**HonorsChemistry - Unit 8: Chapter 11 – Stoichiometry**

**Stoich Quiz:** Wednesday, Dec. 5   **EQs/Problem Set Due:** Friday, Dec. 7 **Test Date:** Friday, Dec. 7

**VOCABULARY**

|  |  |  |
| --- | --- | --- |
| stoichiometry | percentage yield | mole ratio |
| mass-mass problem | limiting reagent | excess reagent |
|  |  |  |

**OBJECTIVES:**

* Be able to do stoichiometry problems (mass-mass problems).
* Be able to calculate the limiting reagent for a given chemical reaction.
* Be able to calculate percent yield.
* Be able to correctly use a mole ratio.
* Be able to write and balance chemical equations for use in stoichiometric problems.

**MOLES**

**“GIVEN”**

**MOLES**

**“WANTED”**

**PARTICLES**

**Given**

**PARTICLES**

**Wanted**

**MASS Wanted**

**MASS Given**

**VOLUME Given**

**VOLUME Wanted**

**Mole Ratio from Balanced Equation**

**Guided Notetaking – Stoichiometry**

* **Stoichiometry**Reaction Stoichiometry – mass relationships between reactants and products in a chemical rxn.
* **Mole Ratio**

Mole ratio is determined from a *balanced* equation!

**Example:** 2Al2O3 🡪 4Al + 3O2

mole ratios:

***Practice w/ mol to mol ratios***

***Example 1:***

* Given this equation N2 + 3H2 2 NH3, write the following molar ratios:
  1. N2 /H2
  2. N2 / NH3
  3. H2 / NH3

***Example 2:***

* Given the following equation: 8 H2 + S8 ---> 8 H2S, write the following molar ratios:

1. H2 / H2S
2. H2 / S8
3. H2S / S8

Predict the product of the following equations, balance the equations and record the mole ratios:

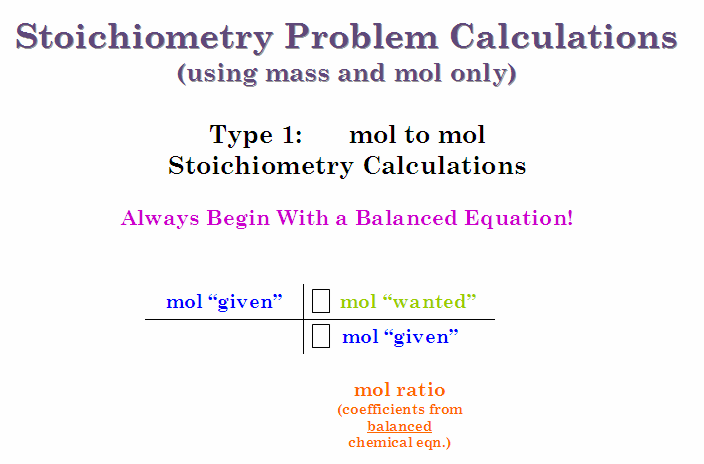
cobalt(II) carbonate →

zinc + hydrochloric acid →

sulfuric acid + sodium hydroxide →

* **Reaction Stoichiometry Problems - “Given” and “Unknown”**

***\*\*Type 1: mol to mol problems***

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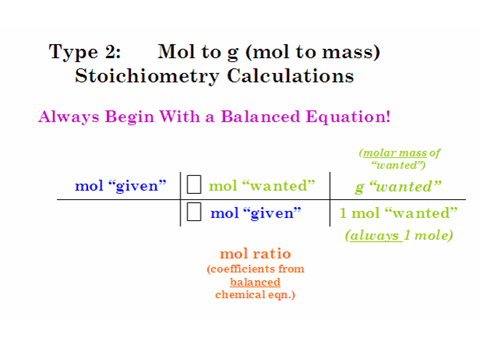
**Example:** Using the reaction, **2Al2O3  🡪 4Al + 3O2** how many mol of Al can be produced from 13 mol of aluminum oxide?

**You Try:**

**4 FeCr2O7 + 8 K2CO3 + 1 O2 🡪 2 Fe2O3 + 8 K2CrO4 + 8 CO2**

* How many moles of FeCr2O7 are required to produce 44 moles of CO2?
* How many moles of O2 are required to produce 107.9 moles of Fe2O3?
* If 309 moles of FeCr2O7 react, how many moles of O2 will be consumed?

\*\****Type 2: mol to g problems***



**2Al2O3  🡪 4Al + 3O2**

**Example:** Using the same reaction as above, how many g of O2 can be produced from 13 mol Al2O3?

**Example:**  Using the same rxn, how many g of Al will be produced at the same time as 3 mol O2?

**You Try:**

In a reaction between the elements aluminum and chlorine, aluminum chloride is produced.

**\_\_\_Al + \_\_\_Cl2 \_\_\_AlCl3**

* 2 moles of Al will react with \_\_\_\_\_\_ mole(s) of Cl2 to produce \_\_\_\_\_\_mole(s) of AlCl3.
* How many grams of AlCl3 will be produced if 2.50 moles of Al react?

***\*\*Type 3: g to mol problems***

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**2Al2O3  🡪 4Al + 3O2**

**Example:** Using the same rxn, how many mol of Al can be produced from 25g Al2O3?

**Example:** Using the same rxn, how many mol of Al2O3 will be needed to produce 25 g Al?

***You try:***

How many moles of salt can be formed from 12.0g of sodium reacting with Cl2?

Given: MgCl2 + 2 K 🡪2 KCl + Mg How many moles of KCl can be formed from 10 g of magnesium chloride?

***\*\*Type 4: g to g problems (aka mass to mass problems)***

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**2Al2O3  🡪 4Al + 3O2**

**Example:**  Using the same rxn, how many g of Al can be produced from 25g Al2O3?

**Example:**  Using the same rxn, how many g of Al2O3 will be needed to produce 25 g Al?

***You Try:***

Given: BaCl2 + 2 K 🡪2 KCl + Ba How many grams of barium can be formed from 10 g of potassium?

**Type 5** – molar volume of gas problems – similar to mass-mass

***Example:*** If 10.0 g of carbon reacts with oxygen at STP, what volume of carbon dioxide can be formed?

***You try:***

If 8.5 L of I2 are produced (at STP) in the following equation:

2 KI (aq) + Cl2 (g) 🡪2 KCl (aq) + I2 (g)

* how many grams of KI were used?

**Particle and Volume Stoichiometry**

Sometimes quantities of particles or volumes are used in stoichiometry. Remember that 1 mole is equal to 6.02 x 1023 representative particles and that 1 mole of any gas at STP (1 atm, 0°C) is equal to 22.4 L.

1 mol , 6.02 x 1023 particles, 1 mol , 22.4 L

6.02 x 1023 particles 1 mol 22.4 L 1 mol

Given in Particles Grams

Liters

1 mol

6.02 x 1023  ***or***

molar mass (g) ***or***

22.4 L

Coefficient of Unknown

Coefficient of Given

6.02 x 1023 ***or***

molar mass (g) ***or***

22.4 L

1 mol

**For example:** Given that 2 H2O (g) 🡪 2 H2 (g) + O2 (g), how many molecules of O2 will be produced if 2.65 x 1025 molecules of water decompose?

2.65 x 1023 molecules H2O 1 mol H2O 1 mol O2 6.02 x 1023 molecules O2 = 1.33 x 1023

6.02 x 1023 molecules 2 mol H2O 1 mol O2 molecules O2

How many liters of hydrogen would be produced if 6.0 liters of water reacted completely?

6.0 L H2O 1 mol H2O 2 mol H2 22.4 L H2 = 6.0 L H2

22.4 L 2 mol H2O 1 mol H2

**1) Na2CO3 (aq) + H2SO4 (aq)🡪 H2O (l)+ CO2 (g) + Na2SO4 (aq)**

1. If 18.0 g of water were produced, how many molecules of carbon dioxide gas were also produced? (6.01 x 1023 molecules)
2. If 2.31 moles of sodium carbonate reacted completely, how many molecules of water were produced? (1.39 x 1024 molecules)

**2) 2 Na + 2 H2O → 2 NaOH + H2**

If 3.45 x 1026 atoms of sodium reacted, how many molecules of hydrogen gas would be produced? (1.73 x 1026 molecules)

**3) P4 (s) + 5 O2 (g) 🡪 2 P2O5 (g).**

1. If 2.5 mole of oxygen reacted, how many molecules of diphosphorus pentoxide were produced?

(6.0 x 1023 molecules)

b. 3.65 g solid phosphorus (P4) reacted with excess oxygen gas, how many molecules of the product were produced? (3.55 x 1022 molecules)

**4) C10H8 (g) + 12 O2 (g ) → 10 CO2 (g ) + 4 H2O (g).**

If 6.00 moles of oxygen reacted, how many liters of carbon dioxide would be produced? (112 L)

* L**imiting Reagent (Reactant) – (LR)**
* Controls the amt. of product formed
* Completely consumed in the rxn.
* “runs out” first
* Example:   
  People on plane 🡪 300 people; 250 seats  
  \*\*Seats are the limiting factor\*\*

***Limiting Reagent Problems***

* Do mass – mass (g to g) calc. for all reactants.
* Whichever reactant produces the least is the Limiting Reagent (LR)

**Example:** If 5.0g of hydrogen reacts w/ 5.0g of oxygen to make water, which reactant is the LR? How much H2O is produced?

**You try:** Given: 2 Mg + O2 🡪 2 MgO

If you react 10 g of magnesium with 10 g of oxygen – what is the maximum amount of magnesium oxide that can be produced and what is the limiting reagent?

* **Excess Reactant (ER)**

To find the amount of excess reactant leftover after a rxn:

* Do two mass-mass (g to g) problems to find LR
* Use LR to calculate excess reactant used.
* Subtract excess reactant used from original amt. of excess reactant = leftover excess reactant

**ER Example:**

If 15.0g of salt (NaCl) reacts with 20.0g silver nitrate:

1. How much AgCl is formed?

b) What is the limiting reagent?

c) How much of the excess reagent is left over?

If 13.0g of KOH reacts with 17.0g of Al(NO3)3:  
 a) How much KNO3 is produced?

b) What is the limiting reagent?

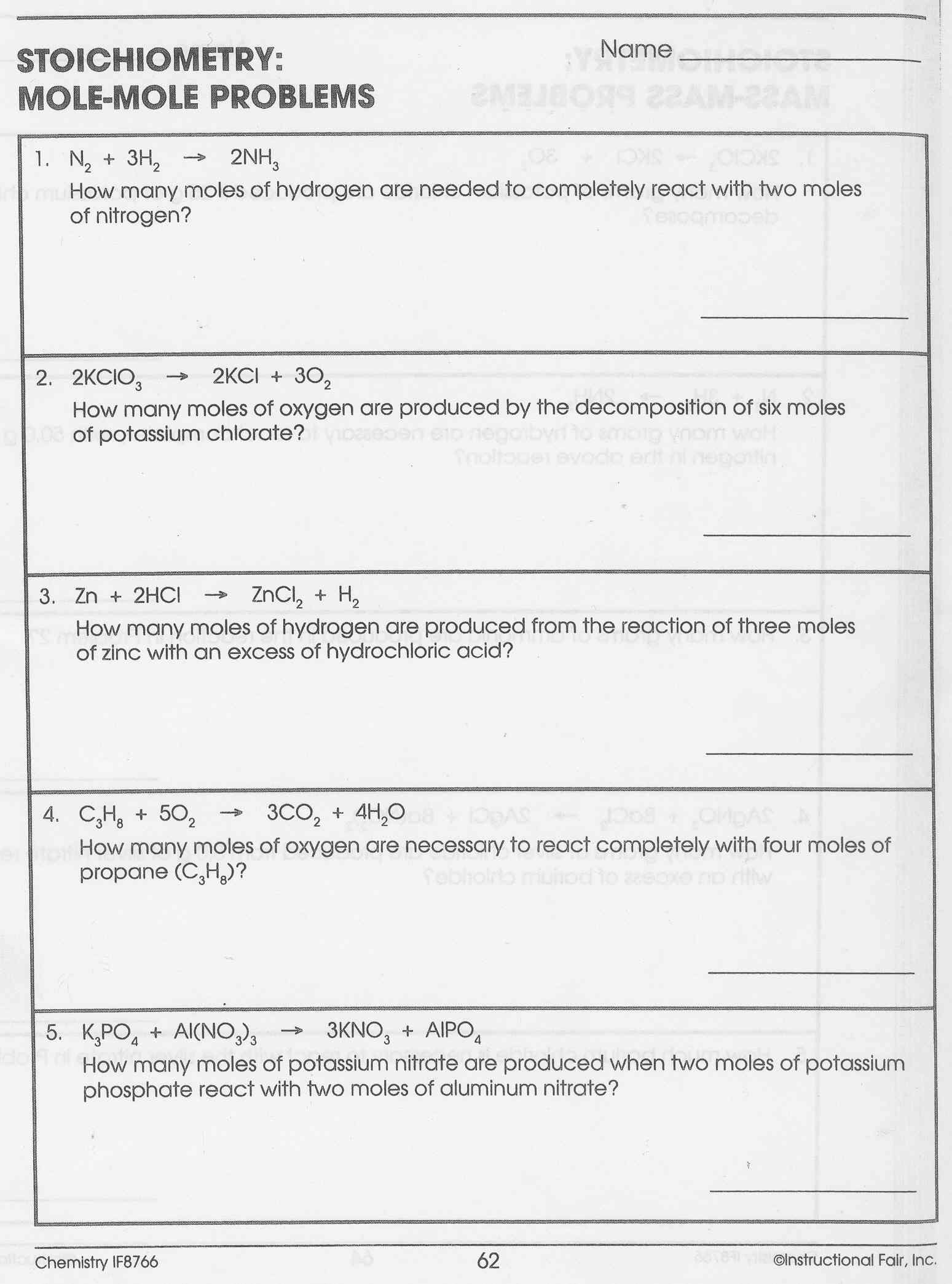
c) How much of the excess reactant is left over?

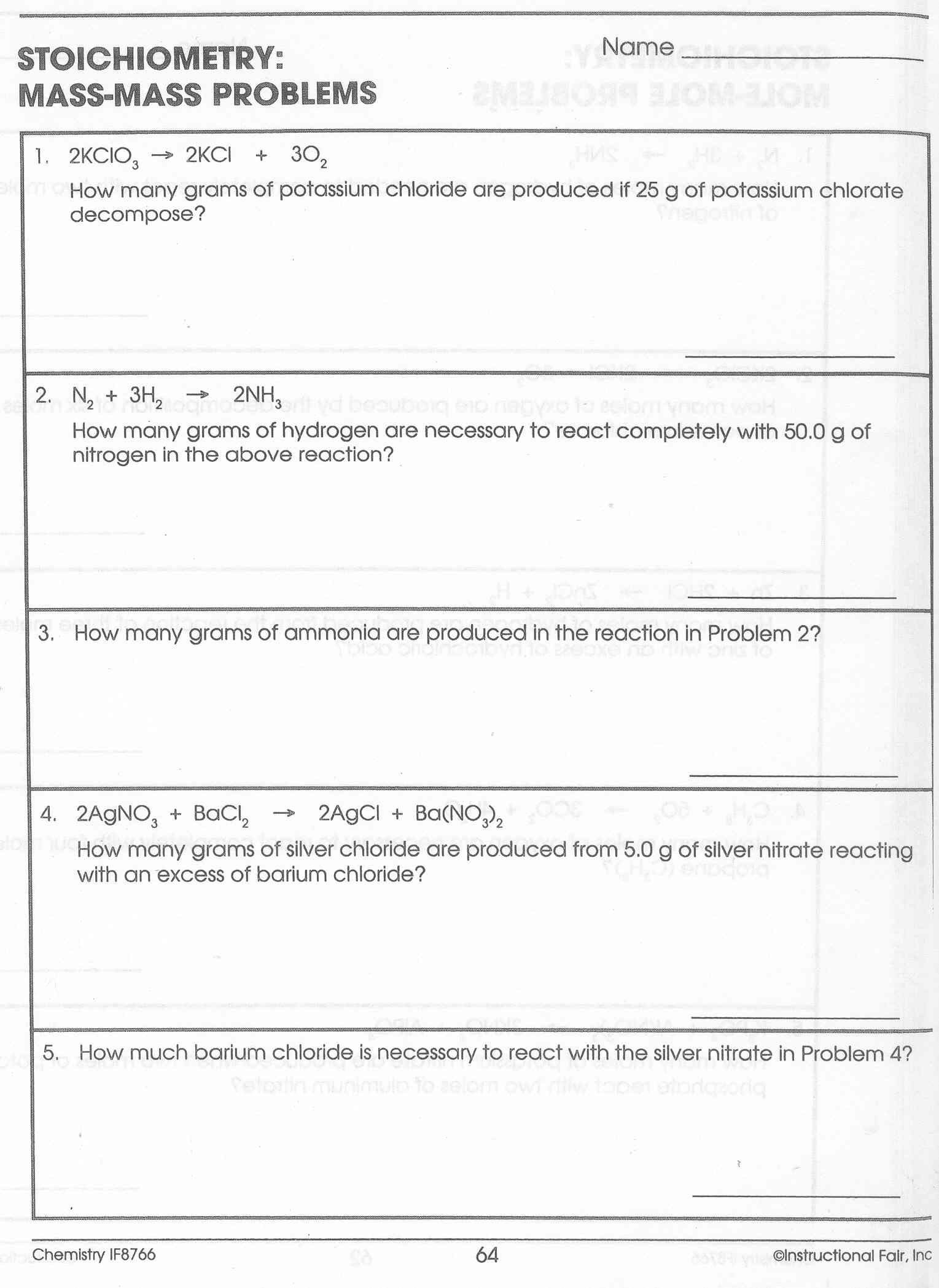
* **Percent Yield**
* % yield = actual yield X 100%  
   theoretical yield
* theoretical yield:
  + maximum amt. of product
  + from mass-mass (g to g) problem
* actual yield:
  + actual amt. of product
  + from lab result; or given in a problem

**Example:** In lab you complete an experiment that produces 25 g of NaCl – you should have produced 29 g of salt – what is your percent yield?

**You try:** Given: 2 Al + 3CuSO4 🡪 Al2(SO4)3 + 3 Cu If you produce3.70 g of Cu but you should have produced 3.55 g - what is the percent yield?

**Example # 2:** CO + 2H2 🡪 CH3OHIf 75.0g of CO reacts to produce 68.4g of CH3OH, what is the % yield?





**Stoichiometry Worksheet #1**

**Perform the following calculations. Be sure to use proper units!**

Answer the following **g 🡪 mol** and/or **mol 🡪 g** conversion problems.

1. How many g in 7.00 mol of N2? \_\_\_\_\_\_\_
2. How many g in 0.455 mol of NaCl? \_\_\_\_\_\_\_
3. How many mol in 23.0 g of CaCO3? \_\_\_\_\_\_\_

**Answer questions 4-9 given the following equation.**

2AgNO3(aq) + Na2CO3(aq) 🡪 Ag2CO3(s) + 2NaNO3(aq)?

1. What is the ratio of mol of AgNO3 to mol of Ag2CO3? \_\_\_\_\_\_\_\_
2. What is the ratio of mol of Na2CO3 to mol of NaNO3? \_\_\_\_\_\_\_\_
3. What is the ratio of mol of AgNO3 to mol of Na2CO3? \_\_\_\_\_\_\_
4. How many mol of Na2CO3 are required to produce 2.00 Mol of Ag2CO3? \_\_\_\_\_\_\_
5. How many mol of Ag2CO3 are produced from 3.00 mol of AgNO3? \_\_\_\_\_\_\_
6. How many g of Na2CO3 are required to produce 1 mol of Ag2CO3? \_\_\_\_\_\_\_

**Answer questions 10-13 given the following equation.**

3BaCl2(aq) + 2H3PO4(aq) 🡪 Ba3(PO4)2(s) + 6HCl(aq)

1. What is the mol ratio between BaCl2 and Ba3(PO4)2? \_\_\_\_\_\_\_
2. Given 10.0 g of BaCl2, how many g of Ba3(PO4)2 will be produced? \_\_\_\_\_\_\_

**Remember: g 🡨🡪 mol 🡨🡪 mol 🡨🡪 g**

1. Given 10.0 g of BaCl2, how any g of HCl will be produced? \_\_\_\_\_\_\_\_

13. How many g of BaCl2 is required to produce 20.0g of HCl? \_\_\_\_\_\_\_

**Stoichiometry Worksheet #2**

**Perform the following calculations. Be sure to use proper units!**

Write the equation for the reaction in chemical symbols when necessary, then answer the following mass-mass problems.

1. (a) Write the equation for the synthesis of carbonic acid from water and carbon dioxide.

(b) Given 15.0 g of water and an excess of carbon dioxide, how much carbonic acid would be produced?

2.(a) Write the decomposition reaction for sodium chloride.

1. How many g of sodium chloride will produce 19.0 g of sodium?

1. How many g of chlorine will be produced from the conditions in (b)?

3. Given this equation: Al(NO3)3(aq) + 3NaOH(aq) 🡪 Al(OH)3(s) + 3NaNO3(aq)

(a) If 15.0 g of aluminum nitrate reacts completely with sodium hydroxide, what would be the resulting mass of aluminum hydroxide?

(b) Would be the resulting mass of sodium nitrate under the same conditions?

(c) How many g of sodium hydroxide would be needed to form 13.0 g of aluminum hydroxide?

# 4. Given 10.0 g of BaCl2 and 10.0 g of H3PO4- how any g of HCl will be produced? \_\_\_\_\_\_\_\_

# What is the limiting reagent:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# 

# 

# 5. In lab you start with 45.7 L of sulfur dioxide gas and produce 155 g of sulfurous acid. How much sulfurous acid should be produced and what is your percent yield?

# SO2 + H2O 🡪 H2SO3

# Mass of H2SO3 that should be produced:\_\_\_\_\_\_\_\_\_\_\_ % yield:\_\_\_\_\_\_\_\_\_\_\_

# **STOICHIOMETRY PRACTICE – Work problems on a separate piece of paper.**

**Remember: You must have correct, balanced equations to work these problems!!**

1. In the synthesis reaction of iron (II) with sulfur, what mass of iron is needed to react completely with 32.0 g of sulfur?
2. **Given:** Zn + 2 HBr 🡪 ZnBr2 + H2 ; What mass of zinc bromide can be produced from 25.0 g of hydrobromic acid ?
3. Silver bromide can be precipitated by the reaction of silver nitrate with sodium bromide. What weight of precipitate can be produced starting with 34.3 g of sodium bromide?
4. Hydrochloric acid is added to 50.0 g of iron (II) sulfide. What mass of hydrogen sulfide is produced?
5. Given the Haber process: N2 + 3 H2 🡪 2NH3

If 3.41 g of hydrogen reacts with 2.2 g of nitrogen – what is the limiting reagent? How much ammonia is produced?

1. When 25 g of calcium reacts with 25 g of chlorine, how much calcium chloride is produced?

7. In lab, you start with 128 g of sulfur dioxide to produce 150 g of sulfurous acid. How much sulfurous acid should be produced and what is your percent yield?

SO2 + H2O 🡪 H2SO3

8. In the synthesis reaction of potassium with sulfur, what mass of potassium is needed to react completely with 32.0 g of sulfur? 2 K + S 🡪 K2S

# **Review Sheet Unit 6 - Stoichiometry**

1. Write a balanced equation for the reaction of aluminum nitrate with sodium hydroxide. What type of rxn is this?

2. How many g of sodium hydroxide would be needed to from 13.0 g of Al(OH)3?

3. How many mol of aluminum hydroxide would be formed from 15.0 g of Al(NO3)3?

1. For the decomposition of mercury (II) oxide how many g of O2 are formed from 10 mol of HgO?
2. Given: C7H6O3 + CH3OH 🡪 C8H8O3 + H2O A chemist starts with 1.75 g of C7H6O3 and produces 1.42 g of C8H8O3 – what is her percent yield?
3. Suppose a solution containing 3.50 g of sodium phosphate is mixed with a solution containing 6.40 g of barium nitrate. How many grams of barium phosphate can be formed?

**Answers:**

1. Al(NO3)3 + 3 NaOH 🡪 Al(OH)3 + 3 NaNO3 Double displacement

2. 20.0 g NaOH 3. 0.0704 mol Al(OH)3 4. 160 g O2 5. 73.6% 6. 4.92 g

**PROBLEM SET Unit 8 – Stoichiometry:**

**Review:**

1. Write balanced equations for the following reactions:
2. Sodium oxide is added to water.
3. A solution of lead (II) chloride is added to a solution of iron (III) sulfate
4. Chlorine gas is bubbled into a solution of potassium iodide.
5. C3H7 is burned in oxygen
6. What is the molarity of 35 g of iron (II) acetate dissolved in enough water to make 250 ml of solution?

**Current Unit Material**

1. Suppose a solution containing 3.50 g of sodium phosphate is mixed with a solution containing 6.40 g of barium nitrate. How many grams of barium phosphate can be produced?
2. Octane, C8H18, is a component of gasoline.
3. Write the balanced equation for the complete combustion of octane.
4. How many grams of O2 are needed to burn 5.00 g of octane?
5. Octane has a density of 0.692 g/ml at 20 C. How many g of O2 are required to burn 2.00 L of octane?
6. One of the steps in the commercial process for converting ammonia to nitric acid involves the conversion of NH3 to NO:

**4 NH3 + 5 O2 🡪 4 NO + 6 H2O**

1. How many grams of NO form when 3.50 g of NH3 reacts with 2.85 g of O2?
2. Which reactant is the limiting reactant and which is the excess reactant?
3. How much of the excess reactant remains after the limiting reactant is completely consumed?