BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER : V**
BRANCH: BT **SESSION : MO/19**

SUBJECT: BT5023 CHEMICAL ENGINEERING III

TIME: 3 HOURS **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) A liquid mixture of benzene and toluene in equilibrium with its vapour at 101 kPa and 373 K. The vapor pressure of benzene and toluene at 373 K respectively are 156 and 63 kPa. Assuming the system obeys Raoult's law, the mole fraction of benzene I the liquid phase is _____. [2]

Q.1(b) A charge of 50 mole of a mixture of benzene and chlorobenzene having 55 mol% of the less volatile is to be batch distilled. (a) If 25 moles of the solution is vaporized and condensed as the distillate, calculate the concentration of the accumulated distillate. (b) If the concentration of the accumulated product is found to be 72 mol% benzene, calculate its amount. The relative volatility of benzene in the mixture is 4.15. [4]

Q.1(c) A mixture of 40 mol% benzene and 60% mol% toluene is being flash distilled at a rate of 10 kmol/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 by analytically? [6]

Q.2(a) Write Fenske's equation and write the assumption? [2]

Q.2(b) A binary distillation column is designed by McCabe -Thiele method to get a distillate mole fraction of 0.9. The enriching section operating line has an intercept with y axis at 0.3 mole fraction. The ratio of liquid to vapour molar flow rate in the enriching section is _____ [4]

Q.2(c) A continuous fractionating column is to be designed for separating 10,000 kg per hour of a liquid mixture containing 40 mole percent methanol and 60 mole percent water into an overhead product containing 97 mole percent methanol and a bottom product having 98 mole percent water. A mole reflux ratio of 3 is used. Calculate (i) moles of overhead product obtained per hour and (ii) number of ideal plates and location of the feed plate if the feed is at its bubble point. [6]

Equilibrium data:

x	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y	0.417	0.579	0.669	0.729	0.78	0.825	0.871	0.915	0.959

Q.3(a) Write about Plait point in extraction process? [2]

Q.3(b) It is desired to reduce the concentration of pyridine in 500 kg of aqueous solution form 20 weight percent to 5 wt percent in a single batch extraction using chloro-benzene as solvent. Equilibrium composition (end points of the tie line) in terms of weight percent of pyridine-water-chlorobenzene are (5,95,0) and (11,0,89). The amount of pure solvent required in kg for the operation is _____ [4]

Q.3(c) In a single stage extraction process, 10 kg of pure solvent S (Containing no solute A) is mixed with 30 kg of Feed containing A at a mass fraction X_F =0.2. The mixture splits in to an extract phase E and a Raffinate phase R, containing at X_E =0.05 and X_R = 0.05 respectively. The total mass of the extract phase is (in kg) _____ [6]

Q.4(a) What are the advantages and problems of carrying out extraction of solid at an elevated temperature? [2]

Q.4(b) Write in detail about Bonotto extractor for solid liquid separation? [4]

Q.4(c) 500 kg/hour of an ore, containing 20 wt% copper, is leached in an agitator with a 1000 kg/hour solution of sulphuric acid to extract copper. Assume that all of the copper is extracted in to solution, and perfect mixing is achieved. If 1 kg of solvent solution per kg f solid ore is entrained in each thickener, calculate the number of agitator required to extract more than 99 wt % copper in the combined overflow sloutions? [6]

Q.5(a) Write about the characteristics and properties of adsorbents? [2]

Q.5(b) At 30 °C the amounts of acetone adsorbed at partial pressures of 10 and 100 mmHg are 0.1 and 0.4 kg acetone/ kg activated carbon, respectively. Assume Langmuir isotherm describes the adsorption of acetone on activated carbon. What is the amount of acetone adsorbed (in kg per kg of activated carbon) at a partial pressure of 50 mmHg and 30°C ? [4]

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Q.5(c) Adsorption on activated carbon is to be used for reducing phenol concentration in wastewater from 0.04 mol/L to 0.008 mol/L. The adsorption isotherm at the operating temperature can be expressed as $q = 0.025\ C^{1/3}$; where q is the phenol concentration in solid (mol/g solid) and C is the phenol concentration in water (mol/L). The minimum amount of solid (in grams) required per liter of wastewater is _____ [6]

Q.6(a) Define sphericity? [2]

Q.6(b) Calculate the volume-surface mean diameter for the following particulate material [4]

Size range, μm	-710+300	-300+180	-180+90	-90+38	Pan
Mass of particles in the range, g	30	35	65	70	55

Q.6(c) A sample of materials is crushed in a Blake jaw crusher such that the average size of the particle is reduced from 50 mm to 10 mm with the energy consumption of 13 kW/ (kg/s). Determine the consumption of energy to crush the same material of 75mm average size to an average size of 25 mm using Rittinger's and Kick's law? [6]

Q.7(a) Write about drag force and terminal velocity? [2]

Q.7(b) A viscous solution containing particles with density ρ_p=1461 Kg/m^3 is clarified by centrifugation. Solution density ρ=801 Kg/m^3 ; Viscosity μ=100 cp. Centrifuge bowl with r_2=0.02225 m.; r_1=0.00716 m.; height=b=0.197 m.; Calculate critical particle diameter of the largest particles in the exit stream if N=23000 rev/min, q=0.002832 m^3 /hr. [4]

Q.7(c) A water-based slurry of mineral is being filtered under vacuum, with a controlled pressure drop of 38 kPa, through a filter paper of 0.07 m^2 . The slurry is at 24 kg solids per m^3 fluid. Use $\mu = 8.9 \times 10^{-4}$ Pa.s and the following data: [6]

v (L)	0.5	1	2	3	4
t (s)	19	38	95	178	280

i. Calculate medium resistance, Rm
ii. Calculate specific cake resistance, α
iii. Calculate the cake resistance Rc at t = 280 s

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