Name:_____ Class: _____ Date: _____

Skills Worksheet

Sample Problem Set

Stoichiometry

So far in your chemistry course, you have learned that chemists count quantities of elements and compounds in terms of moles and that they relate moles of a substance to mass by using the molar mass. In addition, you have learned to write chemical equations so that they represent the rearrangements of atoms that take place during chemical reactions, and you have learned to balance these equations. In this chapter you will be able to put these separate skills together to accomplish one of the most important tasks of chemistry—using chemical equations to make predictions about the quantities of substances that react or are given off as products and relating those quantities to one another. This process of relating quantities of reactants and products in a chemical reaction to one another is called *stoichiometry*.

First, look at an analogy.

Suppose you need to make several sandwiches to take on a picnic with friends. You decide to make turkey-and-cheese sandwiches using the following "equation:"

2 bread slices + 2 turkey slices + 1 lettuce leaf + 1 cheese slice
→ 1 turkey-and-cheese sandwich

This equation shows that you need those ingredients in a ratio of 2:2:1:1, respectively. You can use this equation to predict that you would need 30 turkey slices to make 15 sandwiches or 6 cheese slices to go with 12 turkey slices.

Zinc reacts with oxygen according to the following balanced chemical equation:

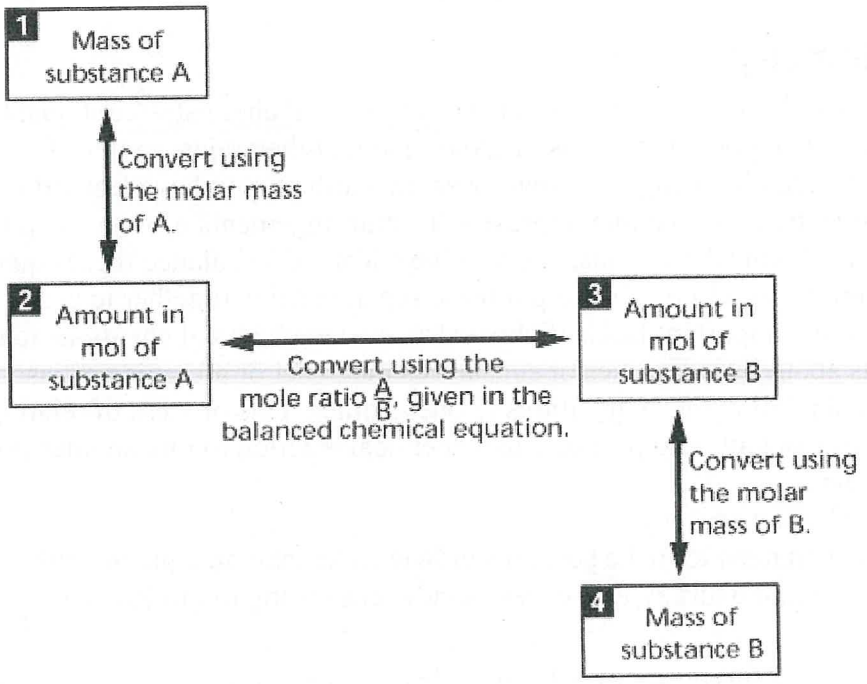
$$2Zn + O_2 \rightarrow 2ZnO$$

Like the sandwich recipe, this equation can be viewed as a "recipe" for zinc oxide. It tells you that reacting two zinc atoms with a molecule of oxygen will produce two formula units of zinc oxide. Can you predict how many zinc oxide units could be formed from 500 zinc atoms? Could you determine how many moles of oxygen molecules it would take to react with 4 mol of zinc atoms? What if you had 22 g of zinc and wanted to know how many grams of ZnO could be made from it? Keep in mind that the chemical equation relates amounts, not masses, of products and reactants. The problems in this chapter will show you how to solve problems of this kind.

Name:_____ Class: _____ Date: _____

Sample Problem Set *continued*

General Plan for Solving Stoichiometry Problems



Name:_____ Class: _____ Date: _____

Sample Problem 1

Ammonia is made industrially by reacting nitrogen and hydrogen under pressure, at high temperature, and in the presence of a catalyst. The equation is $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$. If 4.0 mol of H_2 react, how many moles of NH_3 will be produced?

Solution

ANALYZE

What is given in the problem? **the balanced equation, and the amount of H_2 in moles**

What are you asked to find? **the amount of NH_3 produced in moles**

Organization of data is extremely important in dealing with stoichiometry problems. You will find that it is most helpful to make data tables such as the following one.

Items	**Data**	
Substance	H_2	NH_3
Coefficient in balanced equation	3	2
Molar mass	NA*	NA
Amount	4.0 mol	? mol
Mass of substance	NA	NA

*NA means *not applicable to the problem*

PLAN

What steps are needed to calculate the amount of NH_3 that can be produced from 4.0 mol H_2?

Multiply by the mole ratio of NH_3 to H_2 determined from the coefficients of the balanced equation.

$$\overset{2}{\text{Amount of } H_2 \text{ in mol}} \xrightarrow[\text{multiply by mole ratio: } \frac{NH_3}{H_2}]{} \overset{3}{\text{Amount of } NH_3 \text{ in mol}}$$

$$\overset{\text{given}}{\text{mol } H_2} \times \overset{\text{mole ratio}}{\frac{2 \text{ mol } NH_3}{3 \text{ mol } H_2}} = \text{mol } NH_3$$

COMPUTE

$$4.0\,\text{mol}\,H_2 \times \frac{2\,\text{mol}\,NH_3}{3\,\text{mol}\,H_2} = 2.7\,\text{mol}\,NH_3$$

EVALUATE

Are the units correct?
Yes; the answer has the correct units of moles NH_3.

Is the number of significant figures correct?
Yes; two significant figures is correct because data were given to two significant figures.

Is the answer reasonable?
Yes; the answer is 2/3 of 4.0.

Practice

1. How many moles of sodium will react with water to produce 4.0 mol of hydrogen in the following reaction?

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$ **ans: 8.0 mol Na**

2. How many moles of lithium chloride will be formed by the reaction of chlorine with 0.046 mol of lithium bromide in the following reaction?

$2LiBr(aq) + Cl_2(g) \rightarrow 2LiCl(aq) + Br_2(l)$ **ans: 0.046 mol LiCl**

Name:_____ Class: _____ Date: _____

Sample Problem Set *continued*

3. Aluminum will react with sulfuric acid in the following reaction.

$$2Al(s) + 3H_2SO_4(l) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

a. How many moles of H_2SO_4 will react with 18 mol Al? **ans: 27 mol H_2SO_4**

b. How many moles of each product will be produced?
ans: 27 mol H_2, 9 mol $Al_2(SO_4)_3$

4. Propane burns in excess oxygen according to the following reaction.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

a. How many moles each of CO_2 and H_2O are formed from 3.85 mol of propane? **ans: 11.6 mol CO_2, 15.4 mol H_2O**

b. If 0.647 mol of oxygen is used in the burning of propane, how many moles each of CO_2 and H_2O are produced? How many moles of C_3H_8 are consumed? **ans: 0.388 mol CO_2, 0.518 mol H_2O, 0.129 mol C_3H_8**

Name:_____ Class: _____ Date: _____

Sample Problem 2

Potassium chlorate is sometimes decomposed in the laboratory to generate oxygen. The reaction is $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$. What mass of $KClO_3$ do you need to produce 0.50 mol O_2?

Solution

ANALYZE

What is given in the problem? **the amount of oxygen in moles**

What are you asked to find? **the mass of potassium chlorate**

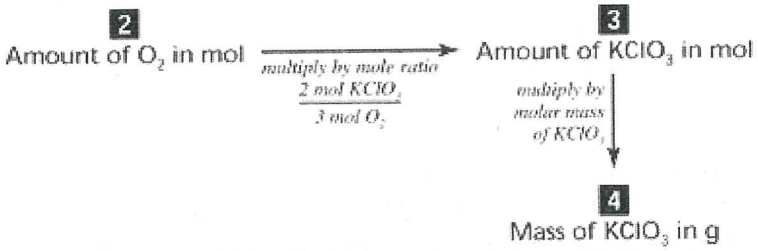
Items	Data	
Substance	$KClO_3$	O_2
Coefficient in balanced equation	2	3
Molar mass*	122.55 g/mol	NA
Amount	? mol	0.50 mol
Mass	? g	NA

*determined from the periodic table

PLAN

What steps are needed to calculate the mass of $KClO_3$ needed to produce 0.50 mol O_2?

Use the mole ratio to convert amount of O_2 to amount of $KClO_3$. Then convert amount of $KClO_3$ to mass of $KClO_3$.



$$\text{given mol } O_2 \times \frac{\text{mole ratio}}{\frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2}} \times \frac{\text{molar mass } KClO_3}{\frac{122.55 \text{ g } KClO_3}{1 \text{ mol } KClO_3}} = \text{g } KClO_3$$

COMPUTE

$$0.50 \text{ mol } O_2 \times \frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2} \times \frac{122.55 \text{ g } KClO_3}{1 \text{ mol } KClO_3} = 41 \text{ g } KClO_3$$

EVALUATE

Are the units correct?

Yes; units canceled to give grams of $KClO_3$.

Is the number of significant figures correct?
Yes; two significant figures is correct.

Is the answer reasonable?
Yes; 41 g is about 1/3 of the molar mass of $KClO_3$, and 0.5 × 2/3 = 1/3.

Practice

1. Phosphorus burns in air to produce a phosphorus oxide in the following reaction:

$$4P(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$$

   a. What mass of phosphorus will be needed to produce 3.25 mol of P_4O_{10}?
   ans: 403 g P

   b. If 0.489 mol of phosphorus burns, what mass of oxygen is used? What mass of P_4O_{10} is produced? **ans: 19.6 g O2, 15.4 g P_2O_4**

2. Hydrogen peroxide breaks down, releasing oxygen, in the following reaction:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

   a. What mass of oxygen is produced when 1.840 mol of H_2O_2 decomposes?
   ans: 29.44 g O_2

   b. What mass of water is produced when 5.0 mol O_2 is produced by this reaction? **ans: 180 g H_2O**

Name:_____ Class: _____ Date: _____

Sample Problem 3

How many moles of aluminum will be produced from 30.0 kg Al_2O_3 in the following reaction?

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Solution

ANALYZE

What is given in the problem? **the mass of aluminum oxide**

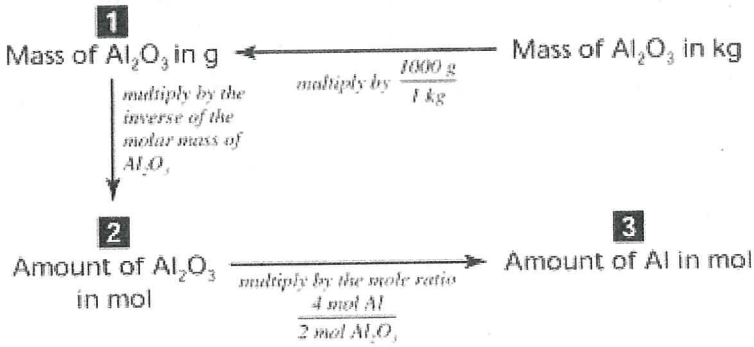
What are you asked to find? **the amount of aluminum produced**

Items	Data	
Substance	Al_2O_3	Al
Coefficient in balanced equation	2	4
Molar mass	101.96 g/mol	NA
Amount	? mol	? mol
Mass	30.0 kg	NA

PLAN

What steps are needed to calculate the amount of Al produced from 30.0 kg of Al_2O_3?

The molar mass of Al_2O_3 can be used to convert to moles Al_2O_3. The mole ratio of Al:Al_2O_3 from the coefficients in the equation will convert to moles Al from moles Al_2O_3.



$$\text{kg Al}_2\text{O}_3 \times \frac{1000\ \text{g}}{\text{kg}} \times \frac{1\ \text{mol Al}_2\text{O}_3}{101.96\ \text{g Al}_2\text{O}_3} \times \frac{4\ \text{mol Al}}{2\ \text{mol Al}_2\text{O}_3} = \text{mol Al}$$

(given; 1 / molar mass Al_2O_3; mole ratio)

COMPUTE

$$30.0\ \text{kg Al}_2\text{O}_3 \times \frac{1000\ \text{g}}{\text{kg}} \times \frac{1\ \text{mol Al}_2\text{O}_3}{101.96\ \text{g Al}_2\text{O}_3} \times \frac{4\ \text{mol Al}}{2\ \text{mol Al}_2\text{O}_3} = 588\ \text{mol Al}$$

EVALUATE

Are the units correct?

Yes; units canceled to give moles of Al.

Is the number of significant figures correct?

Yes; three significant figures is correct.

Is the answer reasonable?

Yes; the molar mass of Al_2O_3 is about 100, so 30 kg of Al_2O_3 is about 300 mol. The mole ratio of Al:Al_2O_3 is 2:1, so the answer should be about 600 mol Al.

Practice

1. Sodium carbonate reacts with nitric acid according to the following equation.

$$Na_2CO_3(s) + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$$

   a. How many moles of Na_2CO_3 are required to produce 100.0 g of $NaNO_3$?
   ans: 0.5882 mol Na_2CO_3

   b. If 7.50 g of Na_2CO_3 reacts, how many moles of CO_2 are produced?
   ans: 0.0708 mol CO_2

2. Hydrogen is generated by passing hot steam over iron, which oxidizes to form Fe_3O_4, in the following equation.

$$3Fe(s) + 4H_2O(g) \rightarrow 4H_2(g) + Fe_3O_4(s)$$

   a. If 625 g of Fe_3O_4 is produced in the reaction, how many moles of hydrogen are produced at the same time? **ans: 10.8 mol H_2**

   b. How many moles of iron would be needed to generate 27 g of hydrogen?
   ans: 10. mol Fe

Name:_____ Class: _____ Date: _____

Sample Problem 4

Methane burns in air by the following reaction:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

What mass of water is produced by burning 500. g of methane?

Solution

ANALYZE

What is given in the problem? **the mass of methane in grams**

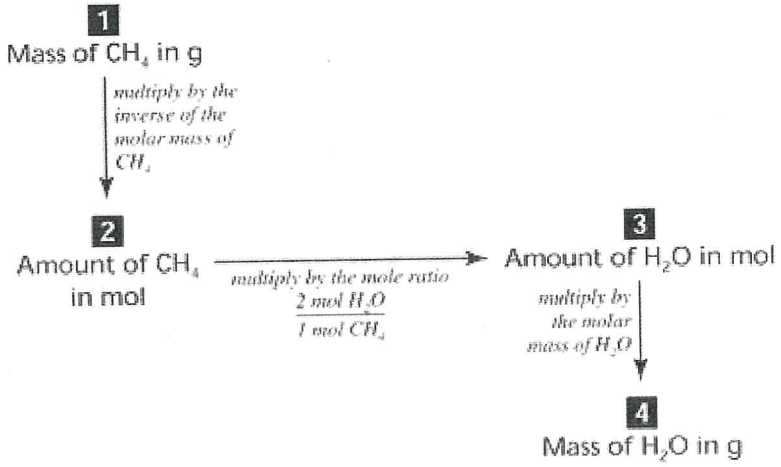
What are you asked to find? **the mass of water produced**

Items	Data	
Substance	CH_4	H_2O
Coefficient in balanced equation	1	2
Molar mass	16.05 g/mol	18.02 g/mol
Amount	? mol	? mol
Mass	500. g	? g

PLAN

What steps are needed to calculate the mass of H_2O produced from the burning of 500. g of CH_4?

Convert grams of CH_4 to moles CH_4 by using the molar mass of CH_4. Use the mole ratio from the balanced equation to determine moles H_2O from moles CH_4. Use the molar mass of H_2O to calculate grams H_2O.



$$\text{given g } CH_4 \times \frac{1}{\text{molar mass } CH_4} \times \frac{\text{mole ratio}}{\frac{2 \text{ mol } H_2O}{1 \text{ mol } CH_4}} \times \frac{\text{molar mass } H_2O}{\frac{18.02 \text{ g } H_2O}{1 \text{ mol } H_2O}} = \text{g } H_2O$$

COMPUTE

$$500.\ \text{g CH}_4 \times \frac{1\ \text{mol CH}_4}{16.05\ \text{g CH}_4} \times \frac{2\ \text{mol H}_2\text{O}}{1\ \text{mol CH}_4} \times \frac{18.02\ \text{g H}_2\text{O}}{1\ \text{mol H}_2\text{O}} = 1.12 \times 10^3\ \text{g H}_2\text{O}$$

EVALUATE

Are the units correct?

Yes; mass of H_2O was required, and units canceled to give grams H_2O.

Is the number of significant figures correct?

Yes; three significant figures is correct because the mass of CH_4 was given to three significant figures.

Is the answer reasonable?

Yes; CH_4 and H_2O have similar molar masses, and twice as many moles of H_2O are produced as moles CH_4 burned. So, you would expect to get a little more than 1000 g of H_2O.

Practice

1. Calculate the mass of silver bromide produced from 22.5 g of silver nitrate in the following reaction:

   $2AgNO_3(aq) + MgBr_2(aq) \rightarrow 2AgBr(s) + Mg(NO_3)_2(aq)$ **ans: 24.9 g AgBr**

2. What mass of acetylene, C_2H_2, will be produced from the reaction of 90. g of calcium carbide, CaC_2, with water in the following reaction?

   $$CaC_2(s) + 2H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(s)$$ **ans: 37 g C_2H_2**

3. Chlorine gas can be produced in the laboratory by adding concentrated hydrochloric acid to manganese(IV) oxide in the following reaction:

   $$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

   a. Calculate the mass of MnO_2 needed to produce 25.0 g of Cl_2.
   ans: 30.7 g MnO_2

   b. What mass of $MnCl_2$ is produced when 0.091 g of Cl_2 is generated?
   ans: 0.16 g $MnCl_2$

Worksheet for Basic Mass to Mass Stoichiometry

1) Using the following equation:

$$2\ NaOH + H_2SO_4 \rightarrow 2\ H_2O + Na_2SO_4$$

How many grams of sodium sulfate will be formed if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid? **(ANSWER 355.3g Na_2SO_4)**

2) Using the following equation:

$$Pb(SO_4)_2 + 4\ LiNO_3 \rightarrow Pb(NO_3)_4 + 2\ Li_2SO_4$$

How many grams of lithium nitrate will be needed to make 250 grams of lithium sulfate, assuming that you have an adequate amount of lead (IV) sulfate to do the reaction? **(ANSWER 386.3g of $LiNO_3$)**

3) Using the following equation:

$$Fe_2O_3 + 3\ H_2 \text{ ----------> } 2\ Fe + 3\ H_2O$$

Calculate how many grams of iron can be made from 16.5 grams of Fe_2O_3 by the following equation.

4) Using the following equation:

$$2\ I_2 + KIO_3 + 6HCl \text{ ---------> } 5ICl + KCl + 3H_2O$$

Calculate how many grams of iodine are needed to prepare 28.6 grams of ICl by this reaction.

5) Using the following equation:

$$5\ KNO_2 + 2\ KMnO_4 + 3\ H_2SO_4 \text{ ------> } 5\ KNO_3 + 2\ MnSO_4 + K_2SO4 + 3\ H_2O$$

How many moles and how many grams of $KMnO_4$ are needed to carry out this reaction on 11.4 grams of KNO_2?

6) Using the following equation:

$$4\ NH_3 + 5\ O_2 \text{ ----------> } 4\ NO + 6\ H_2O$$

How many moles and how many grams of oxygen (O_2) are needed to react with 56.8 grams of ammonia by this reaction?

7) Using the following equation:

$$NaIO_3 + 6\ HI \text{ ----------> } 3\ I_2 + NaI + 3\ H_2O$$

Calculate the number of moles and the number of grams of iodine (I_2) that can be made this way from 16.4 grams of $NaIO_3$.

8) The combustion of a sample of butane, C4H10 (lighter fluid), produced 2.46 grams of water.

$$2\ C_4H_{10} + 13O_2 \text{ -------> } 8CO_2 + 10H_2O$$

(a) How many moles of water formed?
(b) How many moles of butane burned?
(c) How many grams of butane burned?
(d) How much oxygen was used up in moles?
(e) How much oxygen was used up in grams?

Stoichiometry – Simpler Questions

1. When heated, potassium chlorate decomposes into potassium chloride and oxygen gas:

$$2\ KClO_{3(s)} \rightarrow 2\ KCl_{(s)} + 3\ O_{2(g)}$$

   a. How many moles of O_2 gas will be produced from 10.0 g of $KClO_3$?
   b. What is the volume of this amount of O_2 gas at STP?

2. The reaction of aluminium and iron(III) oxide gives off a great deal of heat and light:

$$2\ Al_{(s)} + Fe_2O_{3(s)} \rightarrow 2\ Fe_{(s)} + Al_2O_{3(s)}$$

   a. What mass of $Fe_2O_3(s)$ is required to react completely with 1.0 kg of $Al(s)$?
   b. What mass of $Fe(s)$ will be produced based on the quantities in a)?

3. The Marsh test was used historically to detect arsenic in cases of suspected poisoning:

$$As_2O_{3(s)} + 6\ H_{2(g)} \rightarrow 2\ AsH_{3(g)} + 3\ H_2O_{(g)}$$

   A sample contains 640 mg of As_2O_3. What mass of AsH_3 will be isolated from the above reaction? Assume that there is enough H_2 to react with all the As_2O_3.

4. Glucose can be fermented by yeast to produce ethanol by the following reaction:

$$C_6H_{12}O_{6(s)} \rightarrow 2\ C_2H_6O_{(l)} + 2\ CO_{2(g)}$$

   a. What mass of glucose is needed to produce 800 g of ethanol?
   b. What volume of CO_2 (at 25°C and 1 atm pressure) will be produced by the fermentation of the amount of glucose you calculated in part a?

5. Titanium(IV) chloride reacts spectacularly with water vapour to form titanium dioxide and hydrogen chloride gas:

$$TiCl_{4(l)} + 2\ H_2O_{(g)} \rightarrow TiO_{2(s)} + 4\ HCl_{(g)}$$

   a. What mass of water vapour is needed to react with 4.0 g of $TiCl_4$?
   b. How many moles of $HCl(g)$ will be formed given the amounts in a)?

6. The following *unbalanced* reaction is for the complete combustion of toluene, the main ingredient of paint thinner:

$$C_7H_{8(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$$

   a. What is the balanced equation for this transformation?
   b. What volume of O_2 gas at STP is required for the complete combustion of 45.0 g of C_7H_8?
   c. What mass of CO_2 is formed by the complete combustion of 45.0 g of C_7H_8?

7. Baking soda can be heated to form sodium carbonate by the following reaction:

$$2\ NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$$

   a. What mass of baking soda is required to make 100.0 g of Na_2CO_3?
   b. How many moles of CO_2 are produced by the above reaction?

Stoichiometry – Excess/limiting reagents & percent yield and purity

8. The Haber-Bosch process produces ammonia from elemental nitrogen and hydrogen:

$$N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$$

   a. If 10.0 kg of nitrogen gas are reacted with 10000 L of hydrogen gas (at SLC), which gas is the limiting reactant?
   b. What mass of ammonia is produced from the amounts in a)?
   c. *How much of the excess of the excess reactant is left over?

9. Titanium (IV) chloride can be made by the following reaction:

$$2\ FeTiO_{3(s)} + 7\ Cl_{2(g)} + 6\ C_{(s)} \rightarrow 2\ TiCl_{4(g)} + 6\ CO_{(g)} + 2\ FeCl_{3(s)}$$

   a. If you start with 100.0 g of each reactant, which one limits the reaction?
   b. What is the theoretical yield of $TiCl_4$ based on the amounts in a)?
   c. If only 70.0 g of $TiCl_4$ is recovered, what is the percent yield of the reaction?

10. Small amounts of hydrogen gas can be generated by reacting magnesium metal with hydrochloric acid:

$$Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

   a. What is the theoretical yield of hydrogen gass in litres at STP if 200 mL of 0.4M $HCl_{(aq)}$ was reacted with excess Mg?
   b. What is the theoretical volume of H_2 gas produced at SLC if 575 mg of a Mg sample are reacted with excess HCl?
   c. What is the percent purity of the Mg sample if only 4L of H_2 were collected at SLC?

11. Reacting carbon monoxide with silver(II) fluoride generates carbonyl fluoride and silver(I) fluoride:

$$CO_{(g)} + 2\ AgF_{2(s)} \rightarrow COF_{2(g)} + 2\ AgF_{(s)}$$

   a. What mass of $AgF_2(s)$ is required to make 10.0 g of $COF_2(g)$?
   b. If 25.0 g of CO are reacted with a 250.0 g of a 90% pure sample of $AgF_2(s)$, what is the theoretical yield of $COF_2(g)$?

12. When sodium sulfate and lead(II) nitrate are mixed, a precipitate of lead(II)sulfate forms:

$$Na_2SO_{4(aq)} + Pb(NO_3)_{2(aq)} \rightarrow PbSO_{4(s)} + 2\ NaNO_{3(aq)}$$

   a. When a sample of Na_2SO_4 is mixed with excess $Pb(NO_3)_2$, 2.27 g of $PbSO_4$ was formed. Assuming the reaction is 100% efficient, what mass of Na_2SO_4 was dissolved in the sample?
   b. If 2.00 M $Pb(NO_3)_2$ was used, what was the minimum volume required to react with all the Na_2SO_4 in part a?

13. When calcium carbonate solution is mixed with hydrochloric acid, carbon dioxide is among the products:

$$CaCO_{3(aq)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

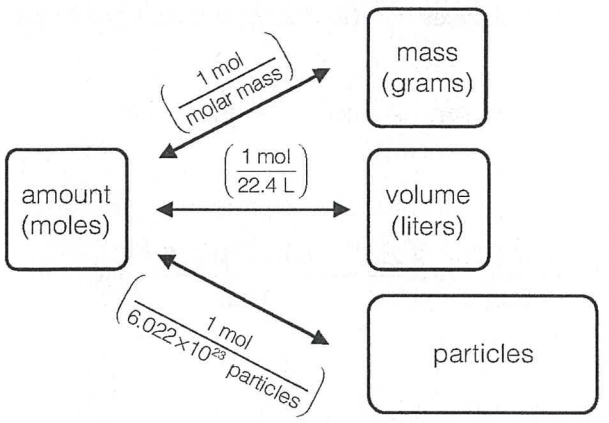
   a. Which reactant is in excess if 25.0 mL of a 0.100 M solution of $CaCO_3$ is mixed with 20.0 mL of 0.275 M HCl?
   b. What is the final concentration of the excess reactant in solution?

name: _____ date: _____

mole conversions - practice problems

It is important to be able to convert between units of mass and volume measurement and 'moles.' The mole is a unit for counting atoms and molecules representing 602,000,000,000,000,000,000,000 particles. This is often written as 6.02×10^{23} particles and is known as 'Avogadro's number.' Using the periodic table it is possible to calculate the 'molar mass,' or the mass of a single mole of a substance. The 'molar volume' is the volume of a single mole of gaseous substance. All gases have the same molar volume when measured at standard temperature and pressure or STP, which is 22.4 liters per mole.

mole conversion chart



example:

Calculate the number of molecules in 1.62 grams of calcium chloride, $CaCl_2$.

-develop a strategy: grams → moles → particles

-calculate and solve:

$$1.62 \text{ g } CaCl_2 \times \left(\frac{1 \text{ mol}}{111 \text{ g}}\right) \times \left(\frac{6.022 \times 10^{23} \text{ particles}}{1 \text{ mol}}\right)$$

$$= \boxed{8.79 \times 10^{21} \text{ particles of } CaCl_2}$$

$$= \boxed{8.79 \times 10^{21} \text{ particles of } CaCl_2}$$

practice problems:

1. A sample of neon has a volume of 75.8 L at STP . Calculate the number of moles.

2. Calculate the mass of an 8.4 mole sample of iron.

3. Convert 0.45 g of sodium hydroxide, NaOH, into moles.

4. Calculate the number of molecules in a sample of carbon dioxide with a mass of 168.2 grams.

5. Calculate the number of moles of potassium nitrate, KNO_3, in a sample with a mass of 85.2 grams.

6. Calculate the mass of 0.94 moles of sodium bicarbonate, $NaHCO_3$.

7. Convert 7.8 liters of carbon tetrafluoride, CF_4, to grams.

8. Calculate the mass of 3.47×10^{23} gold atoms.

9. Calculate the volume, in liters, of 7500 g of helium atoms. Assume STP conditions.

10. Calculate the number of particles in 5.0 grams of NaCl.

11. Calculate the mass of 5.0×10^{14} molecules of water.

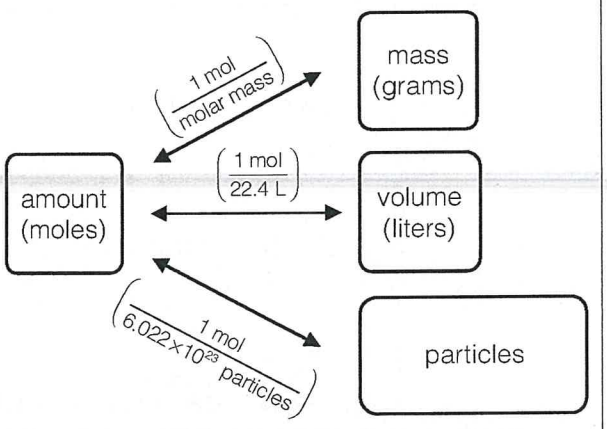
12. Calculate the volume of 5.0 grams of NO gas at STP.

name: **suggested answers** date: _____

mole conversions - practice problems

It is important to be able to convert between units of mass and volume measurement and 'moles.' The mole is a unit for counting atoms and molecules representing 602,000,000,000,000,000,000,000 particles. This is often written as 6.02×10^{23} particles and is known as 'Avogadro's number.' Using the periodic table it is possible to calculate the 'molar mass,' or the mass of a single mole of a substance. The 'molar volume' is the volume of a single mole of gaseous substance. All gases have the same molar volume when measured at standard temperature and pressure or STP, which is 22.4 liters per mole.

mole conversion chart



example:

Calculate the number of molecules in 1.62 grams of calcium chloride, $CaCl_2$.

-develop a strategy: grams → moles → particles

-calculate and solve:

$$1.62 \text{ g } CaCl_2 \times \left(\frac{1 \text{ mol}}{111 \text{ g}}\right) \times \left(\frac{6.022 \times 10^{23} \text{ particles}}{1 \text{ mol}}\right)$$

practice problems:

1. A sample of neon has a volume of 75.8 L at STP . Calculate the number of moles. 3.38 mol Ne

2. Calculate the mass of an 8.4 mole sample of iron. 469.14 g Fe

3. Convert 0.45 g of sodium hydroxide, NaOH, into moles. 0.0112 mol NaOH

4. Calculate the number of molecules in a sample of carbon dioxide with a mass of 168.2 grams. 2.30×10^{24} molecules CO_2

5. Calculate the number of moles of potassium nitrate, KNO_3, in a sample with a mass of 85.2 grams. 0.843 mol KNO_3

6. Calculate the mass of 0.94 moles of sodium bicarbonate, $NaHCO_3$. 78.96 g $NaHCO_3$

7. Convert 7.8 liters of carbon tetrafluoride, CF_4, to grams. 30.64 g CF_4

8. Calculate the mass of 3.47×10^{23} gold atoms. 113.52 g Au

9. Calculate the volume, in liters, of 7500 g of helium atoms. Assume STP conditions. 42000 L He

10. Calculate the number of particles in 5.0 grams of NaCl. 5.15×10^{22} particles NaCl

11. Calculate the mass of 5.0×10^{14} molecules of water. 1.49×10^{-8} g H_2O

12. Calculate the volume of 5.0 grams of NO gas at STP. 3.73 L NO

EMPIRICAL FORMULA WORKSHEET

Name _____ Date _____

1. What is the empirical formula for a compound which contains 0.0134 g of iron, 0.00769 g of sulphur and 0.0115 g of oxygen?

2. Find the empirical formula for a compound which contains 32.8% chromium and 67.2% chlorine.

3. NAME the compound which contains 0.463 g Tl (#81), 0.0544 g of carbon, 0.00685 g of hydrogen and 0.0725 g oxygen by finding its empirical formula.

4. What is the empirical formula for a compound which contains 67.1% zinc and the rest is oxygen?

5. Barry Um has a sample of a compound which weighs 200 grams and contains only carbon, hydrogen, oxygen and nitrogen. By analysis, he finds that it contains 97.56 grams of carbon, 4.878 g of hydrogen, 52.03 g of oxygen and 45.53 g of nitrogen. Find its empirical formula.

6. The characteristic odour of pineapple is due to ethyl butyrate, an organic compound which contains only carbon, hydrogen and oxygen. If a sample of ethyl butyrate is known to contain 0.62069 g of carbon, 0.103448 g of hydrogen and 0.275862 g of oxygen, what is the empirical formula for ethyl butyrate?

7. 300.0 grams of a compound which contains only carbon, hydrogen and oxygen is analyzed and found to contain the exact same percentage of carbon as it has oxygen. The percentage of hydrogen is known to be 5.98823%. Find the empirical formula of the compound.

8. 200.00 g of an organic compound is known to contain 83.884 g of carbon, 10.486 g of hydrogen, 18.640 g of oxygen and the rest is nitrogen. What is the empirical formula of the compound?

9. 300 g of an organic sample which contains only carbon, hydrogen and oxygen is analyzed and found to contain 145.946 g of carbon, 24.3243 g of hydrogen and the rest is oxygen. What is the empirical formula for the compound?

5. Barry Um has a sample of a compound which weighs 200 grams and contains only carbon, hydrogen, oxygen and nitrogen. By analysis, he finds that it contains 97.56 grams of carbon, 4.878 g of hydrogen, 52.03 g of oxygen and 45.53 g of nitrogen. Find its empirical formula.

$C = (97.56g)(\frac{mol}{12g}) = 8.13 \div 3.252 = 2.5 \times 2 = 5$

$H = (4.878g)(\frac{mol}{1g}) = 4.878 \div 3.252 = 1.5 \times 2 = 3$

$O = (52.03g)(\frac{mol}{16g}) = 3.252 \div 3.252 = 1 \times 2 = 2$

$N = (45.53g)(\frac{mol}{14g}) = 3.252 \div 3.252 = 1 \times 2 = 2$

$C_5H_3O_2N_2$

6. The characteristic odour of pineapple is due to ethyl butyrate, an organic compound which contains only carbon, hydrogen and oxygen. If a sample of ethyl butyrate is known to contain 0.62069 g of carbon, 0.103448 g of hydrogen and 0.275862 g of oxygen, what is the empirical formula for ethyl butyrate?

$C = (0.62069g)(\frac{mol}{12g}) = 0.051724 \div 0.017241 = 3$

$H = (0.103448g)(\frac{mol}{1.0g}) = 0.103448 \div 0.017241 = 6$

$O = (0.275862g)(\frac{mol}{16.0g}) = 0.017241 \div 0.017241 = 1$

C_3H_6O

7. 300.0 grams of a compound which contains only carbon, hydrogen and oxygen is analyzed and found to contain the exact same percentage of carbon as it has oxygen. The percentage of hydrogen is known to be 5.98823%. Find the empirical formula of the compound.

$H = (5.98823g)(\frac{mol}{1g}) = 5.98823 \div 2.937867 = 2 \times 3 = 6$

$C = (47.005885g)(\frac{mol}{12g}) = 3.917157 \div 2.937867 = 1.33 \times 3 = 4$

$O = (47.005889)(\frac{mol}{16g}) = 2.937367 \div 2.937867 = 1 \times 3 = 3$

$(C = O = \frac{100 - 5.98823}{2} = 47.005885\%)$

$C_4H_6O_3$

8. 200.00 g of an organic compound is known to contain 83.884 g of carbon, 10.486 g of hydrogen, 18.640 g of oxygen and the rest is nitrogen. What is the empirical formula of the compound?

$C = (83.884g)(\frac{mol}{12g}) = 6.9903 \div 1.165 = 6 \times 3 = 18$

$H = (10.486g)(\frac{mol}{1g}) = 10.486 \div 1.165 = 9 \times 3 = 27$

$O = (18.640g)(\frac{mol}{16g}) = 1.165 \div 1.165 = 1 \times 3 = 3$

$N = (86.99g)(\frac{mol}{14g}) = 6.21357 \div 1.165 = 5.33 \times 3 = 16$

$C_{18}H_{27}O_3N_{16}$

9. 300 g of an organic sample which contains only carbon, hydrogen and oxygen is analyzed and found to contain 145.946 g of carbon, 24.3243 g of hydrogen and the rest is oxygen. What is the empirical formula for the compound?

$C = (145.946g)(\frac{mol}{12g}) = 12.16216 \div 8.1081 = 1.5 \times 2 = 3$

$H = (24.3243g)(\frac{mol}{1g}) = 24.3243 \div 8.1081 = 3 \times 2 = 6$

$O = (129.7297g)(\frac{mol}{16g}) = 8.1081 \div 8.1081 = 1 \times 2 = 2$

$C_3H_6O_2$

KEY

EMPIRICAL FORMULA WORKSHEET

Name _____ Date _____

1. What is the empirical formula for a compound which contains 0.0134 g of iron, 0.00769 g of sulphur and 0.0115 g of oxygen?

Fe = $(0.0134g)\left(\frac{mol}{55.8g}\right)$ = 0.0002401 ÷ .0002396 = 1

S = $(0.00769g)\left(\frac{mol}{32.1g}\right)$ = 0.0002396 ÷ 0.0002396 = 1

O = $(0.0115g)\left(\frac{mol}{16.0g}\right)$ = 0.00071875 ÷ 0.0002396 = 3

$FeSO_3$

iron (III) sulph.

2. Find the empirical formula for a compound which contains 32.8% chromium and 67.2% chlorine.

Cr = $(32.8g)\left(\frac{mol}{52.0g}\right)$ = 0.6307 ÷ 0.6307 = 1

Cl = $(67.2g)\left(\frac{mol}{35.3g}\right)$ = 1.89295 ÷ 0.6307 = 3

$CrCl_3$

chromium III chloride

3. NAME the compound which contains 0.463 g Tl (#81), 0.0544 g of carbon, 0.00685 g of hydrogen and 0.0725 g oxygen by finding its empirical formula.

Tl = $(.4639)\left(\frac{mol}{204.4g}\right)$ = 0.002265 ÷ .002265 = 1

C = $(0.0544g)\left(\frac{mol}{12g}\right)$ = 0.004533 ÷ .002265 = 2

H = $(0.00685g)\left(\frac{mol}{1g}\right)$ = 0.00685 ÷ .002265 = 3

O = $(0.0725g)\left(\frac{mol}{16g}\right)$ = 0.004531 ÷ .002265 = 2

$TlC_2H_3O_2$

thallium (I) acetate

4. What is the empirical formula for a compound which contains 67.1% zinc and the rest is oxygen?

Zn = $(67.1g)\left(\frac{mol}{65.4g}\right)$ = 1.02599 ÷ 1.02599 = 1

O = $(32.9g)\left(\frac{mol}{16.0g}\right)$ = 2.05625 ÷ 1.02599 = 2

100 - 67.1 = 32.9%

ZnO_2

zinc oxide