STOICHIOMETRY FOR STUDENTS

STOICHIOMETRY Defined:

Based on the Law of Conservation of Mass:

INTERPRETING EQUATIONS: Write the balanced chemical equation for the synthesis of ammonia from nitrogen and hydrogen gases.

Interpret equation in terms of ① _____, ② _____, and ③ _____. Then, ④ show Law of Conservation of Mass is observed.

① _____: number for each substance indicated by _____; four types:

② _____: number for each substance indicated by _____

③ _____: multiply number of moles of each reactant and product by its _____

g N_2 = ——— = g H_2 = ——— =

g NH_3 = ——— =

④ Observation of Law of Conservation of Mass

Add the masses of the _____:	Add the masses of the _____:
When the mass of reactants equals the mass of the products, the Law of Conservation of Mass is observed.	

MOLE RATIO:

Determine all possible mole ratios for the balanced chemical equation showing the synthesis of ammonia.

How many ratios are possible? This reaction has _____ participating species. _____ the number of species by the next lower number to determine the number of possible mole ratios. For the synthesis of ammonia, _____ mole ratios are possible.

Which mole ratio should be used?

Stoichiometric Calculations:

1. Write the _____.
2. Identify the _____ and the _____, and draw the _____.
3. The GIVEN must be in _____ or _____.
4. Identify the _____ that will cancel the _____.
5. Set up _____ and cancel _____ until the only unit left standing matches the _____.
6. Do the _____ and express the answer to the correct number of _____.

MOLE-to-MOLE Conversions: _____

Example: How many moles of ammonia are produced when 10.0 moles of hydrogen react with excess nitrogen?

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

=

MOLE-to-MOLE Conversions

Practice 1: How many moles of zinc chloride will be formed when 17.0 moles of hydrochloric acid react with excess zinc metal?

How many mole ratios are possible for this balanced equation? _____

Write all possible mole ratios.

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

=

Practice 2: Potassium chlorate decomposes into potassium chloride and oxygen. How many moles of oxygen are formed when 3.20 mol $KClO_3$ decompose?

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

=

MOLE-to-MASS Conversions: _____

Example: Balance the following equation for the combustion of propane. Calculate the molar mass for each substance.

_____ C_3H_8 + _____ O_2 → _____ CO_2 + _____ H_2O

MOLAR MASS ⇒ [ ] [ ] [ ] [ ]

If 10.0 moles of propane are used, how many grams of water are formed?

Write the mole ratios involving the UNKNOWN and the GIVEN.

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

= [ ]

Practice 1: Sulfuric acid is produced when sulfur dioxide reacts with oxygen and water. How many grams of sulfuric acid is produced when 1.50 moles sulfur dioxide completely reacts?

_____ SO_2 + _____ O_2 + _____ H_2O → _____ H_2SO_4

MOLAR MASS ⇒ [ ] [ ] [ ] [ ]

Write the mole ratios involving the UNKNOWN and the GIVEN.

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)

=

MASS-to-MOLE Conversions: _____

Example: Methane and sulfur produce carbon disulfide and hydrogen sulfide gas, as indicated by the following equation. Suppose that 19.75 g sulfur react with an excess of methane. How many moles of carbon disulfide will form?

_____ CH_4 + _____ S_8 → _____ CS_2 + _____ H_2S

MOLAR MASS ⇒ | | | | |

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

=

Practice 1: Sodium fluoride is formed when sodium metal reacts with fluorine gas. How many moles of sodium fluoride can be formed when 4.57 grams of fluorine gas reacts completely with excess sodium?

MOLAR MASS ⇒

_____ Na + _____ F_2 → _____ NaF

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)

=

MASS-to-MASS Conversions: _____

Example: Balance the following equation for the combustion of butane. Calculate the molar mass for each substance.

_____ C_4H_{10} + _____ O_2 → _____ CO_2 + _____ H_2O

MOLAR MASS ⇒

If 75.5 grams of carbon dioxide are produced, how many grams of butane were used?

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

=

Practice 1: Use the balanced equation for the combustion of butane. How many grams of oxygen are necessary to react completely with 217 grams of butane?

_____ C_4H_{10} + _____ O_2 → _____ CO_2 + _____ H_2O

Molar Mass
UNKNOWN:
GIVEN:

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)

=

Practice 2: Balance the following single replacement reaction.

_____ Fe + _____ H_2O → _____ Fe_2O_3 + _____ H_2

How many grams of iron must react in order to produce 75.9 grams of iron (III) oxide?

Molar Mass
UNKNOWN:
GIVEN:

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)
=				

=

WHY DO REACTIONS STOP?

The Beta Club is making Valentine's Day treat bags for Ms. Gillihan's 4th grade class at Riverside Elementary. Each bag contains: 1 box of Sweet Heart candies, 2 watermelon Blow-Pops, 4 Hershey's Kisses, 3 Hershey's Hugs, and 1 heart-shaped Valentine card.

Beta Club members are meeting this afternoon to assemble the treat bags for the students in Ms. Gillihan's class. The following inventory of supplies is available:

27 boxes of Sweet Heart candies	50 watermelon Blow-Pops
100 Hershey's Kisses	72 Hershey's Hugs
30 heart-shaped Valentine cards	30 bags with closures

How many treat bags can be assembled? _____ Why can't additional bags be put together? _____

_____

The _____ represent the limiting reactant. All other items are _____ reactants.

LIMITING REACTANT (LR):

EXCESS REACTANT (XR):

The balanced equation to the right illustrates the synthesis of magnesium hydroxide. $MgO + H_2O \rightarrow Mg(OH)_2$

Interpret this equation in terms of moles.

If 2 moles MgO reacts with 3 mol water, which reactant will be used up first? _____

Which reactant is available in excess? _____ The amount of magnesium hydroxide that can be produced depends upon the amount of which reactant? _____ This substance then is the _____ reactant.

Balance the equation for the single replacement reaction to the right. _____ KI + _____ Cl_2 → _____ KCl + _____ I_2

Interpret this equation in terms of moles.

When given ___ mol KI and ___ mol Cl_2, identify the limiting reactant and excess reactant.

Compare moles AVAILABLE (_____) to moles NEEDED (_____).

$$\frac{\text{AVAILABLE}}{\text{NEEDED}} \qquad \frac{\text{mol KI}}{\text{mol KI}} \qquad \frac{\text{mol } Cl_2}{\text{mol } Cl_2}$$

The _____ result indicates the _____ reactant. All other reactants are _____ reactants.

DETERMINING THE LIMITING REACTANT *(GIVEN is moles)*

Practice 1: Pilkington, a subsidiary of Nippon Sheet Glass Company, is one of the world's largest manufacturers of glass and glazing products. The main component of flat gas, used in windows and windshields, is silicon dioxide, also known as silica or silica sand. Silicon dioxide can be produced by reacting elemental silicon with water according to the following reaction.

$$\_\_\_\_\_\ Si + \_\_\_\_\_\ H_2O \rightarrow \_\_\_\_\_\ SiO_2 + \_\_\_\_\_\ H_2$$

Balance the equation. What type of reaction is indicated by this equation? _____

Suppose that the reaction starts with 3.25 moles silicon and 3.25 moles water.

① Identify the limiting reactant. [*Compare moles AVAILABLE to moles NEEDED.*]

② Determine the mass of silicon dioxide that can be produced. [*Use the limiting reactant as the GIVEN.*]

③ Determine the amount (in moles) of the excess reactant that remains after the reaction stops. [*Use the amount of product formed in #2 above as the GIVEN.*]

DETERMINING THE LIMITING REACTANT *(GIVEN is not moles)*

Method: Determine how much product can be formed from the amounts given for each reactant. Two bridges are required, and the UNKNOWN for each bridge is the amount of product (in moles or grams, as appropriate).

Example: Write the balanced chemical equation for the synthesis of aluminum oxide from aluminum and oxygen. If the reaction is conducted with 7.50 g aluminum and 7.00 g oxygen, what are the limiting and the excess reactants? How much aluminum oxide will be produced?

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)

=

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)

=

The reactant that forms the lesser amount of product is the _____ reactant (_____). The reactant that forms the greater amount of product is the _____ reactant (_____). In this example, the actual amount of product formed is _____.

PERCENT YIELD

Defined:

THEORETICAL YIELD (TY):

ACTUAL YIELD (AY):

Formula for Percent Yield: $\%\ \text{yield} = \frac{\text{AY}}{\text{TY}} \times 100$

Example: Balance the following equation. What type of chemical reaction is taking place? _____

$$\_\_\_\_\ Mg + \_\_\_\_\ HNO_3 \rightarrow \_\_\_\_\ Mg(NO_3)_2 + \_\_\_\_\ H_2$$

a. If the reaction begins with 40.0 grams magnesium and an excess of nitric acid, how many grams hydrogen will be produced?

UNKNOWN	GIVEN	g → mol (GIVEN)	MOLE RATIO	mol → g (UNKNOWN)

=

b. If 2.70 grams hydrogen is actually produced, what was the percent yield of hydrogen?

Practice Problem: Limiting Reactant and Percent Yield

Write the balanced chemical equation for the reaction of lead(II) nitrate with sodium iodide to form sodium nitrate and lead(II) iodide.

If the reaction starts with 25.0 grams of lead(II) nitrate and 25.0 grams of sodium iodide, how many grams of sodium nitrate will be produced?

a. What is the limiting reactant?
b. What is the excess reactant? How much of the excess reactant will be left over once the reaction stops?
c. If 8.37 grams of sodium nitrate is actually produced, what is the percent yield for sodium nitrate?