

**TRANSFER OPERATION – II**  
**(BIOT 3104)**

**Time Allotted : 2½ hrs**

**Full Marks : 60**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.*

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

**Group – A**

1. Answer any twelve:

**12 × 1 = 12**

*Choose the correct alternative for the following*

- (i) 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.
- (ii) Molecular diffusivity of a liquid  
(a) increases with temperature  
(b) decreases with temperature  
(c) may increase or decrease with temperature  
(d) is independent of temperature.
- (iii) When the boiling temperature is plotted against the liquid composition, then it is called  
(a) Cooling Curve (b) Heating Curve  
(c) Bubble point curve (d) Volatility Phase Diagram.
- (iv) The process of heating a liquid mixture to form vapours and then cooling the vapours to get pure component is called \_\_\_\_\_.  
(a) Crystallisation (b) Distillation  
(c) Chromatography (d) Sublimation
- (v) In Azeotropic distillation \_\_\_\_\_ remains low.  
(a) heat (b) volatility  
(c) relative volatility (d) none of the mentioned
- (vi) What will happen if an air-water vapour sample is cooled below the dew point?  
(a) Its humidity will increase  
(b) Its percentage saturation will increase  
(c) Its percentage saturation will decrease  
(d) Its humidity will decrease.

- (vii) What is meant by crystallization?  
 (a) Concentration of atoms into a highly structured form  
 (b) Solidification of atoms into a highly structured form  
 (c) Solidification of solution  
 (d) Concentration of solution.
- (viii) For fixing the effective drying conditions, which processing factor is essential?  
 (a) Humidity (b) Pressure  
 (c) Temperature (d) All the above.
- (ix) Consequence of concentration polarization is  
 (a) solvent diffuses back from the membrane surface to the solution  
 (b) solute diffuses back from the membrane surface to the solution  
 (c) rate of diffusion increases  
 (d) none of the above.
- (x) The only membrane separation in which the permeate undergoes a phase change is  
 (a) Electrodialysis (b) Pervaporation  
 (c) Ultrafiltration (d) Reverse osmosis.

*Fill in the blanks with the correct word*

- (xi) The relationship between the temperature of saturated liquid feed and bubble point is \_\_\_\_\_.
- (xii) Mole fraction of MVC in distillate is always \_\_\_\_\_ than mole fraction of MVC in feed.
- (xiii) \_\_\_\_\_ type of dryer is known as lyophiliser.
- (xiv) Diffusivity coefficient is \_\_\_\_\_ proportional to pressure.
- (xv) Extraction factor is related to distribution coefficient by the relation \_\_\_\_\_.

### Group - B

2. (a) Prove that  $D_{AB} = D_{BA}$ . [[CO1](Understand/LOCQ)]  
 (b) Derive a mathematical expression for measuring diffusion flux in pseudo steady state one way diffusion. [[CO2](Apply/IOCQ)]  
**6 + 6 = 12**
3. (a) Liquid acetone is contained in a capillary tube at 292K and 102kPa. The initial level of acetone was at 20mm from the top of the tube. The vapour pressure of acetone at 292K is 22.7kPa and density of liquid acetone is 790kg/m<sup>3</sup>. Determine the fall in level of acetone after 2 hours if the diffusivity of acetone in air at 292K is  $9.0 \times 10^{-6} \text{ m}^2/\text{s}$ . [[CO1](Calculate/IOCQ)]  
 (b) NH<sub>3</sub> is diffusing through an inert film 2mm thick at a temperature of 20°C and a pressure of 1 atm. The concentration of NH<sub>3</sub> is 10% by volume on one side of the film and zero on the other side.  $D_{AB}$  at 0°C and 1atm is  $0.198 \text{ cm}^2/\text{s}$ . Estimate the rate of diffusion if the temperature is 20°C and the pressure is raised to 5atm. [[CO1](Evaluate/IOCQ)]  
**6 + 6 = 12**

### Group - C

4. A mixture of n-heptane and n-octane containing 40 mol% n-heptane is subjected to simple distillation at 101.3 KPa. Equilibrium data is given below:

|   |   |       |       |       |       |   |
|---|---|-------|-------|-------|-------|---|
| X | 0 | 0.157 | 0.312 | 0.487 | 0.655 | 1 |
| Y | 0 | 0.279 | 0.492 | 0.674 | 0.810 | 1 |

- (i) Determine the composition of the residue and distillate if half of the feed is distilled off.
- (ii) Determine the composition of the residue and moles of the distillate product, if it is desired that the distillate product has an average composition of 57 mol% n-heptane and waste product generated is to be of 77 kmol, when 100 kmol of feed is introduced.

[[CO3](Analyse/HOCQ)]

**(9 + 3) = 12**

5. (a) Describe in details vapour liquid equilibrium curve of a liquid- liquid mixture when heated at different temperature. Assume that the liquids have appreciable difference in their volatility.
- (b) Define relative volatility. Derive the relationship of mole fraction of more volatile component in vapour to more fraction of more volatile component in liquid in relation to relative volatility of two components of a liquid-liquid mixture.

[[CO3](Analyse/IOCQ)]

[[CO3](Remember/LOCQ)]

**6 + 6 = 12**

### Group - D

6. (a) Write short note on: (i) adsorption isotherm (ii) counter-current extraction.
- (b) Draw and explain drying characteristics curve for drying of a solid material under constant humidity.
7. Data on the drying curve of a particular solid is given below. The weight of the dry material in the solid is 48.0 kg/m<sup>2</sup>. Calculate the time required to dry the material from 20% to 8% moisture.

[[CO3](Analyse/IOCQ)]

[[CO4](Understand/LOCQ)]

**(4 + 4) + 4 = 12**

|   |      |      |      |      |      |      |      |      |
|---|------|------|------|------|------|------|------|------|
| X | 0.30 | 0.20 | 0.18 | 0.15 | 0.14 | 0.11 | 0.07 | 0.05 |
| N | 1.22 | 1.22 | 1.14 | 0.90 | 0.80 | 0.56 | 0.22 | 0.05 |

[[CO5](Analyse/HOCQ)]

**12**

### Group - E

8. (a) What are the working principles of ultra-filtration, electro dialysis and reverse osmosis?
- (b) Where can you apply the above unit operations in the field of biotechnology?

[[CO6](Calculate/IOCQ)]

[[CO6](Understand/LOCQ)]

**6 + 6 = 12**

9. Experiments at 25°C were performed to determine the permeabilities of a cellulose-acetate membrane. The laboratory test section shown in figure has membrane area  $A = 2.00 \times 10^{-3} \text{m}^2$ . The inlet feed solution concentration of NaCl is  $C_1 = 10.0 \text{kg NaCl/m}^3$  solution ( $10.0 \text{g NaCl/L}$ ,  $\rho_1 = 1004 \text{kg solution/m}^3$ ). The water recovery is assumed low so that the concentration  $C_1$  in the entering feed solution flowing past the membrane and the concentration of the exit feed solution are essentially equal. The product solution contains  $C_2 = 0.39 \text{kg NaCl/m}^3$  solution ( $\rho_2 = 997 \text{kg solution/m}^3$ ) and its measured flow rate is  $1.92 \times 10^{-8} \text{m}^3 \text{ solution/s}$ . A pressure differential of  $54.42 \text{ atm}$  is used. Calculate the permeability constants of the membrane and the solute rejection  $R$ . (Given  $\pi = 7.48 \text{ atm}$ ).

[[CO6](Evaluate/HOCQ)]

12

---

| Cognition Level         | LOCQ  | IOCQ  | HOCQ  |
|-------------------------|-------|-------|-------|
| Percentage distribution | 22.92 | 39.58 | 37.50 |