(Following Roll No. to be filled by candidate)

Roll No.

B TECH
SIXTH SEMESTER EXAMINATION 2015-2016
ECH601
MASS TRANSFER OPERATION-II

Time: 3 Hours **Max. Marks: 100**

NOTE:

- Attempt all questions
- You are trained to be an engineer and not a story writer, answer point to point.
- Assume missing data suitably and wisely. Illustrate the measures with suitable sketches.

1. Attempt any four parts of the following: [4x5]
   a. Define relative volatility in terms of distillation with its expression.
   b. Derive the necessary relationship for flash distillation.
   c. A mixture of 40 mol % benzene and 60 mol % toluene is being flash distilled at a rate of 10kmol/h at 1 atm total pressure. The liquid product should not contain more than 30 mol % benzene. Calculate the amounts and the compositions of the top and bottom products. The relative volatility of benzene in the mixture is 2.5. Solve analytically.
   d. 100 moles of benzene and toluene containing 50 mol% benzene is subjected to a differential distillation at atmospheric pressure till the composition of the benzene in the residue is 33% by mole. Calculate the total moles of the mixture distilled. Take $\alpha = 2.4$
   e. Explain boiling point diagram for constant pressure vapor-liquid equilibrium.
2. Attempt any four parts of the following: [4x5]
   a. What are minimum boiling azeotropes? Explain with chloroform-acetone system at one atmosphere.
   b. Define following:
      i. Reflux ratio
      ii. HTU
      iii. NTU
      iv. HETP
      v. Murphee plate efficiency
   c. A binary distillation column is operating under conditions specified below:
      Feed rate=350 kmol/h, overhead product ratte=150kmol/h
      Mole fraction of more volatile component in overhead product = 0.97
      Bottom product=0.02
      Bottom product rate=200 kmol/h
      Reflux ratio = 3.5

   In the stripping section, it is found that mole fraction of more volatile component in the vapor leaving a plate is 0.33 while its mole fraction in the liquid coming to the same plate is 0.25. Assuming constant molar overflow, determine whether the feed is vapor, liquid or partially vaporized.
   d. A mixture of 35 mol% A and 65 mol% B is to be separated in a distillation column. The concentration of A in the distillate is 92 mol% and 96% of component A is recovered in distillate. The feed is all vapor. The reflux ratio is 4 and relative volatility is 2.4. How many equilibrium stages are required in each section of column? What is minimum reflux ratio?
   e. Derive the necessary relation for a binary distillation column to find out number of trays using McCabe Thiele Method

3. Attempt any two parts of the following: [2x10]
   a. In a liquid-liquid extraction process, how will you select a solvent for extraction of liquid? Explain at least 5 criteria. And solve the following:
      A solution containing 5% acetaldehyde and 95% toluene is to be extracted with water in five stage crosscurrent extraction unit to extract acetaldehyde. Toluene and water are essentially insoluble. If 25kg of water each time are used per 100 kg of feed, calculate the amount of acetaldehyde extracted and final concentration of exit solution.
      The equilibrium relationship is given as:
      $Y = 2.20X$
      Where Y = kg acetaldehyde/kg water
      X= kg acetaldehyde/kg toluene
   b. A 25% solution of dioxane in water is to be continuously extracted at a rate of 1000 kg/h in countercurrent extraction system with benzene to remove 95% of dioxane the equilibrium distribution of dioxane between water and benzene is as follows:

Weight % dioxane in water	5.1	18.9	25.2
Weight % dioxane in benzene	5.2	22.5	32

      At these concentrations, benzene and water are substantially insoluble. Determine number of theoretical stages required if 900 kg of benzene is used per hour.
   c. A continuous contact extraction column is used to extract a solute from a aqueous stream (F) using organic solvent (B). the distribution coefficients $\left(\frac{y'}{x}\right) = 1.0$, where x and y are the mass fractions of the solute in the raffinate and extract phases and solvent are immiscible, find the height of the column required.
      Data: i) Flow rate of aqueous solution (F) =100kg/h
      ii) Flow rate of solvent (B) =100 kg/h. the solvent used is pure.
      iii) Weight fraction of solute in aqueous solution =0.10 and that in raffinate leaving the column is 0.01.

4. Attempt any two parts of the following: [2x10]

a. Describe the construction and working of following solid-liquid extractor:
   i. Rotocel Extractor
   ii. Dorr Agitator

b. Oil is to be extracted from meal by means of benzene using continuous countercurrent extraction unit. The unit is expected to treat 1000kg of meal (based on completely exhausted solid) per hour. The untreated meal contains 365 kg of oil and 30kg of benzene. The solvent used contains 14kg of oil and 590 kg of benzene. The exhausted solids are to contain 55 kg of unextracted oil. Experimental data on the extraction of oil from meal of benzene at a given operating temperature are as follows:

Solution composition, kg oil/kg solution	Solution retained (in underflow) kg solution/kg solids
0	0.500
0.10	0.505
0.20	0.515
0.30	0.530
0.4	0.550
0.5	0.571
0.6	0.595
0.7	0.620

Find the number of ideal stages required.

c. Taking an example explain the concept of single stage leaching with its equations.

5. Attempt any two parts of the following: [2x10]

a. Differentiate between Physical adsorption and chemisorption and write done at least 5 applications of adsorption.

b. Describe the ion exchange method with its principle and explain the sodium cation exchanger and Hydrogen cation exchanger for a water softening process.

c. Experiments on decolorization of oil yielded the following equilibrium relationship:

$y = 0.5\,x^{0.5}$

Where y=g color removed/ g adsorbent

x = color in oil, g color/ 1000g color free oil

100 kg oil containing 1 part of color to 3 parts of oil is agitated with 25 kg of adsorbent, calculate the % color removed if all 25 kg of adsorbent is used in one step.