PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Midterm Examination : Semester I — Academic Year : 2005

Date : 7 August 2005 — Time : 09.00 — 12.00

Subject : 230 — 531 Membrane Separation Processes — Room : R 300

Student Name: ..... **ID no. :** .....

Number of questions : 4

Time : 3 hours

Total marks : 100

Calculators are allowed.

Books and notes are allowed.

Question	Full Marks	Marks Received
1	30	
2	25	
3	20	
4	25	
Total	100	

ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

Student Name: ..... ID No.: .....

1) a) What is a composite membrane? Explain with help of a sketch of the membrane microscopic structure.

(5 marks)

b) Please describe how to construct a spiral-wound module. Explain the flow direction of all streams through this type of membrane module.

(5 marks)

c) What are the advantages and disadvantages of ceramic membranes in comparison to polymeric membranes?

(5 marks)

d) Provide a sketch of a ceramic membrane module. Show stream flow paths in ultrafiltration. Give some details on pore sizes and materials of construction.

(5 marks)

e) Briefly explain transport mechanisms of pervaporation for a silicone membrane.

(5 marks)

f) Fuel cell vehicles are expected to offer an extremely quiet ride, improved fuel economy and zero emissions. Briefly describe the basic principle of fuel cell operation.

(5 marks)

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2) It is desired to determine the membrane area needed to separate an air stream using a membrane thickness t =2.54 x 10^{-3} cm. with an oxygen permeability of P''_A = 500 x 10^{-10} cm^3 (STP).cm/(s.cm^2.cm Hg). An α^* = 10 for oxygen permeability divided by nitrogen permeability will be used. The feed rate is L_f = 1 x 10^6 cm^3 (STP)/s , x_f = 0.209 and the fraction cut θ = 0.35. The pressures selected for use are p_h = 190 cm Hg and p_l = 19 cm Hg. Assuming the crossflow model, calculate permeate composition, the reject composition, and the membrane area.

Simulation results at some values of θ or θ^* are given in the table below.

Use the graph provided on page 8 for determination of membrane area..

Perform only one and first trial using x=0.05.

θ or θ^*	x	y_p	F_i
0	0.209	0.6550	0.6404
0.1482	0.1420	0.5940	0.9603
0.2000	0.1190	0.5690	1.1520

(25 marks)

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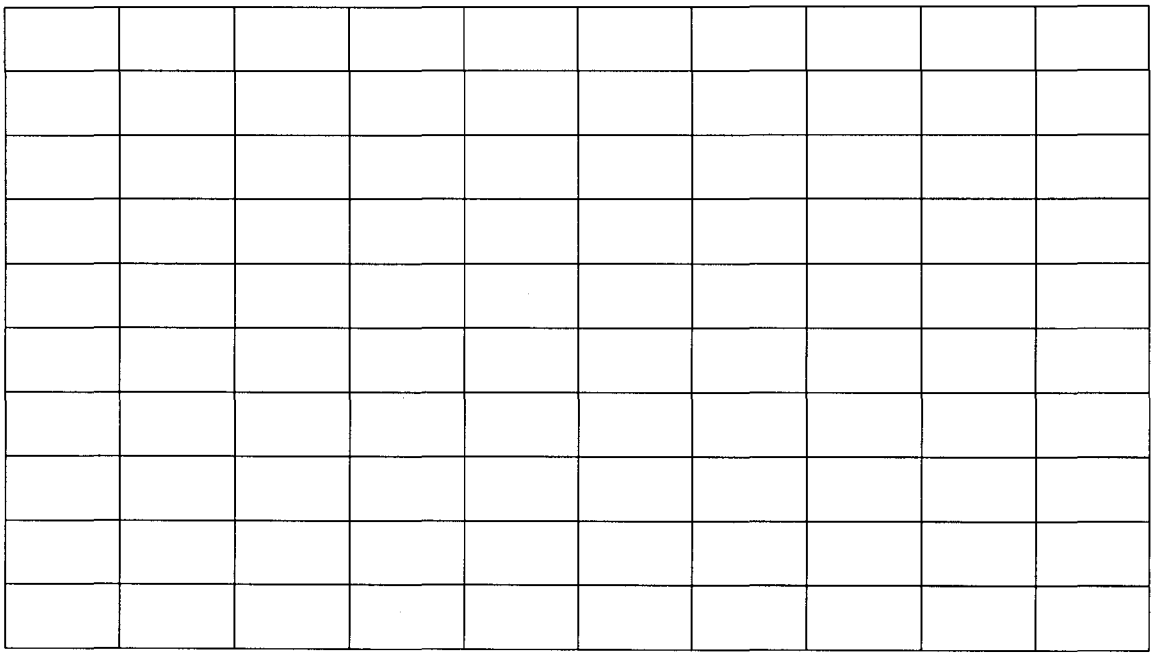
Answer to Q2.(continued)

Graph for determination of membrane area in Q2



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3) The following experimental data were obtained from the pervaporation of liquid mixtures of ethanol (1) and water (2) at feed temperature of 60°C for a permeate pressure of 76 mmHg, using a commercial silicone membrane.

wt % ethanol		Total Permeation Flux
Feed	Permeate	Kg/m^2-h
60.0	90.0	3.2

Molecular weights for ethanol and water are 46.07 and 18.02 respectively.

At 60°C, vapour pressures for ethanol and water are 352 and 149 mmHg, respectively.

Liquid-phase activity coefficients at 60°C for the feed ethanol(1)-water(2) system are given by the van Laar equations as:

$$\ln \gamma_1 = 1.6276 \left[\frac{0.9232x_2}{1.6276x_1 + 0.9232x_2} \right]^2$$

$$\ln \gamma_2 = 0.9232 \left[\frac{1.6276x_1}{1.6276x_1 + 0.9232x_2} \right]^2$$

a) Calculate values of permeance for ethanol and water in kmol/(h-m^2-mmHg).

b) The separation factors for ethanol $\alpha_{1,2}$.

(20 marks)

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4) A reverse osmosis plant is being used to treat 85 m^3/h feed of brackish water at 27 °C containing 2,000 NaCl mg/l to produce potable water with 200 mg/l of dissolved NaCl. The plant uses cellulose acetate membranes arranged in two stages. The first stage consists of 10 pressure vessels and one element per vessel. The second stage consists of 8 pressure vessels and one element per vessel. The feed-side pressure at the first stage is 7 atm, while the concentrate from the first stage is fed at 16 atm to the second stage. The recovery for the first and second stages are 30% and 10%,respectively. The permeability constant for water A_B= 4.20 x 10^{-4} kg /s.m^2.atm and permeability constant for NaCl solute A_A = 4.0 x 10^{-7} m/s. Molecular weight of NaCl is 58.5 g/mol. R= 82.057x10^{-3} m^3.atm/(k mol.K).

Calculate the followings:

a) The overall membrane area for the first stage in m^2.

b) The salt passage in the first stage in kg/(m^2.s)

c) The total permeate product flow in m^3/h.

(25 marks)

---------- End of questions.