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

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI (NEW) - EXAMINATION – SUMMER 2017

Subject Code: 2160503 **Date: 01/05/2017**

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 Short Questions **14**

1 Write equation for optimum pipe size for carbon steel pipe for turbulent flow.

2 ERW pipes stands for_____.

3 In orifice meter minimum flow area achieved by free flowing jet is known as _____.

4 % baffle cut ranges from _____ to _____.

5 What is the type of shell in case of BKU as per TEMA?

6 Conversion factor from Kcal/hr-M^2 ^{0}C to W/M^2 K is _____.

7 In Tinker's Flow Model, pass-partition bypass stream is Stream _____.

8 Distribution coefficient in Liquid Extraction is ratio of _____.

9 Define heavy key in multi component distillation.

10 The value of 'q' for saturated vapour is _____.

11 The slope of feed line for feed is saturated liquid is _____.

12 With increase in baffle spacing, shell side pressure drop increases for no phase change fluid on shell side. (True/False)

13 Write Fenkey's equation for finding minimum number of theoretical stages.

14 In TEMA designation, third letter indicates _____.

Q.2 (a) Estimate the optimum pipe diameter for a flow of dry chlorine gas of 20000 kg/hr at 3 atma and 25^0 C through carbon steel pipe. **03**

(b) Write about Tinker's Flow Model. **04**

(c) Benzene at 40 ^{0}C is pumped through the system at a rate of 10 m^3/h with the help of a centrifugal pump. The reservoir is at atmospheric pressure. Pressure at the end of discharge line is 350 kPag. The discharge head is 3.05 m and the pump suction head is 1.1 m above the level of liquid reservoir. The friction loss in suction line 3.45 kPa and that in discharge line is 39 kPa. The mechanical efficiency of the pump is 0.65. The density of benzene is 870 kg/m^3 and its vapour pressure at 40 ^{0}C is 29 kPa. Calculate (a) $(NPSH)_A$ and (b) power required by centrifugal pump. **07**

OR

(c) Write general design procedure for shell & tube heat exchanger. **07**

Q.3 (a) Discuss the criteria for fluid allocation in shell & tube heat exchanger. **03**

(b) Discuss advantage and disadvantage of plate heat exchanger over shell and tube heat exchanger. **04**

(c) Discuss the process design of kettle type reboiler. **07**

OR

Q.3 Design shell and tube horizontal condensor for condensation of 39000 kg/hr n-propanol at 0.3 kgf/cm^2g by cooling water at 32 ^{0}C to 45 ^{0}C. The condensing temp. at this pressure is 85.2 ^{0}C. The dirt factors of both shell & tube side is 2200 kcal/hr m^2 ^{0}C. Assume that allowable pressure drop on both the side is within limit. Assume the tube o.d. of 19.05 mm and 23.81 mm triangular pitch. Tube wall thickness to be taken as 1.65 mm. Assume isothermal condensation. Properties for n-propanol: **14**

Latent heat of condensation: 158 kcal/kg
Thermal conductivity : 0.14 kcal/hr m C
Liquid density : 800 kg/m^3
Liquid viscosity: 0.62 cP
Vapor viscosity: 0.008 cP
Thermal conductivity of tube metal = 39 kcal/hr m ^{0}C.
Condensation coefficient is to be calculated as:

$$h_c = 0.95 k_c \left[\frac{\rho_c(\rho_c - \rho_v)g}{\mu_c \Gamma} \right]^{1/3} (N_R)^{-1/6} \text{ kcal/hrm}^2\text{C}$$

Where, kc = condensate thermal conductivity, kcal/hrm^{0}C
ρ_c = condensate density, kg/m^3
ρ_v = vapor density, kg/m^3
μ_c = condensate viscosity, kg/m-s
Γ = tube loading, condensate flow per unit length of tube, kg/m-s
N_R = (2/3)rd of maximum tubes in central row.

Water side coefficient is calculated as:

$$h_i = \frac{4200(1.35 + 0.02t)}{d_i^{0.2}} u_t^{0.8} x0.86 \quad \text{kcal/hr m}^2\ ^0\text{C}$$

t = water side average temperature, ^{0}C
di = inside diameter of tube, mm
u_t = tube side velocity, m/sec

For triangular pitch, constants for bundle diameter are as:

No of passes	1	2	4	6	8
k1	0.319	0.249	0.175	0.0743	0.0365
n1	2.142	2.207	2.285	2.499	2.675

Q.4 (a) Determine the minimum reflux ratio for the binary distillation at standard atmospheric pressure based on the following data: **03**
Feed = 100 kmol/hr has mole fraction of benzene= 0.4 and rest toluene.
Feed is saturated liquid and mole fraction of benzene in distillate = 0.99
Mole fraction of benzene in residue required = 0.02, α_{av} = 2.25.

(b) Explain FUG method for multicomponent distillation. **04**

(c) Explain McCabe-Thiele method for binary distillation. **07**

OR

Q.4 (a) Discuss criteria of selection between horizontal condenser and vertical condenser. **03**

(b) Write procedure for calculation of tube side pressure drop for shell & tube heat exchanger. **04**

(c) In vertical thermosyphon reboiler recirculation ratio is fixed by trial and error method. Discuss how to find or fix the recirculation ratio in the following conditions: **07**
(i) $\Delta P_{av} \approx \Delta P_t$
(ii) $\Delta P_{av} > \Delta P_t$
(iii) $\Delta P_{av} < \Delta P_t$

Q.5 (a) List the steps for determination of minimum amount of solvent for absorber. **03**

(b) Discuss about various types of liquid distributors and redistributors. **04**

(c) Discuss the process design of Venturi scrubber. **07**

OR

Q.5 (a) List important industrial application of liquid-liquid extraction. **03**

(b) Discuss the desirable solvent properties for liquid-liquid extraction. **04**

(c) Discuss the steps for process design of counter current multistage extractor. **07**

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