CHEMICAL CALCULATIONS WITH THE GAS LAWS

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

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

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 sodium bicarbonate to moles using 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.

1 $84.007\ g\ NaHCO_3 = mol\ NaHCO_3$ | 2 $2\ mol\ NaHCO_3 = 2\ mol\ CO_2$

$$25.0\ g\ NaHCO_3 \times \underbrace{\frac{mol\ NaHCO_3}{84.007\ g\ NaHCO_3}}_{1} \times \underbrace{\frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3}}_{2} = 0.2975942481\ mol\ CO_2$$

$PV = nRT$

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

$n = 0.2975942481\ mol\ CO_2$

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

$T = 25.0°C = 298.2K$

$P = 0.950\ atm$

$$V = \frac{(0.2975942481\ mol\ CO_2)\left(0.08206\ \frac{L\cdot atm}{mol\cdot K}\right)(298.2K)}{(0.950\ atm)} = \boxed{7.67\ L\ CO_2\ gas}$$

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

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

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

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

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

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

$$\frac{(0.950\ atm)(7.67\ L)}{(298.2\ K)} = \frac{(1\ atm)\ V_2}{(273.2\ K)}$$

$$\boxed{6.67\ L \text{ at STP}} = V_2$$

Alternately, we could just plug in the new P and T into the ideal gas equation (since we already knew the number of moles from the previous problem) and solve it that way ... which would give you the same volume we calculated above.

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

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 caclulation, let's calculate the TOTAL MOLES OF GAS rather than calculating each gas separately...

1 - Convert 15.0 g ammonium nitrate to moles, Use FORMULA WEIGHT.
2 - Convert moles ammonium nitrate to TOTAL MOLES GAS using CHEMICAL EQUATION
3 - Convert total moles gas to volume using IDEAL GAS EQUATION

① $80.052\,g\ NH_4NO_3 = mol\ NH_4NO_3$ | ② $2\ mol\ NH_4NO_3 = 7\ mol\ gas$ $(2+1+4)$

$$15.0\,g\ NH_4NO_3 \times \frac{mol\ NH_4NO_3}{80.052\,g\ NH_4NO_3} \times \frac{7\ mol\ gas}{2\ mol\ NH_4NO_3} = 0.6558237146\ mol\ gas$$

① ②

③ $V = \dfrac{nRT}{P}$ | $n = 0.6558237146\ mol\ gas$ $T = 300\,°C = 573\,K$

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

$$V = \frac{(0.6558237146\ mol\ gas)\left(0.08206\,\frac{L\cdot atm}{mol\cdot K}\right)(573\,K)}{(1.00\ atm)} = \boxed{30.8\,L\ gas\ @\ 300°C,\ 1.00\ atm}$$

$2\bar{5}00$ L of chlorine gas at 25.0 C and 1.00 atm are used to make hydrochloric acid. How many kilograms of hydrochloric acid could be produced if all the chlorine reacts?

$$H_2 + Cl_2 \rightarrow 2\,HCl$$

1 - Convert 2500L chlorine gas to moles using IDEAL GAS EQUATION.
2 - Convert moles chlorine gas to moles HCl using CHEMICAL EQUATION
3 - Convett moles HCl to mass using FORMULA WEIGHT

1 $PV = nRT$ $\quad n = \frac{PV}{RT}$

$P = 1.00\text{ atm} \quad V = 2\bar{5}00\text{ L} \quad R = 0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$

$T = 25.0^\circ C = 298.2\text{ K}$

$$n_{Cl_2} = \frac{(1.00\text{ atm})(2\bar{5}00\text{ L})}{\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(298.2\text{ K})} = 102.164698\text{ mol } Cl_2$$

2 $\text{mol } Cl_2 = 2\text{ mol } HCl$

3 $36.458\text{ g } HCl = \text{mol } HCl \qquad \text{kg} = 10^3\text{ g}$

$$102.164698\text{ mol } Cl_2 \times \underbrace{\frac{2\text{ mol } HCl}{\text{mol } Cl_2}}_{2} \times \underbrace{\frac{36.458\text{ g } HCl}{\text{mol } HCl}}_{3} \times \frac{\text{kg}}{10^3\text{ g}} = \boxed{7.45\text{ kg } HCl}$$

$$2\,HCl + Na_2CO_3 \rightarrow CO_2 + H_2O + 2\,NaCl$$

If 48.90 mL of 0.250 M HCl solution reacts with sodium carbonate to produce 50.0 mL of carbon dioxide gas at 290.2 K, what is the pressure of the carbon dioxide gas?

1 - Convert 48.90 mL of 0.250 M HCl to moles using MOLARITY.
2 - Convert moles HCl to moles carbon dioxide gas using CHEMICAL EQUATION
3 - Convert moles carbon dioxide gas to pressure using IDEAL GAS EQUATION.

1 $0.250\text{ mol HCl} = L \qquad mL = 10^{-3}\,L$

2 $2\text{ mol HCl} = \text{mol } CO_2$

$$48.90\,mL \times \frac{10^{-3}\,L}{mL} \times \frac{0.250\text{ mol HCl}}{L} \times \frac{\text{mol } CO_2}{2\text{ mol HCl}} = 0.006112\text{5 mol } CO_2$$

3 $PV = nRT$ | $n = 0.0061125\text{ mol } CO_2 \quad R = 0.08206\,\frac{L\cdot atm}{mol\cdot K}$

$P = \frac{nRT}{V}$ | $T = 290.2\,K \quad V = 50.0\,mL$

$$50.0\,mL \times \frac{10^{-3}\,L}{mL} = 0.0500\,L$$

$$P = \frac{(0.0061125\text{ mol } CO_2)\left(0.08206\,\frac{L\cdot atm}{mol\cdot K}\right)(290.2\,K)}{(0.0500\,L)} = \boxed{2.91\text{ atm}}$$