

$3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$

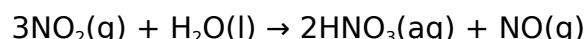
a. How Many Grams Of H_2O Are Required To React With 28.0 G of NO_2 ?b.

$3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$ **a. How Many Grams Of H_2O Are Required To React With 28.0 G of NO_2 ?b.**

Understanding chemical reactions and stoichiometry is fundamental in chemistry, especially when quantifying reactants and products. In this article, we will analyze the reaction between nitrogen dioxide (NO_2) and water (H_2O), explore how to calculate the grams of water needed to react with a specified amount of NO_2 , and provide a comprehensive guide to solving such problems. By the end, you'll be equipped with the skills to approach similar stoichiometry questions confidently.

Understanding the Chemical Equation

Let's first examine the balanced chemical equation:



This equation indicates that three moles of nitrogen dioxide react with one mole of water to produce two moles of nitric acid and one mole of nitric oxide gas.

Key Components of the Reaction

- Reactants:
 - Nitrogen dioxide (NO_2): a reddish-brown gas, common in nitrogen oxides.
 - Water (H_2O): liquid, universal solvent.
- Products:
 - Nitric acid (HNO_3): a strong acid used in various industrial processes.
 - Nitric oxide (NO): a colorless gas involved in atmospheric reactions.

Stoichiometry and Its Role in Calculations

Stoichiometry involves the quantitative relationship between reactants and products in a chemical reaction. It allows us to determine how much of one substance is needed or produced based on the amount of another.

In our case, we're asked:

"How many grams of H₂O are required to react with 28.0 g of NO₂?"

This involves:

1. Converting grams of NO₂ to moles.
2. Using the molar ratio between NO₂ and H₂O from the balanced equation.
3. Converting the moles of H₂O to grams.

Step-by-Step Calculation Process

Let's break down the process into clear steps.

Step 1: Calculate Moles of NO₂

The molar mass of NO₂:

- Nitrogen (N): approximately 14.01 g/mol
- Oxygen (O): approximately 16.00 g/mol

Calculating molar mass:

$$M(\text{NO}_2) = 14.01 \text{ g/mol} + 2 \times 16.00 \text{ g/mol} = 14.01 + 32.00 = 46.01 \text{ g/mol}$$

Now, convert grams of NO₂ to moles:

$$\text{Moles of NO}_2 = 28.0 \text{ g} \div 46.01 \text{ g/mol} \approx 0.6087 \text{ mol}$$

Step 2: Use Stoichiometric Ratios to Find Moles of H₂O

From the balanced equation:



So, for every 3 moles of NO₂, 1 mole of H₂O is consumed.

Calculate moles of H₂O required:

$$\text{Moles of H}_2\text{O} = (\text{Moles of NO}_2) \times (1 \text{ mol H}_2\text{O} / 3 \text{ mol NO}_2) = 0.6087 \text{ mol} \times (1/3) \approx 0.2029 \text{ mol}$$

Step 3: Convert Moles of H₂O to Grams

The molar mass of H₂O:

- Hydrogen (H): approximately 1.008 g/mol
- Oxygen (O): approximately 16.00 g/mol

Calculating:

$$M(\text{H}_2\text{O}) = 2 \times 1.008 \text{ g/mol} + 16.00 \text{ g/mol} = 2.016 + 16.00 = 18.016 \text{ g/mol}$$

Now, convert moles to grams:

$$\text{Mass of H}_2\text{O} = 0.2029 \text{ mol} \times 18.016 \text{ g/mol} \approx 3.652 \text{ g}$$

Answer: Approximately 3.65 grams of water are required to react with 28.0 grams of NO₂.

Additional Considerations in Stoichiometry Problems

While the above calculations are straightforward, several factors can influence real-world applications:

- Purity of Reactants: Industrial processes may involve reactants that are not 100% pure, affecting calculations.
- Reaction Conditions: Temperature and pressure can influence reaction rates but do not typically affect stoichiometric ratios.
- Limitations and Excess Reactants: Sometimes, reactants are present in excess, and limiting reactant theory is applied.
- Yield: Actual yields may be less than theoretical yields due to side reactions or incomplete reactions.

Practical Applications of This Calculation

Understanding how to determine the amount of water needed in reactions involving nitrogen oxides has practical applications in:

- Industrial Manufacturing: Optimizing reactant quantities in nitric acid production.
- Environmental Chemistry: Modeling nitrogen oxide reactions in atmospheric conditions.
- Laboratory Synthesis: Planning reagent amounts for chemical synthesis experiments.

- Environmental Control: Designing processes to mitigate NO₂ pollution.

Additional Tips for Solving Similar Problems

- Always start with a balanced chemical equation.
- Convert given quantities to moles for easier ratio application.
- Use molar masses accurately, considering significant figures.
- Keep units consistent throughout calculations.
- Double-check ratios from the balanced equation.
- Convert final moles back to grams or desired units.

Conclusion

Calculating the amount of water required to react with a specific amount of nitrogen dioxide involves understanding the stoichiometry of the reaction, converting grams to moles, applying mole ratios, and then converting back to grams. In our example, approximately 3.65 grams of water are needed to fully react with 28.0 grams of NO₂. Mastery of these steps is essential for chemists and students aiming to perform accurate quantitative analyses in various chemical scenarios.

By mastering stoichiometry, you'll be able to predict reactant requirements, optimize chemical processes, and understand the underlying principles governing chemical reactions.

Frequently Asked Questions

What is the balanced chemical equation for the reaction between NO₂ and water?

The balanced equation is $3 \text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2 \text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$.

How many moles of NO₂ are present in 28.0 grams of NO₂?

Moles of NO₂ = $28.0 \text{ g} \div 46.01 \text{ g/mol} \approx 0.608 \text{ mol}$.

According to the balanced equation, what is the molar ratio of NO₂ to H₂O?

The molar ratio of NO₂ to H₂O is 3:1.

How many moles of H₂O are needed to react with 0.608 mol of NO₂?

Moles of H₂O = $(1/3) \times 0.608 \text{ mol} \approx 0.203 \text{ mol}$.

What is the molar mass of water (H₂O)?

The molar mass of H₂O is approximately 18.02 g/mol.

How many grams of H₂O are required to react with 28.0 g of NO₂?

Grams of H₂O = $0.203 \text{ mol} \times 18.02 \text{ g/mol} \approx 3.66 \text{ g}$.

Why is it important to balance the chemical equation in this calculation?

Balancing ensures the correct molar ratios are used, which is essential for accurate stoichiometric calculations.

If you have excess water, how does that affect the reaction?

Excess water drives the reaction to completion, ensuring all NO₂ reacts as per the stoichiometry.

Can this reaction be used to produce nitric acid industrially?

Yes, the reaction of NO₂ with water is part of processes involved in nitric acid production, although industrial methods are more complex.

What safety precautions should be taken when handling NO₂ and H₂O in the lab?

NO₂ is toxic and a strong oxidizer; proper ventilation, protective gear, and handling procedures are essential to ensure safety.

Additional Resources

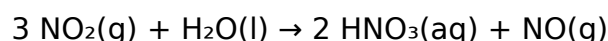
Understanding the Reaction Between Nitrogen Dioxide and Water: How Many Grams of H₂O Are Needed to React With 28.0 g of NO₂?

When exploring chemical reactions involving gases and liquids, a fundamental question often arises: how much of a reactant is needed to completely react with a given amount of

another? In this article, we delve into the reaction between nitrogen dioxide (NO₂) and water, a process that results in the formation of nitric acid (HNO₃) and nitric oxide (NO). Specifically, we'll examine how many grams of water are required to fully react with 28.0 grams of NO₂. This detailed analysis will guide you through understanding the reaction, performing stoichiometric calculations, and applying them to practical scenarios.

The Chemical Reaction: An Overview

Before diving into calculations, it's essential to understand the reaction involved. The reaction between nitrogen dioxide and water is a classic example of a redox process involving a nitrogen oxide and aqueous solution. The balanced chemical equation is:



Key Points:

- Reactants: Nitrogen dioxide (NO₂) gas and water (H₂O) liquid.
- Products: Nitric acid (HNO₃) aqueous solution and nitric oxide (NO) gas.
- Stoichiometry: The molar ratio of NO₂ to H₂O is 3:1, meaning three moles of NO₂ react with one mole of water.

Step-by-Step Guide to Calculating the Required Grams of Water

1. Identify Known and Unknown Quantities

- Known: Mass of NO₂ = 28.0 grams
- Unknown: Mass of H₂O needed to react completely.

2. Calculate Moles of NO₂

The molar mass of NO₂ is computed as:

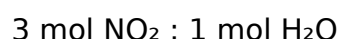
- Nitrogen (N): 14.01 g/mol
- Oxygen (O): 16.00 g/mol
- NO₂ molar mass = 14.01 + (2 × 16.00) = 14.01 + 32.00 = 46.01 g/mol

Number of moles of NO₂:

$$\begin{aligned} \backslash[\\ \text{\text{moles of NO}}_2 &= \frac{\text{\text{mass of NO}}_2}{\text{\text{molar mass of NO}}_2} = \\ &= \frac{28.0 \text{ g}}{46.01 \text{ g/mol}} \approx 0.609 \text{ mol} \\ \backslash] \end{aligned}$$

3. Use the Stoichiometry of the Reaction

From the balanced equation:



Calculate moles of H₂O needed:

$$\text{moles of H}_2\text{O} = \frac{1}{3} \times \text{moles of NO}_2 = \frac{1}{3} \times 0.609 \approx 0.203, \text{ mol}$$

4. Calculate Grams of Water Required

The molar mass of H₂O:

- Hydrogen (H): 1.008 g/mol
- Oxygen (O): 16.00 g/mol
- H₂O molar mass = (2 × 1.008) + 16.00 = 2.016 + 16.00 = 18.02 g/mol

Mass of water:

$$\text{mass of H}_2\text{O} = \text{moles} \times \text{molar mass} = 0.203 \times 18.02 \approx 3.66, \text{ g}$$

Practical Implications and Additional Considerations

Understanding the Stoichiometry

The calculation reveals that approximately 3.66 grams of water are required to completely react with 28.0 grams of NO₂ under ideal conditions. This ratio is crucial in laboratory settings, environmental engineering, and industrial applications where precise reactant quantities are necessary for safety and efficiency.

Reaction Conditions and Real-World Factors

While stoichiometry provides a theoretical framework, real-world reactions may vary due to:

- Temperature and pressure: Affect gas solubility and reaction rates.
- Reaction completeness: Incomplete reactions may require excess water.
- Impurities: Can influence the reaction pathway and efficiency.

Environmental and Safety Considerations

Nitrogen dioxide is a toxic, reddish-brown gas that poses health hazards. Proper handling, ventilation, and safety measures are essential during experiments or industrial processes involving NO₂ and water.

Summary of Key Steps

Here's a quick reference for performing similar calculations:

Step	Action	Formula / Description	Result
1	Calculate moles of NO ₂	$\text{moles} = \frac{\text{mass}}{\text{molar mass}}$	0.609 mol

1	Find molar mass of NO₂	N: 14.01 g/mol, O: 16.00 g/mol	46.01 g/mol
2	Calculate moles of NO₂	mass / molar mass	28.0 g / 46.01 g/mol ≈ 0.609 mol
3	Use molar ratio to find moles of H₂O	(1 mol H₂O / 3 mol NO₂) × NO₂ moles	0.203 mol
4	Convert moles of H₂O to grams	moles × molar mass of H₂O	0.203 mol × 18.02 g/mol ≈ 3.66 g

Final Thoughts

Understanding how to determine the amount of water required to react with a specific quantity of nitrogen dioxide is a fundamental aspect of chemical stoichiometry. This process not only enhances comprehension of chemical reactions but also aids in practical applications such as designing reactors, managing environmental emissions, and conducting laboratory experiments safely and efficiently.

By mastering these calculations, chemists and engineers can accurately plan and control reactions, ensuring optimal use of materials and adherence to safety protocols. Remember, always consider real-world variables and safety practices when translating theoretical calculations into practice.

In conclusion, based on the balanced chemical equation and stoichiometric calculations, approximately 3.66 grams of H₂O are needed to completely react with 28.0 grams of NO₂ under ideal conditions. This example underscores the importance of stoichiometry in chemical reaction planning and highlights the critical role of precise calculations in chemistry.

3no2 G H2o L 2hno3 Aq No G A How Many Grams Of H2o Are Required To React With 28 0 Gof No2 B

3no2 G H2o L 2hno3 Aq No G A How Many Grams Of H2o Are Required To React With 28 0 Gof No2 B

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