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Given The Equation Below, 12.35 Grams Of H2SO4, And Excess Ca(OH)2, What Mass Of H2O Can Be Produced?

Understanding the chemical reaction between sulfuric acid (H_2SO_4) and calcium hydroxide ($Ca(OH)_2$) is essential in many chemistry applications, including titrations, manufacturing, and environmental science. When these two substances react, they produce calcium sulfate ($CaSO_4$) and water (H_2O). This article explores how to determine the mass of water produced when 12.35 grams of sulfuric acid reacts with excess calcium hydroxide, covering key concepts, calculations, and practical implications.

The Balanced Chemical Equation

To accurately determine the amount of water produced, it’s vital to understand the chemical reaction involved.

Reaction Between H_2SO_4 and $Ca(OH)_2$

The reaction is a typical acid-base neutralization:

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$

This balanced equation indicates that:

- One mole of sulfuric acid reacts with one mole of calcium hydroxide.
- The products formed are calcium sulfate ($CaSO_4$) and water (H_2O).

Understanding the molar ratios in this reaction is fundamental for stoichiometric calculations.

Calculating Moles of H_2SO_4

The first step is to convert the given mass of sulfuric acid into moles.

Step 1: Find the molar mass of H_2SO_4

Element	Atomic Mass (g/mol)	Calculation
Hydrogen (H)	1.008 g/mol	2 × 1.008 = 2.016 g/mol
Sulfur (S)	32.06 g/mol	1 × 32.06 g/mol
Oxygen (O)	16.00 g/mol	4 × 16.00 = 64.00 g/mol

Total molar mass of H_2SO_4 = 2.016 + 32.06 + 64.00 = 98.08 g/mol

Step 2: Convert grams to moles

Number of moles of H_2SO_4:

$$
\text{Moles of } H_2SO_4 = \frac{\text{Mass of } H_2SO_4}{\text{Molar mass of } H_2SO_4} = \frac{12.35\, \text{g}}{98.08\, \text{g/mol}} \approx 0.1259\, \text{mol}
$$

Determining Moles of Water Produced

From the balanced chemical equation:

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$

The molar ratio of H_2SO_4 to H_2O is 1:2.

Step 3: Calculate moles of water formed

$$
\text{Moles of } H_2O = 2 \times \text{Moles of } H_2SO_4 = 2 \times 0.1259\, \text{mol} = 0.2518\, \text{mol}
$$

This means approximately 0.2518 moles of water are produced when 12.35 grams of sulfuric acid completely reacts with excess calcium hydroxide.

Calculating the Mass of Water Produced

Next, convert the moles of water into grams.

Step 4: Find the molar mass of H_2O

Element	Atomic Mass (g/mol)	Calculation
Hydrogen (H)	1.008 g/mol	2 × 1.008 = 2.016 g/mol
Oxygen (O)	16.00 g/mol	1 × 16.00 = 16.00 g/mol

Total molar mass of H_2O = 2.016 + 16.00 = 18.02 g/mol

Step 5: Calculate mass of water

$$
\text{Mass of } H_2O = \text{Moles of } H_2O \times \text{Molar mass of } H_2O = 0.2518\, \text{mol} \times 18.02\, \text{g/mol} \approx 4.54\, \text{g}
$$

Therefore, approximately 4.54 grams of water can be produced.

Practical Considerations and Excess Reagents

The problem states that calcium hydroxide is in excess. This means that all the sulfuric acid reacts completely, and the limiting reagent is sulfuric acid. The calculation above assumes complete reaction of the given 12.35 grams of H_2SO_4.

Impact of Excess $Ca(OH)_2$

Since calcium hydroxide is in excess, it does not limit the reaction. The amount of water produced depends solely on the amount of sulfuric acid present. This simplifies the calculation because we do not need to calculate the molar amount of $Ca(OH)_2$.

Other Factors to Consider

- Purity of reactants: Impurities may slightly alter the actual yield.
- Reaction conditions: Temperature and pressure can influence the reaction efficiency.
- Completeness of reaction: Assumed complete reaction; in practical scenarios, some unreacted reactants may remain.

Summary of Key Steps in the Calculation

- Calculate molar mass of H_2SO_4 (98.08 g/mol).
- Convert 12.35 grams of H_2SO_4 to moles (≈0.1259 mol).
- Use the molar ratio from the balanced equation (1:2) to find moles of H_2O (≈0.2518 mol).
- Calculate the mass of water using molar mass of H_2O (18.02 g/mol), resulting in approximately 4.54 grams.

Real-World Applications of This Calculation

Understanding the amount of water produced during such reactions has practical applications:

Industrial Processes

- In chemical manufacturing, knowing the exact water produced helps in designing appropriate distillation or separation processes.
- In wastewater treatment, understanding water production aids in volume calculations.

Laboratory Experiments

- Precise calculations ensure accurate stoichiometry in titrations.
- Helps in predicting yields and optimizing reaction conditions.

Environmental Science

- Quantifying water formed in reactions helps in environmental impact assessments, particularly when dealing with acid neutralization.

Conclusion

Given 12.35 grams of sulfuric acid reacting with excess calcium hydroxide, approximately 4.54 grams of water can be produced. This calculation hinges on the stoichiometry of the neutralization reaction, the molar masses of the reactants and products, and the assumption of complete reaction. Mastering such calculations is essential for chemists and engineers to design processes, analyze reactions, and optimize yields effectively. Whether in industrial applications or academic exercises, understanding how to determine the water produced from specific reactants enhances both practical skills and theoretical knowledge in chemistry.

Frequently Asked Questions

How do you determine the amount of water produced when reacting 12.35 grams of H_2SO_4 with excess $Ca(OH)_2$?

First, write the balanced chemical equation: $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$. Then, convert 12.35 g H_2SO_4 to moles, use the molar ratio to find moles of H_2O produced, and finally convert moles of water to grams.

What is the molar mass of H_2SO_4 and how is it used in calculating water production?

The molar mass of H_2SO_4 is approximately 98.08 g/mol. It is used to convert grams of H_2SO_4 to moles by dividing the mass by the molar mass, which then helps determine the amount of water produced based on the stoichiometry.

Why is it important that $Ca(OH)_2$ is in excess in this reaction?

Having excess $Ca(OH)_2$ ensures that all the H_2SO_4 reacts completely, allowing us to base calculations solely on the amount of H_2SO_4 present to find the maximum amount of water produced.

How do you calculate the mass of water produced from 12.35 grams of H_2SO_4?

Convert 12.35 g H_2SO_4 to moles, then use the molar ratio from the balanced equation (2 moles H_2O per 1 mole H_2SO_4) to find moles of water, and finally multiply by the molar mass of water (18.02 g/mol) to get the mass produced.

What is the final answer for the mass of water produced from 12.35 grams of H_2SO_4 reacting with excess $Ca(OH)_2$?

Approximately 4.28 grams of H_2O can be produced, based on stoichiometric calculations from the given amount of sulfuric acid and the balanced chemical reaction.

Additional Resources

Given The Equation Below, 12.35 Grams Of H_2SO_4, And Excess $Ca(OH)_2$, What Mass Of H_2O Can Be Produced?

Understanding how to determine the mass of water produced from a chemical reaction involving sulfuric acid (H_2SO_4) and calcium hydroxide ($Ca(OH)_2$) is a fundamental skill in chemistry. This type of problem combines stoichiometry, molar calculations, and an understanding of chemical equations to compute the amount of water generated. In this comprehensive guide, we will walk through each step of the process, from writing the balanced chemical equation to performing calculations based on given quantities. Whether you're a student preparing for exams or a professional refining your analytical skills, this detailed breakdown will clarify how to approach similar chemical problems confidently.

Understanding the Chemical Reaction

The Reaction Between Sulfuric Acid and Calcium Hydroxide

The first step in solving this problem is to identify the reaction taking place between H_2SO_4 (sulfuric acid) and $Ca(OH)_2$ (calcium hydroxide). Both are common reactants in acid-base chemistry, and their reaction results in the formation of a salt and water.

The balanced chemical equation for the reaction is:

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2\ H_2O$

This reaction shows:

- One mole of sulfuric acid reacts with one mole of calcium hydroxide.
- The products are calcium sulfate ($CaSO_4$) and water (H_2O).

Key Point: Since calcium sulfate is insoluble in water, it precipitates out, but for the purposes of mass calculations, the primary focus is on the water produced.

Step-by-Step Breakdown of the Problem

Step 1: Write the Balanced Chemical Equation

As shown above, the balanced equation is:

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2\ H_2O$

This tells us the molar ratio:

- 1 mol H_2SO_4 produces 2 mol H_2O

Step 2: Convert Mass of H_2SO_4 to Moles

Given data:

- Mass of H_2SO_4 = 12.35 grams

Molar mass of H_2SO_4:

- H: 1.008 g/mol
- S: 32.065 g/mol
- O: 16.00 g/mol (4 atoms)

Calculating:

Molar mass of H_2SO_4 = (2 × 1.008) + 32.065 + (4 × 16.00)
= 2.016 + 32.065 + 64.00
= 98.081 g/mol

Number of moles of H_2SO_4:

Number of moles = Mass / Molar mass
= 12.35 g / 98.081 g/mol ≈ 0.1259 mol

Step 3: Determine Moles of Water Produced

From the balanced equation:

1 mol H_2SO_4 → 2 mol H_2O

So, the moles of water produced:

Moles of H_2O = 2 × moles of H_2SO_4
= 2 × 0.1259 mol ≈ 0.2518 mol

Step 4: Convert Moles of Water to Mass

Molar mass of H_2O:

- H: 1.008 g/mol
- O: 16.00 g/mol

Molar mass of H_2O = (2 × 1.008) + 16.00 = 2.016 + 16.00 = 18.016 g/mol

Mass of water produced:

Mass = moles × molar mass
= 0.2518 mol × 18.016 g/mol ≈ 4.537 g

Final Answer:
Approximately 4.54 grams of water can be produced when 12.35 grams of H_2SO_4 reacts with excess $Ca(OH)_2$.

Additional Considerations and Practical Implications

Excess Reactant and Reaction Completeness

The problem states that calcium hydroxide is in excess, meaning all the sulfuric acid will be consumed, and the amount of water produced depends solely on the amount of H_2SO_4 present. This simplifies the calculations because no limiting reagent considerations for $Ca(OH)_2$ are necessary.

Purity of Reactants

In real-world scenarios, purity of chemicals affects the actual yield. If the H_2SO_4 wasn't pure or contained impurities, the actual amount of water produced might deviate slightly from theoretical calculations.

Yield and Reaction Efficiency

Chemical reactions rarely proceed with 100% efficiency due to side reactions, incomplete mixing, or losses during transfer. Therefore, lab yields are often less than theoretical yields, and this should be considered for practical applications.

Summary of the Calculation Process

To recap, the process involves:

- Writing the balanced chemical equation
- Calculating the molar mass of the reactant
- Converting grams of reactant to moles
- Using molar ratios to find moles of water produced
- Converting moles of water to grams

This systematic approach ensures accurate results and can be applied broadly to other stoichiometry problems involving different reactants and products.

Additional Tips for Solving Similar Problems

- Always start with a balanced equation.
- Convert all given masses to moles before proceeding.
- Use molar ratios from the balanced equation for conversions.
- Remember to convert moles back to grams if the final answer requires mass.
- Keep track of significant figures based on the given data.
- Consider purity and reaction efficiency for real-world applications.

Conclusion

Determining the mass of water produced from a given amount of sulfuric acid reacting with excess calcium hydroxide is a fundamental example of stoichiometry in action. By carefully balancing the chemical equation,

performing mole conversions, and applying ratios, you can confidently find that approximately 4.54 grams of water are generated from 12.35 grams of H_2SO_4. Mastery of these steps enhances your understanding of chemical reactions and prepares you for tackling more complex quantitative chemistry problems with accuracy and confidence.

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