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

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

$$25.0\ g\ NaHCO_3 \times \underbrace{\frac{mol\ NaHCO_3}{84.007\ g\ NaHCO_3}}_{1} \times \underbrace{\frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3}}_{2} = 0.297594248\ mol\ CO_2$$

$PV = nRT$

$\downarrow$

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

$n = 0.297594248\ mol\ CO_2$ $\quad T = 25.0°C = 298.2\ K$

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

$$V = \frac{(0.297594248\ mol\ CO_2)\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(298.2\ K)}{(0.950\ atm)}$$

$$= \boxed{7.67\ L\ CO_2\ gas}$$

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 calculate volume at the new conditions.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \; ; \; \frac{P_1V_1T_2}{T_1P_2} = V_2$$

$P_1 = 0.950\ atm$ $\quad P_2 = 1\ atm$

$V_1 = 7.67\ L$ $\quad V_2 = ?$

$T_1 = 298.2\ K$ $\quad T_2 = 273.2\ K$

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

Alternate solution (try it!): Since we know the number of moles of gas. we can also calculate the volume at STP using the ideal gas equation. You should get the same answer as the one above.

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

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

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 calculations, let's caluclate the TOTAL MOLES OF GAS instead of trying to calculate each gas amount separately.

1 - Convert 15.0g 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 ideal gas equation.

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

$$15.0\ g\ NH_4NO_3 \times \underbrace{\frac{mol\ NH_4NO_3}{80.0434\ g\ NH_4NO_3}}_{①} \times \underbrace{\frac{7\ mol\ gas}{2\ mol\ NH_4NO_3}}_{②} = 0.6558941774\ mol\ gas$$

③ $V = \frac{nRT}{P}$

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

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

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