# MASS TRANSFER COEFF. FOR VARIOUS GEOMETRIES – MASS TRANSFER INSIDE A TUBE

A TUBE IS COATED ON THE INSIDE WITH NAPHTHALENE AND HAS AN INSIDE DIAM. OF 2.0 CM AND A LENGTH OF 11.0 CM. AIR AT 45°C AND AN AVG. PRESSURE OF 1.0 atm FLOWS THROUGH THE TUBE AT A VELOCITY OF 8.0 cm/s. ASSUMING THAT THE ABSOLUTE PRESSURE REMAINS ESSENTIALLY CONSTANT, CALCULATE THE CONC. OF NAPHTHALENE IN THE EXIT AIR. AIR ENTERING THE TUBE HAS A 0 CONC. OF NAPHTHALENE.

GIVEN: DIFFUSIVITY NAPHTHALENE - AIR = $6.92 \times 10^{-2}$ cm²/s @ 45°C

GIVEN: VAPOR PRESSURE; NAPHTHALENE IN AIR = $7.31 \times 10^{-4}$ atm

PROPERTIES: @ 45°C = 318 K

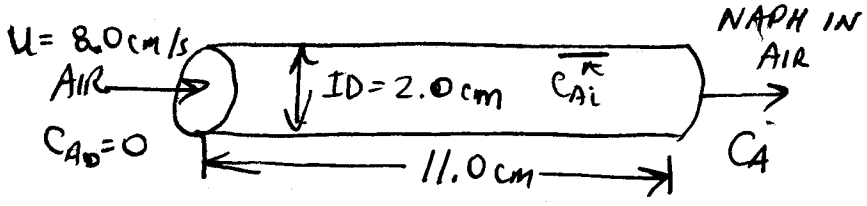
$\mu_{AIR} = 0.0187$ cp = $1.87 \times 10^{-4}$ g/cm·s

VISCOSITY NOMOGRAPH OR USE TABLES

$$\rho_{AIR} = \frac{(MW)n}{V} = \frac{P}{RT}(MW) = \frac{(1\,atm)(29\,g/mol)}{\left(82.06\,\frac{cm^3\,atm}{mol\,K}\right)(318\,K)}$$

$\rho_{AIR} = 1.11 \times 10^{-3}$ g/cm³

(OR USE TABLES)




NAPHTHALENE = 'A' (vapor/liquid)

AIR = 'B' (gas)

$$Sc = \frac{\mu}{\rho D_{AB}}$$

$\mu$ AND $\rho$ ARE PROPERTIES OF 'B'

$$Sc = \frac{1.87 \times 10^{-4}\,g/cm\cdot s}{(1.11 \times 10^{-3}\,g/cm^3)(6.92 \times 10^{-2}\,cm^2/s)} = 2.43$$

$$Re = \frac{D u \rho}{\mu}$$

$\mu, \rho$ ARE PROPERTIES OF 'B'

$D$ = TUBE DIAM.

$$Re = \frac{(2.0\,cm)(8.0\,cm/s)(1.11\times10^{-3}\,g/cm^3)}{(1.87\times10^{-4}\,g/cm\cdot s)}$$

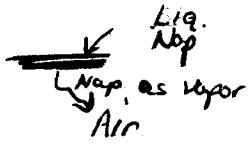
$Re = 94.97 \rightarrow$ LAMINAR

$$\frac{C_A - C_{A0}}{C_{Ai} - C_{A0}} = 5.5\left(Re\,Sc\,\frac{D}{L}\,\frac{\pi}{4}\right)^{-2/3}$$

$$\frac{C_A - C_{A0}}{C_{Ai} - C_{A0}} = 5.5\left[(94.97)(2.43)\left(\frac{2.0}{11.0}\right)\left(\frac{\pi}{4}\right)\right]^{-2/3}$$

$$= 0.5350$$

AT G-L INTERFACE, $C_{Ai}$, IS THE VAPOR PRESSURE OF NAPH. IN AIR = ~~0.73 atm~~




$$C_{Ai} = \frac{n}{V} = \frac{P_{Ai}}{RT} = \frac{7.31\times10^{-4}\,atm}{\left(82.06\,\frac{cm^3 atm}{mol\,K}\right)(318\,K)}$$

$$C_{Ai} = 2.80 \times 10^{-8} \frac{mol}{cm^3}$$

$$\frac{C_A - C_{A0}}{C_{Ai} - C_{A0}} = \frac{C_A - 0}{2.80 \times 10^{-8} - 0} = 0.5350$$

$$C_A = 1.50 \times 10^{-8} \frac{mol}{cm^3}$$