

Exercise

A fixed quantity of gas at 23 °C exhibits a pressure of 748 mm Hg and occupies a volume of 10.3 L. Use Boyle's law to calculate the volume the gas will occupy at 23 °C if the pressure is increased to 1.55 atm.

Sol: 6.54 L



$$\frac{\text{initial state}}{P_1 \times V_1} = \frac{\text{final state}}{P_2 \times V_2}$$

conversions:

$$P_1 = 748 \text{ mm Hg} \frac{1 \text{ atm}}{760 \text{ mm Hg}} = 0.984 \text{ atm}$$

$$V_1 = 10.3 \text{ L}$$

$$P_2 = 1.55 \text{ atm}$$

$$V_2 \dots \text{ unknown}$$

$$0.984 \text{ atm} \times 10.3 \text{ L} = 1.55 \text{ atm} \times V_2$$

$$V_2 = \frac{0.984 \text{ atm} \times 10.3 \text{ L}}{1.55 \text{ atm}} = \boxed{6.54 \text{ L}}$$

EXERCISES (PROBLEMS)

An spray can with a volume of 250 mL contains 2.3 g of propane gas ($\text{CH}_3\text{-CH}_2\text{-CH}_3$). If the can is at 18°C , what is the pressure in the can?

Atomic mass: C=12; H=1.

$$\textcircled{1} \quad P \times V = n \times R \times T$$

Conversions:

$$V = 250 \text{ mL} \frac{1 \text{ L}}{1000 \text{ mL}} = 0.25 \text{ L}$$

$$T = 18 + 273 = 291 \text{ K}$$

$$\text{Molar mass... } M = (3 \times 12) + (8 \times 1) = 44 \text{ g/mol}$$

$$n = 2.3 \text{ g C}_3\text{H}_8 \frac{1 \text{ mol}}{44 \text{ g C}_3\text{H}_8} = 0.0523 \text{ mol}$$

$$P \times 0.25 \text{ L} = 0.0523 \text{ mol} \times 0.082 \frac{\text{atm}\cdot\text{L}}{\text{K}\cdot\text{mol}} \times 291 \text{ K}$$

$$P = \frac{0.0523 \text{ mol} \times 0.082 \frac{\text{atm}\cdot\text{L}}{\text{K}\cdot\text{mol}} \times 291 \text{ K}}{0.25 \text{ L}} = \textcircled{4.99 \text{ atm}}$$

Calculate the number of molecules in a deep breath of air whose volume is 2.55 L at body temperature, 37°C, and a pressure of 740 mmHg.

②

$$P \times V = n \times R \times T$$

Conversions:

$$V = 2.55 \text{ L}$$

$$T = 37 + 273 = 310 \text{ K}$$

$$P = 740 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.974 \text{ atm}$$

$$R = 0.082 \frac{\text{atm} \cdot \text{L}}{\text{K} \cdot \text{mol}}$$

$$0.974 \text{ atm} \times 2.55 \text{ L} = n \times 0.082 \frac{\text{atm} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 310 \text{ K}$$

$$n = \frac{0.974 \text{ atm} \times 2.55 \text{ L}}{0.082 \frac{\text{atm} \cdot \text{L}}{\text{K} \cdot \text{mol}} \times 310 \text{ K}} = 9.77 \times 10^{-2} \text{ mol}$$

conversion into
of molecules

$$x = 9.77 \times 10^{-2} \text{ mol} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 5.88 \times 10^{22} \text{ gas molecules}$$

Calculate the density of NO_2 gas at 0.97 atm and 35°C

Atomic mass: N=14; O=16

③

$$P \times V = n \times R \times T$$

↓ Values and conversions

$$P = 0.97 \text{ atm}$$

$$R = 0.082 \frac{\text{atm}\cdot\text{L}}{\text{K}\cdot\text{mol}}$$

$$T = 35 + 273 = 308 \text{ K}$$

$$0.97 \text{ atm} \times V = n \times 0.082 \frac{\text{atm}\cdot\text{L}}{\text{K}\cdot\text{mol}} \times 308 \text{ K}$$

↓ combining and isolating the unknown variables

$$\frac{n}{V} = \frac{0.97 \text{ atm}}{0.082 \frac{\text{atm}\cdot\text{L}}{\text{K}\cdot\text{mol}} \times 308 \text{ K}} = 3.84 \times 10^{-2} \frac{\text{mol}}{\text{L}}$$

↓ converting the moles into grams:
molar mass... $M = (1 \times 14) + (2 \times 16) = 46 \text{ g/mol}$

$$\text{density ... } d = 3.84 \times 10^{-2} \frac{\text{mol}}{\text{L}} \frac{46 \text{ g NO}_2}{1 \text{ mol NO}_2} = \boxed{1.77 \frac{\text{g NO}_2}{\text{L}}}$$