**Homework 01**

**Problem 13.2-1**

Given:

C1 = 2.0e-2 kg mol A/m­3 K’ = 0.75

C2 = 0.3e-2 kg mol A/m3 DAB = 3.5e-11 m2/s

Kc1 = 3.5e-5 m/s k­c2 = 2.1e-5 m/s

L = 1.59e-5 m

Find:

R­1, R2, Rm, Rtot, R%1, R%2, Membrane Area

Solution:

a.)

b.)

= 2.49e-8 kgmol A/s-m2

Area = 0.01 kgmol/h x 1 hr/60 min x 1 min/60 s x 1/2.49e-8 kgmol A/s-m­­2 = 111.557 m2

**Problem 12.2-2**

Given:

L = 0.029 mm

C1= 1.0e-4 g mol/cm3 = 100 g mol/m3

C2 = 5.0e-7 g mol/cm3 = 0.5 g mol/m3

Kc1 = kc2 = 5.24e-5 m/s

NA = 8.11e-4 gmol NaCl/s-m2

Find:

Pm, DABK’, % resistance to diffusion in the liquid films

Solution:

which can be rearranged to give the following:

Thus, pm = 1.2e-5 m/s

= 3.48e-10 m2/s

**Problem 13.10-1**

Given:

C1 = 3500 mg NaCl/L (ρ=999.5 kg/m3)

Aw = 3.50 x 10-4 kg solvent/s-m2-atm

As = 1.00 x 10-7 m/s

ΔP = 35.50 atm, 17.20 atm, 27.20 atm, 37.20 atm

Find:

NNaCl­, solute rejection R, c2

Solution:

from linear interpolation

From this data we can calculate the values of water flux across the membrane at each pressure differential:

|  |  |
| --- | --- |
| **ΔP, atm** | **Nw, kg H2O water/s-m2** |
| |  | | --- | | 17.2 | | 0.0053 |
| 27.2 | 0.0088 |
| 35.5 | 0.017 |
| 37.2 | 0.012 |

We can then subsequently calculate R from this value.

|  |  |
| --- | --- |
| **ΔP, atm** | **R** |
| |  | | --- | | 17.2 | | 0.95 |
| 27.2 | 0.97 |
| 35.5 | 0.98 |
| 37.2 | 0.98 |

Finally, we can calculate the second concentration, c2

|  |  |
| --- | --- |
| **ΔP, atm** | **C2, mg NaCl/L** |
| |  | | --- | | 17.2 | | 158.23 |
| 27.2 | 96.79 |
| 35.5 | 73.20 |
| 37.2 | 69.72 |

We can plot these data on a graph v the pressure differential:

**Problem 13.10-3**

Given:

AW = 3.50e-4 kg solvent/s-m2 θ = 0.1

As = 2.00e-7 m/s q2 = 100 gal/hr

ΔP 35.50 atm

Cf = 3500 mg NaCl/L

Find:

Area, c1, c2

Solution:

We can find area with the flowrate given q­2. We can relate the water flowrate through the membrane to the following equation:

This can be rearranged to produce the following equation:

Nw must be converted to kg/s before calculating area.

We can calculate qf using the “cut” parameter, and then use a mass balance to calculate q1.

Plugging in and calculating, we get:

Now, we can plug these values into the system of equations to solve and get out concentrations:

And R can be calculated with:

This gives us the following system:

Solving this set of equations gives us the answers:

C1 = 3.88 kg/m3

C2 = 0.08 kg/m3

**Problem 13.11-1**

Known:

0.9 wt % protein.

ΔP = 5 psi = 0.34 atm

Aw = 1.37e-2 kg/s-m2-atm

Find:

Nw

Solution:

We can use the following equation to calculate flux:

Now, we must calculate the osmotic pressure from the wt % data given.

We can also assume negligible osmotic pressure differential.

)(0.34 atm) = 0.0047 kg/s-m2 = 9.88 gal/day-ft^2

**Problem 13.11-2**

Known:

Ms = 800 kg

C1 = 0.05 wt %

C­2 = 1.1 wt %

Area = 9.9 m2

Aw = 2.50e-2 kg/s-m2-atm

ΔP = 0.50 atm

Find:

Nw, time to filter

Solution:

We can calculate the flux with the following equation:

With ultrafiltration processes, the osmotic pressure differential can be considered negligible.

Thus,

We also have the definitions for the mass percent’s given. We can also redefine the second mass fraction to be in terms of the first with the parameter, r, defining amount of water recovered.

We can combine the two equations to calculate r. With the flux known, we can then calculate the time needed to filter the solution:

Thus,