Gas Stoichiometry

__**AT STP:**__

For problems at STP conditions, 1 mole of any gas has a volume of 22.4 liters. Volume to volume ratios in a balanced equation can also be considered mole to mole ratios at STP.

Example #1:

An excess of hydrogen reacts with 14.0 g of N_2. How many liters of ammonia are produced at STP?

Step 1. Balance the equation:

$$3\ H_2 + N_2 \rightarrow 2\ NH_3$$

Step 2. *Use dimensional analysis (remember at STP, 1 mole of gas has a volume of 22.4 L).*

$$14.01\ \cancel{g\ N_2} \times \frac{1\ \cancel{mol\ N_2}}{28.02\ \cancel{g\ N_2}} \times \frac{2\ \cancel{mol\ NH_3}}{1\ \cancel{mol\ N_2}} \times \frac{22.4\ L\ NH_3}{1\ \cancel{mol\ NH_3}} = \mathbf{22.4\ L\ of\ NH_3}$$

__NON STP Conditions:__

For problems not at STP conditions, you will need to use the ideal gas law (PV= nRT) with stoichiometry conversions. If you are *__given__* liters in the problem, start with the ideal gas law THEN do a stoichiometry conversion using dimensional analysis. If you are *__looking__* for liters, start with a stoichiometry conversion and then use PV=nRT.

Example #2 – You are given the volume

Calculate the mass of potassium chlorate needed to produce 5.00 L of oxygen at 25°C and 1.00 atm. Potassium chlorate decomposes into oxygen gas and potassium chloride

Step 1: Write a balanced equation

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$

Step 2: Write down what you are given:

$P = 1atm,\ \ V = 5.00\ L\ \ \ T = 25^{o}C + 273 = 298K,\ R = 0.0821\ {}^{L\ atm}/_{mol\ K}$

Step 3: Solve for moles of O_2 using PV=nRT

$$n = \frac{PV}{RT} = \frac{(1.00\ atm)(5.00L)}{(0.0821)(298K)} = 0.204\ mol\ O_2$$

Step 4: Use stoichiometry to convert from moles of O_2 to grams of $KClO_3$.

$$0.204\ \cancel{mol\ O_2} \times \frac{2\ \cancel{mol\ KClO_3}}{3\ \cancel{mol\ O_2}} \times \frac{122.55\ g\ KClO_3}{1\ \cancel{mol\ KClO_3}} = \mathbf{33.4\ g\ KClO_3}$$

Example #3 – You are asked for the volume

Calcium carbonate decomposes into calcium oxide and carbon dioxide. What volume of CO_2 forms from 5.25 g of $CaCO_3$ at 1.02 atm & 25°C?

Step 1**:** Write a balanced equation

$$CaCO_3 \rightarrow CaO + CO_2$$

***Step 2*:** Convert grams of $CaCO_3$ to moles of CO_2:

$$5.25\ \cancel{g\ CaCO_3} \times \frac{1\ \cancel{mol\ CaCO_3}}{100.09\ \cancel{g\ CaCO_3}} \times \frac{1 mol\ CO_2}{1\ \cancel{mol\ CaCO_3}} = \mathbf{1.26\ mol\ CO_2}$$

$P = 1 atm$, $V = 5.00\ L$ $T = 25^oC + 273 = 298K$, $R = 0.0821\ ^{L.atm}/_{mol.K}$

Step 3**:** Solve for volume of CO_2 using PV=nRT

$P = 1.02\ atm$, $V = ?$, $T = 25^oC + 273 = 298K$, $R = 0.0821\ ^{L.atm}/_{mol.K}$

$n = 1.26\ mol$

$$V = \frac{nRT}{P} = \frac{(1.26\ mol)(0.0821\ ^{L.atm}/_{mol.K})(298K)}{(1.02\ atm)} = \mathbf{30.22\ L\ CO_2}$$