

STOICHIOMETRY NOTES WITH LIMITING REACTANT AND PERCENT YIELD

STOICHIOMETRY

Stoichiometry is the relationship between the masses of the reactants and products of chemical reactions.

- Stoichiometry is possible because of the Law of Conservation of Mass.
- The law of conservation of mass states that the amount of matter before a reaction occurs is equal to the amount of matter present after the reaction occurs.
- Thanks to this idea, we can build ratios between reactants and product that allow us to calculate amounts of each.

Using Ratios

Reactants and products are related through stoichiometry.

Each coefficient in the balanced equation can be used to define a ratio between the individual reactants and products of the chemical reaction for the given balanced formula and division of formula.

Consider the reaction:

$$2\text{NaCl} + \text{MgSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{MgCl}_2$$

We can write these ratios:

NaCl to NaCl	$\frac{2\text{NaCl}}{2\text{NaCl}}$ and $\frac{1\text{NaCl}}{1\text{NaCl}}$
NaCl to MgSO ₄	$\frac{2\text{NaCl}}{1\text{MgSO}_4}$ and $\frac{1\text{MgSO}_4}{2\text{NaCl}}$
NaCl to Na ₂ SO ₄	$\frac{2\text{NaCl}}{1\text{Na}_2\text{SO}_4}$ and $\frac{1\text{Na}_2\text{SO}_4}{2\text{NaCl}}$
NaCl to MgCl ₂	$\frac{2\text{NaCl}}{1\text{MgCl}_2}$ and $\frac{1\text{MgCl}_2}{2\text{NaCl}}$
MgSO ₄ to NaCl	$\frac{1\text{MgSO}_4}{2\text{NaCl}}$ and $\frac{2\text{NaCl}}{1\text{MgSO}_4}$
MgSO ₄ to Na ₂ SO ₄	$\frac{1\text{MgSO}_4}{1\text{Na}_2\text{SO}_4}$ and $\frac{1\text{Na}_2\text{SO}_4}{1\text{MgSO}_4}$
MgSO ₄ to MgCl ₂	$\frac{1\text{MgSO}_4}{1\text{MgCl}_2}$ and $\frac{1\text{MgCl}_2}{1\text{MgSO}_4}$

Example: Finding the Limiting Reactant

In the reaction:

$$2\text{HClO}_4(aq) + \text{MgO}(s) \rightarrow \text{H}_2\text{O}(l) + \text{Mg}(\text{ClO}_4)_2(aq)$$

6.37 grams of HClO₄ react with 0.43 grams of Mg. What is the limiting reactant and what mass of Mg(ClO₄)₂ can be formed?

How many moles of HClO₄ react? $\frac{6.37 \text{ grams}}{100.46 \text{ g/mol}} = 0.0634 \text{ moles}$

How many moles of MgO react? $\frac{0.43 \text{ grams}}{40.30 \text{ g/mol}} = 0.0107 \text{ moles}$

How many moles of Mg(ClO₄)₂ can be formed from HClO₄? $0.0634 \text{ moles HClO}_4 \times \frac{1 \text{ mole Mg}(\text{ClO}_4)_2}{2 \text{ moles HClO}_4} = 0.0317 \text{ moles}$

How many moles of Mg(ClO₄)₂ can be formed from MgO? $0.0107 \text{ moles MgO} \times \frac{1 \text{ mole Mg}(\text{ClO}_4)_2}{1 \text{ mole MgO}} = 0.0107 \text{ moles}$

0.0107 moles of Mg(ClO₄)₂ will form and HClO₄ is the limiting reactant.

Using Mole Ratios

From the last page, we looked at the reaction:

$$2\text{NaCl} + \text{MgSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{MgCl}_2$$

We also defined ratios of moles of each substance using the coefficients of the balanced equation.

How do we use the ratios we defined?

How many moles of NaCl can be produced from 4 moles of MgSO₄ reacting alone?

We choose the ratio of moles of NaCl to moles of MgSO₄ that is the given number of moles of MgSO₄. By setting this ratio equal to the denominator, we determine the ratio moles of NaCl and are left with moles of NaCl.

$$4 \text{ moles MgSO}_4 \times \frac{2 \text{ moles NaCl}}{1 \text{ mole MgSO}_4} = 8 \text{ moles NaCl}$$

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Table of Contents Teacher Edition 12 4 Percent Yield Study Guide Chemistry

1. Understanding the eBook Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - The Rise of Digital Reading Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Advantages of eBooks Over Traditional Books
2. Identifying Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - User-Friendly Interface
4. Exploring eBook Recommendations from Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Personalized Recommendations
 - Teacher Edition 12 4 Percent Yield Study Guide Chemistry User Reviews and Ratings

- Teacher Edition 12 4 Percent Yield Study Guide Chemistry and Bestseller Lists
- 5. Accessing Teacher Edition 12 4 Percent Yield Study Guide Chemistry Free and Paid eBooks
 - Teacher Edition 12 4 Percent Yield Study Guide Chemistry Public Domain eBooks
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 - Teacher Edition 12 4 Percent Yield Study Guide Chemistry Budget-Friendly Options
- 6. Navigating Teacher Edition 12 4 Percent Yield Study Guide Chemistry eBook Formats
 - ePub, PDF, MOBI, and More
 - Teacher Edition 12 4 Percent Yield Study Guide Chemistry Compatibility with Devices
 - Teacher Edition 12 4 Percent Yield Study Guide Chemistry Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Highlighting and Note-Taking Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Interactive Elements Teacher Edition 12 4 Percent Yield Study Guide Chemistry
- 8. Staying Engaged with Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Teacher Edition 12 4 Percent Yield Study Guide Chemistry
- 9. Balancing eBooks and Physical Books Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Teacher Edition 12 4 Percent Yield Study Guide Chemistry
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Setting Reading Goals Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Fact-Checking eBook Content of Teacher Edition 12 4 Percent Yield Study Guide Chemistry
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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