① $J_A = -D_{AB}\dfrac{dC_A}{dx}$

Only A is diffusing not B

Binary, non-reactive, steady state, single phase, const. geometry

$$N_A = \frac{C_A}{C}(N_A + N_B) = -D_{AB}\frac{dC_A}{dx}$$

$$\frac{dN_A}{dx} = 0, \qquad N_B = 0$$

$$\frac{N_A}{C}(C - C_A) = -D_{AB}\frac{dC_A}{dx}$$

$$\int_0^L \frac{N_A}{C D_{AB}}\,dx = -\int_{C_{A1}}^{C_{A2}} \frac{dC_A}{C - C_A}$$

$$\therefore \frac{N_A}{C D_{AB}} L = -\left[\ln(C - C_A)\right]_{C_{A1}}^{C_{A2}}$$

$$\Rightarrow N_A = -\frac{C D_{AB}}{L}\ln\left(\frac{C - C_{A2}}{C - C_{A1}}\right)$$

$$\therefore N_A = \frac{C D_{AB}}{L}\ln\left(\frac{C - C_{A1}}{C - C_{A2}}\right)$$

Since total ~~pressure~~ conc. is uniform,

$$C = C_{A1} + C_{B1} = C_{A2} + C_{B2}$$

$$\Rightarrow C - C_{A1} = C_{B1}$$

Using these results,

$$N_A = \frac{C D_{AB}}{L}\,\frac{C_{A1} - C_{A2}}{C_{A1} - C_{A2}}\ln\frac{C_{B2}}{C_{B1}}$$

$$\therefore N_A = \frac{D_{AB} C}{L}\,\frac{C_{A1} - C_{A2}}{(C_{B2} - C_{B1})/\ln(C_{B2}/C_{B1})}$$

$$N_A = \frac{D_{AB} C}{L}\,\frac{C_{A1} - C_{A2}}{C_{BLM}}$$

where, $C_{BLM} = \dfrac{C_{B2} - C_{B1}}{\ln(C_{B2}/C_{B1})}$

(2) case 2 : Binary, non-reactive, steady state, single phase, const. geometry

$N_A = -n N_B$ $n = 1$
(Equimolar counter diff)

Fick's law :

$$N_A - \frac{C_A}{c}(N_A + N_B) = -D_{AB}\frac{dC_A}{dx}$$

$\because N_A = -N_B$

$$\therefore N_A = -D_{AB}\frac{dC_A}{dx} \quad - (1)$$

At $x = 0$ $C_A = C_{A1}$
$x = L$ $C_A = C_{A2}$

On integrating eqn. (1)

$$\int_0^L N_A\, dx = -\int_{C_{A1}}^{C_{A2}} D_{AB}\, dC_A$$

$$N_A = \frac{D_{AB}}{L}(C_{A1} - C_{A2})$$