

ME 6201

Mass Transport

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Group---(3)

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Chapter (5)

Number--- 1, 2, 3

No. (1)

To find diffusion coefficient of CO₂

P = 740 mmHg

T = 37 °C = 310 K

Diffusion coefficients in gases model

By the Chapman-Enskog Theory

$$D = 1.86 * 10^3 T^{3/2} (1/M_1 + 1/M_2)^{1/2} / (p \sigma^2 \Omega)$$

Where

D = diffusion coefficient (cm²/sec)

T = absolute temperature (K)

M_i = molecular weight (g/mole)

p = pressure (atm)

σ = collision diameter (Å)

$$\sigma = (\sigma_1 + \sigma_2) / 2$$

Ω = dimensionless quantity

From Table 5.1-2 , 5.1-2 and 5.1-3,

$$\sigma = (3.711 + 2.9) / 2$$

$$= 3.826 \text{ Å}$$

$$\varepsilon_{12} = \sqrt{\varepsilon_1 / k_B * \varepsilon_2 / k_B} / T$$

$$= \sqrt{78.6 * 195.2 / 298}$$

$$= 0.3995$$

$$k_B T / \varepsilon = 2.5$$

$$\Omega = 0.9995$$

$$D = 1.86 * 10^{-3} * 310^{1.5} (1/44 + 1/28.58)^{0.5} * 760 / (740 * 3.826^2 * 0.9995)$$

$$D = 0.1707 \text{ cm}^2 / \text{sec}$$

From experiment, $D = 0.177 \text{ cm}^2 / \text{sec}$

$$\% \text{ error} = (0.177 - 0.1707) / 0.177 = 3.559 \%$$

No.2

To measure diffusion coefficient of ammonia in 25° C air

See Fig. 3.1-2

Volume of bulbs = 17 cm³

Capillary length, l = 2.6 cm

d = 0.083 cm

(a) using Chapman-Enskog theory

$$M_1 = 17$$

$$M_2 = 28.58$$

$$\sigma = (3.711 + 2.9) / 2$$

$$\sigma = 3.3055$$

$$\varepsilon_{12} / k_B T = \sqrt{78.6 * 558.3 / 298}$$

$$= 0.702$$

$$k_B T / \varepsilon_{12} = 1.42$$

$$\Omega = 1.23$$

$$D = 0.21806 \text{ cm}^2/\text{sec}$$

$$V \frac{dc_1}{dt} = AD / l (c_{1sat} - c_1)$$

$$\int_{c_i}^{c_f} V l / AD \frac{1}{c_{1sat} - c_1} dc = \int_{t_i}^{t_f} dt$$

$$-Vl/AD \ln ((c_{sat} - c_f) / (c_{sat} - c_i)) = \Delta t$$

$$-17 * 1.3 * \ln(0.5) * 4 / (\pi * 0.083^2 * 0.21806) = \Delta t$$

$$\Delta t = 12983.615 \text{ sec} = 3.606 \text{ hr}$$

No.3

Traces of ethanol in water at 25°C

Liquid diffusion model,

Stokes-Einstein Equation

$$D = k_B T / 6\pi\mu R_o$$

k_B = Boltzmann's constant

μ = solvent viscosity

R_o = solute radius

$$R_o = \sigma / 2 = 4.53 / 2 = 2.265 * 10^{-8} \text{ cm}$$

$$D = 1.38 * 10^{-16} \text{ g-cm}^2/\text{sec}^2\text{-K} * 298 / (6\pi * 0.01 \text{ g/cm-sec} * 2.265 * 10^{-8})$$
$$= 0.96 * 10^{-5} \text{ cm}^2 / \text{sec}$$

Traces of water in alcohol

$$\mu = 0.012 \text{ g / cm - sec}$$

$$R_o = 2.641 / 2 = 1.3205 * 10^{-8} \text{ cm}$$

$$D = 1.37 * 10^{-5} \text{ cm}^2 / \text{sec}$$