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Petroleum Engineering

In order to avoid pressure build up gas at atmosphere 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~~ diffusing in per hour. Assume  $D = 0.28 \times 10^{-4} \text{ m}^2/\text{s}$   $M = 17 \text{ kg/kg mole}$ .

Solution

$$N_A = \frac{m_A}{M} \quad \text{Equation (1)}$$

$$P_{A1} = 1 \text{ atm} = 1.013 \times 10^5 \text{ Nm}^{-2}$$

$P_{A2} = 0$ , since the gas is vented to the atmosphere

$$L = 20 \text{ m}$$

$$d = 3 \text{ mm} = 0.003 \text{ m}$$

$$A = \frac{\pi}{4} (d^2) = \frac{\pi}{4} \times (0.003)^2 = 7.069 \times 10^{-6} \text{ m}^2$$

Molar mass,  $M = 17 \text{ kg/mol}$

$$R = 8315 \text{ J/kg mole K}$$

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

Using the equimolar counter diffusion equation

$$N_A = \frac{D}{RT} \cdot \frac{P_{A1} - P_{A2}}{L}$$

$$N_A = \frac{DA}{RT} \cdot \frac{P_{A1} - P_{A2}}{L}$$

Recall  $T$  is the temperature in absolute unit i.e.  $^{\circ}\text{K}$

$$N_A = \frac{DA}{R} \cdot \frac{P_{A1} - P_{A2}}{L}$$

Substituting Equ (1)

$$\frac{M_a}{m} = \frac{DA}{R} \cdot \frac{P_{a1} - P_{a2}}{L}$$

$$M_a = \frac{D \cdot A}{R} \cdot \frac{P_{a1} - P_{a2}}{L} \cdot M$$

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

$$M_a = \frac{DA}{R} \cdot \frac{P_{a1} - P_{a2}}{L} \cdot M (\times 3600)$$

$$M_a = \frac{(0.28 \times 10^{-4}) \times (7.0695 \times 10^{-6})}{8315} = \frac{(1.013 \times 10^3 - 0) \times 17 \times 3600}{20}$$

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

b.) Mass of air diffusing in,  $M_{air}$

Recall

$$\frac{N_a}{A} = -\frac{N_b}{A}$$

$$\therefore N_a = -N_b$$

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

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

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

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

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