

Stoichiometry

Section 12.1 What is stoichiometry?

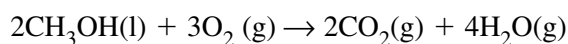
In your textbook, read about stoichiometry and the balanced equation.

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 \rightarrow carbon dioxide + water



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			

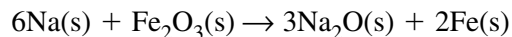
10. What are the reactants? _____
11. What are the products? _____
12. What is the total mass of the reactants? _____
13. What is the total mass of the products? _____
14. How do the total masses of the reactants and products compare? _____

Section 12.1 *continued*

In your textbook, read about mole ratios.

Answer the questions about the following chemical reaction.

sodium + iron(III) oxide \rightarrow sodium oxide + iron



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? _____

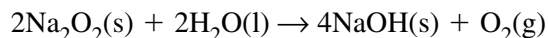
21. Which mole ratio has the largest value? _____

Section 12.2 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.



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

$$1.00 \text{ mol Na}_2\text{O}_2 \times \quad = \quad \text{mol NaOH}$$

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

$$0.500 \text{ mol Na}_2\text{O}_2 \times \quad = \quad \text{mol O}_2$$

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

$$1.00 \text{ mol NaOH} \times \quad = \quad \text{mol Na}_2\text{O}_2$$

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

$$2.15 \text{ mol O}_2 \times \quad = \quad \text{mol H}_2\text{O}$$

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

$$0.100 \text{ mol Na}_2\text{O}_2 \times \quad = \quad \text{mol H}_2\text{O}$$

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

$$0.600 \text{ mol NaOH} \times \quad = \quad \text{mol O}_2$$

Section 12.2 *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?

Step 1 Write a balanced chemical equation for the reaction.

Solution	
Step 1	$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$
Step 2	$20.0 \text{ g } C_2H_2 \times \frac{1 \text{ mol } C_2H_2}{26.04 \text{ g } C_2H_2} = 0.768 \text{ mol } C_2H_2$
Step 3	$0.768 \text{ mol } C_2H_2 \times \frac{4 \text{ mol } CO_2}{2 \text{ mol } C_2H_2} = 1.54 \text{ mol } CO_2$
Step 4	$1.54 \text{ mol } CO_2 \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 67.8 \text{ g } CO_2$

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.

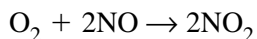
Step 4 Determine the mass of the unknown substance, using mole-to-mass conversion.

- 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? _____
- 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?
- 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 12.3 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.



The molar masses of O₂, NO, and NO₂ 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 12.4 Percent Yield

In your textbook, read about the yields of products.

Study the diagram and the example problem.

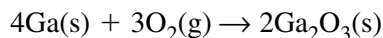
$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

mass of product from experimental measurement

mass of product predicted from stoichiometric calculation using

- mass of reactant
- 4-step mass-to-mass conversion
 - Write the balanced chemical equation.
 - Calculate the number of moles of reactant, using molar mass.
 - Calculate the number of moles of product, using the appropriate mole ratio.
 - 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.



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.

- actual yield: unknown _____
- mass of reactant: 7.00 g Ga _____
- number of moles of reactant: $7.00 \text{ g Ga} \times \frac{69.72 \text{ g Ga}}{1 \text{ mol Ga}}$ _____
- number of moles of product: $0.100 \text{ mol Ga} \times \frac{2 \text{ mol Ga}_2\text{O}_3}{1 \text{ mol Ga}}$ _____
- theoretical yield: $0.0500 \text{ mol Ga}_2\text{O}_3 \times \frac{187.44 \text{ g Ga}_2\text{O}_3}{1 \text{ mol Ga}_2\text{O}_3}$ _____
- percent yield: $\frac{9.37 \text{ g Ga}_2\text{O}_3}{7.42 \text{ g Ga}_2\text{O}_3} \times 100$ _____