Registration No: | | | | | | | | | | |

Total Number of Pages: 02

M.TECH
P2CHBC02

2nd Semester RegularExamination 2016-17
ADVANCED SEPARATION TECHNIQUES
BRANCH: CHEMICAL ENGINEERING
Time: 3 Hours
Max Marks: 100
Q.CODE:Z473

Answer Question No.1 which is compulsory and any FOUR from the rest.
The figures in the right hand margin indicate marks.

Q1 Answer the following questions: ***Short answer type*** **(2 x 10)**

a) Differentiate between symmetric and Asymmetric membrane.
b) What do you understand by molecular weight cut off?
c) What is the separation mechanism and membrane material used in reverse osmosis membrane?
d) What are the limitations of cellulose acetate and polyamide membranes?
e) What is the relationship of osmotic pressure with concentration and molecular weights? What is the relationship between observed and real retention?
f) Write-down the applications of reverse osmosis membrane.
g) Explain the principle of 'permporometry' to characterize UF membranes.
h) What are the basic differences in SEM, FESEM, TEM and AFM to characterize a membrane?
i) Describe the working principle of a supported liquid membrane.
j) Write a short note on haemodialysis.

Q2 **a)** Write a note on fouling of microfiltration membranes while elaborating on the factors affecting membrane fouling and how to control it. **(10)**

b) Consider filtration of 5 kg/m^3 concentration of ultra filtrationis gel layer controlled with gel concentration of 150 kg/m^3. Filtration occurs in a tube of diameter 25 mm and length 1m. The flow rate is 150 L/h, protein diffusivity is 3×10^{-11} m^2/s. Find the permeate flux? **(10)**

Q3 **a)** What is coupled transfer? Describe the process of recovering copper from waste liquor using coupled transport. **(10)**

b) A 75 µm thick polysulphonemicroporous membrane has an average porosity of $\varepsilon = 0.35$. Pure water flux through the membrane is 25 m^3/m^2h at a pressure drop of 1.2 bar at 25 ^oC. The average pore size is estimated to be 1 µm. Calculate the tortuosity factor of the pores, the resistance to flow offered by the membrane and its water permeability. The viscosity of water at 25 ^oC is 0.9 cp. **(10)**

Q4 **a)** What is pervaporation? What are the sequences of steps in a pervaporation process? Describe how pervaporation can be coupled with distillation for the separation of *50/50 azeotropic mixture*. **(10)**

b) Blood from a patient's body is pumped through a concurrent haemodialyser at a rate of 280 mL/min to reduce the urea concentration from 200 mg % to 20 %. The undesirable substances are removed as well. The available membrane area is 1.15 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 liter. If the flow rate of the dialysate fluid is maintained high ($Q_d >> Q_b$), estimate the time of dialysis. Also dialysis fluid is solute-free. **(10)**

Q5 **a)** What is the difference between active and passive transport? Give examples of such transport. Explain schematically how cation transport occurs by means of *symport* and *antiport*. **(10)**

b) It is required to design an *RO* module for production of 1500 m^3/day potable water containing not more than 250 ppm salt from sea water containing 34 g salt per liter. A proprietary asymmetric cellulose acetate membrane with an inherent salt rejection ability of 98 % is to be used. The water permeation coefficient is 0.043 m^3/m^2. day. atm. The recovery of the feed water should be 35 % and an operating pressure of 70 atm gauge is suggested. The permeate side is at essentially atmospheric pressure. If spiral wound module of 5 m^2 effective membrane area each is used, how many module in parallel are required? What fraction of the input power can be recovered from the retentate if a turbine of 70 % efficiency is used for energy recovery? The osmotic pressure of 5% brine is 39.5 atm. **(10)**

Q6 **a)** Describe the *sol-gel process* for preparing inorganic membranes with the help of a schematic drawing and the hydrolysis and condensation reaction. **(10)**

b) In a membrane selective permeation of CO_2 from a mixture of 10 % CO_2 (A) and 90 % CH_4 (B) occurs at 35 ^oC and 10 atm total pressure in a small apparatus with a well-mixed feed compartment. As asymmetric polysulphone membrane of 1 micron skin layer thickness is used. The permeate side is continuously swept with nitrogen gas. Given the following data calculate (a) the flux of CO_2, (b) the average diffusivity of CO_2 in polysulphone and (c) the permeance of CH_4 in polysulphone. The permeation of N_2 gas through the membrane may be neglected. **(10)**

Data: Ideal separation factor of CO_2 over CH_4, α^*_{AB} = 22; Henry's constant for solubility of CO2 at 35 ^oC in polysolphone, S_A= 2.1 cm3 (STP)/ (cm3) (atm); permeability of CO_2 P_A = 5.6 barrer.

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Q7 **a)** A macromolecular solution (mol. Wt. = 6000; concentration = 1 mass %) is passed through a tubular ceramic UF membrane of 1 cm internal diameter and 1 m long at 27 ^oC. The membrane admits of a pure water permeability of 2.11 gal/(ft^2) (day) (psi). Given the following data, calculate the flow velocity to be maintained in the tube in order to prevent formation of a gel layer on the membrane surface. Rejection coefficient, *R'* = 0.995; applied pressure difference, ΔP = 1.5 bar; diffusivity of the solute, D = 8 x 10^{-7} cm^2/s; viscosity of the solution = 3 cP; concentration at which the solute forms a gel, Cg = 10.5 %. Pore leakage and fouling may be ignored. **(10)**

b) Write short notes of electrodialysis and reverse osmosis with schematic diagram. **(10)**