

Question 1 (4pts)

Solve for the total pressure of a mixture of gases containing 4 moles of nitrogen 2 moles of helium and 1 mole of oxygen, given $(P_{O_2} = 115 \text{ mm Hg})$

Answer

When two or more gases are enclosed in a vessel, then total pressure would be due to total moles of gas present in container.

Given in question.

$$\text{Moles of Nitrogen } (n_{N_2}) = 4$$

$$\text{Moles of Helium } (n_{He}) = 2$$

$$\text{Moles of Oxygen } (n_{O_2}) = 1$$

Now under certain condition of temperature and pressure

$$1 \text{ mole of } O_2 = 115 \text{ mm Hg} \quad (\text{pressure})$$

∴ Under same condition of temperature and pressure

$$\begin{aligned} 2 \text{ moles of He} &= (2 \times 115) \text{ mm Hg} \quad (\text{pressure}) \\ &= 230 \text{ mm Hg} \end{aligned}$$

and under same condition of temperature and pressure

$$4 \text{ mole of } n_2 \text{ would exert pressure, 4 times } 115 \text{ mm Hg pressure.}$$

$$\text{i.e., } 4 \text{ moles of He} = (4 \times 115) \text{ mm Hg} \quad (\text{pressure})$$

$$= 460 \text{ mm Hg}$$

$$\begin{aligned} \text{Total pressure} &= P_{N_2} + P_{He} + P_{O_2} \\ &= 460 + 230 + 115 \\ &= \mathbf{805 \text{ mm Hg}} \end{aligned}$$

Answer

Question 2 (5 pts)

A guy is sucking the helium out of balloons but wants to make sure they stay afloat. The balloons have a volume of 3.0 L on a day where the pressure is 750 mm Hg and the temperature is 19°C. He removes half of the volume and replaces it with CO₂. Will it stay afloat if the density needs to be below 1.29 g/L ? The volume returns to 3.0 L and the gases completely mix.

Hint : Each has a volume of 3 liters but only half the pressure.

Answer

According to question, balloon will remain afloat if the density of gases filled in balloon is less than 1.29 g/L.

We will solve the problem keeping this density in mind.

From ideal gas equation

$$PM = dRT$$

P is pressure in atm

M is gram molecular mass

D is density in g/L

R is constant (0.0821 L atm K⁻¹ mol⁻¹)

T is temperature in Kelvin

Useful data :

$$P = 750 \text{ mm Hg} = \frac{750}{760} \text{ atm}$$

$$M_{\text{He}} = 4$$

$$M_{\text{CO}_2} = 44$$

$$T = 19^\circ\text{C} = (19 + 273) \text{ K} \\ = 292 \text{ K}$$

- (1) Lets calculate density of He, under given condition, using above equation

$$PM = dRT$$

$$0.98 \times 4 = d_{\text{He}} \times 0.0821 \times 292$$

$$d_{\text{He}} = 0.164 \text{ g/L}$$

- (2) Similarly density of CO₂ in identical condition

$$PM = dRT$$

$$0.98 \times 44 = d_{\text{CO}_2} \times 0.0821 \times 292$$

$$d_{\text{CO}_2} = 1.81 \text{ g/L}$$

According to question given, both gases are present in equal amount i.e. (1.5 L of each), and they completely mix into one another.

Now density of this gaseous mixture in balloon would be average of density of individual gas.

$$d_{\text{(mixture)}} = \frac{d_{\text{He}} + d_{\text{CO}_2}}{2} \\ = \frac{0.164 + 1.81}{2} \\ = 0.985 \text{ g/L} \\ \approx 0.99 \text{ g/L}$$

Conclusion : As the density of gaseous mixture in balloon is less 1.29 g/L, It will remain afloat.

Question 3 (5pts)

Solder is an alloy of lead and tin. Nitric Acid is used to treat 4.77 g of solder causing the tin to react according to the following equation.

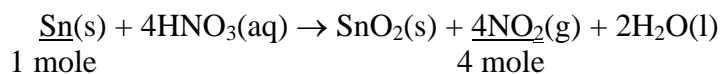


The reaction releases 1.94 L of nitric dioxide collected over water at 691 mm Hg and

- (a) Calculate the mass of tin that reacted and
 (b) The percentage of tin in the alloy

Answer

Step 1 Find molar relation between Sn(s) and NO(g) from the equation



4 mole of NO₂(g) are formed when 1 mole Sn(s) reacts.

∴ 1 mole of NO₂(g) is formed when $\frac{1}{4}$ mole of Sn reacts.

∴

$$\boxed{1 \text{ mole of Sn reacts} = \frac{1}{4} \times \text{moles of NO(g) formed}}$$

Step 2 Calculate pressure exerted by pure NO(g).

According to Dalton Law of partial pressure.

$$P_{\text{Total}} = P_{\text{H}_2\text{O}} + P_{\text{NO}}$$

The total pressure is 691 mmHg, given in question.

$$P_{\text{Total}} = 691 \text{ mm Hg}$$

$$P_{\text{H}_2\text{O}} = 16.5 \text{ mm Hg}$$

$$\therefore P_{\text{NO}} = P_{\text{Total}} - P_{\text{H}_2\text{O}}$$

$$= 691 - 16.5$$

$$P_{\text{NO}} = 674.5 \text{ mm Hg}$$

Step 3 Calculate mole of NO(g) formed in reaction using gaseous equation

$$P = 674.5 \text{ mm} = \frac{674.5}{760} \text{ atm}$$

$$V = 1.94 \text{ L}$$

$$T = 19^\circ\text{C} = (19 + 273) = 292 \text{ K}$$

$$PV = n_{\text{NO}} RT$$

$$0.887 \times 1.94 = n_{\text{NO}} \times 0.0821 \times 292$$

$$\text{Mole of NO (} n_{\text{NO}} \text{)} = 0.0718 \text{ mol}$$

Step 4 Calculate mole of Sn(s)

We know from step (1) that mole of Sn required is $\frac{1}{4}$ the mole of NO(g) formed then

$$\text{Mole of Sn} = \frac{1}{4} \times 0.0718$$

$$= 0.01795 \text{ mol.}$$

Step 5 Calculate of weight of Sn

$$W(\text{g}) = n \times \text{MM}_{\text{Sn}}$$

$$= 0.01795 \times 118.7$$

$$= 2.130 \text{ g}$$

(because Molecular Mass (MM) of Sn is = 118.7)

Step 6 Calculation of percentage of tin in the alloy.

$$\text{Weight of alloy} = 4.77 \text{ g}$$

$$\text{Weight of Sn} = 2.130 \text{ g}$$

$$\% \text{ of Sn} = \frac{\text{Weight of Sn}}{\text{Weight of alloy}} \times 100$$

$$= \frac{2.130}{4.77} \times 100$$

$$\% \text{ of Sn} = 44.7$$

Answer