposition of the rich and lean stream.

Q.2 Attempt any four 14

1] Write a short note on Heat Integration.
2] Discuss the significance of pinch point in HENS.
3] Discuss--- Threshold approach temp. and optimum approach temp. for HENS.
4] Define various policies used for scheduling batch processes.
5] Write the formulas for calculating ΔTLMTD and Area required for heat exchanger.

Q. 3 A Estimate the fewest number of heat exchangers required above and below pinch for the data given below. 7

Stream	Tin(deg.F)	Tout(deg.F)	FCp(BTU/Deg. F)	Comment
C1	310	395	7	liquid
C2	370	460	32	vapor
H1	430	340	15	liquid

B Prepare Transhipment model for the above data (3 A) and prepare LP formulations. 7

OR

Q. 3 A Describe in details sequential and simultaneous approaches of optimization and integration. 7

B Explain Concentration-Interval method to determine minimum flow rate of MSA (mass separating agents). 7

Q.4 A Determine the size of the vessels of a single product batch plant that consists of two stages for manufacturing product 500,000 lb/hr. 7

Horizon time : 6000 hrs per year. Recipe is as following :

1] Mix a lb of A, 1 lb of B, and react for 4 hours to from C. The yield is 40 % in weight and the density of the mixture, 60 lb/ft3.

2] Add 1 lb of solvent and separate by centrifuge during 1 hour to recover 95 % of product C. The density of the mixture is 65 lb/ft3.

B Explain overlapping and non-overlapping operation as well as flowshop plant and jobshop plant with diagram. 7

OR

Q.4 A Given the processing times for these products A, B, C, below. Determine with a Gantt Chart the make span and cycle time for manufacturing two batches of A, 1 of B and 1 of C for the case unlimited intermediate storage policy with sequence AABC and BAAC. 7

Processing Times (hr)			
	Stage 1	**Stage 2**	**Stage 3**
A	5	4	3
B	3	1	3
C	4	3	2
Zero Cleanup Times			

B Explain in detail Parallel units and intermediate storage with example 7

Q.5 A Discuss T-Q diagram of four component species A, B, C and D for which ease of separation is given below in the table. 7

Sr. No.	Species	Amount	Ease of separation
1	A	Lots	
2	B	Moderate amount	Difficult
3	C	Moderate amount	Very easy
4	D	lots	Very very difficult

B Write a short note on Graphical Techniques for simple reacting systems. 7

OR

A Discuss the method for discovering the amount of heat to remove from the condenser and the reboiler. 7

B Explain positioning of heat engine and heat pump. 7
