Membrane Technology
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Lecture-26
Problems and solutions based on UF

Good morning students. Today is lecture 26 under module 9 And in today’s lecture we will solve some of the problems related to ultrafiltration.

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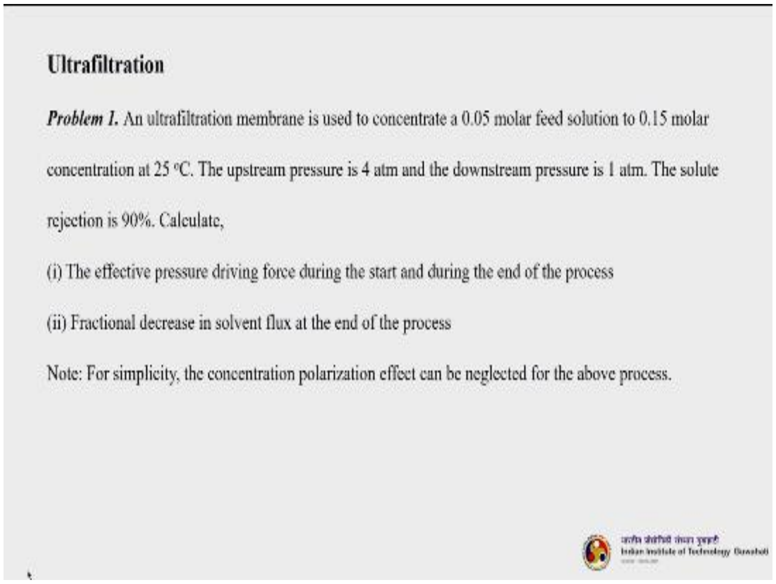

Ultrafiltration

Problem 1. An ultrafiltration membrane is used to concentrate a 0.05 molar feed solution to 0.15 molar concentration at 25 °C. The upstream pressure is 4 atm and the downstream pressure is 1 atm. The solute rejection is 90%. Calculate,

(i) The effective pressure driving force during the start and during the end of the process

(ii) Fractional decrease in solvent flux at the end of the process

Note: For simplicity, the concentration polarization effect can be neglected for the above process.

So let us see the problem 1. I am just reading out the statement and ultrafiltration membrane is used to concentrate a 0.05 molar feed solution to 0.15 molar concentrations at 25 degree centigrade. The upstream pressure is 4 atmosphere and the downstream pressure is 1 atmosphere. The solute rejection is 99 %. So you have been asked to calculate; the effective pressure driving force during the start and during the end of the process.

Then fractional decrease in solvent flux at the end of the process. So it is further given that for simplicity the concentration polarization effect can be neglected for the above process. Let us start how to solve this problem.

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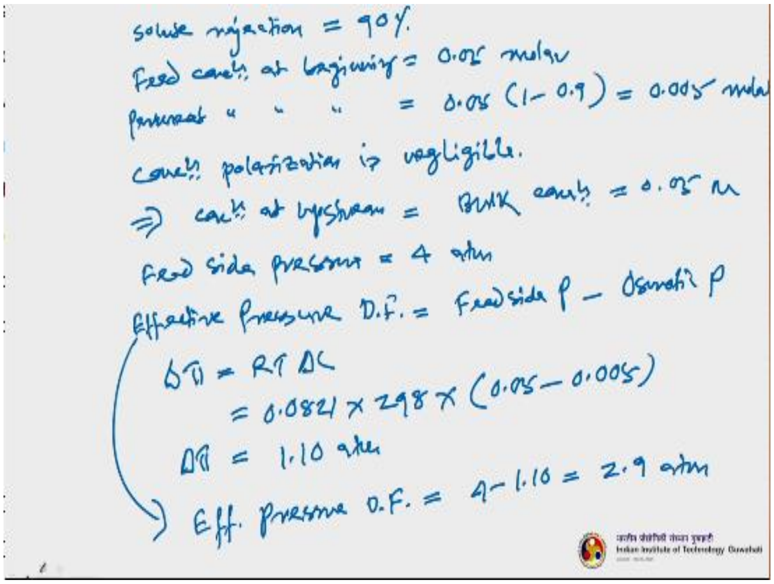

solute rejection = 90%

Feed conc^n at beginning = 0.05 molar

Permeat " " " = 0.05 (1 − 0.9) = 0.005 mola

conc^n polarization is negligible.

⇒ conc^n at upstream = Bulk conc^n = 0.05 M

Feed side pressure = 4 atm

Effective pressure D.F. = Feed side P − Osmotic P

$\Delta\pi = RT\Delta C$

$= 0.0821 \times 298 \times (0.05 - 0.005)$

$\Delta\pi = 1.10$ atm

Eff. pressure D.F. = 4 − 1.10 = 2.9 atm

So solute rejection is given. So it is always a good practice to write down whatever the data is given. So solute rejection is given 90 %, feed concentration, feed concentration at beginning it is given 0.05 molar and permeate concentration, concentration at beginning. So it is equals to 0.05 into 1-0.9. So 90% rejection, that is why. So point 0.005 so molar.

So it is considered that the concentration polarization is negligible. So concentration it is given in the statement concentration polarization is negligible. So that means the concentration at the upstream phase of the membrane is equal to the bulk of the concentration also. So, what is the meaning of this? Now concentration at upstream equals to bulk concentration. So, which is 0.05 molar.

Now, further things feed side pressure it is given is 4 atmosphere. So you have to calculate the effective pressure. So effective pressure driving force means how it will be, so effective pressure driving force. So that is nothing but feed side pressure - osmotic pressure. So this is actually your pressure driving force, so now we have to calculate the osmotic pressure.

So osmotic pressure can be calculated. delta Pi equals to RT delta C, this you know, your last class also have discussed. So R is your gas constant, T is your temperature and delta c is here concentration difference. So which we can write that R equals to you can take R equals to 0.0821 into temperature is given 25 degree centigrade to 298 kelvin into delta C, delta C equals to 0.05 – 0.005 in moles, that is what we have calculated.

So here delta Pi if equals to 1.10 atmospheres, so your effective pressure difference that becomes effective pressure driving force. Now it becomes feed side pressure, so feed side pressure is given is equals to 4 atmosphere 4 – 1.10. So it becomes 2.9 atmosphere.

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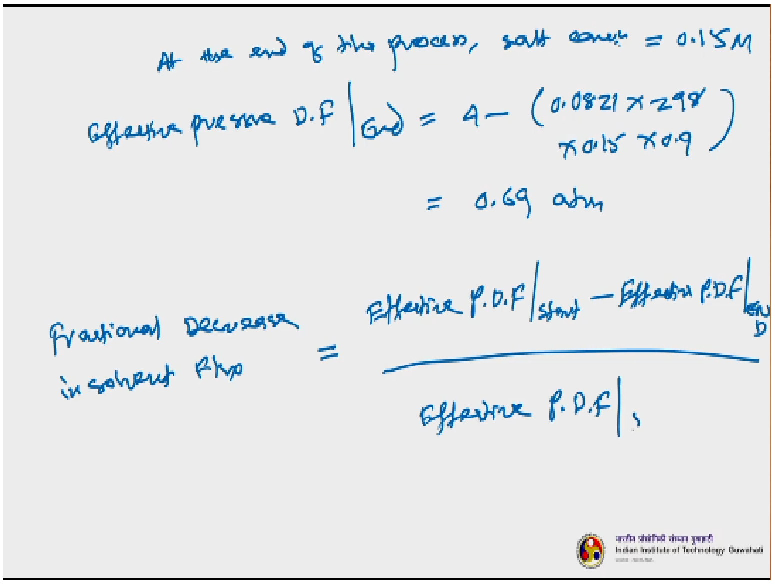

At the end of the process, salt concn = 0.15M

$$\text{Effective pressure D.F}\Big|_{\text{End}} = 4 - (0.0821 \times 298 \times 0.15 \times 0.9)$$

$$= 0.69 \text{ atm}$$

$$\text{Fractional Decrease in solvent flux} = \frac{\text{Effective P.D.F}\big|_{\text{start}} - \text{Effective P.D.F}\big|_{\text{END}}}{\text{Effective P.D.F}\big|_{s}}$$

So at the end of the process, salt concentration is given 0.15 mole. So effective pressure driving force at the end will be 4 - this 0.0821 that same pi equals to same from that equation only into 298 into 0.15 into 0.9, so this becomes 0.69 atmosphere. So then is the solvent flux is proportional to the pressure difference the fractional decrease can be calculated.

So even ask to calculate actually the fractional decrease in solvent flux, so we can write this equation, so fractional decrease in solvent flux, how much actually decreases happening in the solvent flux. So that we can calculate is that effective pressure driving force, so that is nothing but effective pressure driving force. So f Start-effective pressure driving force at end whole divided by effective pressure driving force at the Start.

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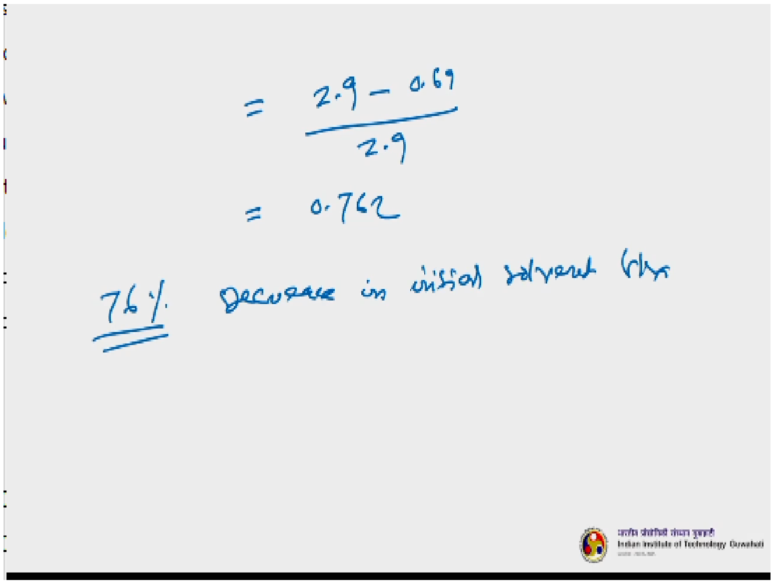

$$= \frac{2.9 - 0.69}{2.9}$$

$$= 0.762$$

76% decrease in initial solvent flux

So we can calculate its 2.9-0.69, the effective driving force at the beginning is 2.69 atmosphere - 0.69 is the effective driving force during at the end of the process divided by 2.9, so this is become 0.762 so you can say that 76% decrease in initial solvent flux. So occur due to as an osmotic reduction in the effective pressure difference. So this is what you have been asked to calculate so how much what is the effective pressure driving force at the beginning and at the end.

And from this equation, we found out that how much is the decrease in solvent flux occurs from the initial solvent flux to the end of the process. So this is one of the very simple example actually, no much of calculation involved only you know, that you have to use the pi equals to CRT equation and the effective pressure driving force is start minus beginning that plus this one.

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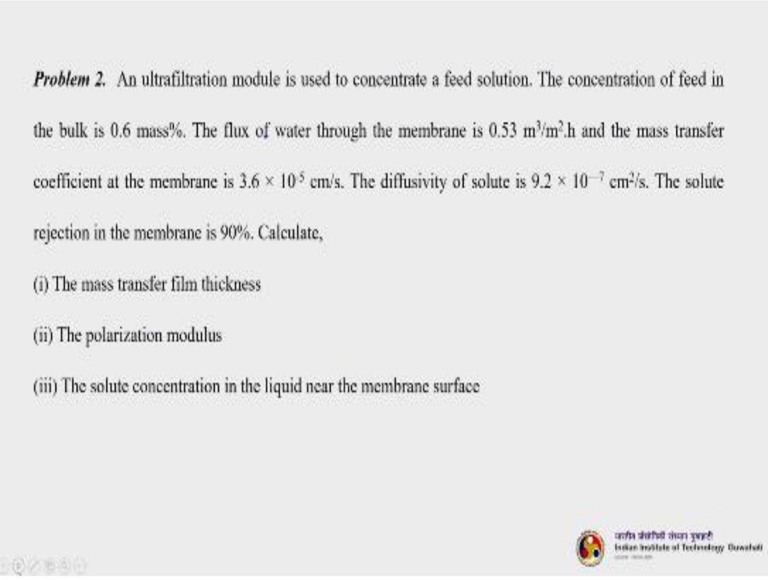

Problem 2. An ultrafiltration module is used to concentrate a feed solution. The concentration of feed in the bulk is 0.6 mass%. The flux of water through the membrane is 0.53 $m^3/m^2.h$ and the mass transfer coefficient at the membrane is 3.6×10^{-5} cm/s. The diffusivity of solute is 9.2×10^{-7} cm^2/s. The solute rejection in the membrane is 90%. Calculate,

(i) The mass transfer film thickness

(ii) The polarization modulus

(iii) The solute concentration in the liquid near the membrane surface

So let us see another example, I am reading out that actually the problem statement, so an ultrafiltration module is used to concentrate a feed solution, the concentration of heat in the bulk is 0.6 mass %. The flux of water through the membrane is 0.53 meter cube per meter square hour and mass transfer coefficient at the membrane is 3.6 into 10 power of -5 centimeter per second.

The diffusivity of solute is given to be 9.2 into 10 power of -7 centimeters square per second. The solute rejection in the membrane is 90%. You have been asked to calculate the mass transfer film thickness the small delta. The polarization modulus Cm by Cb the cross and the solute concentration the liquid near the membrane surface.

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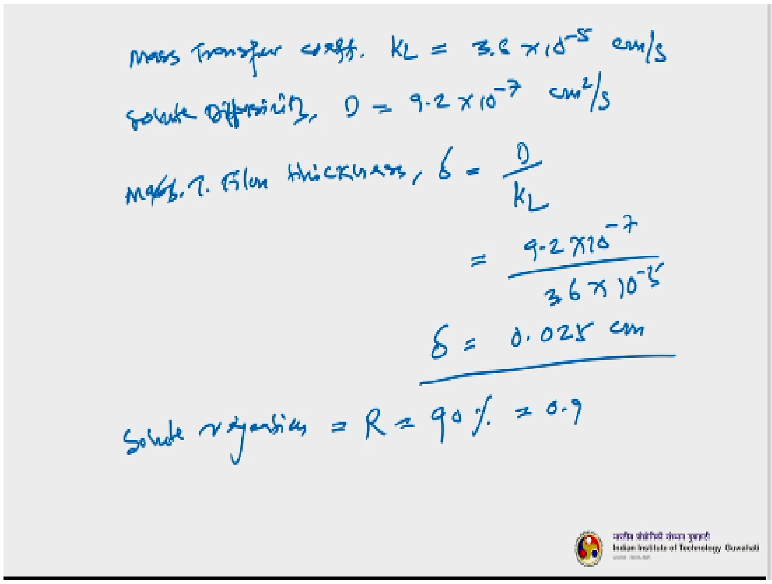

Mass Transfer coeff. $K_L = 3.6 \times 10^{-5}$ cm/s

Solute Diffusivity, $D = 9.2 \times 10^{-7}$ cm^2/s

Mass. T. Film thickness, $\delta = \frac{D}{K_L}$

$= \frac{9.2 \times 10^{-7}}{3.6 \times 10^{-5}}$

$\underline{\delta = 0.025 \text{ cm}}$

Solute rejection $= R = 90\% = 0.9$

That data given is mass transfer coefficient. That is KL, KL it is given is 3.6, 10 to the power of -5 centimeter per second. Solute diffusivity is also given, that is D equals to 9.2 into 10 power of -7 centimeters square per second, so your mass transfer film thickness, that is this lambda equals to D by KL. So it is 9.2 into 10 power of - 7 divided by 3.6 into 10 power of -5 this is 0.025 centimeter.

So, this is the thickness of the mass transform film. So further solute rejection is given so that R equals to 90 % or you can write 0.9. So you have to find out the concentration polarization modulus. So you are concentration.

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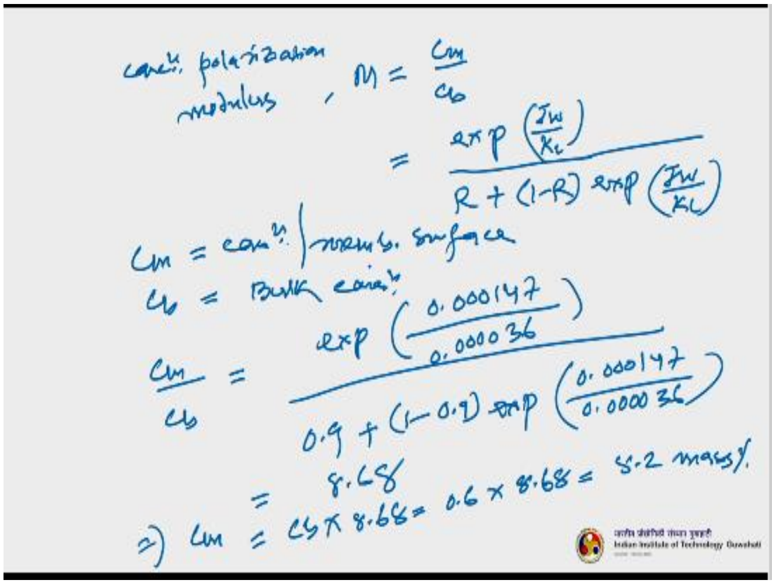

concn. polarization modulus, $M = \frac{C_m}{C_b}$

$$= \frac{\exp\left(\frac{J_w}{K_L}\right)}{R + (1-R)\exp\left(\frac{J_w}{K_L}\right)}$$

C_m = concn. | memb. surface

C_b = Bulk concn.

$$\frac{C_m}{C_b} = \frac{\exp\left(\frac{0.000147}{0.000036}\right)}{0.9 + (1-0.9)\exp\left(\frac{0.000147}{0.000036}\right)}$$

$$= 8.68$$

$\Rightarrow C_m = C_b \times 8.68 = 0.6 \times 8.68 = 5.2$ mass%

Polarization modulus, so that is basically it is M, it is Cm by Cb. So Cm by Cb, so that equation equals to exponential of Jw by KL, Jw is your water flux divided by KL is the mass transfer coefficient, so divided by R+ 1 - R again exponential to the power of Jw by KL.

So this is your equation for concentration polarization modulus. So, where Cm is concentration at membrane surface and Cb is bulk concentration. So now we can calculate the Cm by Cb equals to exponential to the power of put all the values substituting everything 0.000147 divided by 0.000036. So divided by 0.9 + 1- 0.9 again exponential to the power of 0.000147 divided by 0.000036. So this comes to 8.68.

So from here, so we can say that Cm equals to Cb into 8.68. So 0.6 into 8.68 equals to 5.2 mass %. So this is how you can calculate our concentration at the membrane surface, using the concentration polarization modulus equation.

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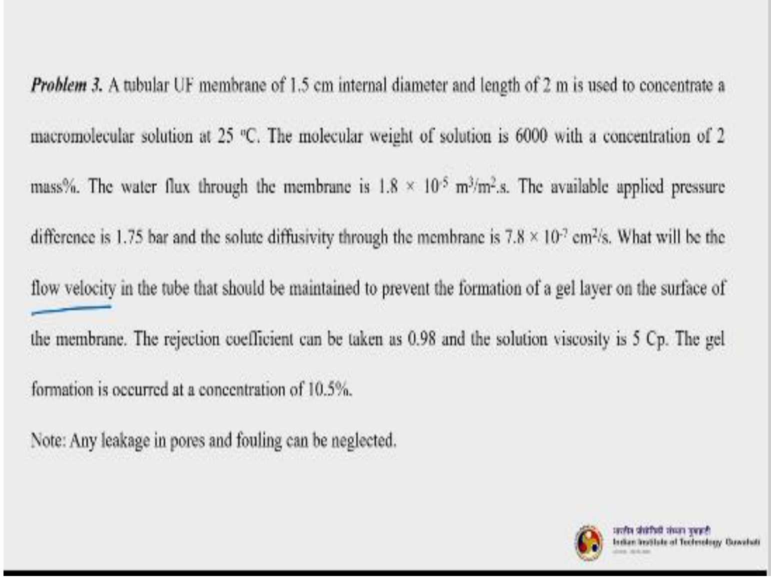

Problem 3. A tubular UF membrane of 1.5 cm internal diameter and length of 2 m is used to concentrate a macromolecular solution at 25 °C. The molecular weight of solution is 6000 with a concentration of 2 mass%. The water flux through the membrane is 1.8×10^{-5} $m^3/m^2.s$. The available applied pressure difference is 1.75 bar and the solute diffusivity through the membrane is 7.8×10^{-7} cm^2/s. What will be the flow velocity in the tube that should be maintained to prevent the formation of a gel layer on the surface of the membrane. The rejection coefficient can be taken as 0.98 and the solution viscosity is 5 Cp. The gel formation is occurred at a concentration of 10.5%.

Note: Any leakage in pores and fouling can be neglected.

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Let us see another problem. this is a little big problem actually, so let us do it slowly and understand how to proceed so I am reading the statement, a tubular ultrafiltration membrane of 1.5 centimetre internal diameter and length of 2 meter is used to concentrate at a macromolecular solution at 25 degree centigrade. The molecular weight of the solution is 6000 with a concentration of 2 mass %.

The water flux through the membrane is 1.8 into 10 power of -3 meter cube per meter square second. The available applied pressure difference is 1.75 bar and the solute diffusivity through the membrane is 7.8 into 10 power of -7 centimeter square per second. So it has been asked that what will be the flow of velocity. In the tube that means you need to calculate V mostly from the Reynolds number.

We will see how we will do it. so you have been asked to calculate what will be the flow velocity in the tube, that should be maintained to prevent the formation of a gel layer on the surface of the membrane. The rejection coefficient is given as 0.98 and the solution viscosity is 5 centipoles, the gel formation is occur at a concentration of 10.5 %, so any leakage in the pores and fouling can be neglected. So let us see how will solve this.

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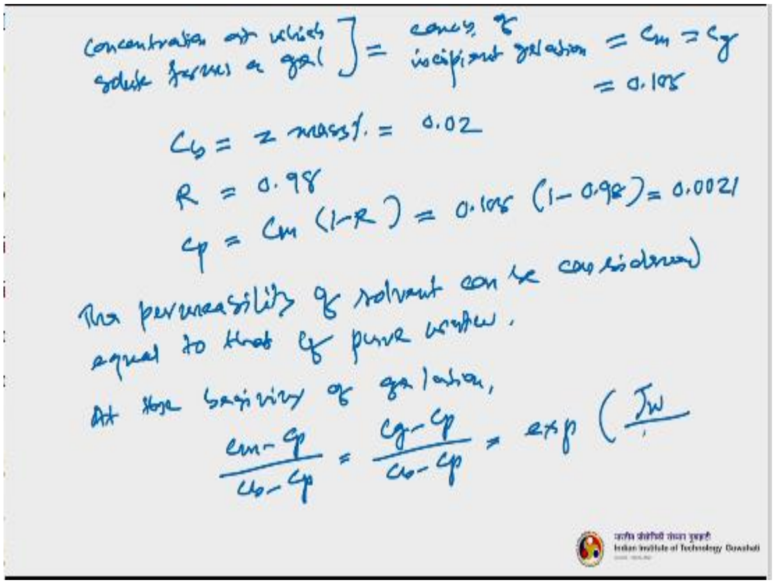

Concentration at which solute forms a gel] = conc. of incipient gelation $= C_m = C_g$

$= 0.105$

$C_b = 2$ mass% $= 0.02$

$R = 0.98$

$C_p = C_m (1-R) = 0.105 (1-0.98) = 0.0021$

The permeability of solvent can be considered equal to that of pure water.

At the beginning of gelation,

$$\frac{C_m - C_p}{C_b - C_p} = \frac{C_g - C_p}{C_b - C_p} = \exp\left(\frac{J_w}{\;}\right.$$

So concentration at which solute forms a gel, at what concentration the solute forms the gel that is what is being, we have to calculate the question nothing but the concentration of incipient gelation. So that is Cm equals to Cg, and it is given 0.105% is given so much percentage, so you can write 0.105, then it is given Cb, bulk feed concentration is 2 Mass %, so in fraction we can write 0.02 rejection coefficient R is given 0.98.

So Cp equals to the permeate concentration equals to Cm into 1-R. That is 0.105 into 1- 0.98. So your Cp equals to 0.0021. So the permeability of water the permeability of solvent can be considered equal to that of pure water, where this considering that. pure water, why because it is being told that there is no fouling of the membrane as taken place.

So at the beginning of gelation. at the concentration polarization, starts then the gel layer formation is actually starting. So we can write at the beginning of gelation. So you have Cm-Cp divided by Cb-Cp the concentration polarization modulus equation equals to Cg-Cp divided by Cb-Cp. So that is what exponential to the power of Jw by KL mass transfer coefficient.

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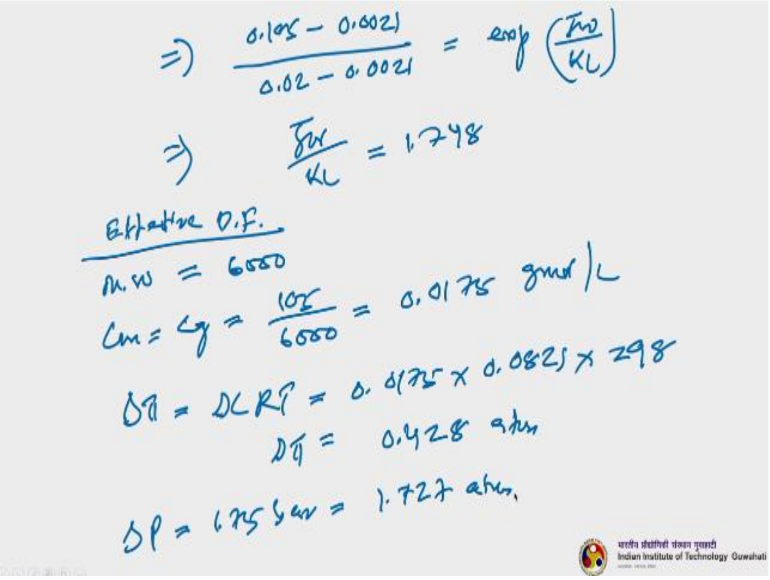

$$\Rightarrow \frac{0.105 - 0.0021}{0.02 - 0.0021} = \exp\left(\frac{J_w}{K_L}\right)$$

$$\Rightarrow \frac{J_w}{K_L} = 1.748$$

Effective D.F.

$m.w = 6000$

$C_m = C_g = \frac{105}{6000} = 0.0175$ gmol/L

$\Delta\pi = \Delta CRT = 0.0175 \times 0.0821 \times 298$

$\Delta\pi = 0.428$ atm

$\Delta P = 1.75$ bar $= 1.727$ atm.

So just let us substitute the equations. So, 0.105-0.0021, so divided by 0.02-0.0021, goes to exponential to the power of Jw by KL. So from here, we can write Jw by KL equals to 1.748 take it will become ln of this. So now we have to calculate the effective driving force. So effective driving force molecular weight of the solute is given a 6000, so the concentration of the incipient gelation.

So Cm equals to Cg equals to 105 divided by 6000 equals to 0.0175, this is gram moles per liter. So then here delta pi osmotic pressure equals to delta CRT is 0.0175 into 0.0821 is the value of R into T is 25 degree centigrade that is 298 kelvin. So this becomes 0.428 atmosphere. So that is your delta pi and here delta p that is applied pressure difference is given 1.75 bar.

We can write it in terms of atmosphere so 1.727 atmosphere always be consistent with the units that is very important.

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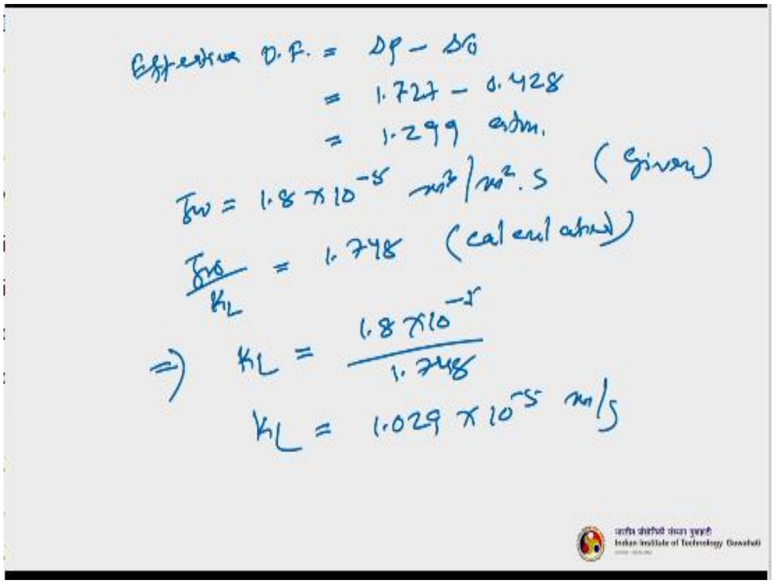

Effective D.F. $= \Delta P - \Delta \pi$

$= 1.727 - 0.428$

$= 1.299$ atm.

$J_w = 1.8 \times 10^{-5}\ m^3/m^2.s$ (given)

$\frac{J_w}{K_L} = 1.748$ (calculated)

$\Rightarrow K_L = \frac{1.8 \times 10^{-5}}{1.748}$

$K_L = 1.029 \times 10^{-5}\ m/s$

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So your effective driving force is nothing but delta P minus delta Pi. so that is 1.727- 0.428, so effective driving force is 1.299 atmosphere. So Jw is given 1.8 into 10 power of -5 meter cube per meter square second. This is given in the problem statement, so and we have calculated that Jw by KL from the concentration polarization equation modulus KL to be 1.748, this is calculated.

From the concentration polarization equation, so from here we can calculate the mass transfer coefficient is 1.8, 10power of -5 divided by 1.748. So it is nothing but 1.029 into 10 power of -5 meter per second, so this is your mass transfer coefficient. Now you have been asked to calculate the liquid velocity, the liquid velocity at which the gel formation will not happen.

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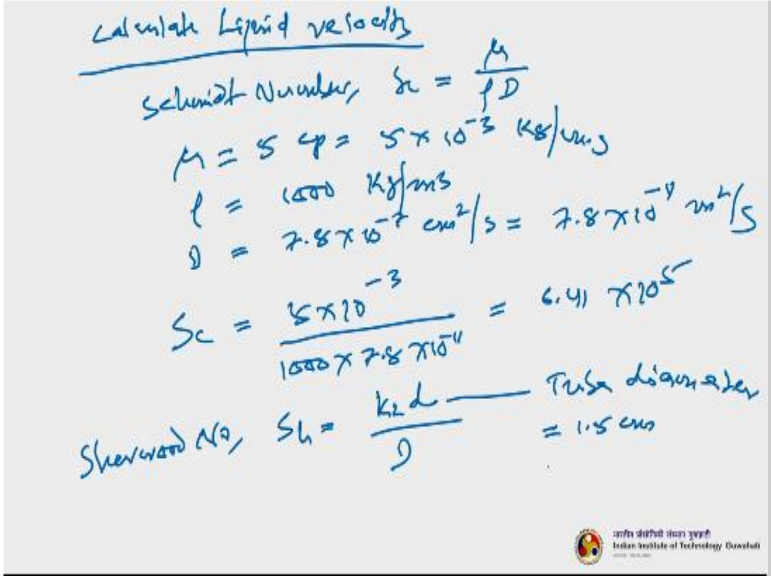

Calculate Liquid velocity

Schmidt Number, $S_c = \frac{\mu}{\rho D}$

$\mu = 5\ cp = 5 \times 10^{-3}\ kg/m.s$

$\rho = 1000\ kg/m^3$

$D = 7.8 \times 10^{-7}\ cm^2/s = 7.8 \times 10^{-4}\ m^2/s$

$S_c = \frac{5 \times 10^{-3}}{1000 \times 7.8 \times 10^{-11}} = 6.41 \times 10^{5}$

Sherwood No, $S_h = \frac{k_L d}{D}$ — Tube diameter $= 1.5\ cm$

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So how do you calculate liquid velocity? So let us start with Schmidt number, you know Schmidt number SC is nothing but mu by rho into D. So where mu is the viscosity, so viscosity is given is 5 cp, is 5 into 10 powers of - 3 kg per meter second. Then density is given 1000 is, since we are assuming water. So the solvent has to be the pure water so we can assume take the density of the pure water.

So that is 1000 kilograms per meter cube and diffusivity is also given 7.8 into 10 power of -7 centimeter square per second. So let us convert to meter square into 10 power of -11 meter square per second. Now so find out what is Schmidt number, so Schmidt number is 5 into 10 we just substitute all these values whatever given, 1000 into 7.8 into 10 power of -11, so it becomes 6.41 into 10 power of 5.

Now, you know, Schmidt number, Sh equals to KL d by D. So what is this d is that tube diameter, which is given is 1.5 centimeter. so we can write 0.015 meter, we are converting everything in terms of meter.

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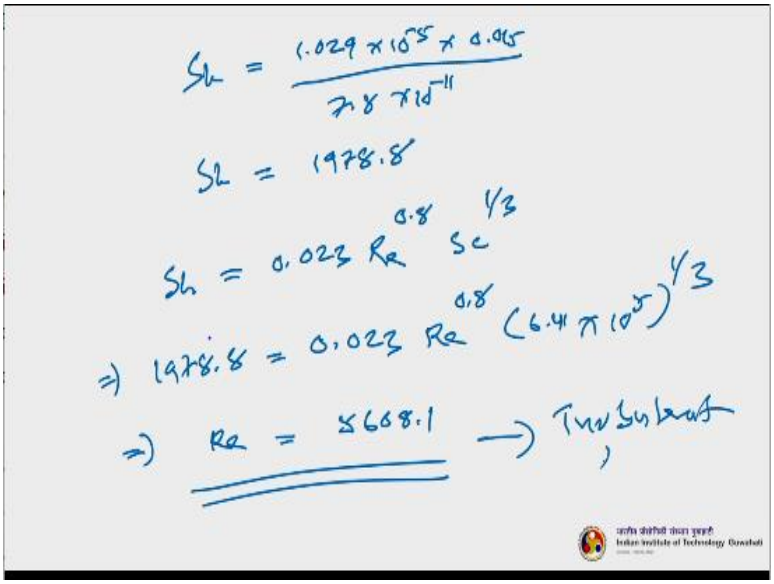

$$Sc = \frac{1.029 \times 10^{-5} \times 0.015}{7.8 \times 10^{-11}}$$

$$Sc = 1978.8$$

$$Sh = 0.023\, Re^{0.8}\, Sc^{1/3}$$

$$\Rightarrow 1978.8 = 0.023\, Re^{0.8} \left(6.41 \times 10^{5}\right)^{1/3}$$

$$\Rightarrow Re = 5608.1 \longrightarrow \text{Turbulent}$$

So you can calculate Schmidt number by substituting all these values so Schmidt number equals to 1.029 into 10 power of -5 into 0.015 divided by 7.8 into 10 power of -11, so your Schmidt number becomes 1978.8 and you know you can write Schmidt number in terms of the Reynolds number. Because ultimately you have to express these things in the terms of Reynolds number from where you can calculate velocity directly.

So Reynolds number is rho dv by mu, so v is there velocity of the fluid. So that is how it will calculate it, so we can write sayroot number the expression sayroot number equals to 0.023 Reynolds number to the power of 0.8 and schmidt number to the power of 1/3. This data point equation or we can write this substitute 1978.8 equals to 0.023 Reynolds number to the power of 0.8 then Schmidt number is we got it is 6.41 into 10 to the power 5 to the power 1/3.

So from here we get Reynolds number is 5608.1, so what does it indicate say indicates turbulence or Turbulent flow. So we got the number now, it is very easy to calculate the velocity.

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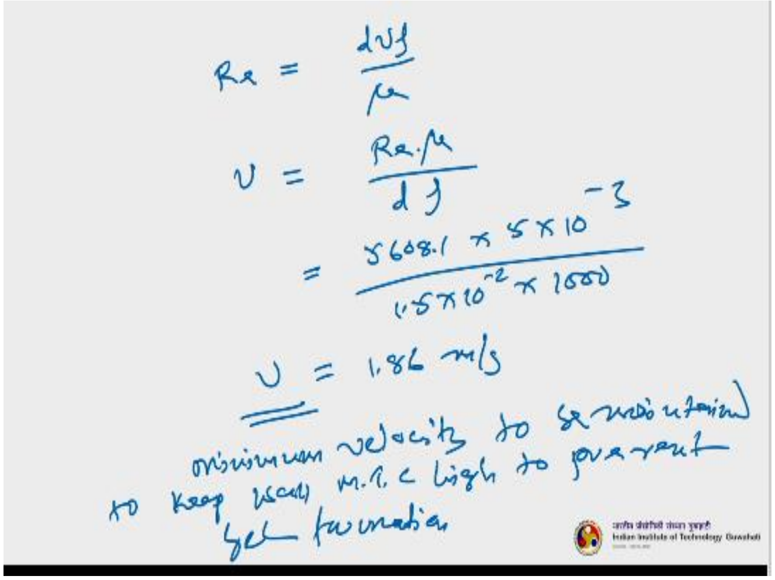

$$Re = \frac{dv\rho}{\mu}$$

$$v = \frac{Re \cdot \mu}{d\rho}$$

$$= \frac{5608.1 \times 5 \times 10^{-3}}{1.5 \times 10^{-2} \times 1000}$$

$$\underline{\underline{v = 1.86\ m/s}}$$

minimum velocity to be maintained to keep (wall) m.t.c high to prevent gel formation

So you know Reynolds number is equals to d v rho by mu or v equals to Reynolds number mu divided by dm rho. Substitute this 5608.1 into viscosity is 5 into 10 power -3, and d is 1.5 into 10 power of -2 into rho is 1000, so you get v to be 1.86 meter per second, so this is v this is the minimum velocity, this is what we have calculated is the minimum velocity to be maintained to keep wall mass transfer coefficient high to prevent Gel formation.

This is what you have been asked calculate the velocity at which gel formation will not happen. So this is how you have calculated I think it is clear to you that how you will calculate any time velocity is been asked, please write down your equations in such a way that you can calculate the Reynolds number then it is very easy to calculate your velocity. If Reynolds number is not directly calculable, then you can go use Schmidt number and sayroot number as we have used different dimensions number.

So this importance dimensionless numbers actually how you use them in calculating various parameters. So, let us see another small problem.

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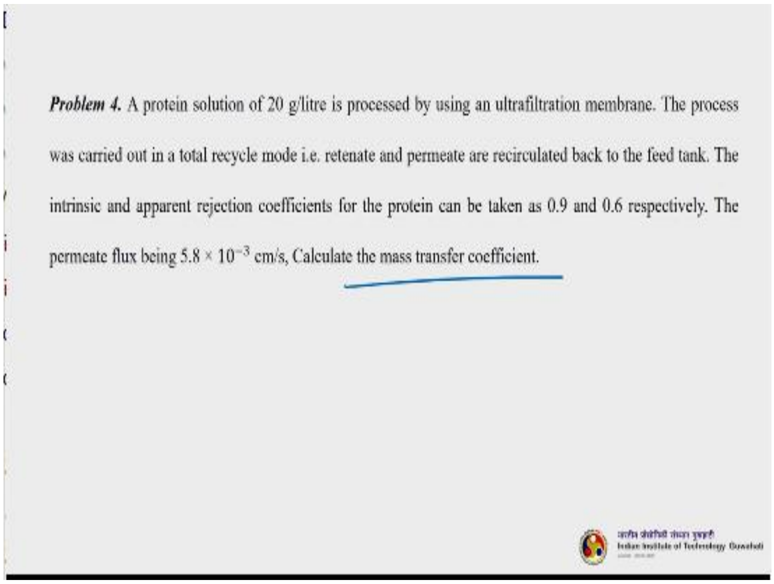

Problem 4. A protein solution of 20 g/litre is processed by using an ultrafiltration membrane. The process was carried out in a total recycle mode i.e. retenate and permeate are recirculated back to the feed tank. The intrinsic and apparent rejection coefficients for the protein can be taken as 0.9 and 0.6 respectively. The permeate flux being 5.8×10^{-3} cm/s, Calculate the mass transfer coefficient.

So it says that a protein solution of 20 grams per liter is processed by using an ultrafiltration membrane. The process was carried out in a total recycle mode that is retenate and permeate are recirculated back to the feed tank. The increasing and apparent rejection coefficients for the protein can be taken as 0.9 and 0.6 respectively. The permeate flux is given to be 5.8 into 10 to the power of -3 centimeter per second. Calculate the mass transfer coefficients.

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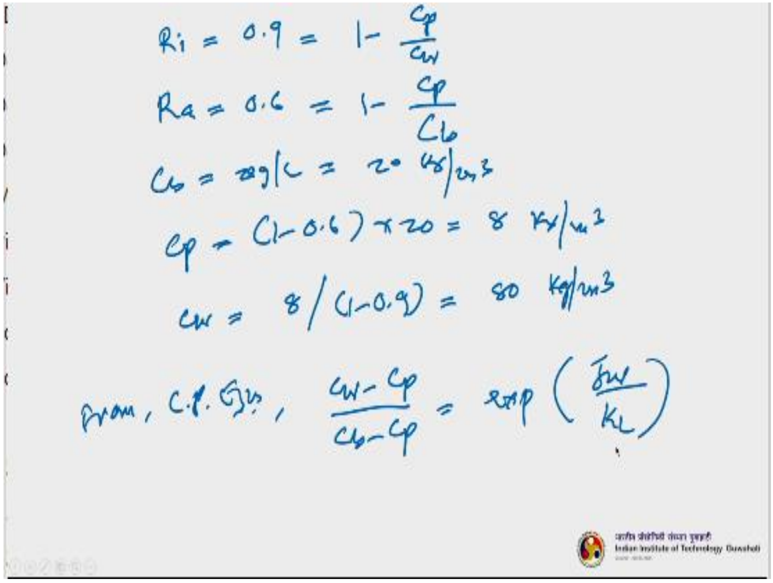

$$R_i = 0.9 = 1 - \frac{C_p}{C_w}$$

$$R_a = 0.6 = 1 - \frac{C_p}{C_b}$$

$$C_b = 20 g/L = 20 \; kg/m^3$$

$$C_p = (1-0.6) \times 20 = 8 \; kg/m^3$$

$$C_w = 8/(1-0.9) = 80 \; kg/m^3$$

From, C.P. Eqn,
$$\frac{C_w - C_p}{C_b - C_p} = \exp\left(\frac{J_w}{K_L}\right)$$

Let us see how you will do it. So here increasing rejection coefficient so is Ri. Ri equals to 0.9 and what is Ri? So Ri equals to 1- Cp by Cw and here apparent rejection coefficient Ra is 0.6, which is 1- Cp by Cb. So this is that the difference between apparent and intrinsic. So intrinsic is the real actually Cw. Cw is the membrane, what membrane concentration, concentration of the surface of the membrane.

Since you cannot calculate it, so you can use Cb, the bulk concentration to calculate the apparent rejection coefficient or sieving coefficient later. So here protein concentration Cb is given is 20 grams per liter or we can write 20 kg per meter cube. So we can calculate Cp then Cp is 1-0.6 into 20. So that is 8 kg per meter cube and we can calculate Cw equals to Cw is 8 divided by 1 - 0.9 is nothing but 80 kg per meter cube.

So from concentration polarization equation, we know that, Cw–Cp. divided by Cb-Cp is nothing but exponential Jw by KL. So this equation has been used twice here in todays problem.

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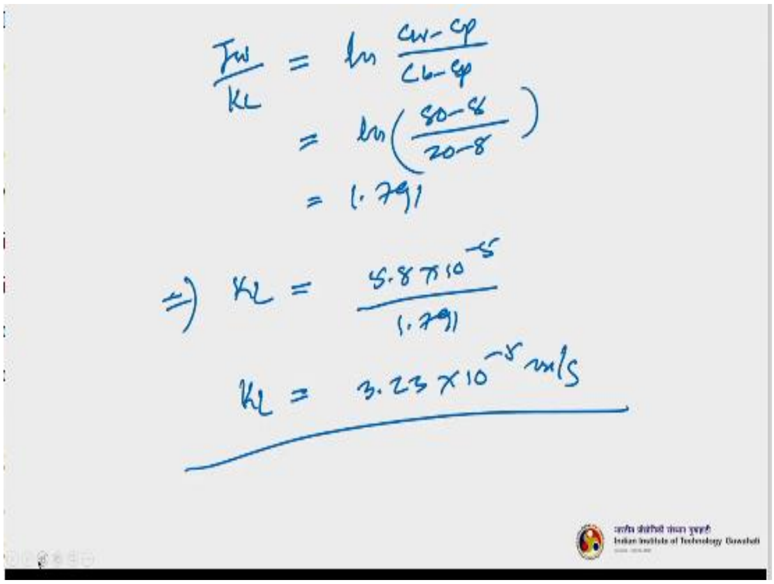

$$\frac{J_w}{K_L} = \ln\frac{C_w - C_p}{C_b - C_p}$$

$$= \ln\left(\frac{80-8}{20-8}\right)$$

$$= 1.791$$

$$\Rightarrow K_L = \frac{5.8\times10^{-5}}{1.791}$$

$$K_L = 3.23\times10^{-5}\ \text{m/s}$$

So we can calculate from mass transfer co-efficeint from this equation, so Jw by KL equals to ln of Cw-Cp divided by Cb-Cp. So which is ln of 80 - 8 divided by 20 - 8, so it is nothing but 1.791, but you know Jw is given, so you can calculate KL, so KL equals to your Jw is 5.8 into 10 to the power – 5 divided by 1.791, so your mass transfer coefficient equals to 3.23 into 10 power of -5 meter per second.

So this is your mass transfer coefficient, you know how it sees it to calculate always mass transfer coefficient using the concentration polarization modulus equation provided, you know, the bulk concentration, and any other concentration either the feed this one here permeate concentration or a CwR. You can calculate the concentrations if you are you have been given either the sieving coefficients or the rejection coefficients. So let us now see 2 more small,

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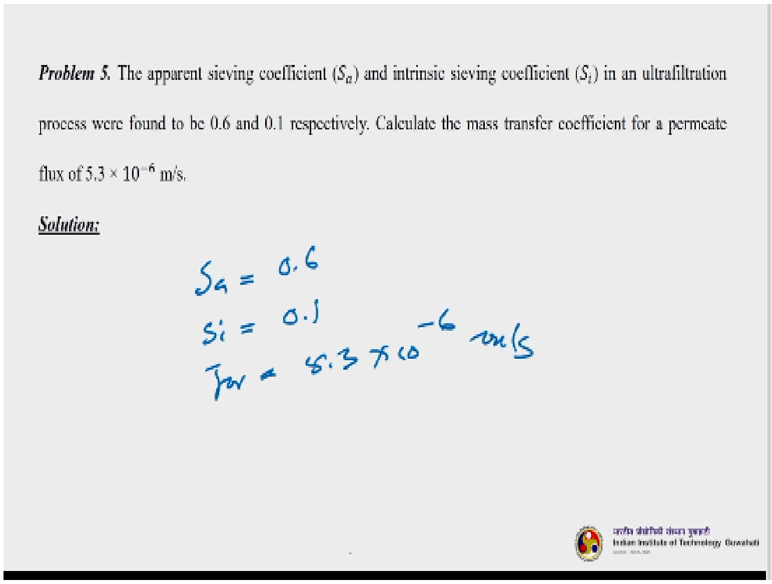

Problem 5. The apparent sieving coefficient (S_a) and intrinsic sieving coefficient (S_i) in an ultrafiltration process were found to be 0.6 and 0.1 respectively. Calculate the mass transfer coefficient for a permeate flux of 5.3×10^{-6} m/s.

Solution:

$S_a = 0.6$

$S_i = 0.1$

$J_w = 5.3 \times 10^{-6}$ m/s

Small problems so this is how you use the sieving coefficient equation actually. So the apparent sieving coefficient and intrinsic sieving coefficient Sa and Si in an ultrafiltration process were found to be 0.6 and 0.1 respectively. So calculate the mass transfer coefficient for a flux of 5.3 into 10 power of -6 meter per second, so you know here Sa apparent sieving coefficient equals to 0.6 here Si is given to be 0.1 there permeate flux is given 5.3 into10 power of -6 meter per second. Now you can use the equation.

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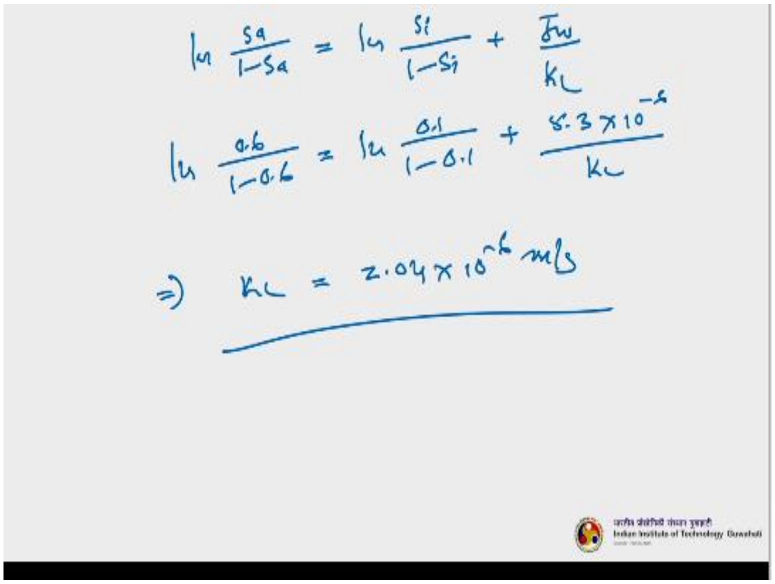

$$\ln \frac{s_a}{1-s_a} = \ln \frac{s_i}{1-s_i} + \frac{J_w}{K_L}$$

$$\ln \frac{0.6}{1-0.6} = \ln \frac{0.1}{1-0.1} + \frac{5.3 \times 10^{-6}}{K_L}$$

$$\Rightarrow \quad K_L = 2.04 \times 10^{-6}\ m/s$$

So which is ln of sa divided by 1-sa equals to ln of si divided by 1- si + Jw by KL. So you can write substitute all these values, so sa is 0.6 divided by 1-0.6 equals to ln of, it is 0.1 divided by 1-0.1 is given 5.3 into 10 power of -6 divided by KL. So from here this equation we can find KL to be 2.04 into 10 power of -6 meter per second. So this is the mass transfer.

This is very easy one only thing this you need to know this equation. So this problem and the last problem we have seen that how do we use the apparent sieving coefficients intrinsic sieving coefficient as well as apparent and intrinsic rejection coefficients to calculate mass transfer coefficients

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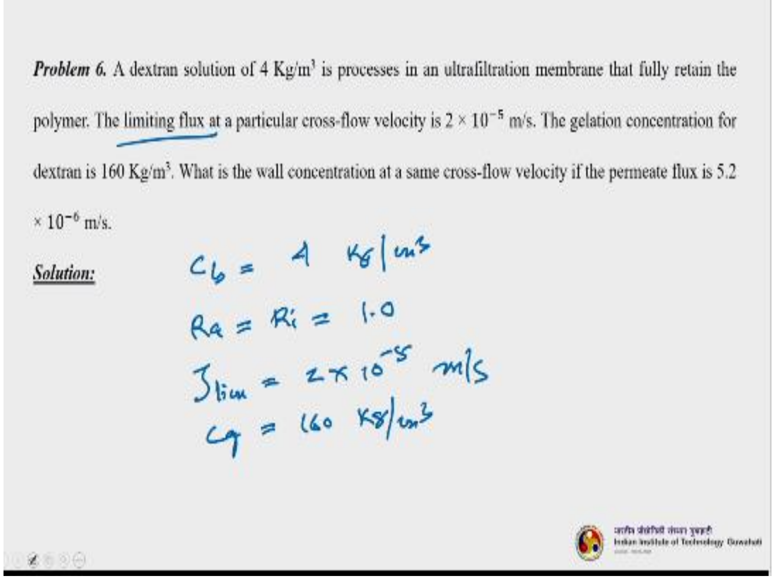

Problem 6. A dextran solution of 4 Kg/m^3 is processes in an ultrafiltration membrane that fully retain the polymer. The limiting flux at a particular cross-flow velocity is 2×10^{-5} m/s. The gelation concentration for dextran is 160 Kg/m^3. What is the wall concentration at a same cross-flow velocity if the permeate flux is 5.2×10^{-6} m/s.

Solution:

$C_b = 4\ Kg/m^3$

$R_a = R_i = 1.0$

$J_{lim} = 2 \times 10^{-5}\ m/s$

$C_g = 160\ Kg/m^3$

So a very small problem we will see then we will wind up todays lecture. A dextran solution of 4 kilogram per meter cube is processes, in a ultrafiltration membrane that fully return the polymer. The limiting flux that is J limiting, at a particular cross flow velocity is given to be 2 into 10 power of - 5 meter per second. The gelation concentration for the dextran is 160 kilo per meter cube.

What is the wall concentration at the same cross flow of velocity if the permit flux is given 5.2 into 10 power of - 6 meter per second, so let us note down what is been given, so it is given Cb equals to 4 Kg per meter cube Ra equals to Ri equals to given 1, J limiting, in our ultrafiltration lecture we have discussed what is limiting flux, if you can recall, then Cg equals to 160 kg per meter cube and you know.

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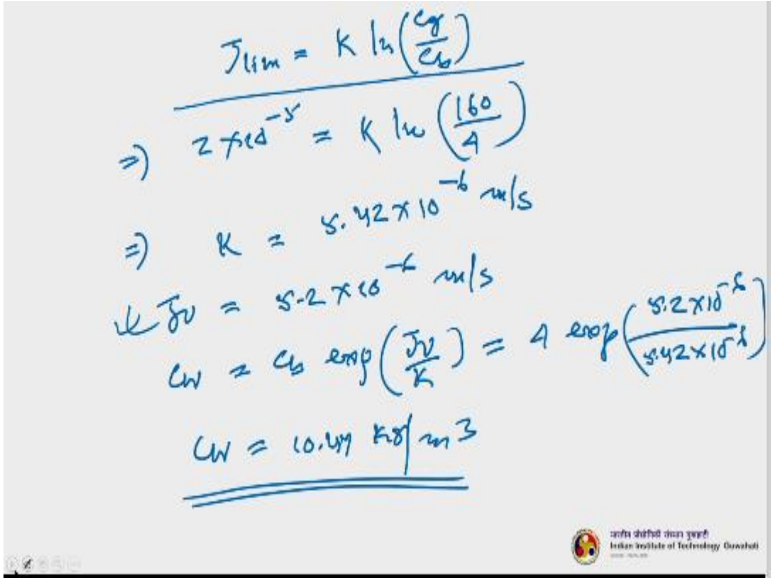

$$J_{lim} = K \ln\left(\frac{C_g}{C_b}\right)$$

$$\Rightarrow 2\times10^{-5} = K \ln\left(\frac{160}{4}\right)$$

$$\Rightarrow K = 5.42\times10^{-6} \text{ m/s}$$

$$\& \; J_v = 5.2\times10^{-6} \text{ m/s}$$

$$C_w = C_b \exp\left(\frac{J_v}{K}\right) = 4 \exp\left(\frac{5.2\times10^{-6}}{5.42\times10^{-6}}\right)$$

$$C_w = 10.44 \text{ Kg/m}^3$$

You can use that gel limiting equation, so J lim is K ln Cg by Cb. So this is the limiting flux equation. So substitute the values, so 2 into 10 power of -5 equals to K ln, Cg is 160 divided by Cb is 4, so from here,we can calculate K equals to 5.42 into 10 power of -6 meter per second. Let us certain constituency the permeate flux is given is 5.2 into 10 power of -6 meter per second.

So you have to calculate Cw equals to Cb exponential to the power of Jv by K. So it is 4, exponential to the power of 5.2 into 10 power of - 6 divided by 5.42 into 10 power of - 6. So Cw is 10.44 kg per meter cube. So this is what you have been asked to calculation. A calculate, what is the wall concentration at the same cross flow velocity if the flux is given as 5.2 into 10 power of -6.

So today we see how will you use even the limiting flux equation is the limiting flux equation. J limiting equals to K ln Cg by Cb to calculate the wall or predict the wall concentration.

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Text/References

- M. H. Mulder, Basic Principles of Membrane Technology, Springer, 2004
- B. K. Dutta, Mass Transfer and Separation Processes, PHI, 2007.
- K. Nath, Membrane Separation Processes, PHI, 2008.
- M. Cheryan, Ultrafiltration & Microfiltration Handbook, Technomic, 1998.
- Richard W. Baker, Membrane Technology and Applications, Wiley, 2012.

So, thank you very much. Please as I told you in the last class, please see B.K Dutta book and K. Nath book, they have so many solved examples please go through them and there are so many also examples also please try to solve them in case you have any problem.

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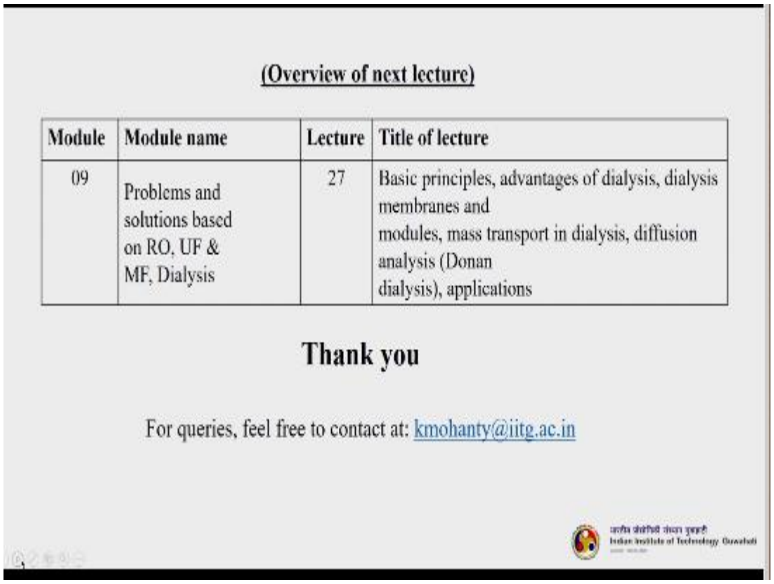

(Overview of next lecture)

Module	Module name	Lecture	Title of lecture
09	Problems and solutions based on RO, UF & MF, Dialysis	27	Basic principles, advantages of dialysis, dialysis membranes and modules, mass transport in dialysis, diffusion analysis (Donan dialysis), applications

Thank you

For queries, feel free to contact at: kmohanty@iitg.ac.in

Please feel free to like to meet kmohanty@iitg.ac.in and thank you very much. In the next class will be discussing dialysis, will discuss what is the basic principles of dialysis? What is the advantages of dialysis? Then different types of membranes that is used for dialysis and modules then how mass transport happens in dialysis and will discuss about diffusion or what is known as the donan dialysis.

And few applications of dialysis from will discuss up wards the hemodialysis; this is one of the most important applications. So, thank you very much.