Name_____ Date_____ Class_____

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.

methanol + oxygen → carbon dioxide + 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.

sodium + iron(III) oxide → sodium oxide + 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? _____

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.

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

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
$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$
$20.0\ \cancel{g\ C_2H_2} \times \frac{1\ mol\ C_2H_2}{26.04\ \cancel{g\ C_2H_2}}$ $= 0.768\ mol\ C_2H_2$
$0.768\ \cancel{mol\ C_2H_2} \times \frac{4\ mol\ CO_2}{2\ \cancel{mol\ C_2H_2}}$ $= 1.54\ mol\ CO_2$
$1.54\ \cancel{mol\ CO_2} \times \frac{44.01\ g\ CO_2}{1\ \cancel{mol\ CO_2}}$ $= 67.8\ g\ CO_2$

Step 1 Write a balanced chemical equation for the reaction.

Step 2 Determine the number of moles of the known substance, using mass-to-mole conversion.

Step 3 Determine the number of moles of the unknown substance, using mole-to-mole conversion.

Step 4 Determine the mass of the unknown substance, using mole-to-mass conversion.

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?

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.

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

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: $\frac{9.37 \text{ g } Ga_2O_3}{7.42 \text{ g } Ga_2O_3} \times 100$ _____

Study Guide - Chapter 11 – Stoichiometry

Section 11.1 What is stoichiometry?

1. true
2. true
3. false
4. true
5. true
6. 2, 2, 64.10
7. 3, 3, 96.00
8. 2, 2, 88.02
9. 4, 4, 72.08
10. methanol and oxygen gas
11. carbon dioxide and water
12. 160.10 g
13. 160.10 g
14. They are equal.
15. A mole ratio is a ratio between the numbers of moles of any two substances in a balanced chemical equation.
16. A mole ratio is written for two substances in a balanced chemical equation as a fraction by placing the number of moles of one substance in the numerator and the number of moles of another substance in the denominator.
17. 12
18.

1 mol Fe_2O_3/6 mol Na	3 mol Na_2O/6 mol Na	2 mol Fe/6 mol Na
6 mol Na/1 mol Fe_2O_3	3 mol Na_2O/1 mol Fe_2O_3	2 mol Fe/1 mol Fe_2O_3
6 mol Na/3 mol Na_2O	1 mol Fe_2O_3/3 mol Na_2O	2 mol Fe/3 mol Na_2O
6 mol Na/2 mol Fe	1 mol Fe_2O_3/2 mol Fe	3 mol Na_2O/2 mol Fe

19. 6 mol Na/2 mol Fe
20. 2 mol Fe/6 mol Na
21. 6 mol Na/1 mol Fe_2O_3

Section 11.2 Stoichiometric Calculations

1. 4 mol NaOH/2 mol Na_2O_2, 2.00
2. 1 mol O_2/2 mol Na_2O_2, .250
3. 2 mol Na_2O_2/4 mol NaOH, 0.500
4. 2 mol H_2O/1 mol O_2, 4.30
5. 2 mol H_2O/2 mol Na_2O_2, 0.100
6. 1 mol O_2/4 mol NaOH, 0.150
7. Step 2
8. $Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(s) + 3CO(g)$

   150 ~~g Fe_2O_3~~ × 1 mol Fe_2O_3/159.7 ~~g Fe_2O_3~~ = 0.939 mol Fe_2O_3

   0.939 ~~mol Fe_2O_3~~ × 2 mol Fe/1 ~~mol Fe_2O_3~~ = 1.88 mol Fe

   1.88 ~~mol Fe~~ 55.85 g Fe/1 ~~mol Fe~~ = 105 g Fe
9. $SF_4(s) + 2H_2O(l) \rightarrow SO_2(g) + 4HF(aq)$

   20.0 ~~g~~ ~~SF_4~~ × 1 mol SF_4/108.07 ~~g~~ ~~SF_4~~ = 0.185 mol SF_4

   0.185 ~~mol SF_4~~ × 2 mol H_2O/1 ~~mol SF_4~~ = 0.370 mol H_2O

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. 4 molecules**	**2. O_2**	**3. 4 molecules NO**
1.00 mol	2.00 mol	**4. 2.00 mol**	**5. none**	**6. none**
4.00 mol	4.00 mol	**7. 4.00 mol**	**8. NO**	**9. 2.00 mol O_2**
5.00 mol	7.00 mol	**10. 7.00 mol**	**11. NO**	**12. 1.50 mol O_2**
1.00 mol	4.00 mol	**13. 2.00 mol**	**14. O_2**	**15. 2.00 mol NO**
0.500 mol	0.200 mol	**16. 0.200 mol**	**17. NO**	**18. 0.400 mol O_2**
32.00 g	60.02 g	**19. 92.02 g**	**20. none**	**21. none**
16.00 g	80.00 g	**22. 46.01g**	**23. O_2**	**24. 50.12 g NO**
10.00 g	20.00 g	**25. 28.76 g**	**26. O_2**	**27. 1.24 g NO**

0.370 ~~mol H_2O~~ ×18.02 g H_2O/1 ~~mol H_2O~~ = 6.67 g H_2O

balanced equation mole ratio = 2 mol NO/1 mol O_2

10.00 ~~g O_2~~ ×1 mol O_2/32.00 ~~g O_2~~ = 0.3125 mol O_2

20.00 ~~g NO~~ ×1 mol NO/30.01 = 0.6664 mol NO

actual mole ratio = 0.6664 mol NO/0.3125 mol O_2 = 2.132 mol NO/1.000 mol O_2

Because the actual mole ratio of NO:O_2 is larger than the balanced equation mole ratio of NO:O_2, there is an excess of NO; O_2 is the limiting reactant.

Mass of NO used = 0.3125 ~~mol O_2~~ ×2 mol NO/1 ~~mol O_2~~ = 0.6250 mol NO

0.6250 ~~mol NO~~ ×30.01 g NO/1 ~~mol NO~~ = 18.76 g NO

Mass of NO_2 produced = 0.6250 ~~mol NO_2~~ ×46.01 g NO_2/1 ~~mol NO_2~~ = 28.76 g NO_2

Excess NO = 20.00 g NO − 18.76 g NO = 1.24 g NO

Section 11.4 Percent Yield

1. 7.42 g Ga_2O_3
2. correct
3. 7.00 g Ga × 1 mol Ga/69.72 g Ga
4. 0.100 mol Ga × 2 mol Ga_2O_3/4 mol Ga
5. correct
6. 7.42 Ga_2O_3/9.37 g Ga_2O_3 × 100