

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-VI(NEW) EXAMINATION – WINTER 2022****Subject Code:2160503****Date:14-12-2022****Subject Name:Process Equipment Design -I****Time:02:30 PM TO 05:30 PM****Total Marks:70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Simple and non-programmable scientific calculators are allowed.

- | | | Marks |
|------------|---|-----------|
| Q.1 | (a) Estimate the optimum pipe diameter for a flow of dry chlorine gas of 10000 kg/hr at 6 atm a and 20 °C through carbon steel pipe. | 03 |
| | (b) Explain concept of NPSH in pumping system. If $(NPSH)_A$ is less than $(NPSH)_R$, then suggest corrective action to make $(NPSH)_A$ greater than $(NPSH)_R$ | 04 |
| | (c) Discuss step wise design procedure for shell and tube heat exchanger without phase change. | 07 |
| Q.2 | (a) Discuss the five standard locations of pressure taps in orifice meter. | 03 |
| | (b) Explain Tinker's Flow Model. | 04 |
| | (c) In vertical thermosyphon reboiler recirculation ratio is fixed by trial and error method. Discuss in detail how to find or fix the recirculation ratio in the following conditions: | 07 |
| | 1. $\Delta P_{av} > \Delta P_t$
2. $\Delta P_{av} \ll \Delta P_t$
3. $\Delta P_{av} \approx \Delta P_t$ | |

OR

- (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-nickel tubes with triangular pitch $P_t = 1.25d_o$. Based on overall heat transfer coefficient $600 \text{ W/m}^2 \text{ °C}$ Calculate (1) Number of tubes (2) Shell Diameter K_1 and n_1 for tube bundle diameter: (For triangular pitch $P_t = 1.25d_o$)

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

Take: $F_t = 0.85$ and bundle diamerical clearance 68 mm

- Q.3 (a)** Discuss selection criteria between kettle type and thermosyphon reboiler **03**
- (b)** Describe determination of minimum reflux ratio by McCabe-Thiele method. **04**
- (c)** A saturated liquid, consisting of phenol, o-cresol, m-cresol with some xylenols, is fractionated to give a top product of 95.3 mole % phenol, 4.55 mole % of o-cresol and 0.15 mol % om-cresol. The bottom product contains 5.24 mol% of phenol. Total condenser is used. The composition of the feed and relative volatilities is given in the table. For a feed rate of 100 kmol/h complete the material balance over still and calculate the minimum reflux ratio. **07**

Component	Average relative volatilities	Feed ,Mole %
Phenol	1.98	35
o-Cresol	1.59	15
m-cresol	1.00	30
xynols	0.59	20

OR

- Q.3 (a)** Discuss the criteria for fluid allocation in shell & tube heat exchanger. **03**
- (b)** Determine the minimum reflux ratio for the binary distillation at standard atmospheric pressure based on the following data: 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, $\alpha_{av} = 2.25$. **04**
- (c)** Estimate minimum reflux ratio and minimum number of ideal stages needed for the butane-pentane splitter defined by the compositions given in table below. The column is operated at a pressure of 8.3 bar. The feed is at its boiling point. Top and bottom temperatures are 65 °C and 120 °C respectively. **07**

Component	Feed, Kmol/hr	Distillate, Kmol/hr	Bottom, Kmol/hr	Relative volatility at 65 °C	Relative volatility at 120 °C
Propane	5	5	?	5.5	4.5
i-butane	15	15	?	2.7	2.5
n-butane	25	24	?	2.1	2

i-pentane	20	?	19	1	1
n-pentane	35	?	35	0.84	0.85

- Q.4** (a) Describe effect of increase in reflux ratio on number of theoretical stages and utility requirement. **03**
- (b) Write a brief note on packings used for packed bed absorption. **04**
- (c) Discuss about the Liquid distributors, Liquid redistributors, Packing support and Hold-down plate for packed tower type absorber. **07**

OR

- Q.4** (a) Discuss jet and downcomer flooding with figure. **03**
- (b) Draw falling film type absorber and explain its advantages and disadvantages over the adiabatic type packed tower. **04**
- (c) Explain design procedure for Absorption tower for finding the height (Cornell's method) and diameter of column. **07**
- Q.5** (a) Explain the procedure to fix the operating pressure of distillation column. **03**
- (b) List important industrial application of liquid-liquid extraction **04**
- (c) Discuss design steps for a vertical decanter for extraction column. **07**

OR

- Q.5** (a) Explain the terms flooding and weeping in distillation column. **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**
