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Petroleum Engineering
Car

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/kg mole.

Answer

$$N_a = \frac{M_a}{M} \quad \text{---------- Equ (1)}$$

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

$P_{a_2} = 0$, since the gas is vented to the 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 equimolal 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 is the temperature in absolute unit i.e. $0^\circ K$

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

Substituting equ (1)

$$\frac{Mq}{M} = \frac{DA}{R} \cdot \frac{Pq_1 - Pq_2}{L}$$

$$Mq = \frac{D \cdot A}{R} \cdot \frac{Pq_1 - Pq_2}{L} \cdot M$$

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

$$Mq = \frac{DA}{R} \cdot \frac{Pq_1 - Pq_2}{L} \cdot M \ (\times 3600) \quad \text{kg/hr}$$

$$Mq = \frac{(0.28 \times 10^{-4}) \times (7.0693 \times 10^{-6})}{8315} \cdot \frac{(1013 \times 10^5 - 0)}{20} \times 17 \times 3600$$

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

b) Mass of air diffusing in, Mair

Recall

$$\frac{Na}{A} = \frac{-Nb}{A}$$

$$\therefore Na = -Nb$$

$$Nb = -Na$$

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

$$\text{mole of air} = \frac{-7.38 \times 10^{-6}}{19}$$

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

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

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