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CHAPTER 11 STUDY GUIDE

Stoichiometry

Section 11.1 What is stoichiometry?

In your textbook, read about stoichiometry and the balanced equation.

For each statement below, write *true* or *false*.

_____ **1.** The study of the quantitative relationships between the amounts of reactants used and the amounts of products formed by a chemical reaction is called stoichiometry.

_____ **2.** Stoichiometry is based on the law of conservation of mass.

_____ **3.** In any chemical reaction, the mass of the products is less than the mass of the reactants.

_____ **4.** The coefficients in a chemical equation represent not only the number of individual particles but also the number of moles of particles.

_____ **5.** The mass of each reactant and product is related to its coefficient in the balanced chemical equation for the reaction by its molar mass.

Complete the table below, using information represented in the chemical equation for the combustion of methanol, an alcohol.

$$\text{methanol} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}$$

$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$$

Substance	Molar Mass (g/mol)	Number of Molecules	Number of Moles (mol)	Mass (g)
6. Methanol	32.05			
7. Oxygen gas	32.00			
8. Carbon dioxide	44.01			
9. Water	18.02			

10. What are the reactants? _____

11. What are the products? _____

12. What is the total mass of the reactants? _____

13. What is the total mass of the products? _____

14. How do the total masses of the reactants and products compare? _____

Section 11.1 *continued*

In your textbook, read about mole ratios.

Answer the questions about the following chemical reaction.

$$\text{sodium} + \text{iron(III) oxide} \rightarrow \text{sodium oxide} + \text{iron}$$

$$6Na(s) + Fe_2O_3(s) \rightarrow 3Na_2O(s) + 2Fe(s)$$

15. What is a mole ratio?

_____

_____

16. How is a mole ratio written?

_____

_____

_____

_____

17. Predict the number of mole ratios for this reaction. _____

18. What are the mole ratios for this reaction?

19. What is the mole ratio relating sodium to iron? _____

20. What is the mole ratio relating iron to sodium? _____

21. Which mole ratio has the largest value? _____

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Section 11.2 Stoichiometric Calculations

In your textbook, read about mole-to-mole conversion.

Read the following passage and then solve the problems. In the equation that follows each problem, write in the space provided the mole ratio that can be used to solve the problem. Complete the equation by writing the correct value on the line provided.

The reaction of sodium peroxide and water produces sodium hydroxide and oxygen gas. The following balanced chemical equation represents the reaction.

$$2Na_2O_2(s) + 2H_2O(l) \longrightarrow 4NaOH(s) + O_2(g)$$

1. How many moles of sodium hydroxide are produced when 1.00 mol sodium peroxide reacts with water?

1.00 mol Na_2O_2 × _____ = _____ mol NaOH

2. How many moles of oxygen gas are produced when 0.500 mol Na_2O_2 reacts with water?

0.500 mol Na_2O_2 × _____ = _____ mol O_2

3. How many moles of sodium peroxide are needed to produce 1.00 mol sodium hydroxide?

1.00 mol NaOH × _____ = _____ mol Na_2O_2

4. How many moles of water are required to produce 2.15 mol oxygen gas in this reaction?

2.15 mol O_2 × _____ = _____ mol H_2O

5. How many moles of water are needed for 0.100 mol of sodium peroxide to react completely in this reaction?

0.100 mol Na_2O_2 × _____ = _____ mol H_2O

6. How many moles of oxygen are produced if the reaction produces 0.600 mol sodium hydroxide?

0.600 mol NaOH × _____ = _____ mol O_2

Section 11.2 *continued*

In your textbook, read about mole-to-mass and mass-to-mass conversions.

Solving a mass-to-mass problem requires the four steps listed below. The equations in the boxes show how the four steps are used to solve an example problem. After you have studied the example, solve the problems below, using the four steps.

Example problem: How many grams of carbon dioxide are produced when 20.0 g acetylene (C_2H_2) is burned?

	Solution
Step 1 Write a balanced chemical equation for the reaction.	$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$
Step 2 Determine the number of moles of the known substance, using mass-to-mole conversion.	$20.0\ \text{g}\ C_2H_2 \times \frac{1\ \text{mol}\ C_2H_2}{26.04\ \text{g}\ C_2H_2} = 0.768\ \text{mol}\ C_2H_2$
Step 3 Determine the number of moles of the unknown substance, using mole-to-mole conversion.	$0.768\ \text{mol}\ C_2H_2 \times \frac{4\ \text{mol}\ CO_2}{2\ \text{mol}\ C_2H_2} = 1.54\ \text{mol}\ CO_2$
Step 4 Determine the mass of the unknown substance, using mole-to-mass conversion.	$1.54\ \text{mol}\ CO_2 \times \frac{44.01\ \text{g}\ CO_2}{1\ \text{mol}\ CO_2} = 67.8\ \text{g}\ CO_2$

7. In some mole-to-mass conversions, the number of moles of the known substance is given. In those conversions, which step of the above solution is not necessary? _____

8. In a blast furnace, iron and carbon monoxide are produced from the reaction of iron(III) oxide (Fe_2O_3) and carbon. How many grams of iron are formed when 150 g iron(III) oxide reacts with an excess of carbon?

9. Solid sulfur tetrafluoride (SF_4) and water react to form sulfur dioxide and an aqueous solution of hydrogen fluoride. How many grams of water are necessary for 20.0 g sulfur tetrafluoride to react completely?

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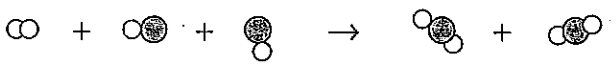
Section 11.3 Limiting Reactants

In your textbook, read about why reactions stop and how to determine the limiting reactant.

Study the diagram showing a chemical reaction and the chemical equation that represents the reaction. Then complete the table. Show your calculations for questions 25–27 in the space below the table.



$$O_2 + 2NO \rightarrow 2NO_2$$

The molar masses of O_2, NO, and NO_2 are 32.00 g/mol, 30.01 g/mol, and 46.01 g/mol, respectively.

Amount of O_2	Amount of NO	Amount of NO_2	Limiting Reactant	Amount and Name of Excess Reactant
1 molecule	2 molecules	2 molecules	none	none
4 molecules	4 molecules	4 molecules	NO	2 molecules O_2
2 molecules	8 molecules	**1.**	**2.**	**3.**
1.00 mol	2.00 mol	**4.**	**5.**	**6.**
4.00 mol	4.00 mol	**7.**	**8.**	**9.**
5.00 mol	7.00 mol	**10.**	**11.**	**12.**
1.00 mol	4.00 mol	**13.**	**14.**	**15.**
0.500 mol	0.200 mol	**16.**	**17.**	**18.**
32.00 g	60.02 g	**19.**	**20.**	**21.**
16.00 g	80.00 g	**22.**	**23.**	**24.**
10.00 g	20.00 g	**25.**	**26.**	**27.**

Section 11.4 Percent Yield

In your textbook, read about the yields of products.

Study the diagram and the example problem.

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

mass of product from experimental measurement

mass of product predicted from stoichiometric calculation using
a. mass of reactant
b. 4-step mass-to-mass conversion
1. Write the balanced chemical equation.
2. Calculate the number of moles of reactant, using molar mass.
3. Calculate the number of moles of product, using the appropriate mole ratio.
4. Calculate the mass of product, using the reciprocal of molar mass.

Example Problem: The following chemical equation represents the production of gallium oxide, a substance used in the manufacturing of some semiconductor devices.

$$4Ga(s) + 3O_2(g) \rightarrow 2Ga_2O_3(s)$$

In one experiment, the reaction yielded 7.42 g of the oxide from a 7.00-g sample of gallium. Determine the percent yield of this reaction. The molar masses of Ga and Ga_2O_3 are 69.72 g/mol and 187.44 g/mol, respectively.

Use the information in the diagram and example problem to evaluate each value or expression below. If the value or expression is correct, write *correct*. If it is incorrect, write the correct value or expression.

1. actual yield: unknown _____

2. mass of reactant: 7.00 g Ga _____

3. number of moles of reactant: $7.00 \text{ g Ga} \times \frac{69.72 \text{ g Ga}}{1 \text{ mol Ga}}$ _____

4. number of moles of product: $0.100 \text{ mol Ga} \times \frac{2 \text{ mol } Ga_2O_3}{1 \text{ mol Ga}}$ _____

5. theoretical yield: $0.0500 \text{ mol } Ga_2O_3 \times \frac{187.44 \text{ g } Ga_2O_3}{1 \text{ mol } Ga_2O_3}$ _____

6. percent yield: $\frac{9.37 \text{ g } Ga_2O_3}{7.42 \text{ g } Ga_2O_3} \times 100$ _____

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Stoichiometry and Molar Volume Worksheet

1) For the reaction $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$, how many grams of potassium chloride can be produced from 150 g of potassium bromide?

2) For the reaction $2Na + 2H_2O \rightarrow 2NaOH + H_2$, how many grams of hydrogen are produced by 40 g of water?

3) For the reaction $2Na + Cl_2 \rightarrow 2NaCl$, how many grams of sodium chloride can be produced from 250 g of chlorine gas?

4) For the reaction $SO_3 + H_2O \rightarrow H_2SO_4$, how many grams of sulfuric acid can be produced from 100.0 g of sulfur trioxide?

5) For the reaction $2Zn + O_2 \rightarrow 2ZnO$, how many grams of zinc oxide can be produced from 50 g of zinc?

Chapter 12 WS

Gas Stoichiometry

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Solve each of the following sets of problems. Make sure to show ALL work and write your answers in the space on the right. All reactions are at STP.

1) Combustion of Propane that burns 8.75 L of propane.

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

a. Volume of O_2 that reacts _____

b. Volume of CO_2 produced _____

c. Volume of H_2O produced _____

2) Combustion of Acetylene that produces 0.775 mol of carbon dioxide.

$$2C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(g)}$$

a. Volume of CO_2 produced _____

b. Volume of O_2 that reacts _____

c. Moles of C_2H_2 that react _____

d. Mass of H_2O produced _____