Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI(NEW) – EXAMINATION – SUMMER 2019

Subject Code:2160503 **Date:14/05/2019**

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)** Define NPSH and give its importance for pump design. **03**

(b) Why Radius tapping is more suitable compared to Vena contracta tapping for orifice meter. Mention advantages and disadvantages of orifice meter. **04**

(c) A centrifugal pump is drawing water from an overhead tank, exposed to atmosphere. Vertical distance between free surface of liquid in the tank and centre line of the pump is 10 m. Capacity of centrifugal pump is 10000 kg/h. Maximum operating temperature is 50 °C. Vapor pressure of water at 50 °C is 92.51 torr. Total length of suction pipe 10.5 m, having two 90 ° elbows. Material of pipe is carbon steel. Density of water = 1000 kg/m^3, Viscosity of water = 0.558 cP. K-Value for 90ºelbow is 0.75. friction factor f = 0.0394 Re$^{-0.16}$. **07**

For the velocity of water in suction line 1 m/s, Determine

(1) The size of suction pipe

(2) Total frictional pressure drop in suction line

(3) $(NPSH)_A$ of centrifugal pump.

Q.2 **(a)** How baffle cut and baffle spacing affect tube outside heat transfer coefficient. **03**

(b) Discus in brief about fluid allocation for shell and tube heat exchanger. **04**

(c) 1-2 shell and tube heat exchanger is used to cool methanol condensate from 95 °C to 40°C. Flow rate of methanol is 100000 kg/h. Brackish water is used as coolant with temperature rise from 25 °C to 40 °C. **07**

Property	Methanol	Brackish Water
Heat Capacity, kJ/kg °C	2.84	4.2
Density, kg/m^3	750	995
Viscosity, mN·s/m	0.34	0.8
Thermal conductivity, W/m °C	0.19	0.59

Choose 20mm od, 16 mm id, 4.88 m long cupro-nickle tubes with triangular pitch Pt = 1.25d_O. Based on overall heat transfer coefficient 600 W/m^2°C

Calculate (1) Number of tubes (2) Shell Diameter

K_1 and n_1 for tube bundle diameter: (For triangular pitch Pt= 1.25d_O)

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

(c) In design of vertical thermosyphon reboiler recirculation ratio is determined via trial and error calculations. In these case calculations, one of the following hypothetical conditions arises for the assumed value of recirculation ratio. **07**

(i) Δ Pav ≈ ΔPt

(ii) ΔPav >> ΔPt

(iii) ΔPav < ΔPt

Discuss how to find or fix the recirculation ratio in each of the above condition.

Q.3 **(a)** How reflux ratio affects distillation column design. **03**

(b) Discuss in brief the factors affecting selection of tray type. **04**

(c) Acetic acid to be separated from a process stream containing 80% acetic acid and 20% water (by mass) by continuous distillation column at atmospheric pressure. Concentration of water in bottom product (pure acetic acid) should not be greater than 50 ppm. Top product (distillate) contains 80% water and 20% acetic acid (by mass). Feed is liquid at 30 °C. Estimate the number of theoretical stages required both graphically and empirically. **07**

Mole fraction of water in liquid, x	Mole fraction of water in vapor, y
0.0	0.0
0.1881	0.3063
0.3084	0.4467
0.4498	0.5973
0.5195	0.6580
0.5824	0.7112
0.6750	0.7797
0.7261	0.8239
0.7951	0.8671
0.8556	0.9042
0.8787	0.9186
0.9134	0.9409
0.9578	0.9708
1.0	1.0

Take q= 1.272 & R = $2R_m$

OR

Q.3 **(a)** Mention disadvantages of vacuum distillation. **03**

(b) Discuss in brief jet flooding and downcomer flooding. **04**

(c) A continuous rectifying column handles a mixture consisting of 40 per cent of benzene by mass and 60 per cent of toluene at the rate of 4 kg/s and separates it into a product containing 97 per cent of benzene and a liquid containing 98 per cent toluene. The feed is liquid at its boiling-point. **07**

(a) Calculate the mass flows of distillate and waste liquor.

(b) If a reflux ratio of 3.5 is employed, how many plates are required in the rectifying part of the column?

Mole fraction of benzene in liquid	Mole fraction of benzene in vapor
0.0	0.0
0.1	0.22
0.2	0.38
0.3	0.51
0.4	0.63
0.5	0.70
0.6	0.78
0.7	0.85
0.8	0.91
0.9	0.96
1.0	1.0

Q.4 **(a)** How distribution coefficient affects liquid liquid extraction. **03**

(b) Classify industrially important extractors. **04**

(c) Explain process design of settler. **07**

OR

Q.4 **(a)** How to decide optimum solvent amount based on number of theoretical stages. **03**

(b) Enlist the desirable properties for choice as solvent for extraction. **04**

(c) Explain in detail the process design of counter current multistage extractor. **07**

Q.5 **(a)** List out various equipments used as an absorber/ scrubber. **03**

(b) Discuss advantages of Falling film absorber over Packed tower type absorber. **04**

(c) Sulphur dioxide is recovered from a smelter gas containing 3.5 per cent by volume of SO_2, by scrubbing it with water in a countercurrent absorption tower. The gas is fed into the bottom of the tower, and in the exit gas from the top the SO_2 exerts a partial pressure of 1.14 kN/m^2. The water fed to the top of the tower is free from SO_2, and the exit liquor from the base contains 0.001145 kmol SO_2/kmol water. The process takes place at 293 K, at which the vapour pressure of water is 2.3 kN/m^2. The water flow rate is 0.43 kmol/s. **07**

If the area of the tower is 1.85 m^2 and the overall coefficient of absorption for these conditions $K"_La$ is 0.19 kmol SO_2/sm^3 (kmol of SO_2/kmol H_2O), what is the height of the column required?

The equilibrium data for SO_2 and water at 293 K are:

kmol SO_2/1000 kmol H_2O	0.056	0.14	0.28	0.42	0.56	0.84	1.405
kmol SO_2/1000 kmol Inert gas	0.7	1.6	4.3	7.9	11.6	19.4	35.3

OR

Q.5 **(a)** Differentiate Random and Regular packing. **03**

(b) Write a brief note on packings used for packed bed absorption. **04**

(c) Explain design procedure for Absorption tower for finding the height (Cornell's method) and diameter of column. **07**

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