Q 1.

$$u_y = \frac{\rho g \delta^2}{2\mu}\left[1 - \left(\frac{z}{\delta}\right)^2\right]$$

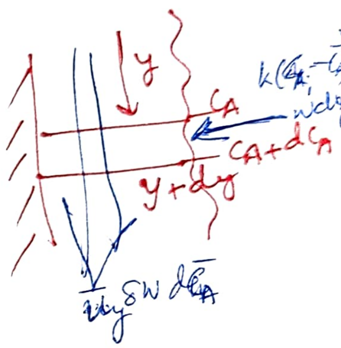
$$u_y\Big|_{max} = \frac{\rho g \delta^2}{2\mu} \qquad \bar{u}_y = \frac{\int_0^{\delta} u_y\,dz}{\delta} = \frac{\rho g \delta^2}{3\mu}$$

$$N_{Re} = \frac{(4\delta)\bar{u}_y \rho}{\mu} = 25 \qquad \delta = \left[\frac{3\bar{u}_y \mu}{\rho g}\right]^{1/2}$$

Combining, $\delta = 1.15 \times 10^{-4}$ m.

$$\bar{u}_y = \frac{\rho g \delta^2}{3\mu} = 0.0486 \text{ m s}^{-1}$$

$$k_{avg} = 3.414\,\frac{D_{AB}}{\delta} = 5.81 \times 10^{-5} \text{ m s}^{-1}$$



$$n_A = \bar{u}_y\,\delta W\, d\bar{C}_A = k\,(C_{A_i} - \bar{C}_A)\,w\,dy$$

$$\Rightarrow k = \frac{\bar{u}_y \delta}{C_{A_i} - \bar{C}_A}\,\frac{d\bar{C}_A}{dy}$$

$$\Rightarrow \underset{\text{over length } L}{k_{avg}} = \frac{\int_0^L k\,dy}{L} = \frac{\bar{u}_y \delta \int_{C_{A_0}}^{\bar{C}_{A_L}} \frac{d\bar{C}_A}{C_{A_i} - \bar{C}_A}}{L}$$

$$= \frac{\bar{u}_y \delta}{L} \ln \frac{C_{A_i} - C_{A_0}}{C_{A_i} - \bar{C}_{A_L}}$$

$$\bar{C}_{A_L} = C_{A_i} - (C_{A_i} - \cancel{C_{A_0}}^{\,0})\,e^{-\frac{k_{avg} L}{\bar{u}_y \delta}}$$

$$\underset{\text{(given)}}{0.5} = \frac{\bar{C}_{A_L}}{C_{A_i}} = 1 - e^{-\frac{k_{avg} L}{\bar{u}_y \delta}}$$

$\Rightarrow$

Q2

$$\frac{\partial C_A}{\partial t} = D\frac{\partial^2 C_A}{\partial x^2}$$

$C_A = C_{A_1}$ at $x=0,\ t>0$

$C_A = C_{A_0}$ at $x=\infty,\ t>0$

$C_A = C_{A_0}$ at ~~$t=0$,~~ $x>0,\ t=0$.

$$\frac{C_A - C_{A_0}}{C_{A_1} - C_{A_0}} = 1 - \mathrm{erf}\left(\frac{x}{\sqrt{4Dt}}\right)$$

For $t = 1$ day $= 3600\times24$ s $= 86400$ s

and $x = 0.06$ m

$$\boxed{C_A = 3.01\times10^{-5}\ \frac{\text{kmole}}{m^3}}$$

For $t = 3$ days

$x = 0.06$ m

$$\boxed{C_A = 4\times10^{-5}\ \frac{\text{kmole}}{m^3}}$$

For the third part After 30 days

The value of x for which $C_A = 3\times10^{-5}$ kmol/m^3 $= C_{A_0}$

$$\Rightarrow \frac{C_{A_0} - C_{A_0}}{C_{A_1} - C_{A_0}} = 1 - \mathrm{erf}\left(\frac{x}{\sqrt{4Dt}}\right)$$

$$\Rightarrow \mathrm{erf}\left(\frac{x}{\sqrt{4Dt}}\right) = 1.$$

From the table,

$$\frac{x}{\sqrt{4Dt}} = 3.0$$

$$\Rightarrow \boxed{x = 0.384\ \text{m}}$$