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PETROLEUM ENGR
~~ACH~~

In order to avoid pressure build up gas at atmospheric pressure in a pipe is vented to atmosphere through a pipe of 3mm diameter and 20m length. Determine the mass of the gas diffusing out and mass of air diffusing in per hour. Assume $D = 0.28 \times 10^{-4} m^2/s$, $M = 17 kg/kgmol$

Solution.

$$N_a = \frac{M_a}{m} \quad --- \quad eq\ (1)$$

$P_{a_1} = 1atm = 1.013 \times 10^{5} Nm^{-2}$

$P_{a_2} = 0$ (gas vented to atmosphere)

$L = 20m$

$d = 3mm = 0.003m$

$A = \pi/4 (d^2) = \pi/4 \times (0.003)^2 = 7.0695 \times 10^{-6} m^2$

Molar mass, $M = 17 kg/mol$

$R = 8315\ J/kgmol\ K$

$D = 0.28 \times 10^{-4} m^2/s$

Using the equimolar counter diffusion equation

$$\frac{N_a}{A} = \frac{D}{RT} \cdot \frac{P_{a_1} - P_{a_2}}{L}$$

$$N_a = \frac{DA}{RT} \cdot \frac{P_{a_1} - P_{a_2}}{L}$$

Recall T = temperature in absolute unit ie $0^\circ K$

$$N_a = \frac{DA}{R} \cdot \frac{P_{a_1} - P_{a_2}}{L}$$

Substituting eq 1

$$\frac{M_a}{m} = \frac{DA}{R} \cdot \frac{P_{a_1} - P_{a_2}}{L}$$

$$M_a = \frac{D \cdot A}{R} \cdot \frac{P_{a_1} - P_{a_2}}{L} \cdot M$$

where M_a is the mass of gas diffusing out in kg/s to convert

$$M_a = \frac{DA}{R} \cdot \frac{P_{a_1} - P_{a_2}}{L} \cdot M(3000) \quad \text{---: kg/hr}$$

$$M_a = \frac{(0.26 \times 10^{-4}) \times (7.0693 \times 10^{-6})}{8315} \cdot \frac{(1.013 \times 10^{5} - 0) \times 17 \times 3000}{20}$$

$$= 7.38 \times 10^{-6} \text{ kg/hr}$$

(b) Mass of air diffusing in, M_{air}

Recall

$$\frac{M_a}{A} = -\frac{M_b}{A}$$

$$\therefore M_a = -M_b$$

$$M_b = -M_a$$

$$= -7.38 \times 10^{-6}$$

$$\text{mole of air} = \frac{-7.38 \times 10^{-6}}{17}$$

$$= -4.34 \times 10^{-7}$$

$$\text{Mass of Air} = -4.34 \times 10^{-7} \times 28.97$$

$$= -1.26 \times 10^{-5} \text{ kg/hr.}$$