Molar Volume of a Gas – Notes and Practice

********** One mole of any gas occupies 22.4 liters at STP. **********

MOLE MAP:

KEY

Example 1: What is the volume of 5.0 moles of carbon dioxide at STP?

$$\frac{5\ \text{mol } CO_2}{1} \left| \frac{22.4\ \text{L } CO_2}{1\ \text{mol } CO_2} \right. = \boxed{112\ \text{L } CO_2}$$

Example 2: Calculate the number of moles of ammonia gas, NH_3, in 2.3 liters measured at STP.

$$\frac{2.3\ \text{L } NH_3}{1} \left| \frac{1\ \text{mol } NH_3}{22.4\ \text{L } NH_3} \right. = \boxed{.10\ \text{mol } NH_3}$$

Example 3: What volume of hydrogen will react with 22.4 liters of oxygen to form water? (All volumes are measured at STP.)

mole ratio = volume ratio *

$$\underset{?\ \text{L}}{2H_2} + \underset{22.4\ \text{L}}{O_2} \rightarrow 2H_2O$$

$$\frac{22.4\ \text{L } O_2}{1} \left| \frac{1\ \text{mol } O_2}{22.4\ \text{L } O_2} \right| \frac{2\ \text{mol } H_2}{1\ \text{mol } O_2} \left| \frac{22.4\ \text{L } H_2}{1\ \text{mol } H_2} \right. = \boxed{44.8\ \text{L } H_2}$$

Example 4: When sulfur burns in air it forms sulfur dioxide. What volume of sulfur dioxide (at STP) is produced when 1 gram of sulfur burns?

$$S + O_2 \rightarrow SO_2$$
$$1\,g \rightarrow ?\,L$$

$$\frac{1\,g\,S}{1}\left|\frac{1\,mol\,S}{32.07\,g\,S}\right|\frac{1\,mol\,SO_2}{1\,mol\,S}\left|\frac{22.4\,L\,SO_2}{1\,mol\,SO_2}\right. = .7\,L\,SO_2$$

Example 5: What is the density of Br_2 at STP?

$$D = \frac{M}{V} = \frac{\text{molar mas}}{\text{molar Volume}} = \frac{159.80\,g}{22.4\,L} = 7.13\,g/L$$

$Br_2 = \frac{159.80\,g \rightarrow M}{1\,mole \rightarrow n}$

$T = 273K$

$P = 1atm$

$PV = nRT$

$V = \frac{nRT}{P}$

$V = 22.4\,L$

$$D = \frac{159.80\,g}{22.4\,L} = 7.13\,g/L$$

Example 6: Nitrogen reacts with hydrogen to produce ammonia (NH_3). If 2.0 grams of nitrogen reacts with an excess of hydrogen, how many liters of ammonia will be produced at STP?

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$
$$2.0\,g \rightarrow ?\,L$$

$$\frac{2.0\,g\,N_2}{1}\left|\frac{1\,mol\,N_2}{28.02\,g\,N_2}\right|\frac{2\,mol\,NH_3}{1\,mol\,N_2}\left|\frac{22.4\,L\,NH_3}{1\,mol\,NH_3}\right. = 3.2\,L\,NH_3$$

Practice Problems

1. Calculate the number of moles contained in 6.500 L of sulfur dioxide at STP?

$V = 6.500\,L$

$T = 0°C = 273K$

$P = 1atm$

$n = ?$

$PV = nRT$

$n = \frac{PV}{RT}$

$$n = \frac{(1)(6.500)}{(.0821)(273)} = .290\,mol\,SO_2$$

$$\frac{6.500\,L\,SO_2}{1}\left|\frac{1\,mole\,SO_2}{22.4\,L\,SO_2}\right. = .290\,mol\,SO_2$$

2. What volume would a 200.0 g sample of hydrogen sulfide gas occupy at STP?

$$\frac{200.0\,g\,H_2S}{1}\left|\frac{1\,mol\,H_2S}{34.09\,g\,H_2S}\right|\frac{22.4\,L\,H_2S}{1\,mol\,H_2S} = 131.4\,L\,H_2S$$

3. If a balloon filled with carbon dioxide gas occupies a volume of 31 L at STP, what is the mass of the gas?

$$\frac{31\ L\ CO_2}{1} \left| \frac{1\ mol\ CO_2}{22.4\ L\ CO_2} \right| \frac{44.01\ g\ CO_2}{1\ mol\ CO_2} = 60.9$$

$$\boxed{61\ g\ CO_2}$$

4. A sample of ammonia (NH_3) contains 0.500 mol. What volume at STP would the gas occupy?

$$\frac{.500\ mol\ NH_3}{1} \left| \frac{22.4\ L\ NH_3}{1\ mol\ NH_3} \right. = \boxed{11.2\ L\ NH_3}$$

5. What is the density of helium at STP?

$$D = \frac{M}{V} = \frac{\text{molar mass}}{\text{molar volume}} = \frac{4.00\ g}{22.4\ L} = \boxed{.179\ g/L}$$

6. If 35.0 grams of methane (CH_4) burns in air, what volume of carbon dioxide is produced at STP?

$$\underset{35.0\ g}{CH_4} + 2O_2 \rightarrow \underset{?\ L}{CO_2} + 2H_2O$$

$$\frac{35.0\ g\ CH_4}{1} \left| \frac{1\ mole\ CH_4}{16.05\ g\ CH_4} \right| \frac{1\ mol\ CO_2}{1\ mol\ CH_4} \left| \frac{22.4\ L\ CO_2}{1\ mol\ CO_2} \right. = \boxed{48.8\ L\ CO_2}$$

7. When 2.0 Liters of hydrogen reacts with excess oxygen, what mass of water vapor is produced? Assume all gases are at STP.

$$2H_2 + O_2 \rightarrow 2H_2O$$

$$\underset{2.0\ L}{} \rightarrow \underset{?\ g}{}$$

$$\frac{2.0\ L\ H_2}{1} \left| \frac{1\ mol\ H_2}{22.4\ L\ H_2} \right| \frac{2\ mol\ H_2O}{2\ mol\ H_2} \left| \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} \right. = \boxed{1.6\ g\ H_2O}$$