Q. Code:237907

Reg. No. | | | | | | | | | | | | | |

B.E / B.TECH. DEGREE EXAMINATIONS, MAY 2024

Sixth Semester

CH18604 – PROCESS EQUIPMENT DESIGN I

(Chemical Engineering)

(Regulation 2018/2018A)

(HEAT AND MASS TRANSFER HANDBOOK AND STANDARD CHARTS ARE ALLOWED)

TIME: 3 HOURS **MAX. MARKS: 100**

CO 1 Impart knowledge on the importance of design information and data.
CO 2 Identify the methods of process design of separation columns.
CO 3 Impart the basics of process design of heat transfer equipment's.
CO 4 Outline the essentials of fluid movers and related items.
CO 5 Evaluate the concepts of piping and instrumentation diagram and site selection.

PART- A (10 x 2 = 20 Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	Write the significance of having control over Design information and data.	**1**	**1**
2.	Distinguish the types of prediction methods of any extensive property of a given sample.	**1**	**3**
3.	Sketch the graphical representation of different possible feed conditions that can feed into a binary distillation column?	**2**	**2**
4.	Sketch the schematic of a flash column used for representing a binary mixture separation.	**2**	**2**
5.	A hot fluid at 100°C enters a heat exchanger at a mass flow rate of 14kg/hr. Its specific heat is 2000 J/kg-K. It is to be cooled by another fluid entering at 25°C with a mass flow rate 25 kg/hr and specific heat 400 J/kg-K. The overall heat transfer coefficient based on outside area of 2.5m^2 is 250W/m^2 K. Find the exit temperature of the hot fluid when the fluids are flowing counter current.	**3**	**3**
6.	Sketch the Temperature profile for a plate type heat exchanger, with proper assumptions.	**3**	**2**
7.	List the guidelines for the control valves in the pump design.	**4**	**2**
8.	Rank the different types of valves based on pressure drop.	**4**	**2**

9.	Differentiate safety valves and rupture disc.	**5**	**2**	
10.	Calculate the optimum pipe diameter for a water flow rate of 12 kg/s. Carbon steel pipe shall be used.	**5**	**3**	

PART- B (5 x 14 = 70 Marks)

			Marks	CO	RBT LEVEL
11. (a)	**(i)**	Elucidate with example the best way to design the pipe network system for your apartment/home, justify your assumptions.	**(7)**	**1**	**3**
	(ii)	Illustrate with example the accuracy of design data and their sensitivity in process equipment design.	**(7)**	**1**	**3**
		(OR)			
(b)		Estimate the important fluid properties of the main component of LPG. List the assumptions if any. Following relevant data base can be used with assumptions.	**(14)**	**1**	**3**
12. (a)		A plant with an annual through put of 0.09 million tonnes requires a distillation column to separate an equimolar mixture of methanol in water available at its boiling point. Design a sieve tray column and find the number of actual plates for the operation at atmospheric pressure with a reflux ratio of 1.5 times the minimum Given: Overhead product – 93.2 mol% methanol Residue – 1.6 mol% methanol Avg. Liq. Density- 875 kg/m^3 Vapour density at top – 2.85 kg/m^3 Vapour density at bottom – 3.21 kg/m^3 Avg. liquid Viscosity – 0.0003kg/m.s Top Column Temp. – 360.6 K Bottom Column Temp. – 379.6 K Tray spacing – 68cm Tray efficiency – 45% Vapour velocity in the column can be estimated by using Brown Sonder's eqn.	**(14)**	**2**	**3**

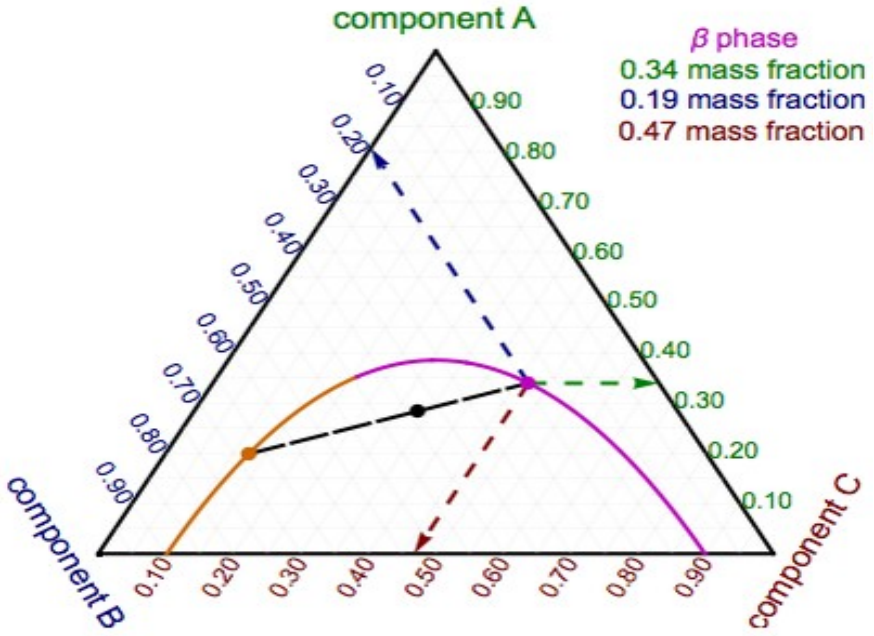
$$Vapour\ velocity = \frac{k_v \sqrt{\rho_L - \rho_v}}{\rho_V}$$

$$kv = 0.0428$$

X	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Y	0	0.42	0.57	0.66	0.73	0.78	0.83	0.87	0.92	0.92	1

(OR)

(b) Referring to the 3-component diagram in Figure given below, if 30,000 kg/h of Ternary mixture of 34 wt% of A, 19% of B, and 47% of C was fed into a decanter (a mixer and settler) operating at 25 ^{0}C, what would the flow rates of two liquid streams leaving the decanter be and comment of minimum solvent required? **(14) 2 3**



13. (a) Estimate the reboiler process design parameters for steam on inside and outside 12 mm & 18mm vertical tube of 2.5m long. The steam generating rate is 0.035kg/s per tube and the boiling take place at 4.2 bar. Density of liquid and vapour are 922 and 2.12 kg/m^3. Saturation temperature is 144^o C. Thermal conductivity and Viscosity are 0.685 W/m^o C & 95 x 10 $^{-6}$kg/m.s, NPr - 1.29. **(14) 3 3**

(OR)

(b) Design 2 - 4 Shell and tube heat exchanger to process 47.5 kg/s of crude oil that's need to be heated from 298 K to 335 K by that heat exchanger with a bottom product in a distillation unit which is to be cooled from 460 K flowing at a rate of 29 kg/s. The physical properties of various streams at **(14) 3 3**

mean temperature are given below.

Property	Crude oil	Bottom Product
Cp (kJ/kg K)	2.2	2.5
μ (kg/m-s)	$3.2x10^{-3}$	$5.1x10^{-3}$
ρ (kg/m3)	810	870
K (W/m K)	0.162	0.115

Assume the relevant data for a feasible design.

14. (a)	A pipeline connecting three tanks contains seven square elbows, a globe valve half open and gate valve fully open. The line is cast iron pipe, 25mm internal diameter, length 125 m. The properties of the fluid are : Viscosity is 0.9995 mNs/m^2, Density is $999kg/m^3$, Calculate the total pressure drop due to friction when the flow rate is 3700kg/h and give the inferences.	**(14)**	**4**	**3**
	(OR)			
(b)	A compressor to be used to draw nitrogen off of a cryogenic storage tank and boost the pressure to feed a plant processes. The flow requirement will vary throughout the 8 hour production day, but will average about 15 CFM. Suction pressure at 5psi and discharge pressure is 65 psi. Site: 1000 ft elevation, outdoors, Ambient 100^oF Utilities: 460V / 3ph/ 60 Hz, 80^0F fresh water Critical Pressure and temperature are 493 psia and 228^0 R Capacity: 20SCFM Design a proper compressor for the above given data.	**(14)**	**4**	**3**
15. (a)	Choose an industry and suggest a suitable plant layout and site selection with a neat chart with involving environmental considerations.	**(14)**	**5**	**2**
	(OR)			
(b)	**(i)** Enumerate Automatic Control Schemes of distillation column used at process industries	**(7)**	**5**	**2**
	(ii) As a chemical engineer, suggest your views on how PFD diagram is useful in process equipment design	**(7)**	**5**	**2**

PART- C (1 x 10 = 10 Marks)

(Q.No.16 is compulsory)

		Marks	CO	RBT LEVEL
16.	Design the solar water heater system for your hotel, assuming that 5 people will be using warm water at 55^0C, with the total water capacity of 250 litres/day and available heat flux is 0.8W/m^2. Assume the missing parameters and list them and justify them.	**(10)**	**3**	**5**

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