Gas Stoichiometry! ♥

Two Types of Gas Stoich

1. **Gas Stoich at STP**: use 1 mol = 22.4 L. Follow normal stoichiometry process!

Example #1: Propane, C_3H_8, is a gas that is sometimes used as fuel for cooking and heating. The complete combustion of propane occurs according to the following equation.

$$C_3H_8(g) + 5\,O_2(g) \rightarrow 3\,CO_2(g) + 4\,H_2O(g)$$

a. What will be the volume, in liters, of oxygen required for the complete combustion of 0.250 L of propane? Assume that all volume measurements are made at STP.

$$0.250\ L\ C_3H_8 \times \frac{1\ mol\ C_3H_8}{22.4\ L\ C_3H_8} \times \frac{5\ mol\ O_2}{1\ mol\ C_3H_8} \times \frac{22.4\ L\ O_2}{1\ mol\ O_2} = \boxed{1.25\ L\ O_2}$$

b. What will be the volume of gaseous products created in the reaction? Assume that all volume measurements are made at STP.

$$0.250\ L\ C_3H_8 \times \frac{7\ L\ products}{1\ L\ C_3H_8} = \boxed{1.75\ L\ products}$$

***Note:** this shortcut works when the volume of ALL gases is measured at the same T and P, not *just* STP!

2. **Gas Stoich NOT at STP**: OR not at the same T and P (when calculating volume → volume)

→ you must use the **Ideal Gas Law** to:

a. Calculate the number of moles from the provided volume of gas (if needed)

b. Calculate the final volume of gas produced from the number of moles (if needed)

A cheer to help you remember!

When you're **NOT** at STP,
Use PV = nRT !
Go chemistry!!

Example #2: Tungsten, W, a metal used in light-bulb filaments, is produced industrially by the reaction of tungsten oxide with hydrogen according to the reaction below. How many liters of hydrogen gas at 35°C and 0.980 atm are needed to react completely with 875 g of tungsten oxide?

$$WO_3(s) + 3\,H_2(g) \rightarrow W(s) + 3\,H_2O(g)$$

① $$875\ g\ WO_3 \times \frac{1\ mol\ WO_3}{231.85\ g\ WO_3} \times \frac{3\ mol\ H_2}{1\ mol\ WO_3} = 11.3\ mol\ H_2$$

② $$V = \frac{nRT}{P} = \frac{(11.3\ mol)(0.08206\ \frac{L\cdot atm}{mol\cdot K})(308\ K)}{0.980\ atm} = \boxed{292\ L\ H_2}$$

in atm

Example #3: If 34 grams of propane gas, C_3H_8, reacts with 18 grams of oxygen gas in a 0.75 L sealed bomb calorimeter, what is the pressure inside the container after the reaction is complete? Assume the reaction happens at 25°C.

$$\frac{34\text{ g } C_3H_8}{44.094\text{ g/mol}} = 0.77\text{ mol}$$

$$\frac{18\text{ g } O_2}{32\text{ g/mol}} = 0.56\text{ mol}$$

$C_3H_8(g)$ +	$5\ O_2(g)$ →	$3\ CO_2(g)$ +	$4\ H_2O(g)$ + heat
0.77	0.56	∅	∅
−0.11	−0.56	+0.34	+0.45
0.66	∅	0.34	0.45

$$\Rightarrow n_{total} = 0.66 + 0.34 + 0.45 = 1.45\text{ mol}$$

$$P_{tot} = \frac{n_{tot}RT}{V} = \frac{(1.45\text{ mol})(0.08206\ \frac{L\cdot atm}{mol\cdot K})(298\text{ K})}{0.75\text{ L}} = \boxed{47\text{ atm}}$$

yikes!

Let's Practice!

1. Solid calcium carbonate, also known as limestone, will decompose upon heating to produce solid calcium oxide, also known as lime (an industrial chemical with a wide variety of uses), and carbon dioxide gas. How many grams of calcium carbonate must be decomposed to produce 5.00 L of carbon dioxide gas at 273 K and 760 torr?

STP!

$$\underline{1}\ CaCO_{3(s)} \rightarrow \underline{1}\ CaO_{(s)} + \underline{1}\ CO_{2(g)}$$

$$5.00\text{ L } CO_2 \times \frac{1\text{ mol } CO_2}{22.4\text{ L } CO_2} \times \frac{1\text{ mol } CaCO_3}{1\text{ mol } CO_2} \times \frac{100.09\text{ g } CaCO_3}{1\text{ mol } CaCO_3} = \boxed{22.3\text{ g } CaCO_3}$$

must show to earn credit!

2. How many liters of gaseous carbon monoxide at 27°C and 0.247 atm (not STP) can be produced from the burning of 65.5 g of carbon according to the following equation?

$$2\ C(s) + O_2(g) \rightarrow 2\ CO(g)$$

$$65.5\text{ g C} \times \frac{1\text{ mol C}}{12.01\text{ g C}} \times \frac{2\text{ mol CO}}{2\text{ mol C}} = 5.45\text{ mol CO}$$

$$V = \frac{nRT}{P} = \frac{(5.45\text{ mol})(0.08206\ \frac{L\cdot atm}{mol\cdot K})(300.\text{ K})}{0.247\text{ atm}} = \boxed{544\text{ L CO}}$$