Ideal gas law:

$$\frac{PV}{T} = \underline{constant}$$

... but this constant actually depends on the amount of gas!

$$= n \times \text{"}R\text{"}$$

The ideal gas constant.

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

... combining this together ...

$$\frac{PV}{T} = nR$$

$$\boxed{PV = nRT}$$

P = pressure atm

V = volume L

T = ABSOLUTE temperature K

R = ideal gas constant

n = number of moles of gas molecules

CHEMICAL CALCULATIONS WITH THE GAS LAWS

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

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?

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

1. g bicarb → mol bicarb
2. mol bicarb → mol CO_2
3. mol CO_2 → volume CO_2

$$25.0\ g\ NaHCO_3 \times \frac{1\ mol\ NaHCO_3}{84.007\ g\ NaHCO_3} \times \frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3} = 0.297594\ mol\ CO_2$$

$PV = nRT$

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

$n = 0.297594\ mol\ CO_2$

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

$T = 25.0° = 298.2\ K$

$P = 0.950\ atm$

$$V = \frac{(0.297594\ mol\ CO_2)\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(298.2\ K)}{(0.950\ atm)}$$

$V = $ **$7.67\ L\ CO_2$**

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

STP: $0°C$, 1 atm

$V_1 = 7.67$ L

$T_1 = 298.2$ K

$P_1 = 0.450$ atm

$P_2 = 1.00$ atm

$T_2 = 273.2$ K

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

$$\frac{(0.450\ \text{atm})(7.67\ \text{L})}{(298.2\ \text{K})} = \frac{(1.00\ \text{atm})\ V_2}{(273.2\ \text{K})}$$

$$\boxed{6.68\ \text{L}} = V_2$$

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

At 300^{0}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?

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

To simplify this problem, let's calculate the TOTAL NUMBER OF MOLES of gas, then plug that single total into the ideal gas equation.

$$2\ mol\ NH_4NO_3 = 7\ mol\ gas\ ,\quad 80.0434\,g\ NH_4NO_3 = 1\ mol\ NH_4NO_3$$

$$15.0\,g\ NH_4NO_3 \times \frac{1\ mol\ NH_4NO_3}{80.0434\,g\ NH_4NO_3} \times \frac{7\ mol\ gas}{2\ mol\ NH_4NO_3} = 0.65589\ mol\ gas$$

$$V = \frac{nRT}{P} \quad \left| \quad \begin{array}{ll} n = 0.65589\ mol\ gas & T = 300^\circ C = 573.2\ K \\ P = 1.00\ atm & R = 0.08206\ \frac{L\cdot atm}{mol\ K} \end{array} \right.$$

$$V = \frac{(0.65589\ mol\ gas)\left(0.08206\ \frac{L\cdot atm}{mol\ K}\right)(573.2\ K)}{(1.00\ atm)}$$

$$= \boxed{30.9\,L}$$