CHAPTER 10: STOICHIOMETRY

Try end of chapter Problems (Answers in Appendix I):
1,3,7,9,11,19,21,23,25,27,29,31,33,35,37,39,43,79,83,89
(Be sure to balance the equations first when necessary)

10.1 Interpreting a Chemical Equation

Stoichiometry (STOY-key-OM-etry) problems are based on quantitative relationships between the different substances involved in a chemical reaction.

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

1 molecule N_2 + **3** molecules H_2 $\rightarrow$ **2** molecules NH_3

It follows that any multiples of these coefficients will be in same ratio!

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

___molecules H_2 + ____molecules O_2 $\rightarrow$ ____molecules H_2O

Similarly, the coefficients also tell us the number of moles of each substance

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

2 moles H_2 : **1** mole O_2 : **2** moles H_2O

Thus, the coefficients in a chemical equation give the **mole ratios** of reactants and products in a reaction.

Give the mole ratios for the following reaction:

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

1 mol C_3H_8 _5_ mol O_2 __3__mol CO_2 __4__mol H_2O

10.2 Mole-Mole Relationships

Example. Consider the following reaction:

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

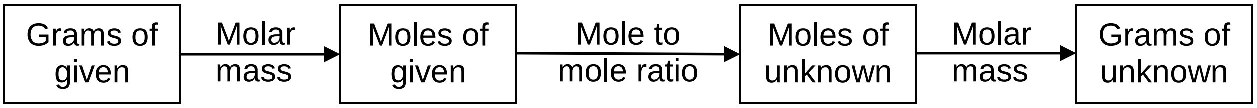
Mole ratios would be $\left(\frac{1\text{ mol }N_2}{3\text{ mol }H_2}\right)$ and $\left(\frac{1\text{ mol }N_2}{2\text{ mol }NH_3}\right)$ and $\left(\frac{2\text{ mol }NH_3}{3\text{ mol }H_2}\right)$ etc…

These mole ratios are used to solve problems such as how many moles of ammonia would be produced from 5.00 moles of hydrogen gas?

Solution: $5.00\text{ mol }H_2 \left(\frac{2\text{ mol }NH_3}{3\text{ mol }H_2}\right) = 3.33\text{ mol }NH_3$ gas

Write examples from class on the back of this page or scratch paper! Do the practice problems at the end of these notes! This is important!

10.4 Mass-Mass (Stoichiometry) Problems



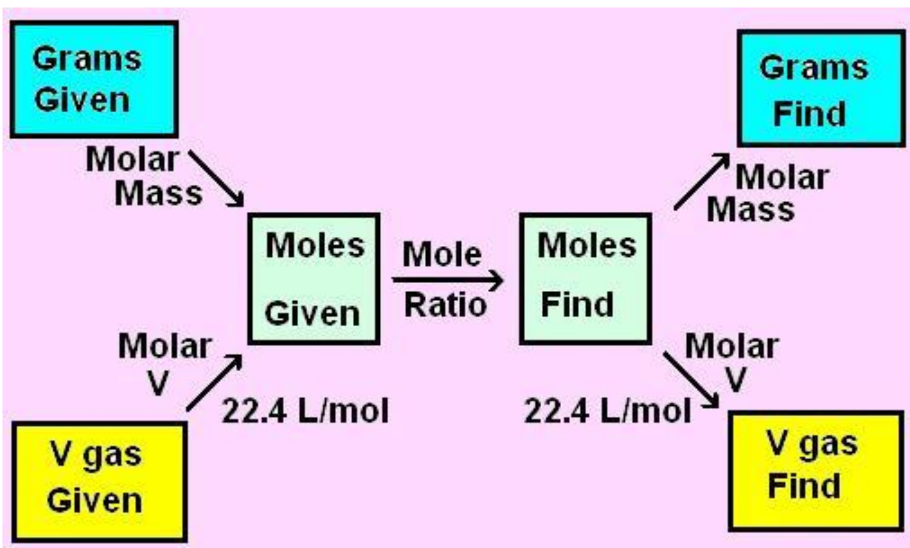
Steps:

1) Grams of given ↔ moles of given (Use the MM of given as your conversion factor.)
2) Moles of given ↔ moles of unknown (Use mole ratios from **balanced** equation.)
3) Moles unknown ↔ grams unknown (Use the MM of unknown as your conversion factor.)

- Important to include units & formulas for all substances- units cancel except wanted units.

Write examples from class on the back of this page or scratch paper! Do the practice problems at the end of these notes! This is important!

10.5-6 Mass-Volume and Volume-Volume (Stoichiometry) Problems



Steps:

1) If given grams, use MM as your conversion factor to get to moles of the given
   If given volume, use molar volume to get to moles of the given
2) Use mol ratios to convert from moles of given to moles of unknown
3) If asked to find grams, use MM as your conversion factor to get to grams of the unknown
   If asked to find volume, use molar volume to get to liters of the unknown

Fact: If you start with liters of the given and are asked to find liters of the unknown, as long as the gases are at the same temperature and pressure the molar volumes will cancel out with each other so you are basically just using the mole ratio to solve this type of problem.

Again write examples from class on the back of this page or scratch paper! Do the practice problems at the end of these notes! This is important!

Examples for sections 4 - 6: **$2\ SO_2(g)\ +\ O_2(g)\ \rightarrow\ 2\ SO_3(g)$**

1) How many liters of oxygen gas are needed to produce 36.5 liters of SO_3 gas at STP?

Solution: $36.5\text{ L SO}_3 \left(\frac{1\text{ mol}}{22.4\text{ L}}\right)\left(\frac{1\text{ mol O}_2}{2\text{ mol SO}_3}\right)\left(\frac{22.4\text{ L}}{1\text{ mol}}\right) = 18.3\text{ L O}_2$

(notice molar volume cancels out with itself on this problem)

2) How many grams of SO_3 gas are produced if 0.234 grams of SO_2 gas react?

Solution: $0.234\text{ g SO}_2 \left(\frac{1\text{ mol SO}_2}{64.07\text{ g SO}_2}\right)\left(\frac{2\text{ mol SO}_3}{2\text{ mol SO}_2}\right)\left(\frac{80.07\text{ g SO}_3}{1\text{ mol SO}_3}\right) = 0.292\text{ g SO}_3$

3) How many liters of oxygen gas are needed to react with 0.234 grams of SO_2 gas at STP?

Solution: $0.234\text{ g SO}_2 \left(\frac{1\text{ mol SO}_2}{64.07\text{ g SO}_2}\right)\left(\frac{1\text{ mol O}_2}{2\text{ mol SO}_2}\right)\left(\frac{22.4\text{ L}}{1\text{ mol}}\right) = 0.0409\text{ L O}_2$

Practice Problems

Example 1: $N_2(g)\ +\ 3\ H_2(g)\ \rightarrow\ 2\ NH_3(g)$

A. How many moles of N_2 are needed to completely react with 6.75 moles of H_2.

B. How many moles of NH_3 form when 3.25 moles of N_2 react?

C. How many moles of H_2 are required to produce 4.50 moles of NH_3?

Example 2: Consider the following reaction to produce iron, Fe (s):

$$Fe_2O_3(s)\ +\ 3\ CO(g)\ \rightarrow\ 2\ Fe(s)\ +\ 3\ CO_2(g)$$

A. Calculate the mass of CO needed to react completely with 50.0 g of Fe_2O_3.

B. Calculate the mass of iron produced when 125 g of CO reacts completely.

C. Calculate the mass of CO_2 produced when 75.0 g of iron is produced.

Example 3: Calculate the volume (in liters) of oxygen gas required to react with 50.0 g of aluminum at STP.

$$4\,Al(s) + 3\,O_2(g) \xrightarrow{\text{spark}} 2\,Al_2O_3(s)$$

Example 4: An automobile airbag inflates when N_2 gas results from the explosive decomposition of sodium azide (NaN_3),

$$2\,NaN_3(s) \xrightarrow{\text{spark}} 2\,Na(s) + 3\,N_2(g)$$

Calculate the mass of NaN_3 required to produce 50.0 L of N_2 gas at STP.

Answers to Practice Problems

Example 1 A $6.75\text{ moles } H_2\left(\frac{1\text{ mol } N_2}{3\text{ mol } H_2}\right) =$ **2.25 mol N_2**

B $3.25\text{ moles } N_2\left(\frac{2\text{ mol } NH_3}{1\text{ mol } N_2}\right) =$ **6.50 mol NH_3**

C $4.50\text{ moles } NH_3\left(\frac{3\text{ mol } H_2}{2\text{ mol } NH_3}\right) =$ **6.75 mol H_2**

Example 2 A $50.0\text{g}Fe_2O_3\left(\frac{1\text{ mole } Fe_2O_3}{159.70\text{ g}Fe_2O_3}\right)\left(\frac{3\text{ mole CO}}{1\text{ mole } Fe_2O_3}\right)\left(\frac{28.01\text{ gCO}}{1\text{ mole CO}}\right) =$ ***26.3 g CO***

B $125\text{g CO}\left(\frac{1\text{ mole CO}}{28.01\text{ gCO}}\right)\left(\frac{2\text{ mole Fe}}{3\text{ mole CO}}\right)\left(\frac{55.85\text{ g Fe}}{1\text{ mole Fe}}\right) =$ **166 g Fe**

C $75.0\text{g Fe}\left(\frac{1\text{ mole Fe}}{55.85\text{ gFe}}\right)\left(\frac{3\text{ mole } CO_2}{2\text{ mole Fe}}\right)\left(\frac{44.01\text{g } CO_2}{1\text{ mole } CO_2}\right) =$ **88.7 g CO_2**

Example 3 $50.0\text{g Al}\left(\frac{1\text{ mole Al}}{26.98\text{ gAl}}\right)\left(\frac{3\text{ mole } O_2}{4\text{ mole Al}}\right)\left(\frac{22.4\text{L } O_2}{1\text{ mole } O_2}\right) =$ **31.1 L O_2**

Example 4 $50.0\text{L}N_2\left(\frac{\text{mol } N_2}{22.4\text{L}N_2}\right)\left(\frac{2\text{mol } NaN_3}{3\text{ mol } N_2}\right)\left(\frac{65.02\text{g } NaN_3}{1\text{mol } NaN_3}\right) =$ **96.8 g NaN_3**