SCIENCE FOUNDATIONS

Stoichiometry

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how a baker scales a recipe from one cake to fifty, or a factory works out exactly how much raw material it needs to fill an order without waste. A baker who needs fifty cakes multiplies every ingredient by the same factor, and a factory does the same with chemicals. Ordering too little stops production, and ordering too much wastes money and storage. Knowing stoichiometry tells you how to scale a reaction up or down exactly, so you buy what you need and no more.



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Rule

Stoichiometry: a balanced equation, one with the same number of each kind of atom on both sides, gives the mole ratio between reactants, what you start with, and products, what you make.

A mole is a chemist's counted amount of a substance. Use that ratio to convert between moles, then use molar mass, the mass of one mole of a substance, to convert between moles and grams. The first step is always a balanced equation. The mole ratio comes from the coefficients, the big numbers in front of each formula.

Worked examples

EXAMPLE 1

Q How many grams of water form from 4.0 moles of hydrogen in $2H_2 + O_2 \rightarrow 2H_2O$?

SOLUTION

Check the ratio: 2 moles H_2 make 2 moles H_2O, a 1 to 1 ratio.

Apply it: 4.0 moles H_2 make 4.0 moles H_2O.

Convert:
4.0 mol × 18.0 g/mol = 72.0 g

The result is 72.0 g of water.

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EXAMPLE 2

Q How many moles of oxygen are needed to make 6.0 moles of water in $2H_2 + O_2 \rightarrow 2H_2O$?

SOLUTION

Check the ratio: 1 mole O_2 makes 2 moles H_2O.

Apply it:

moles $O_2 = \frac{1}{2} \times$ moles H_2O.

Compute:

$\frac{1}{2} \times 6.0 = 3.0$ mol

The result is 3.0 moles of oxygen.

Practice questions

1 From 6.0 mol of hydrogen in $2H_2 + O_2 \rightarrow 2H_2O$, how many grams of water form? Use 18.0 g/mol for water.

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2 In $2H_2 + O_2 \rightarrow 2H_2O$, how many grams of oxygen are needed to react with 4.0 mol of hydrogen? Use 32.0 g/mol for oxygen.

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3 In $2H_2 + O_2 \rightarrow 2H_2O$, how many moles of oxygen are needed to make 8.0 mol of water?

A. 4.0 mol of oxygen

B. 2.0 mol of oxygen

C. 8.0 mol of oxygen

D. 6.0 mol of oxygen

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4 **Which of these equations is balanced?**

- **A** $2H_2 + O_2 \rightarrow 2H_2O$
- **B** $H_2 + O_2 \rightarrow H_2O$
- **C** $H_2 + O_2 \rightarrow 2H_2O$
- **D** $2H_2 + 2O_2 \rightarrow 2H_2O$

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5 **In $N_2 + 3H_2 \rightarrow 2NH_3$, 2.0 mol of N_2 make how many moles of NH_3?**

- **A** 4.0 mol
- **B** 2.0 mol
- **C** 8.0 mol
- **D** 1.0 mol

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6 What must you do first in a stoichiometry problem?

- A Balance the equation
- B Find the molar mass
- C Convert grams to moles
- D Write the word equation

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7 What in the balanced equation gives you the mole ratio?

- A The coefficients of the balanced equation
- B The subscripts in the formulas
- C The molar masses
- D The state symbols

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8 In $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, 3.0 mol of CH_4 makes how many moles of CO_2?

- **A** 3.0 mol
- **B** 6.0 mol
- **C** 1.5 mol
- **D** 2.0 mol

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9 In $N_2 + 3H_2 \rightarrow 2NH_3$, how many grams of ammonia form from 2.0 mol of nitrogen? Use 17.0 g/mol for ammonia.

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10 In $N_2 + 3H_2 \rightarrow 2NH_3$, how many moles of hydrogen are needed to make 6.0 mol of NH_3?

A 9.0 mol

B 4.0 mol

C 3.0 mol

D 12.0 mol

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ANSWER KEY

1. 108.0 g

2. 64.0 g

3. 4.0 mol of oxygen

4. $2H_2 + O_2 \rightarrow 2H_2O$

5. 4.0 mol

6. Balance the equation

7. The coefficients of the balanced equation

8. 3.0 mol

9. 68.0 g

10. 9.0 mol

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