CLASS: BE   SEMESTER : V
BRANCH: BIOENGINEERING   SESSION : MO/18

SUBJECT: BT5023-CHEMICAL ENGINEERING-III

TIME: 03:00   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)   Define Fick's first law of diffusion.   [2]
   (b)   Identify the analogy between heat, mass and momentum transfer with equations.   [4]
   (c)   A mixture of benzene and toluene of 50 mole % each is flash distillate at 1 atm pressure. The feed is   [6]
         heated to a temperature to flash 40% of it. What will be the composition of vapor and liquid leaving
         the flash chamber? Relative volatility is 2.45.

Q.2(a)   What type of distillation you use to obtain >90% ethanol from water.   [2]
   (b)   Calculate the minimum number of plates required in a distillation column to separate an binary   [4]
         mixture of components A and B into an overhead fraction containing 99 mol % A and a bottoms fraction
         containing 98 mol % B? Given α = 2
   (c)   A continuous fractionating column is to be designed for separating 10,000 kg per hour of a liquid   [6]
         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 reflux
         ratio of 3 is used. Calculate number of ideal plates and location of the feed plate if the feed is at its
         bubble point. α = 3.32.

Q.3(a)   Draw a ternary diagram and indicate a point which represents a mixture of 30% A, 40% B and 30% C.   [2]
   (b)   A clarified fermentation beer (H) containing 260 mg/L of antibiotic is to be extracted using butyl   [4]
         acetate (L). K = 57. We plan to use H = 450 L/h and L = 37 L/h to recover 99% antibiotics. How many
         stages are required for this separation?
   (c)   For the batch extraction of an amino acid, the equilibrium relation between toluene and pure water   [6]
         is x^2 = 0.001y. We plan to add 4.7 L of toluene containing 0.006 M amino acid with 1L water. Graphically
         determine the fraction of amino acid extracted.

Q.4(a)   Define leaching.   [2]
   (b)   In a pilot scale test sing a vessel of 1 m^3 volume, a solute was leached from an inert solid. The water   [4]
         was saturated 75% in 10 sec. In a full scale unit, 500 kg of inert solid containing 28% w/w of soluble
         component is agitated with 100 m^3 of water. How long will it take for all the solute to dissolve?
         Assuming the same condition as pilot plant. Water is saturated with the solute at a concentration of
         2.5 kg/m^3.
   (c)   Seeds containing 20% oil are extracted in a counter current extractor. The extract contains 50% oil. If   [6]
         the seeds are extracted in fresh solvent and 1 kg solution (containing 5% oil) is removed in underflow,
         which is associated with 2 kg of insoluble matters, graphically determine the number of ideal stages
         required. Consider 90% efficiency.

Q.5(a)   Write the applications of adsorption in biological process.   [2]
   (b)   Adsorption of enzyme on cellulose follows Langmuir model. The maximum uptake is 70 mg/g   [4]
         adsorbent. Half of this maximum achieve at 50 mg/L of enzyme. We have 1.5 L of feed containing 220
         mg/L of enzyme. How much cellulose do we need to add to obtain 90% recovery of the enzyme?
   (c)   A moving bed column of 4 cm diameter and 0.8 cm^3 resin/ cm^3 porosity is filled with resin of density   [6]
         1.3 g/cm^3. Feed solution (S_0) is 5 g/L, v is 1.5 m/h, K_a is 15 h^{-1}, S' is 0.2 g/L and S* is 0.16 s^2. Calculate
         height of the bed.

Q.6(a)   Define sphericity for an irregular particle with formula.   [2]
   (b)   Determine the power required to crush 100 ton/h of limestone if 80% of feed passes a 50.8 mm screen   [4]
         and product in 3.2 mm screen. Work index for limestone is 12.74.
   (c)   From screen analysis of particles the data obtained was Σ (xi/Dpi) = 0.8284 and Σ (xi/Dpi^3) = 8.83.   [6]
         Density is 2650 kg/m^3 and sphericity is 0.571. Calculate Aw, Dv and Ds. Ignore pan fraction.

Q.7(a) Write two differences between concentration polarization and membrane fouling. [2]
  (b) Write a short note on isopycnic gradient centrifugations. [4]
  (c) In a cross flow UF system used for filtration of proteins from a fermentation broth, gel resistance [6] increases with protein concentration according to the following equation: $R_G = 0.5 + 0.01 \times C$ where C is in mg/L. Pressure at the entrance of the system $P_1 = 6$ atm. and at the exit $P_0 = 2$ atm. The shell side of the filter is opened to the atmosphere. The membrane resistance is $R_m = 0.5$ atm/(mg/m^2.h) and the protein concentration in the broth is C = 100 mg/L. Determine (a) The pressure drop across the membrane, (b) The filtration flux and (c) The rejection coefficient of the membrane for effluent protein concentration of C_f = 5mg/L.

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