Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – VI (OLD).EXAMINATION – WINTER 2016

Subject Code: 160503 Date: 22/10/2016

Subject Name: Process Equipment Design-I

Time: 10:30 AM to 01:30 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)** Hexane at 37.8 °C is pumped through the system at a rate of 9.09 m^3/h. The tank is at atmospheric pressure. Pressure at the end of discharge line is 345 kPa g. The discharge head is 3.05 m and the suction lift is 1.22 m above the level of liquid in the tank. The friction loss in suction line is 3.45 kPa and that in the discharge line is 37.9 kPa. The mechanical efficiency of the pump is 0.6. The density of hexane is 659 kg/m^3 and its vapor pressure at 37.8 °C is 33.71 kPa. Calculate (i) $(NPSH)_A$ and (ii) Power required by the centrifugal pump. **07**

(b) Write a short note on fluid allocation in shell and tube heat exchanger. **07**

Q.2 **(a)** Discuss the Process Design of Fans and compressor. **07**

(b) Discuss the advantages and disadvantages between fixed tube sheets, U-tube and floating head type of heat exchanger. **07**

OR

(b) Discuss in detail about criteria of selection between kettle type and thermosyphon reboiler. **07**

Q.3 **(a)** Discuss the design steps for the calculation of tube side and shell side heat transfer coefficient. **07**

(b) Write a short note on air cooled heat exchangers and air heaters. **07**

OR

Q.3 A feed stream having flow rate of 200 kg/h and containing 20 mass % acetic acid in water is to be extracted at 25 °C with 400 kg/h of recycled MIBK (Methyl IsoButyl Ketone) that contains 0.1 % acetic acid and 0.01 % water. The aqueous raffinate is extracted down to 1 % acetic acid. Calculate (i) N_{tor} considering MIBK and water as partially miscible liquids and (ii) N_{tor} considering MIBK and water as completely immiscible liquids and equilibrium curve as straight line. **14**

Data for equilibrium curve:

X	0	0.0285	0.117	0.205	0.262	0.328	0.346
Y	0	0.0187	0.089	0.173	0.246	0.308	0.336

Data for operating curve:

X	0.2	0.14	0.08	0.01
Y_{S+1}	0.085	0.06	0.035	0.001

Data in terms of mass ratio:

X'(kg of Acetic acid/kg of water)	0	0.0299	0.1364	0.2708
Y'(kg of Acetic acid/kg of MIBK)	0	0.0196	0.1039	0.2354

Q.4 **(a)** Explain the method for determining minimum reflux ratio for binary distillation. **07**

(b) With suitable example explain the concept of selection of operating pressure for distillation. **07**

OR

Q.4 **(a)** A saturated liquid, consisting of phenol and cresol with some xylenols, is fractioned to give a top product of 95.3 mole % phenol. Metacresol is heavy key and phenol is light key component. Total condenser is used. The composition of the top product and of the phenol in the bottom is given. (i) Complete the material balance over the still for a feed rate of 100 kmol/h and (ii) Calculate the minimum reflux ratio by Underwood's method. **07**

Component	α_{av}	Feed, mole %	Top product, mole %	Bottom product, mole %
Phenol	1.98	35	95.30	5.24
o-Cresol	1.59	15	4.55	?
m-Cresol	1.00	30	0.15	?
Xylenols	0.59	20	--	?

(b) Discuss in details the various factors considered for the selection of tray. **07**

Q.5 **(a)** Discuss in details the selection criteria for different absorption equipment. **07**

(b) With neat sketch explain the various types of random packings used in packed column. **07**

OR

Q.5 Venturi scrubber is planned for absorbing NO gases from the exits gas stream of nitric acid plant by using 10 % NaOH solution (by mass). Exist gas mixture, leaving the absorber of nitric acid plant, is having the following composition. **14**

Volumetric flow rate of exist gas mixture = 40586.5 m^3/h, NO concentration in gas mixture = 1821.5 ppm, Discharge pressure of gas from venturi = atmospheric, Solvent to gas ratio = 1.5 L/m^3, Temperature of gas mixture entering the venture scrubber = 50 ^oC, Density of 10 % NaOH solution = 1108.9 kg/m^3, Equilibrium mass of NO per 100 mass of H_2O = 0.030, Average molar mass of gas mixture entering scrubber = 28.43 kg/kmol, Throat velocity of gas phase = 100 m/s. Determine (i) throat diameter of venture scrubber (ii) % removal of NO gases (iii) pressure drop in venture scrubber. Use following design equations.

Fractional solute removal = $$\frac{y_1 - y_2}{y_1} = \eta \frac{\left(1 - mx_2 / y_2\right)}{\left(1 + \frac{mG_M}{L_M}\right)}$$

Venturi pressure drop $$\Delta P = 2.584 \times 10^{-3} v_G{}^2 \rho_G A_{th}{}^{0.133} \left(L' / G'\right)^{0.78}$$

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