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

B.E. / B.TECH. DEGREE EXAMINATION, MAY 2023

Sixth Semester

CH18604 - PROCESS EQUIPMENT DESIGN I

(Chemical Engineering)

(Regulation 2018)

(Mass and Heat Transfer Data book should be provided)

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

CO1 Impart knowledge on the importance of design information and data.
CO2 Identify the methods of process design of separation columns.
CO3 Impart the basics of process design of heat transfer equipments.
CO4 Outline the essentials of fluid movers and related items.
CO5 Evaluate the concepts of piping and instrumentation diagram and site selection.

PART- A (10x2=20Marks)

(Answer all Questions)

		CO	RBT LEVEL
1	Evaluate the surface tension of pure methanol at 21°C, density 801.7 kg/m^3, molecular weight 32.156.	**1**	**3**
2	Compare PPDS and DIPPR used in data collection.	**1**	**2**
3	If Rmin = 1.5 and xD = 0.96, calculate the intercept of enriching line.	**2**	**3**
4	Estimate the distribution coefficient for transferring acetone from water to benzene at 30°C. A/RT value for acetone/water and acetone/benzene is 2.21 and 0.543 respectively.	**2**	**3**
5	If the mass and momentum flux is increased to twice and thrice, what will be the tube side and shell side pressure drop.	**3**	**2**
6	List the points to be considered to reduce the pressure drop of 10 psi.	**3**	**2**
7	Illustrate the importance of chocking velocity.	**4**	**3**
8	Draw the plot to be used to determine the type of pump required for a particular head and flow rate.	**4**	**2**
9	List out the criterion should be followed for P & I diagrams in process equipment design.	**5**	**2**
10	Outline a few ideas on environmental consideration in site selection.	**5**	**2**

PART- B (5x 13 = 65Marks)

			Marks	CO	RBT LEVEL
11(a)	**(i)**	Estimate the specific heat capacity of ethyl bromide at 20 °C using Cheuh and Swanson's method.	**(7)**	**1**	**3**
	(ii)	Engineering Data is an important for designing a process equipment. Is accuracy requirement necessary to design a perfect equipment?	**(7)**	**1**	**3**
		(OR)			
11(b)	**(i)**	Estimate the viscosity of toluene at 20 °C by Gilliland's method.	**(7)**	**1**	**3**
	(ii)	As a chemical Engineer, give your views on getting sources of information on manufacturing process.	**(7)**	**1**	**3**
12(a)		A continuous column is designed for separation of the mixture containing 0.5 mole fraction of n-heptane and rest n-octane. The overhead and the bottom product are to have 99% purity and its column is to operate at atmospheric pressure with reflux of 2.5. Estimate the number of plates and also estimate the actual number of plates if the plate's efficiency is 50%. The feed is admitted as a saturated liquid to the column at the rate of 9 tons/hr. For the following condition find the height and diameter of the column. Given :- Top column temperature = 371 K, Bottom coloumn temperature = 398 K, Plate spacing = 0.45 m, Vapour Velocity = 1.5 m/s	**(14)**	**2**	**3**
		(OR)			
12(b)		Acetone is to be extracted from a solution in water, using 1,1, 2 - trichloro ethane. The feed concentration is 49 % w/w acetone. Determine the number of stages required to reduce the concentration of acetone below 8% using 38 kg of extraction - solvent per 100 kg feed. The raffinate concentration in the first stage is 0.42 w/w basis. The VLE data	**(14)**	**2**	**3**

Q. Code: 823664

TABLE I. LIMITING LIQUID SOLUBILITY CURVE FOR ACETONE–WATER–1,1,2-TRICHLOROETHANE AT 25° C.

Concentration, Weight %			Refractive Index, n_D^{25}	Density, d_4^{25}
$C_2H_3Cl_3$ (a) 100 X_1	Water (b) 100 X_2	Acetone (c) 100 X_3		
99.89	0.11	0.00	1.4683	1.3898
94.73	0.26	5.01	1.4588	1.3737
90.11	0.36	9.53	1.4504	1.3286
84.65	0.59	14.76	1.4416	1.2763
79.58	0.76	19.66	1.4338	1.2336
75.72	0.99	23.29	1.4285	1.2018
70.36	1.43	28.21	1.4218	1.6110
67.52	1.44	31.04	1.4178	1.5120
64.17	1.87	33.96	1.4139	1.1170
60.06	2.11	37.83	1.4088	1.0882
54.88	2.98	42.14	1.4032	1.0592
48.78	4.01	47.21	1.3972	1.0263
43.88	5.00	51.12	1.3927	0.9991
38.31	6.84	54.85	1.3888	0.9784
31.67	9.78	58.55	1.3829	0.9534
26.39	13.35	60.26	1.3792	0.9386
24.04	15.37	60.59	....	....
23.20	16.63	60.17	1.3792	0.9328
20.71	19.31	59.98	1.3758	0.9289
15.39	26.28	58.33	1.3695	0.9240
10.00	34.96	55.04	1.3672	0.9223
9.63	35.38	54.99	1.3672	0.9223
6.77	41.35	51.88	1.3652	0.9259
4.35	48.47	47.18	1.3626	0.9293
2.18	55.97	41.85	1.3601	0.9363
1.72	61.11	37.17	1.3578	0.9452
1.17	66.58	32.25	1.3543	0.9539
1.02	71.80	27.18	1.3518	0.9608
0.92	74.54	24.54	1.3501	0.9647
0.78	80.40	18.82	1.3460	0.9747
0.70	84.94	14.36	1.3430	0.9797
0.65	87.63	11.72	1.3412	0.989
0.52	94.66	4.82	1.3362	0.988
0.44	99.56	0.00	1.3328	0.9984

13(a) Design 2 - 4 Shell and tube heat exchanger to cool a condensate from a methanol condensor from 110 °C to 49 °C. Flow rate of methanol 110000 kg/h. Brackish water is used to be a coolant with the temperature rise from 29 °C to 45 °C. Mild steel is used a material of construction with the thermal conductivity 71.3 W/m.°C The physical properties of fluids at its average temperature are **(14) 3 3**

Property	TSF	SSF
Cp (KJ/Kg°C)	4.2	2.84
μ (mNs/m^2)	0.8	0.34
ρ (kg/m^{33})	995	750
K(W/m°C)	0.59	0.19
OD of tube	24 mm	ID 18mm
Length	4.88 m	

(OR)

13(b) Estimate the heat transfer coefficient for steam condensing on the outside and inside of 35 mm OD, 28 mm ID, vertical tube of 5.5 m long, the steam condensate rate is 144 kg/h per tube and the condensation takes place at 5.2 bar. Saturation temperature is 144.78°C, Density of condensate and vapor is 935 kg/m^3 and 2.01 kg/m^3, kc – 0.66 W/m°C, Prandtl Number – 1.65, Viscosity of condensate is 199 x 10 -6 kg/m.s. NPr – 1.18 **(14) 3 3**

14(a) A tanker carrying organic fluid is unloaded, using the ship's pumps, to an on-shore storage tank. The pipeline is 460 mm internal diameter and 1900 m long. Miscellaneous losses due to fittings, valves, etc., amount to 990 equivalent pipe diameters. The maximum liquid level in the storage tank is 65.8 m above the lowest level in the ship's tanks. The ship's tanks are nitrogen blanketed and maintained at a pressure of 2.15 bar. The storage tank has a floating roof, which exerts a pressure of 1.525 bar on the liquid. The ship must unload 2250 tonnes within 4 hours to avoid demurrage charges. Estimate the power required by the pump. Take the pump efficiency as 72 per cent. Physical properties of toluene: density 954 kg/m^3, viscosity 0.611 mN s m^{-2} **(14) 4 3**

(OR)

14(b) A single stage double action compressor is equipped with pistons with diameter d = 0.8 m and stroke s = 0.62 m, while dead space is c = 0.043. Compressor shaft rotates at n = 200 rpm. The air inside is compressed at pressure from 0.18 MPa to 0.33 MPa and temperature 31°C. Polytropic efficient is assumed to be 1.22, while mechanical and adiabatic efficiency to be equal to 0.92 and 0.88 respectively. **(14) 4 3**

15(a) Enumerate your views on site selection and plant location to start a new factory in your surroundings. **(14) 5 3**

(OR)

15(b) Discuss in detail about site layout to erect a new pharmaceutical industry in your city. **(14) 5 3**

PART- C (1x 10 =10 Marks)

		Marks	CO	RBT LEVEL
16(a)	Create a suitable reboilers design feasibility with commercial requirements for the following vertical thermosyphon reboilers for a column distillating through aniline. The column will operate at atmospheric pressure and vapor rate of 8000 kg/h is required. Steam is available at 23 bar. Take the bottom pressure is 1.28 bar and molecular weight of aniline is 93.13, Critical Temperature and Boiling point of fluid at 1.28 bar are 695 K and 195°C. Latent heat is 45800 kJ/kmol.	(10)	3	6