

**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) In distillation operation we make use of the following as separating agent.
(a) Solvent (b) Condenser (c) Heat (d) Trays.
- (ii) Relative volatility for a binary system
(a) increases with increase in pressure
(b) decreases with increase in pressure
(c) increase with increase in temperature at constant pressure
(d) has no significance in distillation process.
- (iii) 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.
- (iv) If the extent of flash vaporisation is 50%, the slope of operating line is
(a) $\frac{1}{2}$ (b) $-\frac{1}{2}$ (c) 1 (d) -1.
- (v) A material contains 20% water on wet basis. What is the moisture content of the material on dry basis?
(a) 33.3% (b) 25% (c) 16.67% (d) 80%.
- (vi) In a distillation operation, the reflux ratio may vary between
(a) 0 and 1
(b) 0 and infinity
(c) -1 and 1
(d) Minimum reflux ratio and infinity.

- (vii) 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.
- (viii) For a given material, if the thickness of the material is smaller, the critical moisture content
(a) increases (b) decreases
(c) remains unaffected (d) can not be predicted.
- (ix) Which of the following is not a membrane separation process?
(a) Ultra-filtration (b) Chromatography
(c) Flash distillation (d) Pervaporation.
- (x) Packed columns are
(a) differential contact plant (b) stage contact plant
(c) gas-liquid contact plant (d) solid-liquid contact plant.

Group – B

2. A gas mixture containing 15% CO₂ and the balance inerts is admitted into an absorption column operating at 101.3 KPa and 298 K. Methanolamine solution containing 0.06 mol CO₂ per mol solution entering at 298 K is used as the solvent for absorption at a rate 1.2 times the minimum. The leaving gas contains 2% CO₂. The equilibrium partial pressure of CO₂ over methanolamine solution are:

P _{CO₂} , kPa	0.746	1.706	3.865	7.464	20.66
x	0.058	0.06	0.062	0.064	0.068

Determine:

- (i) Minimum liquid to gas ratio.
(ii) The number of plates required.
- (7 + 5) = 12**
3. (a) The diffusivity of benzene in air is measured by Stefan's method. A vertical glass tube is filled with benzene to a depth of 20 mm from the top open end. It took 190 h for the level to fall to 80 mm from the top. The temperature and pressure are maintained at 298 K and 100 KPa. Density of liquid benzene is 875 kg/m³ and the vapour pressure of benzene is 12.6 KPa at 298 K. Calculate the diffusivity of benzene in air at 298 K.
- (b) Water at 293 K and 101.3 kPa is contained in a narrow vertical tube. The level of liquid is maintained 150 mm below the open end, across

which air with a humidity of 0.002 kg water/kg dry air is passed at 293 K and 101.3 KPa. If the diffusivity of water vapour in air is $2.5 \times 10^{-5} \text{ m}^2/\text{s}$, and the vapour pressure of water is 2.34 KPa, calculate the rate of evaporation of water. What will be the rate of evaporation if dry air is passed over the tube?

5 + 7 = 12

Group - C

4. (a) Derive the equation of operating line of rectification section of a distillation column.
 (b) Explain why the plates present in distillation column are called equilibrium plates.

6 + 6 = 12

5. A mixture of n-heptane and n-octane containing 40 mol% n-heptane is subjected to simple flash distillation at 101.3 KPa. Equilibrium data

x	0	0.157	0.312	0.487	0.655	1
y	0	0.279	0.492	0.674	0.81	1

Determine the composition of the residue and the distillate if half of the feed is distilled off.

12

Group - D

6. Air-water vapour mixture at 325 K and 120 KPa has a dew point of 293 K. The vapour pressure of water is given by Antoine equation
 $\ln P_s = 16.26205 - [3799.887/(T - 46.854)]$

Determine:

- (i) Absolute humidity of air
 (ii) Saturation humidity
 (iii) The relative saturation

The dew point if the total pressure is reduced to 100 KPa.

(4 × 3) = 12

7. (a) State the equation and assumptions of Langmuir isotherm for adsorption.
 (b) Explain the primary and secondary nucleation theory of crystallization.

6 + 6 = 12

Group - E

8. A feed solution at 25°C contains 3500 mgNaCl/L ($\rho = 999.5 \text{ kg/m}^3$). The permeability constant $A_w = 3.5 \times 10^{-4} \text{ kg solvent/s.m}^2 \cdot \text{atm}$ and $A_s = 2.5 \times 10^{-7} \text{ m/s}$. Using a $\Delta P = 35.5 \text{ atm}$, calculate the fluxes, solute rejection R and product solution concentration in mg NaCl/L (osmotic pressure = 1.937 atm).

12

9. (a) A solution containing 0.9 wt% protein is to undergo ultrafiltration using a pressure difference of 5 psi. The membrane permeability is $A_w = 1.37 \times 10^{-2} \text{ kg/s.m}^2 \cdot \text{atm}$. Assuming no effects of polarization, predict the mass flux. (1psi = 0.068 atm).

- (b) Write a note on any one membrane separation process mentioning its advantages, disadvantages and applications in the field of biotechnology.

6 + 6 = 12