24-5

- proove that $\sum_{i=1}^{2} J_i^* = 0$ (Binary system)

soln

$$N_{Az} = -c D_{AB} \frac{dx_A}{dz} + x_A N_T \quad ---(1)$$

and $$N_{Bz} = -c D_{BA} \frac{dx_B}{dz} + x_B N_T \quad ---(2)$$

Add (1) to (2);

$$N_{Az} + N_{Bz} = -c D_{AB} \frac{dx_A}{dz} + x_A N_T - c D_{BA} \frac{dx_B}{dz} + x_B N_T$$

$$= -c \left[D_{AB} \frac{dx_A}{dz} + D_{BA} \frac{dx_B}{dz} \right] + (x_A + x_B) N_T$$

But $x_A + x_B = 1$ (Binary comp.)

& $N_T = N_A + N_B$

$$\therefore \quad D_{AB} \frac{dx_A}{dz} + D_{BA} \frac{dx_B}{dz} = 0$$

$dx_A = -dx_B$ and $\frac{dx_A}{dz} = \frac{-dx_B}{dz}$.

$$\therefore \quad D_{AB} - D_{BA} = 0$$

or $D_{AB} = D_{BA}$ (only for Binary component)

- proove that $\sum_{i=1}^{2} N_i = c\vec{v}$ for binary system (as required)

$$\sum_{i=1}^{2} N_i = -c \left[D_{AB} \frac{dx_A}{dz} + D_{BA} \frac{dx_B}{dz} \right] + (x_A + x_B) N_T$$

($\frac{dx_A}{dz}$ and $\frac{dx_B}{dz}$ $\rightarrow 0$)

$$= N_T$$

$$= c \left[\frac{c_A \vec{v}_A}{c} + \frac{c_B \vec{v}_B}{c} \right]$$

$$\vec{N}_A + \vec{N}_B = c\vec{v}$$

24-9

Data for chlorobenzene { Mwt = 112.6, P_c = 44.6 atm, T_c = 632.4 K

To obtain the $D_{AB} = \dfrac{0.001858\, T^{3/2}\left[\frac{1}{Mw_A} + \frac{1}{Mw_B}\right]^{1/2}}{P\, \sigma_{AB}^2\, \Omega_D}$

To obtain Ω_D;

$\frac{\epsilon_A}{k} = 0.77\, T_c$ — eq. 24-37

$= 0.77(632.4) = 486.9$

$\frac{\epsilon_B}{k} = 97$, $\frac{\epsilon_{AB}}{k} = \sqrt{486.9 * 97} = 217.32$

and $\frac{T/\epsilon_{AB}}{k} = \frac{298}{217.3} = 1.371 \rightarrow \Omega_D = 1.245$

To obtain σ_{AB},

$\sigma_A = 2.44\left(\frac{T_c}{P_c}\right)^{1/3} = 2.44\left(\frac{632.4}{44.6}\right)^{1/3} = 5.9$

$\sigma_B = 3.617$

$\sigma_{AB} = \frac{5.9 + 3.617}{2} = 4.758$

$$D_{AB} = \frac{0.001858\,(298)^{3/2}\left[\frac{1}{112.56} + \frac{1}{29}\right]^{1/2}}{(1)(4.758)^2(1.245)}$$

$$= 0.0705\ \frac{cm^2}{s}$$

24-92

$D_{H_2S,mix} = ?$ @ 350k, 1 atm, $Mwt_{H_2S} = 34$, $Mwt_{SO_2} = 64$, $Mwt_{N_2} = 28$

$$D_{H_2S,mix} = \frac{1}{\frac{y'_{SO_2}}{D_{H_2S,SO_2}} + \frac{y'_{N_2}}{D_{H_2S,N_2}}}$$

For the given mixture $y_{H_2S} = 0.03$, $y_{SO_2} = 0.05$, $y_{N_2} = 0.92$

$$\therefore y'_{SO_2} = \frac{y_{SO_2}}{1 - y_{H_2S}} = \frac{0.05}{1 - 0.03} = 0.0515$$

$$y'_{N_2} = \frac{y_{N_2}}{1 - y_{H_2S}} = \frac{0.92}{1 - 0.03} = 0.9485$$

$$D_{H_2S,SO_2} = \frac{0.001858\, T^{3/2} \left[\frac{1}{M_{w_{H_2S}}} + \frac{1}{M_{w_{SO_2}}}\right]^{1/2}}{P\, \sigma_{AB}^2\, \Omega_D}$$

$$\sigma_{H_2S} = 0.841\, V_c^{1/3} = 0.841\,(98.5)^{1/3} = 3.88$$

$$\frac{\epsilon_{H_2S}}{k} = 0.77\, T_c = 0.77\,(373.2) = 287.4$$

For N_2, $\sigma_{N_2} = 3.68$, $\frac{\epsilon_{N_2}}{k} = 91.5$; For SO_2, $\sigma_{SO_2} = 4.29$, $\frac{\epsilon_{SO_2}}{k} = 252$

$$D_{H_2S,SO_2} = \frac{0.001858\,(350)^{3/2} \left[\frac{1}{M_{w_{H_2S}}} + \frac{1}{M_{w_{SO_2}}}\right]^{1/2}}{(1)\,(\sigma_{AB})^2\, \Omega_D}$$

$$= \frac{0.001858\,(350)^{3/2}\,(0.212)}{(1)(16.69)(1.273)} = 0.121 \frac{cm^2}{s}$$

similarly $D_{H_2S,N_2} = 0.208\ cm^2/s$

and $D_{H_2S,mix} = \frac{1}{\frac{0.0515}{0.121} + \frac{0.9485}{0.209}} = 0.2\ cm^2/s$

24-18

A)

Benzen into C_2H_5OH

$$D_{Bz-EoH} = \frac{7.4\times10^{-8}(\phi_B M_B)^{1/2}}{V_A^{0.6}} \frac{T}{\mu_B}$$

$T = 298\ K$

$\mu_B = 1.3\ cp$

$\phi_B = 1.5$

$M_{wB} = 46$

$(\phi_B M_{wB})^{1/2} = 8.3$

$V_A = 6C + 6H - 15$ (Table 24-5)

$= 6(14.8) + 6(3.7) - 15 = 96$

$$D_{Bz-EoH} = \frac{7.4\times10^{-8}(1.5\times46)^{1/2}}{(96)^{0.6}} \frac{298}{1.3} = 8.8\times10^{-6}\ cm^2/s$$

For E-OH into Benzen

$\mu_B = 0.75\ cp$

$\phi_B = 1.0$

$M_B = 78$

$(\phi_B M_B)^{1/2} = (78)^{1/2} = 8.83$

$V_{C_2H_5OH} = 2V_C + 6V_H - 1V_O = 2(14.8) + 6(3.7) + 7.4 = 59.2$

$$D_{EoH-Bz} = \frac{7.4\times10^{-8}(8.83)}{11.57} \frac{298}{0.75} = 2.17\times10^{-5}\ cm^2/s$$

B) $D_{Bz-EoH} = \frac{K}{V_A^{1/3}} \frac{T}{\mu_B}$, $V_A = 96$, $V_B = 59.2$,

$V_A < 2.5\ V_B$

$K = 17.5\times10^{-18}$

$$= \frac{17.5\times10^{-18}}{(96)^{1/3}} \frac{298}{1.3} = 8.46\times10^{-6}\ cm^2/s$$

$$D_{EoH-Bz} = \frac{18.9\times10^{-8}}{(59.2)^{1/3}} \frac{298}{0.75}$$

$= 1.96\times10^{-5}\ cm^2/s$

$V_A = 59.2$, $V_B = 96$ $\rightarrow V_A < 2V_B$

$K = 18.9\times10^{-8}$