Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. Sem-VI Examination May 2011

Subject code: 160503

Subject Name: Process Equipment Design-I

Date:19/05/2011 **Time: 10.30 am – 01.00 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 mixture of benzene and toluene containing 40 mole% of benzene is to be separated to give a top product of 90 mole% benzene and a bottom product with not more than 10 mole% benzene. Using an average value of 2.4 for the volatility of benzene relative to toluene, calculate the following using McCabe-Thiele Method: **14**

1. The minimum reflux ratio(R_m),
2. No. of theoretical stages when $R=2.5R_m$
3. Feed Tray location

Feed entering the column is liquid and at its boiling point.

Q.2 **(a)** Give the stepwise design procedure for shell and tube heat exchanger without any phase change. **08**

(b) Give the comparison between fixed tube sheet, U-tube and floating head type of heat exchanger. **06**

OR

(b) Discuss the different criteria of selection between horizontal condenser and vertical condenser. **06**

Q.3 **(a)** Give merits and demerits of vacuum distillation over conventional distillation. **07**

(b) Benzene is to be recovered from coal gas by scrubbing it with wash oil as an absorbent. Absorber handles 900 m^3/hr of coal gas containing 2% by volume benzene. Coal gas enters at temperature of 300^0k and 107.324 kPa pressure. 95% of benzene should be recovered by the solvent. The solvent enters at 300^0k containing 0.005 mole fraction of benzene and has an average molecular weight of 260. Calculate the circulation rate of oil (solvent) per hour if the column is to be operated at 1.5 times the minimum oil circulation rate. The Equilibrium relationship between liquid and vapor is given as $Y/(1+Y) = 0.125\ X/(1+X)$ **07**

OR

Q.3 **(a)** Write short note on selection of key components in multicomponent distillation. **07**

(b) Discuss the criteria of selection for different absorption equipment. **07**

Q.4 **(a)** Discuss the desirable solvent properties required for choice of solvent in liquid-liquid extraction. **07**

(b) Write short note on Tinker's flow model in shell and tube heat exchanger design. **07**

OR

Q.4 **(a)** Give the stepwise process design procedure for countercurrent multistage extractor. **09**

(b) Find out the power required for a turbo blower for the following duty. **05**
Fluid- Atmospheric Air, Capacity- 1000 Nm^3/hr
Discharge pressure- 2 atm a, Inlet temperature of Air- 50^0c
For air k=1.395.
Power requirement for blower is given by,
$P = 2.78 \times 10^{-4}\ k/(k-1) \times q_{v1} \times p_1[(p_2/p_1)^{(k-1)/k} - 1]$
Where P= Power required in kW,
p_1= inlet pressure in kPa,
p_2= discharge pressure,
q_{v1}= volumetric flow rate of air based on inlet condition in m^3/hr.
Also find the discharge temperature of air.

Q.5 **(a)** Benzene at 38^0c is pumped through the system at a rate of 9.09 m^3/hr with the help of a centrifugal pump. The reservoir is at atmospheric pressure. Pressure at the end of discharge line is 345 kPa g. The discharge head is 3.05 meter and the pump suction head is 1.22 meter above the level of liquid in reservoir. The friction loss in suction line is 3.45 kPa and that in discharge line is 37.9 kPa. The mechanical efficiency of the pump is 0.6. The density of benzene is 865 kg/m^3 and its vapor pressure at 38^0c is 26.2 kPa. Calculate (1) NPSH and (2) power required by pump. **10**
Power required by pump is given by,
$P = (H \times q_v \times \rho) / (3.67 \times 10^5 \times \eta)$
Where P= power required in kW,
H= Total dynamic head in meter,
q_v= volumetric flow rate in m^3/hr,
ρ= density of fluid in kg/m^3,
η= mechanical efficiency of pump.

(b) Estimate the optimum pipe diameter for a flow of dry chlorine gas of 10000 kg/hr at 6 atm a and at 20^0c through carbon steel pipe. Also give the importance of Schedule no. in pipe design. **04**

OR

Q.5 **(a)** Give the functions of various parts of shell and tube heat exchanger. **07**

(b) A rotameter tube with an internal diameter of 25 mm at top and 20 mm at the bottom is 0.3 meter long. The diameter of float is 20 mm. Water flows through the rotameter. Calculate the maximum and minimum flow rate the rotameter can measure. **07**
Data: - Density of float material. ρ_f= 4.8 gm/cm^3,
Density of water= 1000 kg/m^3,
Volume of float, V_f= 6 cm^3,
C_D= 0.7.

****