

Honors Chemistry - Unit 6 Chapter 9 – Stoichiometry**Vocab Assignment Due:** Tuesday, Dec. 2nd**Problem Set Due:** Thursday, Dec. 9th**Test Date:** Friday, Dec. 10th**VOCABULARY Assignment:**

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.

Unit 6 PROBLEM SET – Stoichiometry:**Review Questions:**

1. Write balanced equations for the following reactions:
 - A. Sodium metal is added to water.
 - B. A solution of lead (II) chloride is added to a solution of iron (III) sulfate
 - C. Chlorine gas is bubbled into a solution of potassium iodide.
 - D. C_3H_7 is burned in oxygen
2. What is the molarity of 35 g of iron(II) acetate dissolved in enough water to make 250 ml of solution?

Current Unit Material

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 produced?
4. Octane, C_8H_{18} , is a component of gasoline.
 - A. Write the balanced equation for the complete combustion of octane.
 - B. How many grams of O_2 are needed to burn 5.00 g of octane?
 - C. Octane has a density of 0.692 g/ml at 20°C. How many g of O_2 are required to burn 2.00 L of octane?
5. One of the steps in the commercial process for converting ammonia to nitric acid involves the conversion of NH_3 to NO :

$$4 NH_3 + 5 O_2 \rightarrow 4 NO + 6 H_2O$$
 - A. How many grams of NO form when 3.50 g of NH_3 reacts with 2.85 g of O_2 ?
 - B. Which reactant is the limiting reactant and which is the excess reactant?
 - C. How much of the excess reactant remains after the limiting reactant is completely consumed?

Guided Notetaking – Stoichiometry**Stoichiometry**

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

Mole RatioMole ratio is determined from a *balanced* equation!

mole ratios:

Practice w/ mol to mol ratios Pg. 277, #3

- Reaction Stoichiometry Problems - “Given” and an “Unknown”
- **Type 1: mol to mol problems**

Stoichiometry Problem Calculations

(using mass and mol only)

**Type 1: mol to mol
Stoichiometry Calculations**

Always Begin With a Balanced Equation!

mol “given”	<input type="checkbox"/>	mol “wanted”
	<input type="checkbox"/>	mol “given”

mole ratio
(coefficients from
balanced
chemical eqn.)

Example: Using the previous rxn, how many mol of Al can be produced from 13 mol of aluminum oxide?

Practice w/ mol to mol problems - Pg. 296 - In-class Problems 10a, 11a

****Type 2: mol to g problems****Type 2: Mol to g (mol to mass)
Stoichiometry Calculations****Always Begin With a Balanced Equation!**

mol "given"	<input type="checkbox"/>	mol "wanted"	<input type="checkbox"/>	<i>(molar mass of "wanted")</i>
<input type="checkbox"/>	mol "given"	1 mol "wanted"	<input type="checkbox"/>	<i>(always 1 mole)</i>
mol ratio <i>(coefficients from balanced chemical eqn.)</i>				

Example: Using the same rxn, 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 - Textbook, p. 287 2a, b*****Type 3: g to mol problems****Type 3: g to Mol (mass to mol)
Stoichiometry Calculations****Always Begin With a Balanced Equation!**

<input type="checkbox"/>	g "given"	1 mol "given"	<input type="checkbox"/>	mol "wanted"
<input type="checkbox"/>	g "given"	1 mol "given"	<input type="checkbox"/>	mol "given"
mol ratio <i>(coefficients from balanced chemical eqn.)</i>				

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?*

****Type 4: g to g problems (aka mass to mass problems)****Type 4: g to g (mass to mass)
Stoichiometry Calculations****Always Begin With a Balanced Equation!**

g "given"	1 mol "given"	<input type="checkbox"/> mol "wanted"	g "wanted"
<small>(<i>always 1 mole</i>)</small>	<small>(<i>molar mass of "wanted"</i>)</small>	<small>(<i>molar mass of "given"</i>)</small>	<small>(<i>always 1 mole</i>)</small>
g "given"	<input type="checkbox"/> mol "given"	<input type="checkbox"/> mol "wanted"	g "wanted"
<small>(<i>molar mass of "given"</i>)</small>	<small>(<i>coefficients from balanced chemical eqn.</i>)</small>	<small>(<i>coefficients from balanced chemical eqn.</i>)</small>	<small>(<i>molar mass of "wanted"</i>)</small>

Example: Using the same rxn, how many g of Al can be produced from 25g Al_2O_3 ?**Example:** Using the same rxn, how many g of Al_2O_3 will be needed to produce 25 g Al?You Try: Textbook, p. 287, #4**Limiting 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 H_2O is produced?Practice - pg. 297 #26 a-c:**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:

- How much AgCl is formed?
- What is the limiting reagent?
- How much of the excess reagent is left over?

Practice - p. 297, 26b

If 13.0g of KOH reacts with 17.0g of $\text{Al}(\text{NO}_3)_3$:

- How much KNO_3 is produced?
- What is the limiting reagent?
- How much of the excess reactant is left over?

Percent Yield

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

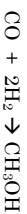
theoretical yield:

- 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:



If 75.0g of CO reacts to produce 68.4g of CH_3OH , what is the % yield?

Practice - pg. 297 #26 a,c, pg. 297 #28, 31

Stoichiometry - Mole to Mole Problems

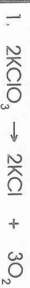
1. $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
How many moles of hydrogen are needed to completely react with two moles of nitrogen?

2. $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$
How many moles of oxygen are produced by the decomposition of six moles of potassium chlorate?

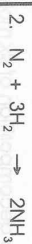
3. $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$
How many moles of hydrogen are produced from the reaction of three moles of zinc with an excess of hydrochloric acid?

4. $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$
How many moles of oxygen are necessary to react completely with four moles of propane (C_3H_8)?

5. $\text{K}_3\text{PO}_4 + \text{Al}(\text{NO}_3)_3 \rightarrow 3\text{KNO}_3 + \text{AlPO}_4$
How many moles of potassium nitrate are produced when two moles of potassium phosphate react with two moles of aluminum nitrate?

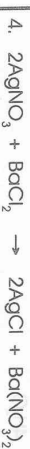


How many grams of potassium chloride are produced if 25 g of potassium chlorate decompose?



How many grams of hydrogen are necessary to react completely with 50.0 g of nitrogen in the above reaction?

3. How many grams of ammonia are produced in the reaction in Problem 2?



How many grams of silver chloride are produced from 5.0 g of silver nitrate reacting with an excess of barium chloride?

5. How much barium chloride is necessary to react with the silver nitrate in Problem 4?

Stoichiometry Worksheet #1
Perform the following calculations. Be sure to use proper units!

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

- How many g in 7.00 mol of N_2 ? _____
- How many g in 0.455 mol of NaCl ? _____
- How many mol in 23.0 g of CaCO_3 ? _____

Answer questions 4-9 given the following equation.



- What is the ratio of mol of AgNO_3 to mol of Ag_2CO_3 ? _____
- What is the ratio of mol of Na_2CO_3 to mol of NaNO_3 ? _____
- What is the ratio of mol of AgNO_3 to mol of Na_2CO_3 ? _____
- How many mol of Na_2CO_3 are required to produce 2.00 Mol of Ag_2CO_3 ? _____

8. How many mol of Ag_2CO_3 are produced from 3.00 mol of AgNO_3 ? _____

9. How many g of Na_2CO_3 are required to produce 1 mol of Ag_2CO_3 ? _____

Answer questions 10-13 given the following equation.



- What is the mol ratio between BaCl_2 and $\text{Ba}_3(\text{PO}_4)_2$? _____
- Given 10.0 g of BaCl_2 , how many g of $\text{Ba}_3(\text{PO}_4)_2$ will be produced? _____
Remember: g ← **→ mol** ← **→ mol** ← **→ g**
- Given 10.0 g of BaCl_2 , how any g of HCl will be produced? _____
- How many g of BaCl_2 is required to produce 20.0g of HCl ? _____

Stoichiometry Worksheet #2
Perform the following calculations. Be sure to use proper units!

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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.
(b) How many g of sodium chloride will produce 19.0 g of sodium?
(c) How many g of chlorine will be produced from the conditions in (b)?
3. Given this equation: $\text{Al}(\text{NO}_3)_3(\text{aq}) + 3\text{NaOH}(\text{aq}) \rightarrow \text{Al}(\text{OH})_3(\text{s}) + 3\text{NaNO}_3(\text{aq})$
(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?

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

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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: $\text{Zn} + 2\text{HBr} \rightarrow \text{ZnBr}_2 + \text{H}_2$: 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: $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
If 3.41 g of hydrogen reacts with 2.2 g of nitrogen – what is the limiting reagent? How much ammonia is produced?
6. 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?
 $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$

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 form 13.0 g of $\text{Al}(\text{OH})_3$?
3. How many mol of aluminum hydroxide would be formed from 15.0 g of $\text{Al}(\text{NO}_3)_3$?
4. For the decomposition of mercury (II) oxide how many g of O_2 are formed from 10 mol of HgO ?
5. Given: $\text{C}_7\text{H}_6\text{O}_3 + \text{CH}_3\text{OH} \rightarrow \text{C}_8\text{H}_6\text{O}_3 + \text{H}_2\text{O}$ A chemist starts with 1.75 g of $\text{C}_7\text{H}_6\text{O}_3$ and produces 1.42 g of $\text{C}_8\text{H}_6\text{O}_3$ – what is her percent yield?
6. 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. $\text{Al}(\text{NO}_3)_3 + 3\text{NaOH} \rightarrow \text{Al}(\text{OH})_3 + 3\text{NaNO}_3$ Double displacement
2. 20.0 g NaOH
3. 0.0704 mol $\text{Al}(\text{OH})_3$
4. 160 g O_2
5. 73.6%
6. 4.92 g