CLL 793 Membrane Science and Engineering

Max Time: 2 hrs, Max Marks: 40, May 16, 2021

1. **Please explain figures/ any material copied from lecture notes in English sentences. Without proper explanation, no marks will be awarded.**
2. **Exam duration 9:30 AM to 11:30 AM**
3. **11:30 AM to 12:00 Noon: Scan and compile your answers in a single PDF file. Upload this file to the Folder 'Major' on Moodle. No submission after 12 noon will be accepted for evaluation**

Q1 Explain facilitated and coupled transport in liquid membranes. Consider the facilitated transport of a gaseous component 'A' in presence of a carrier 'B' in a liquid membrane. The carrier reacts with 'A' according to following reversible reaction,

$A+B \leftrightarrow AB$

and the rate of reaction is given by

$-r_A = k_1 C^2_A C_B - k_2 C_{AB}$

If 'A' also diffuses as pure 'A', determine the flux of 'A' for the case where the fast reaction is taking place throughout the liquid membrane.

(8)

Q2 Write **short** note on following topics (Maximum 100 words)

a. Theory of irreversible thermodynamics
b. Phase inversion technique for making asymmetric membranes
c. Spiral-wound module
d. Permeability of gases in polymer membranes

(2x4=8)

Q3 Explain the principle of pervaporation and its possible applications. Why is it difficult to model membrane transport in pervaporation? Also, determine the approximate heat requirement in a pervaporation unit. **(8)**

Q4 Describe various flow patterns in a gas permeation unit and develop design equation for a 'full mixing' flow pattern. A mixture of 20% O_2 and 80% N_2 is fed into a gas permeation unit. The feed flow rate is 10^8 moles/sec. If the cut off ratio is 0.2, determine the membrane area required and the composition of the permeated stream. Following additional data is given for the problem.

High pressure side pressure = 400 atm

Low pressure side pressure = 1 atm

Permeability of O_2 = 15x 10^{-4} moles/(atm-cm-sec)

Permeability of N_2 = 3x10^{-4} moles/(atm-cm-sec)

Thickness of membrane = 10^{-4} m

(8)

Q5 Explain the principle of electrodialysis by taking 4 pairs of cation/anion exchange membranes. What is the significance of limiting current density? First explain the concept of transport number, and then using the transport numbers, determine the limiting current for the case where an anion exchange membrane is under consideration. Please clearly show both electrodes: anode and cathode in your figures.

(8)