

Stoichiometry and Ideal Gas Law

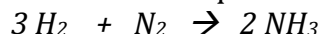
STP Conditions:

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 N₂. How many liters of ammonia are produced at STP?

Step 1. Balance the equation:



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

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

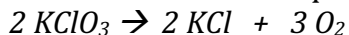
NON STP Conditions:

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

Example #1 – 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



Step 2: Write down what you are given:

$$P = 1 \text{ atm}, V = 5.00 \text{ L} \quad T = 25^\circ C + 273 = 298K, R = 0.08205 \text{ L atm/mol K}$$

Step 3: Solve for moles of O₂ using PV = nRT

$$n = \frac{PV}{RT} = \frac{(1.00 \text{ atm})(5.00 \text{ L})}{(0.08205)(298K)} = 0.204 \text{ mol } O_2$$

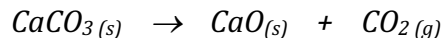
Step 4: Use stoichiometry to convert from moles of O₂ to grams of KClO₃.

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

Example #2 – You are asked for the volume

Calcium carbonate decomposes into calcium oxide and carbon dioxide. What volume of CO₂ forms from 5.25 g of CaCO₃ at 1.02 atm & 25°C?

Step 1: Write a balanced equation



Step 2: Convert grams of CaCO₃ to moles of CO₂:

$$5.25 \text{ g } \cancel{\text{CaCO}_3} \times \frac{1 \text{ mol } \cancel{\text{CaCO}_3}}{100.09 \text{ g } \cancel{\text{CaCO}_3}} \times \frac{1 \text{ mol } \text{CO}_2}{1 \text{ mol } \cancel{\text{CaCO}_3}} = 1.26 \text{ mol } \text{CO}_2$$

Step 3: Solve for volume of CO₂ using PV=nRT

$$P = 1.02 \text{ atm}, \quad V = ?, \quad T = 25^\circ\text{C} + 273 = 298\text{K}, \quad R = 0.08205 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$$
$$n = 1.26 \text{ mol}$$

$$V = \frac{nRT}{P} = \frac{(1.26 \text{ mol})(0.08205 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K})(298\text{K})}{(1.02 \text{ atm})} = 30.22 \text{ L } \text{CO}_2$$