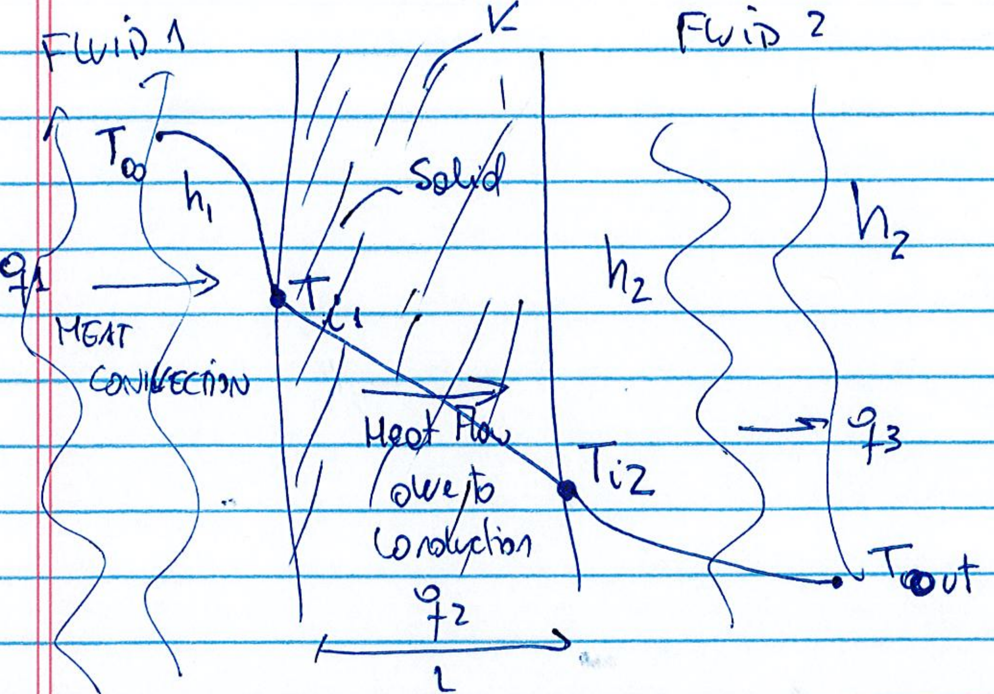
HEAT TRANSFER



q_1 = HEAT CONVECTION $= h_1 A (T_{\infty} - T_{i1}) = \dfrac{T_{\infty} - T_{i1}}{1/h_1 A}$

q_2 = HEAT CONDUCTION $= KA \dfrac{(T_{i1} - T_{i2})}{L} = \dfrac{T_{i1} - T_{i2}}{\frac{L}{KA}}$

q_3 = HEAT CONVECTION $= h_2 A (T_{i2} - T_{out}) = \dfrac{T_{i2} - T_{out}}{\frac{1}{h_2 A}}$

Steady state $q_1 = q_2 = q_3 = q$

$$T_{\infty} - T_{i1} = q \left(\frac{1}{h_1 A}\right) \quad (1)$$

$$T_{i1} - T_{i2} = q \, / L/KA \quad (2)$$

$$T_{i2} - T_{out} = q\left[\frac{1}{h_2 A}\right] \quad (3)$$

Sum Eqs (1) to (3)

$$T_\infty - \cancel{T_{i1}} + \cancel{T_{i1}} - \cancel{T_{i2}} + \cancel{T_{i2}} - T_{out} = q\left[\frac{1}{h_1 A} + \frac{L}{KA} + \frac{1}{h_2 A}\right]$$

$$T_\infty - T_{out} = q\left[\frac{1}{h_1 A} + \frac{L}{KA} + \frac{1}{h_2 A}\right]$$

$$q = \frac{T_\infty - T_{out}}{\underbrace{\left[\frac{1}{h_1 A} + \frac{L}{KA} + \frac{1}{h_2 A}\right]}_{\sum \text{Resistances}}}$$

$$\boxed{\frac{q}{A} = \text{Flux} = \frac{T_\infty - T_{out}}{\frac{1}{h_1} + \frac{L}{k} + \frac{1}{h_2}}}$$

COMPARE WITH EQUATION IN SLIDE 7

MAIN DIFFERENCES BETWEEN HT & MT

(3)

THERMAL CONDUCTIVITY

DIFFUSION MATRIX

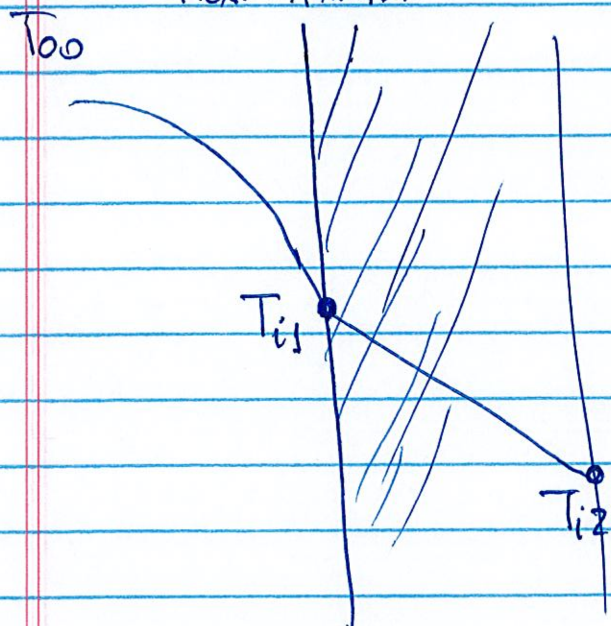
$K \longrightarrow D_{AB}$

corresponds to diffusing species A

h_1 & h_2 $\longrightarrow$ h_{m1} & h_{m2}

Big difference is that we have K^*

HEAT TRANSFER



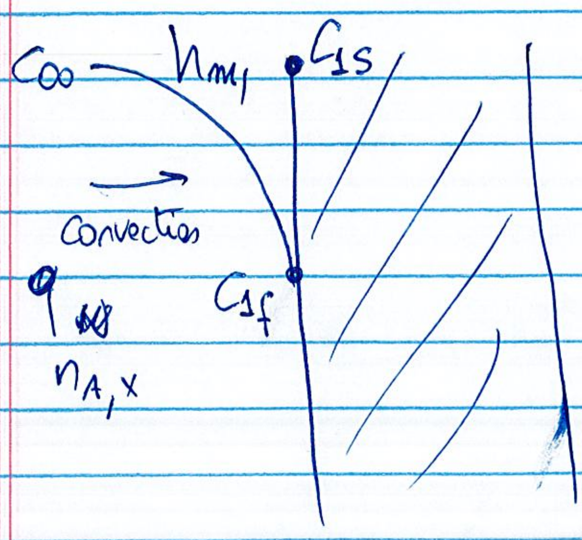
DRIVING FORCE FOR CONVECTION FLUID 1

$T_\infty - T_{i1}$

DRIVING FOR CONDUCTION

$T_{i1} - T_{i2}$

MASS TRANSFER

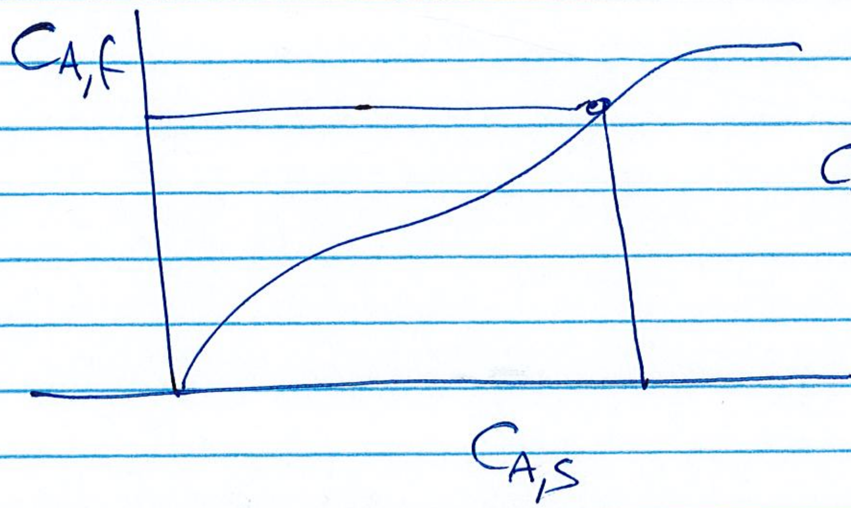


$n_{A,x} = h_{m1}\,[C_\infty - C_{1f}]$

f : indicates that we are measuring concentration of A in fluid phase.

(4)

In the solid phase the concentration of A will be different then the concentration of A in the fluid phase



$C_{A,f} = K^* C_{A,s}$

- Flux of A $\left[\frac{moles}{m^2 \cdot s}\right]$ in the left fluid.

concentration of A in the fluid phase.

$$n_{A,x} = h_{m1} [C_1 - C_2]$$

- Flux of A $\left(\frac{moles}{m^2 s}\right)$ in the membrane.

concentration in the solid membrane

$$n_{A,x} = D_{AB} \frac{C_{2i} - C_{3i}}{L}$$

- Flux of A $(moles/m^2 s)$ convection on the right

$$n_{A,x} = h_{m2} (C_3 - C_4)$$

$$C_1 - \cancel{C_2} = \frac{n_{Ax}}{h_{m1}} = n_{Ax}\left[\frac{1}{h_{m1}}\right]$$

$+$

$$\underbrace{C_{2i}}_{K^* C_2} - \underbrace{C_{3i}}_{K^* C_3} = \frac{n_{Ax}}{\frac{D_{AB}}{L}} = n_{Ax}\left[\frac{1}{\frac{D_{AB}}{L}}\right] \Rightarrow \cancel{C_2} - \cancel{C_3} = n_{AB}\left[\frac{1}{\frac{D_{AB}K^*}{L}}\right]$$

$+$

$$\cancel{C_3} - C_4 = \frac{n_{AK}}{h_{m2}} = n_{Ax}\left[\frac{1}{h_{m2}}\right]$$

$$C_1 - C_4 = n_{A,x}\left[\frac{1}{h_{m1}} + \frac{1}{\frac{D_{AB}K^*}{L}} + \frac{1}{h_{m2}}\right]$$

$$n_{A,x} = \frac{C_1 - C_4}{\underbrace{\left[\frac{1}{h_{m1}} + \frac{L}{D_{AB}K^*} + \frac{1}{h_{m2}}\right]}_{\Sigma \text{ Resistance}}}$$

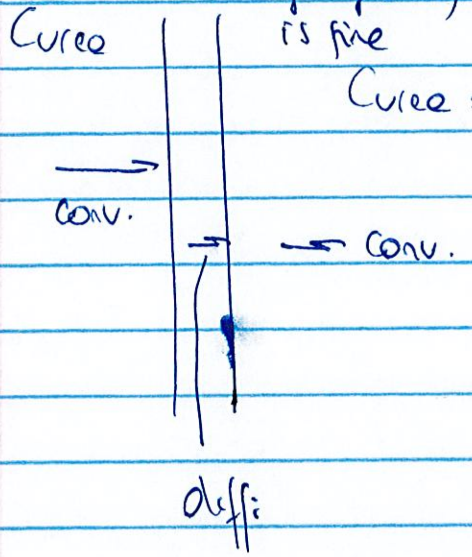
$\boxed{\Delta L \equiv L}$ For consistency with the power point

Calculate the Flux of urea in the dialysis membrane (6)

convert units to g/l or g/m^3

$$n_{urea} = \frac{\left(0.02\,g/100\,cm^3 - 0\right)}{\frac{1}{h_{m1}} + \frac{L}{K^* D_{urea,m}} + \frac{1}{h_{m2}}}$$

diameter is small so rectangular geometry is fine



$$\frac{d^2 C_A(x)}{dx^2} - m^2 C_A(x)$$

Characteristic equation

$$r^2 - m^2 = 0 \Longrightarrow r_{1,2} = \pm\sqrt{m^2} = \pm m$$

$$C_A(x) = A e^{r_1 x} + B e^{-r_1 x}$$

$$\boxed{C_A(x) = A e^{mx} + B e^{-mx}}$$

We need to put Boundary conditions (7)
to find out A & B