Key

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Chemistry 11
THE MOLE + MOLAR VOLUME

Calculations involving gas volumes are simplified by the previously mentioned Avogadro's Hypothesis

Avogadro's Hypothesis: equal volumes of different gases at the same temp. + pressure, contain the same # of particles.

MOLAR VOLUME: the volume occupied by one mole of any gas @ STP = 22.4 L.

STANDARD TEMPERATURE AND PRESSURE (STP) is 0°C and ~~10~~ 101.3 kPa.

It has been experimentally determined that 1 mol of any gas at STP has a volume of 22.4 L

We can use this information to generate TWO important CONVERSION FACTORS:

$$\frac{1\ \text{mol} \_\_(g)}{22.4\ \text{L}} \quad \text{or} \quad \frac{22.4\ \text{L}}{1\ \text{mol} \_\_(g)}$$

Example 1. What is the volume occupied by 0.350 mol of SO_2 at STP?

$$0.350\ \text{mol}\ SO_2 \times \frac{22.4\ \text{L}}{1\ \text{mol}\ SO_{2(g)}} = \boxed{7.84\ \text{L of}\ SO_{2(g)}}$$

Example 2. How many molecules of CO_2 are present in 56.0 L of CO_2 ?

$$56.0\ \text{L}\ CO_{2(g)} \times \frac{1\ \text{mol}\ CO_{2(g)}}{22.4\ \text{L}\ CO_{2(g)}} \times \frac{6.02\times10^{23}\ \text{m.c}}{1\ \text{mol}\ CO_{2(g)}} = \boxed{1.51\times10^{24}\ \text{molecules of}\ CO_{2(g)}}$$

Key

MOLAR VOLUME PROBLEMS

★ Key ★

1. Calculate the volume (L) at STP occupied by the following:

a. 12.5 mol of NH_3 (g)

$12.5 \text{ mol } NH_3 \times \frac{22.4 \text{ L}}{1 \text{ mol } NH_3} = 2.80 \times 10^2 \text{ L } NH_3$

b. 0.350 mol O_2 (g)

$0.350 \text{ mol } O_2 \times \frac{22.4 \text{ L}}{1 \text{ mol } O_2} = 7.84 \text{ L } O_2$

2. Calculate the number of moles in the following gases at STP.

a. 85.9 cL of H_2(g)

$85.9 \text{ cL} \times \frac{1 \times 10^{-2} \text{ L}}{1 \text{ cL}} \times \frac{1 \text{ mol } H_2}{22.4 \text{ L}} = 3.83 \times 10^{-2} \text{ mol } H_2$

b. 375 mL of SO_3 (g)

$375 \text{ mL} \times \frac{1 \times 10^{-3} \text{ L}}{1 \text{ mL}} \times \frac{1 \text{ mol } SO_3}{22.4 \text{ L}} = 1.67 \times 10^{-2} \text{ mol } SO_3$

MIXED PROBLEMS INVOLVING THE USE OF THE MOLE DIAGRAM:

3. What is the **mass,** in grams, of the following:

a. 2.0 x 10^6 CO molecules

$2.0 \times 10^6 \text{ m.c CO} \times \frac{1 \text{ mol CO}}{6.02 \times 10^{23} \text{ m.c}} \times \frac{28.0 \text{ g CO}}{1 \text{ mol CO}} = 9.30 \times 10^{-17} \text{ g CO}$

b. 125 He atoms

$125 \text{ He atoms} \times \frac{1 \text{ mol He}}{6.02 \times 10^{23} \text{ atoms He}} \times \frac{4.0 \text{ g He}}{1 \text{ mol He}} = 8.31 \times 10^{-22} \text{ g He}$

c. 55.0 mL of NO_2 (g) at STP

$55.0 \text{ mL} \times \frac{1 \times 10^{-3} \text{ L}}{1 \text{ mL}} \times \frac{1 \text{ mol } NO_2}{22.4 \text{ L}} \times \frac{46.0 \text{ g } NO_2}{1 \text{ mol } NO_2} = 1.13 \times 10^{-2} \text{ g } NO_2$

c. 15.0 L of Ar (g) at STP

$15.0 \text{ L Ar} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{40.0 \text{ g Ar}}{1 \text{ mol}} = 26.8 \text{ g Ar}$

d. 4.15 x 10^{15} CH_4 molecules

$4.15 \times 10^{15} \text{ m.c} \times \frac{1 \text{ mol } CH_4}{6.02 \times 10^{23} \text{ m.c}} \times \frac{16.0 \text{ g } CH_4}{1 \text{ mol } CH_4} = 1.10 \times 10^{-7} \text{ g } CH_4$

e. 1.00 x 10^8 L of H_2 (g) at STP

$1.00 \times 10^8 \text{ L} \times \frac{1 \text{ mol } H_2}{22.4 \text{ L}} \times \frac{2.0 \text{ g } H_2}{1 \text{ mol } H_2} = 8.9 \times 10^6 \text{ g } H_2$

4. What is the volume (in L) occupied by the following:

a. 16.5 g of AsH_3 (g)

$16.5 \text{ g } AsH_3 \times \frac{1 \text{ mol } AsH_3}{77.9 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol } AsH_3} = 4.74 \text{ L of } AsH_3$

b. 8.56 x 10^{21} molecules of SO_2 (g)

$8.56 \times 10^{21} \text{ m.c} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ m.c}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 3.19 \times 10^{-1} \text{ L } SO_2$

c. 28.4 mg of H_2Te (g)

$28.4 \text{ mg} \times \frac{1 \times 10^{-3} \text{ g}}{1 \text{ mg}} \times \frac{1 \text{ mol } H_2Te}{129.6 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol } H_2Te} = 4.91 \times 10^{-3} \text{ L } H_2Te$

d. 0.750 mg of O_3 (g)

$0.750 \text{ mg} \times \frac{1 \times 10^{-3} \text{ g}}{1 \text{ mg}} \times \frac{1 \text{ mol } O_3}{48.0 \text{ g } O_3} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 3.50 \times 10^{-4} \text{ L } O_3$