Group – E

8. In a cross flow ultra-filtration system for separation of protein from the fermentation broth, the flow rate of liquid through a tube of diameter d = 2 cm and length L= 50 cm is Q= 2 L/min. The flow regime is turbulent, f=0.0005, and C_4= 2 [atm(s/cm)^2]. The inlet pressure is P_i= 2 atm. Protein concentration in the solution and on gel film are C_B=30 mg/L and C_G =100 mg/L, respectively. Determine:
   (i) The transmembrane pressure drop.
   (ii) If the mass transfer coefficient (k) for protein flux is k= 5 cm/s, determine the flux of liquid through the UF membrane.

12

9. A reverse osmosis membrane to be used at 25°C for a NaCl feed solution containing 2.5 g NaCl/L (ρ=999 kg/m^3) has a water permeability constant K_p=4.81×10^{-4} kg/s.m^2.atm and a solute permeability constant, K_P'=4.42× 10^{-7} m/s. Calculate the water flux and solute flux through the membrane using Δ P=27.20 atm and the solute rejection R. Also calculate concentration of the solute in the product solution (π=1.89 atm)

6 + 6 =12

TRANSFER OPERATION- II
(BIOT 3104)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

   (i) For estimating the drier size it is necessary to know _____
   (a) time of drying (b) heat of drying
   (c) Speed of drying (d) all of the mentioned.

   (ii) Solvent extraction is more effective when the extraction is repeated with
   (a) extra solvent (b) large solvent
   (c) small solvent (d) no solvent.

   (iii) What do you mean by the term "Sorption"?
   (a) Attachment (b) Detachment
   (c) Diffusion (d) Thermal Expansion.

   (iv) When the component has a small value of K, it is supposed to have an affinity for
   (a) mobile phase (b) no phase
   (c) stationary phase (d) whole solution.

   (v) Which of the following is NOT true of Raoult's law
   (a) Raoult's law applies to miscible solvents in a closed system
   (b) The toluene-benzene mixtures obey Raoult's law
   (c) A pharmaceutical application of Raoult's law is the formulation of pressurised metered dose inhalers
   (d) The behaviour predicted by Raoult's law is independent of inter-molecular forces.

(vi) For steady-state equimolar counter diffusion, $N_A/(N_A+N_B)$ is
(a) 0 (b)1 (c)∞ (d)1/2.

(vii) If the operating line coincide with the equilibrium curve, which one of the following is not true for absorbers?
(a) The solvent rate is minimum
(b) The number of plates is infinity
(c) The L/G ratio is maximum
(d) The driving force becomes zero.

(viii) Diffusion coefficient in a binary gas mixture at low pressure varies
(a) directly with P (b) inversely with P
(c) directly with P^2 (d) independent of P.

(ix) The only membrane separation in which the permeate undergoes a phase change is
(a) Electrodialysis (b) Pervaporation
(c) Ultrafiltration (d) Reverse osmosis.

(x) Two most important properties of membranes for industrial separations are
(a) selectivity and permeability (b) selectivity and volatility
(c) permeability and strength (d) permeability and productivity.

Group – B

2. A tray tower is to be designed to absorb SO_2 from an air stream by using pure water at 293K. The entering gas contains 20 mol% SO_2 and that leaving 2 mol% at a total pressure of 101.3 kPa. The inert air flow rate is 150 kg air/h.m^2, and the entering water flow rate is 6000 kg water/h.m^2. Assuming an overall tray efficiency of 25%, how many theoretical trays are needed? What should be the number of trays actually to be employed? Assume the tower to operate at 293K and equilibrium relationship is given by $y^*= 20x$.

12

3. An air-ammonia mixture containing 20% (mole) NH_3 is scrubbed with waterin a counter current packed tower to remove 95% ammonia in the entering gas. The gas enters the column at 1000 kg/h.m^2 and the column is operated at 308K and 101.3 kPa. Pure water is admitted at a rate 1.5 times the minimum rate. The equilibrium relation is y=0.75x where, x and y are mole fractions. The mass transfer coefficient (K_ya=34kmol/h.m^3). Find the height of the tower.

12

Group – C

4. A plate column equipped with a total condenser and reboiler is used to separate 100 kmol/hr of a benzene-toluene solution containing 50 mol % benzene into a distillate product containing 95 mol% benzene and bottom product containing 5 mol% benzene. The feed is partially vaporised and is 1/3rd vapour and 2/3rd liquid. Determine the following.

(i) The minimum number of plates analytically using α = 2.39.
(ii) The minimum reflux ratio.
(iii) The number of plates if the operating reflux ratio is 30% in excess of minimum.

x	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	1
y	0	0.205	0.369	0.502	0.618	0.706	0.789	0.849	0.907	0.955	0.978	1

(3 + 3 + 6) = 12

5. (a) State the principle of Flash Distillation with diagram.

(b) Derive the operating line equation for Flash Distillation.

(c) Define relative volatility.

5 + 5 + 2 = 12

Group – D

6. Define the following terms:

(i) Humidity
(ii) Percentage humidity
(iii) Relative humidity
(iv) Dew point temperature
(v) Humid heat
(vi) Humid volume

(6 × 2)=12

7. Batch test were performed in the laboratory using solution of phenol in water and particles of granular activated carbon. The equilibrium data at room temperature are shown in the table below. Determine the adsorption isotherm that fits below:

C(kg of phenol/m^3 of solution)	0.322	0.117	0.039	0.0061	0.0011
Q (kg of phenol/kg carbon)	0.150	0.122	0.094	0.059	0.045

12