Ref. No. : Ex/PG/ChE/T/129B/2024

M.E. CHEMICAL ENGINEERING FIRST YEAR SECOND SEMESTER – 2024

MEMBRANE SCIENCE & ENGINEERING

Full Marks 100

Answer question no. 1 and any four from the rest

All symbols have their usual meaning

Assume any missing Data

1. a) Write down the distinguishing features of the homogeneous and asymmetric membrane. Write the merits and demerits of the both these membranes.

   b) How does hydrophilicity and hydrophobicity of a membrane affects its selection for a particular task? Explain with appropriate example.

   c) Explain the effect of pH on permeation behaviour of an ultrafiltration membrane

   d) Write the importance of module design to maximise the permeate flux of a membrane separation process

   5×4 = 20

2. a) What are the main applications of the nanofiltration process? Cite few application areas where nanofiltration process is advantageous over other pressure driven membrane separation processes.

   b) Explain the method of estimating membrane hydraulic resistance and reversible fouling in pressure driven separation process.

   c) What are the typical characteristics of a membrane intended to be used for gas separation process.

   7+8+5= 20

3. a) For ultrafiltration process of a particular solute following data has been obtained in a stirred dead-end module. Solute concentration was fixed at 1.2kg/m^3 and transmembrane pressure at 175kPa. Use velocity variation technique to find the mass transfer coefficient and membrane surface concentration for each of the following runs.

Run no	Permeate concentration (c_p)kg/m^3	Stirrer speed in rpm	Permeate flux m^3/m^2.s x10^6
1	0.08	60	2.4
2	0.04	80	4.4

3	0.02	100	6.8
4	0.01	120	8.0
5	0.006	150	8.8

b) Write the advantages of hollow fiber membrane module over spiral-wound membrane module.

10+10= 20

4. a) Explain the models for permeate flux in ultrafiltration process.

(b) A feed solution containing a whey protein is to be concentrated from 0.02 (M) to 0.2 (M) by an ultrafiltration unit. The process is being carried out at 25°C. The solute rejection is 93%. If the upstream pressure is 4.6 atmosphere and downstream pressure is essentially atmospheric, find out the effective pressure driving force at start at the end of the operation. Find also the percentage reduction of solvent flux at the end of the operation.

10+10=20

5. a) In a membrane separation process, employing microfiltration pilot plant on a batch basis has a volume reduction factor of 40. The MF membrane has a maximum permeate flux of around 300l/m^2 hr. at maximum typically dropped and approached 80l/m^2.hr at the end of a day's operation. The retentate from MF separation was returned to the feed tank, whereas permeate was routed to the sewer. Design of a full scale plant was performed by using a flux value of 40l/m^2 hr and volume reduction of 20 fold. For the full scale membrane plant, calculate

   i.Permeate and retentate flow rate

   ii.The membrane area required

20

6. (a) Explain the types of membrane module as per flow pattern. With neat diagram. Predict the concentration polarization pattern for all those modules.
   (b) How does selectivity of the membrane change with increasing membrane thickness? Explain the principle of bubble point test for pore size determination.

10+10