

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  $D = 0.28 \times 10^{-4} \text{ m}^2/\text{s}$ ,  $M = 17 \text{ kg/kmole}$ .

Answer

$$N_g = \frac{M_g}{M} \quad \text{Equ (1)}$$

$$P_{g1} = 1 \text{ atm} = 1.013 \times 10^5 \text{ Nm}^{-2}$$

$$P_{g2} = 0, \text{ since the gas is vented to the atmosphere.}$$

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

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

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

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

$$R = 8315 \text{ J/kgmol K}$$

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

Using the equimolar counter diffusion equation

$$N_g = \frac{D}{RT} \cdot \frac{P_{g1} - P_{g2}}{L}$$

$$N_g = \frac{DA}{RT} \cdot \frac{P_{g1} - P_{g2}}{L}$$

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

$$N_g = \frac{DA}{R} \cdot \frac{P_{g1} - P_{g2}}{L}$$

Substituting equ (1)



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

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

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

$$M_a = \frac{D \cdot A}{R} \cdot \frac{P_{a_1} - P_{a_2}}{L} \cdot M \cdot (3600) \quad \text{kg/hr}$$

$$M_a = \frac{(0.28 \times 10^{-7}) \times (9.0695 \times 10^{-6})}{8315} \cdot \frac{(1013 \times 10^3 - 0)}{20} \times 17 \times 3600$$

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

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

Recall

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

$$\therefore N_a = -N_b$$

$$N_b = -N_a$$

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

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

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

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

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