Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI- EXAMINATION – SUMMER 2016

Subject Code:160503 **Date:09/05/2016**

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 (1) $(NPSH)_A$ and (2) Power required by the centrifugal pump. **07**

(b) Explain in brief industrial application of liquid-liquid extraction. **07**

Q.2 **(a)** Write a short note on: **07**

1. Baffles in shell and tube heat exchanger
2. Downcomers in tray column

(b) Discuss in brief various heating and cooling media used in heat exchanger **07**

OR

(b) Discuss the process design of orifice meter **07**

Q.3 **(a)** Write a short note on Tinker's flow model. **07**

(b) Explain the followings in a distillation column. **07**

1. Operating pressure in column
2. Liquid flow pattern
3. Weirs in column

OR

Q.3 **(a)** Predict the fractional solute removal and pressure drop in a ventury scrubber based on the following data: **10**

Volumetric flow rate of boiler flue gas = 24000 Nm^3/h
Discharge pressure of gas from ventury = Atmospheric
Temperature of gas = 80 – 90 °C
SO_2 concentration in boiler flue gas = 4000 ppm
Solvent = 1% lime solution
Density of 1% lime solution = 1012.5 kg/m^3
Solvent to gas ratio = 1.4 L/m^3
Throat velocity of the gas phase = 100 m/s
Average molar mass of flue gas = 29.48 kg/kmole
Equilibrium mass of SO_2 per 100 mass of H_2O = 0.035
Fractional solute removal:

$$1-\frac{y_2}{y_1}=E-\frac{\left(1-m\frac{x_2}{y_2}\right)}{1+m\frac{G_M}{L_M}}$$

Pressure drop: $\Delta P = 2.584 * 10^{-3} v_G^2 \rho_G A_{th}^{0.133} \left(\frac{L'}{G'}\right)^{0.78}$

(b) Explain the types of packing used in packed tower. **04**

Q.4 **(a)** Discuss the process design of counter current multistage extractor. **07**

(b) In the design of vertical thermosyphone reboiler, discuss the various possibilities can arise about the available pressure head and tube side pressure drop and how to fix the recirculation ratio in each case. **07**

OR

Q.4 A sieve tray tower is used for the distillation of acetic acid-water system. Maximum feed flow rate is 12000 kg/h and turn down ratio is 70%. Following data are available for this column. **14**

Feed composition: 54.55% acetic acid and 45.45% water (by mole)

Mole fraction of water: In distillate x_D=0.9302, In Residue x_W= $1.666*10^{-4}$

q=1.272

Reflux ratio R=4.2, Number of theoretical stages required = 25

Tray spacing = 0.45 m, hole diameter = 5 mm.

weir height = 50 mm, weir length l_W = 0.77 Di.

Property	Top	Bottom
Vapor density, kg/m^3	0.6823	2.8368
Liquid density, kg/m^3	967.97	1000
Surface tension, N/m	$55.5*10^{-3}$	$21.34*10^{-3}$

Based on 85% flooding condition, Calculate

(1) Tower diameter required at top and bottom.

(2) Check weeping for enriching section. (top section)

Consider down comer area is 12% of column cross section and hole area is 10% of active area.

Weep point constant K can be taken from the following table:

h_w+h_{ow}	20	40	60	80	100
K	28.3	29.6	30.3	30.75	31.14

Q.5 10900 kg/h of nearly pure saturated methyl ethyl ketone (MEK) vapor at 13.73 kPa g is to be condensed and cooled to 60 °C by cooling water which is available in plant at 32 °C. Consider pressure drops of 13.7 kPa for vapor and 68.7 kPa for the water as permissible. **14**

Condensation temperature of MEK vapor = 83.87 °C

Latent heat of vaporization of MEK at 83.87 °C = 438.27 kJ/kg

Specific heat of MEK liquid at 72 °C = 2.298 kJ/kg °C

Specific heat of water = 4.1868 kJ/kg °C

Outlet temperature of cooling water = 40 °C

Density of water = $992.9 kg/m^3$

Tube dimensions: OD = 19.05 mm, ID = 15.748mm, Length = 6ft, Triangular pitch arrangement, $P_t=1.25d_O$

Tube side passes =4

Viscosity of water = 0.72 cP

Thermal conductivity of water = 0.6228 W/ m °C

Viscosity of liquid MEK at 71.22 °C = 0.32 cP

Density of liquid MEK at 71.22 °C = $805 kg/m^3$

Thermal conductivity of liquid MEK at 71.22 °C = 0.173 W/m °C

Calculate the followings based on the overall heat transfer coefficient for condensation and subcooling are 800 and 200 W/m^2 °C respectively.

1. Number of tubes
2. Shell diameter
3. Shell side and tube side heat transfer coefficient

For P_t/d_O =1.25, Triangular pitch

No of tube side passes	1	2	4	6	8
K_1	0.319	0.249	0.175	0.0743	0.0365
n_1	2.142	2.207	2.285	2.499	2.675

OR

Q.5 **(a)** State various types of shell and tube heat exchanger. Discuss advantages and disadvantages of different type of shell and tube heat exchanger over each other. **07**

(b) Write a short note on selection of type of tray in tray tower. **07**

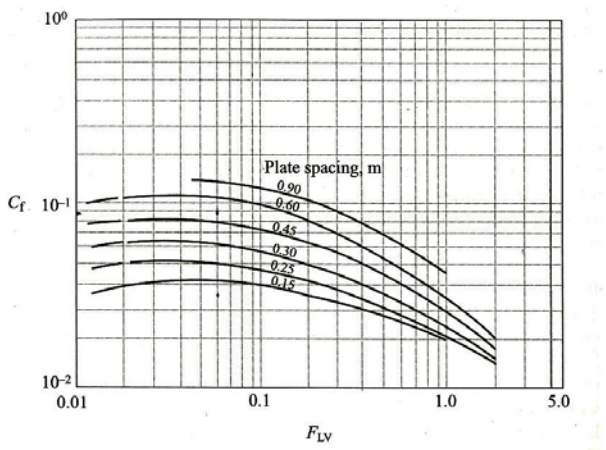

Figure 1: Flooding velocity (sieve tray)

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