B.E. CHEMICAL ENGINEERING FOURTH YEAR FIRST SEMESTER – 2025
SEPARATION PROCESSES-III

Time: 3 Hours Full Marks:100

Answer any two questions between 1-3 and 4-6 (total 4questions to be answered)
Assume any missing data

CO	CO1	CO2	CO3	CO4	Total
Total Marks	30	20	30	20	100

1. **a)** Explain the following terms with examples in the light of multicomponent distillation: Light Non-Key (LNK); Heavy Non-Key (HNK). **(CO1)** **[5]**

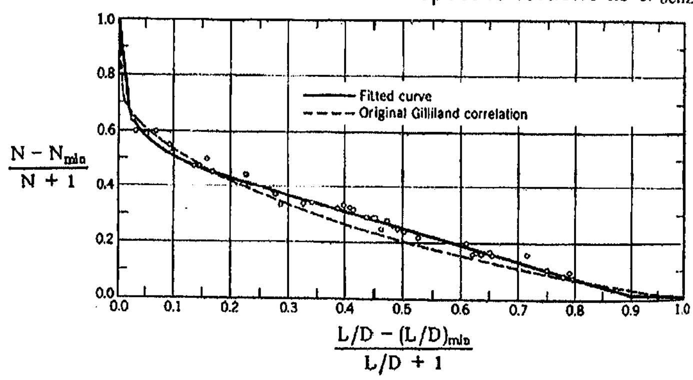
b) Consider a multicomponent distillation column operating at total reflux. Assuming all the stages are equilibrium stages, derive Fenske's equation to calculate the minimum number of trays in terms of the fractional recovery of light key in the distillate, fractional recovery of the heavy key in the bottoms and average relative volatility. **(CO1)** **[10]**

c) A feed consisting of 62 mol% pare-dichlorobenzene in ortho-dichlorobenzene is to be separated by distillation at near atmospheric pressure into a distillate containing 97 mol% para isomer and bottoms containing 95 mol% ortho isomer.
If a total condenser and partial reboiler are used, q = 0.8, average relative volatility = 1.154, and reflux/minimum reflux = 1.17, use the Fenske-Underwood-Gilliland procedure to estimate the number of theoretical stages required. **(CO1)** **[10]**

2. **a)** Write MESH equation for multicomponent distillation. Explain briefly the strategy to solve using modified mass equation using TDMA algorithm. **(CO1)** **[15]**

b) Write down the necessary steps for calculation of product composition using Lewis-Matheson method. Also mention the variables which needs to be specified. **(CO2)** **[10]**

3. An atmospheric distillation column with a total condenser and a partial re-boiler is used to separate a mixture of 40 mol% benzene, 30% toluene, and 30% cumene, in which the feed is input as a saturated vapour. It is required that 98% of toluene be in the distillate and that 98% of cumene be in the bottom. If the CMO is assumed and the reflux is a saturated liquid determine a) the number of equilibrium stage for total reflux distillation and b) the fractional recovery of benzene in the distillate, c) determine the minimum reflux ratio, based on the feed rate of 100 kmol/h, d) estimate total number of equilibrium stages and optimal feed stage (N_F) if actual reflux ratio (L/D) is set at 2.5. **(CO1, CO2)**
Given the constant volatilities with respect to toluene as $\alpha_{\text{benz-tol}} = 2.25$ and $\alpha_{\text{cume-tol}} = 0.21$ **[25]**



Gilliland's correlation chart (modified by Liddle in 1968)

4. **a)** Define clearance and dialysance and explain their physical significance. **(CO3)** **[5]**

b) Derive an expression relating outlet concentration of the concerned species in the blood leaving the dialyser with number of transfer unit (NTU) in a countercurrent hemodialyser. **(CO3)** **[10]**

c) Blood from a patient's body is pumped through a hemodialyser in a concurrent mode at a rate of 250 ml/min to reduce the urea concentration from 150mg% to 15 mg%. The available membrane area is 2 m^2 and the overall mass transfer coefficient is estimated to be 1.2 x 10^{-6} m/s. The volume of blood in a normal human body is about 5 litre. If the flow rate of the dialysate fluid is maintained high (Qd >> Qb), estimate the time of dialysis. Assume that dialysate fluid is solute free. **(CO4)** **[10]**

5. a) Derive the implicit form of Resistance model for permeate flux through an ultrafiltration (UF) membrane. **(CO3)** **[10]**

b) Suggest methods to reduce concentration polarization. **(CO3)** **[5]**

c) A ovalbumin solution having molecular weight of 500 dalton and concentration of 1 mass% is passed through a tbular UF membrane module of 1.5cm in ternal diameter and 100 cm long at a temperature of 25°C. Membrane water permeability is 85.85×10^{-3} m^3/m^2 (day)(psi). Rejection coefficient is 0.925, applied pressure difference 29.02 psi, solute diffusivity 8×10^{-11} m^2/s; viscosity of the solute 3Cp; gel point concentration of solute (Cg) 10.5%. Calculate the flow viscosity to be maintained in the tube in order to prevent formation of a gel layer on the membrane surface. **(CO4)** **[10]**

6. a) Explain different transport mechanism through microfiltration membrane with help of diagram. **(CO3)** **[5]**

b) Derive modified solution-diffusion model for RO. **(CO3)** **[10]**

c) Reverse osmosis experiments are carrued out at 25°C to determine the permeabilites of a cellulose triacetate membrane. The membrane area is 2x10^{-3} m^2. The inlet feed solution concentration of NaCl is 12kg Nacl/m^3 solution and density1004kg solution/m^3. The water recovery is assumed to be low so that the concentration in the entering feed solution flowing past the membrane abd the concentration of the exit feed are essentially equal. The product solution contains 0.42kg NaCl/m^3 solution (density 997 kg solution/m^3) and its measured flowrate is 1.85x10^{-8} m^3 solution/s. A pressure differential of 55atm is used. Calculate the permeability constantsof the membrane and slute rejection R. **(CO4)** **[10]**

Table 1 Osmotic pressure of various dilute aqueous solutions of

gmol NaCl/kg H2O	*Density (kg/m3)*	*Osmotic Pressure (atm)*
0	997.0	0
0.01	997.4	0.47
0.1	1001.1	4.56
0.5	1017.2	22.55
1.0	1036.3	45.8
2.0	1072.3	96.2