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

GUJARAT TECHNOLOGICAL UNIVERSITY
BE SEM-VI Examination-Nov/Dec-2011

Subject code: 160503 **Date: 25/11/2011**
Subject Name: Process Equipment Design I
Time: 10.30 am -1.30 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)** Crude dichlorobenzene is pumped from a storage tank to a distillation column. The tank is blanketed with nitrogen and the pressure above the liquid surface is held constant at 0.1 bar g. The minimum depth of liquid in the tank is 1 m. The distillation column operates at a pressure of 500 mm hg (absolute). The feed point to the column is 12 m above the base of tank. The tank and column are connected by a 50 mm internal diameter commercial steel pipe, 200 m long. The pipe running from the tank to the column contains the valves and fittings: 20 no. of standard radius 90° elbows, two gate valves (fully open), an orifice plate and a flow control valve. Neglect the friction loss in suction line. **10**

If the maximum flow rate required is 20000 kg/hr, calculate the power required by pump. Pump efficiency is 70%. Pressure drop across the control valve is 0.5 bar. Density of the dichlorobenzene is 1300 kg/m^3 and viscosity is 1.4 cP.

Pressure drop for turbulent flow of fluid through commercial steel pipe in KPa/m

$$\frac{\Delta P}{L} = 4.07 \times 10^{10} G^{1.84} Di^{-4.84} \mu^{0.16} \rho^{-1}$$

Where G is in kg/s, Di in mm, μ in kg/(m-s) and ρ in kg/m^3.

Flow meter/ Valve/Elbows	Equivalent nos. of Velocity heads, k
Standard radius 90° Elbows	0.75
Gate valve (fully open)	0.17
Orifice meter	10

(b) Discuss flooding and channeling in packed tower to be used for counter current contact between gas and liquid. **04**

Q.2 **(a)** 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 $\approx$ ΔPt
(ii) Δ Pav >> ΔPt
(iii) Δ Pav < ΔPt

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

(b) Design a vertical decanter for extractor based on the following data. **07**

Flow rate of continuous phase = 441.03 kg/hr
Density of continuous phase = 826.36 kg/m^3
Flow rate of dispersed phase = 200 kg/hr
Density of dispersed phase = 1009.4 kg/m^3
Viscosity of continuous phase = 0.5294 cP.
Residence time of droplets of dispersed phase in dispersion band > 20 seconds.
Diameter of droplet (d_d) = 150 µm

OR

(b) Discuss the criteria of selection for Solvent in liquid-liquid Extraction. **07**

Q.3 A saturated liquid consisting of phenol and cresols with some xylenols, is fractioned to give a top product of 95.3 mole % phenol. Metacresol is heavy key and phenol is light key component. Total condenser is used. The compositions of the top product and of the phenol in the bottom are given. **14**

(1) Complete the material balance over the still for a feed rate of 100 kmol/hr.
(2) Calculate the minimum reflux ratio by Underwood's method.

Component	Relative Volatility (α_{av})	Feed, Mole%	Top Product mole %	Bottom product mole %
Phenol	1.98	35	95.3	5.24
o-Cresol	1.59	15	4.55	?
m-Cresol	1.00	30	0.15	?
Xylenols	0.59	20	--	?
		100	100.00	

OR

Q.3 **(a)** Discuss about the Determination of Optimum Reflux Ratio. **07**

(b) Discuss the Advantages & Disadvantages of Vacuum Distillation. **07**

Q.4 Lube oil is to be cooled from 65˚C to 45˚C by using cooling water in shell and tube heat exchanger. **14**
Lube oil flow rate : 450 L/min
Density of lube oil : 869 kg/m^3
Specific heat of lube oil: 2.1413 kJ/kg˚C
Thermal conductivity of lube oil : 0.13 W/m˚C
Viscosity of lube oil : 15 cP
Cooling water inlet temp. : 35˚C
Cooling water outlet temp. : 39˚C
Specific heat of water : 4.1868 kJ/kg˚C
Viscosity of water : 0.73 cP
Thermal conductivity of water : 0.628 W/m˚C
Fixed tube sheet type shell and tube heat exchanger with following specifications is available for this duty. Decide the fluid allocation and give the justification for the same. Check whether given heat exchanger is suitable for this duty or not. Assuming that tube side and shell side pressure drops are within permissible limit.
Specification of fixed tube sheet heat exchanger:
Shell inside diameter : 418 mm , Tube O.D. : 15.875 mm
Type of baffle : 25% segmental, Tube I.D. : 13.3858 mm
Baffle spacing : 160 mm, Tube length : 3.048 m
Tube pitch : 19.8437 mm, Nos. of Tube : 288

Type of tube arrangement : Triangular,
Nos. of tube side passes : 4,
Thermal conductivity of tube material Kw ; 50 W/m˚C
Oil side fouling coefficient : 3000 W/m^{2}˚C
Water side fouling coefficient : 5000 W/m^{2}˚C
LMTD correction factor : 0.95
Use following correlation for finding shell side heat transfer coefficient.

$$\frac{h_{ode}}{K} = Jh \times Re \times Pr^{1/3}$$

Where $Jh = 10^{x}$, $x = 0.48856 \log_{10} Re - 2.82393$
and $de = \frac{1.1}{do} (Pt^{2} - 0.907 do^{2})$

OR

Q.4 **(a)** Criteria of selection between horizontal condenser and vertical condenser. **07**

(b) Discuss the effect of following in the design of without phase change floating head type shell and tube heat exchanger **07**

(i) Providing sealing strips
(ii) Increase in number to tube side passes
(iii) Decrease in baffle spacing

Q.5 Explain design procedure for Absorption tower for finding the height (Cornell's method) and diameter of column. **14**

OR

Q.5 **(a)** Discuss about the various types of liquid distributor used with packed tower. **07**

(b) Discuss about the criteria of selection of any two of the following equipments as absorber. **07**

(i) Venturi scrubber
(ii) Spray tower
(iii) Falling film absorber

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