Example (3):

The mass flux from a 5 cm diameter naphthalene ball placed in stagnant air at 40°C and atmospheric pressure, is $1.47 \times 10^{-3} \frac{mol}{m^2 \cdot s}$. Assume the vapor pressure of naphthalene to be 0.15 atm at 40 °C and negligible bulk concentration of naphthalene in air. If air starts blowing across the surface of naphthalene ball at 3 m/s by what factor will the mass transfer rate increase, all other conditions remaining the same?

For mass transfer from a single sphere into gas streams:

$$Sh = 2 + 0.552\, Re^{0.5} Sc^{0.33}$$

The viscosity and density of air are $1.8 \times 10^{-5} \frac{kg}{m \cdot s}$ and $1.123 \frac{kg}{m^3}$, respectively and the gas constant is $82.06 \frac{cm^3 \cdot atm}{mol \cdot K}$.

Solution:

The factor of increase in mass transfer $= \frac{Mass\ flux\ in\ moving\ air}{Mass\ flux\ in\ stagnant\ air} = \frac{k_{c_1} \Delta c}{k_{c_2} \Delta c} = \frac{k_{c_1}}{k_{c_2}}$

For k_{c_2}:

$$1.47 \times 10^{-3} = k_{c_2}\left(\frac{p_v}{RT} - 0.0\right) = k_{c_2} \times \frac{0.15 \times 1000}{0.08206 \times 313}$$

$$k_{c_2} = 2.52 \times 10^{-4}\ m/s$$

For k_{c_1}:

$$Sh = 2 + 0.552\, Re^{0.5} Sc^{0.33}$$

$$\frac{k_{c_1} \times 5 \times 10^{-2}}{D_{AB}} = 2 + 0.552 \left(\frac{1.123 \times 3 \times 0.05}{1.8 \times 10^{-5}}\right)^{0.5} \left(\frac{1.8 \times 10^{-5}}{1.123 \times D_{AB}}\right)^{0.33}$$

D_{AB}??

For stagnant air ($Re = 0.0$)

$$Sh = 2$$

$$\frac{k_{c_2} \times 5 \times 10^{-2}}{D_{AB}} = 2$$

$$2.52 \times 10^{-4}$$

$$\frac{2.52 \times 10^{-4} \times 5 \times 10^{-2}}{D_{AB}} = 2$$

$$D_{AB} = 6.2925 \times 10^{-6}\ m^2/s$$

$$\therefore k_{c_1} = 0.0102\ m/s$$

The factor of increase $= \frac{k_{c_1}}{k_{c_2}} = \frac{0.0102}{2.52 \times 10^{-4}} = 40.5$

D Zayed Hammouri

Admin · October 26, 2017

Dear mass transfer students,

Please consider the following selected problem from the text book:
CH 6: 1.1, 1.2, 2.2 , 2.4, 2.8, 2.9, 5.1, 5.9
CH 7: 2.3, 3.2, 3.4, 3.5
CH11: 1.2, 2.1, 3.2
Good luck

Samer Alrifai, Ãlí Qandil and 14 others 9 Comments

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