CHEMICAL CALCULATIONS WITH THE GAS LAWS

$FW_{NaHCO_3} = 84.007\ g/mol$

$$H_2SO_4(aq) + 2NaHCO_3(s) \rightarrow 2H_2O(l) + 2CO_2(g) + Na_2SO_4(aq)$$

Given 25.0 g of sodium bicarbonate and sufficient sulfuric acid, what volume of carbon dioxide gas would be produced at 25.0 C and 0.950 atm pressure?

1 - Convert 25.0 g of sodium bicarbonate to moles. Use formula weight.
2 - Convert moles sodium bicarbonate to moles carbon dioxide using chemical equation.
3 - Convert moles carbon dioxide to VOLUME using IDEAL GAS EQUATION.

$84.007\ g\ NaHCO_3 = mol\ NaHCO_3$ | $2\ mol\ NaHCO_3 = 2\ mol\ CO_2$

$$25.0\ g\ NaHCO_3 \times \frac{mol\ NaHCO_3}{84.007\ g\ NaHCO_3} \times \frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3} = 0.2975942481\ mol\ CO_2$$

(1) (2)

(3) $PV = nRT$

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

$n = 0.2975942481\ mol\ CO_2$ $T = 25.0°C = 298.2\ K$

$R = 0.08206\ \frac{L\cdot atm}{mol\cdot K}$ $P = 0.950\ atm$

$$V = \frac{(0.2975942481\ mol\ CO_2)\left(0.08206\ \frac{L\cdot atm}{mol\cdot K}\right)(298.2\ K)}{(0.950\ atm)} =$$

$$= 7.67\ L\ CO_2\ gas$$

What volume would the gas in the last example problem have at STP?

STP: "Standard Temperature and Pressure" (0 C and 1 atm)

Let's use the COMBINED GAS LAW to change the gas volume, since we know all the conditions for the gas.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \;;\; \frac{P_1 V_1 T_2}{T_1 P_2} = V_2$$

$P_1 = 0.950$ atm $P_2 = 1$ atm

$V_1 = 7.67$ L $V_2 = ?$

$T_1 = 298.2$ K $T_2 = 273.2$ K

$$V_2 = \frac{(0.950 \text{ atm})(7.67 \text{ L})(273.2 \text{ K})}{(298.2 \text{ K})(1 \text{ atm})} = 6.68 \text{ L } CO_2 \text{ at STP}$$

An alternate solution that you can try for practice: Since we know the number of moles of gas from the previous problem, we could simply calculate the volume at STP using the ideal gas equation.

$FW_{NH_4NO_3} = 80.0434\ g/mol$

$$2\ NH_4NO_3(s) \longrightarrow 2\ N_2(g) + O_2(g) + 4\ H_2O(g)$$

At 300°C, ammonium nitrate violently decomposes to produce nitrogen gas, oxygen gas, and water vapor. What is the total volume of gas that would be produced at 1.00 atm by the decomposition of 15.0 grams of ammonium nitrate?

To simplify the calculation a bit, we'll calculate the TOTAL MOLES OF GAS and then use that to calculate the total volume, rather than calculating each gas separately.

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1 - Convert 15.0 grams of ammonium nitrate to moles, using formula weight.
2 - Convert moles ammonium nitrate to TOTAL MOLES OF GAS using chemical equation.
3 - Convert TOTAL: MOLES OF GAS to VOLUME using the ideal gas equation.

$80.0434\ g\ NH_4NO_3 = mol\ NH_4NO_3$ | $2\ mol\ NH_4NO_3 = 7\ mol\ gas\ \ (2+1+4)$

$$15.0\ g\ NH_4NO_3 \times \frac{mol\ NH_4NO_3}{80.0434\ g\ NH_4NO_3} \times \frac{7\ mol\ gas}{2\ mol\ NH_4NO_3} = 0.655894177\mathrm{4}\ mol\ gas$$

(1) (2)

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(3) $V = \frac{nRT}{P}$

$n = 0.6558941774\ mol\ gas$ $\quad T = 300.°C = 573\ K$

$R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$ $\quad P = 1.00\ atm$

$$V = \frac{(0.6558941774\ mol\ gas)\left(0.08206\ \frac{L\cdot atm}{mol\cdot K}\right)(573\ K)}{(1.00\ atm)} = \boxed{30.8\ L}$$