

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

Second Semester 2022-2023

CHE F423 Membrane Science and Engineering

Date: 13.03.2023, 9-10:30 AM

Mid Semester Examination (Closed Book)

Max Marks: 60

1. Explain solution-diffusion mechanism in Reverse Osmosis. Derive expression for the solute rejection (R) in terms of hydraulic pressure difference (ΔP) and osmotic pressure difference ($\Delta\pi$) for the solution-diffusion mechanism.

[15 Marks]

2. A Reverse Osmosis system has the feed side with 5% NaCl solution. The permeate-side is continuously flushed with distilled water so that salt concentration is negligible. A cellulose acetate membrane of 13 micron thickness gave a water flux of $6.3 \mu\text{g}/\text{cm}^2 \cdot \text{s}$, and the salt flux was $0.017 \mu\text{g}/\text{cm}^2 \cdot \text{s}$ at 25°C at a transmembrane pressure difference of 80 atm. The water sorption of the membrane is 0.156 grams per cm^3 of the polymer. The equilibrium sorption of NaCl assumed to follow the Henry's Law with constant value of 0.037. (a) Determine the diffusivities of water and salt of this cellulose acetate membrane. (b) Consider the same system but the cellulose acetate membrane now has higher acetyl content, what are the consequences of this?

[20 Marks]

3. A mixture of 50 mol% H_2 and 50 mol% C_2H_6 is partially separated with a porous inorganic membrane of 1 micron thickness and average pore diameter 20 \AA , to be operated at 300 K. The pressure in the feed compartment is 10 atm and permeate is swept continuously with pure nitrogen. The membrane has 40% porosity and a tortuosity of 1.5. Assume the Knudsen diffusion for transport of gases in the membrane. Calculate: (i) Knudsen diffusivities for H_2 and C_2H_6 , (ii) Effective diffusivities in the membrane, (iii) the flux of H_2 , and C_2H_6 across the membrane in $\text{mol}/(\text{m}^2 \cdot \text{s})$, (iv) Membrane Knudsen selectivity for H_2 over C_2H_6 .

[10 Marks]

4. Answer the following
- A polydisperse sample of polystyrene is prepared by mixing three monodisperse samples in the proportions: 2 grams of 50000 molecular weight and 2 grams of 100000 molecular weight. Determine (a) number average molecular weight, (b) weight average molecular weight, (c) z -average molecular weight of the mixture.
 - Describe the concentration polarization and its effect on the Reverse Osmosis. Define concentration polarization modulus.
 - Show the relation between the tensile modulus and the temperature of polymers. Comment on its relation with the permeability and selectivity of the membrane.
 - Explain the difference between Homopolymer, copolymer, and heteropolymer with examples. Explain the stereoisomerism
 - Explain the phase inversion method. Write important parameters involved in the phase inversion and draw neat sketches of the membrane obtained.

[15 Marks]

DATA: Universal Gas Constant, $R = 0.0821 \text{ (L.atm)/(mol.K)}$, Atomic weights: Na = 23, Cl = 35

All the Best