1-Calculate The Volume (in ML) Of 0.409 M HCl Needed To React Completely With 7.27 G Of MgCO3 In A Gas-foing

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Understanding chemical reactions and their stoichiometry is essential in many fields, from laboratory experiments to industrial manufacturing. One common problem involves calculating the volume of a solution required to completely react with a specific amount of a compound. In this case, we aim to determine the volume in milliliters (mL) of 0.409 M hydrochloric acid (HCl) needed to fully react with 7.27 grams of magnesium carbonate ($MgCO_3$). This calculation involves understanding the chemical reaction, molar relationships, and unit conversions. Let's explore this step-by-step.

Understanding the Chemical Reaction

The Reaction Between $MgCO_3$ and HCl

Magnesium carbonate reacts with hydrochloric acid in a typical acid-base reaction, producing magnesium chloride, carbon dioxide, and water. The balanced chemical equation is:

$MgCO_3$ (s) + 2 HCl (aq) → $MgCl_2$ (aq) + CO_2 (g) + H_2O (l)

This equation indicates that one mole of magnesium carbonate reacts with two moles of hydrochloric acid.

Implications for Stoichiometry

From the balanced reaction, the molar ratio is:

- $MgCO_3$: HCl = 1 : 2

This ratio guides us in calculating the amount of HCl required based on the amount of $MgCO_3$ present.

Calculating the Moles of $MgCO_3$

Step 1: Find the molar mass of $MgCO_3$

To convert grams to moles, we need the molar mass of magnesium carbonate:

Element	Atomic Mass (g/mol)	Quantity in $MgCO_3$	Total Contribution (g/mol)
Mg	24.305	1	24.305
C	12.011	1	12.011
O	16.00	3	48.00
Total			84.326 g/mol

Thus, the molar mass of $MgCO_3$ is approximately 84.33 g/mol.

Step 2: Convert grams of $MgCO_3$ to moles

Using the molar mass:

Number of moles = mass / molar mass
Number of moles of $MgCO_3$ = 7.27 g / 84.33 g/mol ≈ 0.0862 mol

Result:
Approximately 0.0862 moles of $MgCO_3$ are present in 7.27 grams.

Determining the Moles of HCl Needed

Step 3: Use molar ratio to find moles of HCl

From the balanced equation, 1 mol of $MgCO_3$ reacts with 2 mol of HCl:

Moles of HCl = 2 × moles of $MgCO_3$
Moles of HCl = 2 × 0.0862 mol ≈ 0.1724 mol

Result:
Approximately 0.1724 moles of HCl are required for complete reaction.

Calculating the Volume of HCl Solution Needed

Step 4: Use molarity to find volume in liters

Molarity (M) is moles of solute per liter of solution. Rearranged to find volume:

Volume (L) = moles of solute / molarity

Given molarity of HCl = 0.409 M,

Volume (L) = 0.1724 mol / 0.409 mol/L ≈ 0.422 L

Step 5: Convert liters to milliliters

Since 1 L = 1000 mL,

Volume (mL) = 0.422 L × 1000 mL/L = 422 mL

Final answer:
Approximately 422 mL of 0.409 M HCl is needed to react completely with 7.27 grams of $MgCO_3$.

Additional Considerations

1. Purity of Reagents

This calculation assumes that the $MgCO_3$ and HCl are pure and that the reaction proceeds to completion without side reactions. In real laboratory settings, purity levels and reaction conditions may influence the exact volume needed.

2. Measurement Accuracy

Ensure precise measurement of mass and concentration for accurate results. Small errors can significantly affect the calculated volume.

3. Gas Evolution and Safety

As the reaction produces CO_2 gas, consider proper ventilation and safety procedures when performing the reaction physically.

Summary

To summarize, calculating the volume of hydrochloric acid required involves understanding the molar relationship dictated by the balanced chemical equation, converting grams of magnesium carbonate into moles, then using molarity to find the corresponding volume in milliliters. For 7.27 grams of $MgCO_3$ reacting with 0.409 M HCl, approximately 422 mL of acid solution is necessary for complete reaction.

Practical Applications

This type of calculation is fundamental in titration experiments, industrial chemical manufacturing, and environmental chemistry, where precise reagent quantities are crucial. Whether you're preparing a reaction, analyzing samples, or scaling up a process, understanding these calculations enhances accuracy and efficiency.

Conclusion

Mastering the stoichiometric relationships and unit conversions involved in such calculations empowers chemists and students alike to predict reagent requirements accurately. By systematically applying molar mass, molarity, and balanced equations, you can confidently determine the necessary volumes of solutions for various chemical reactions, ensuring both safety and precision in your laboratory and industrial practices.

Frequently Asked Questions

How do you determine the volume of 0.409 M HCl required to react completely with 7.27 g of $MgCO_3$?

First, write the balanced chemical equation: $MgCO_3 + 2\ HCl \rightarrow MgCl_2 + CO_2 + H_2O$. Calculate the moles of $MgCO_3$, then use the molar ratio to find the moles of HCl needed, and finally convert moles of HCl to volume using molarity.

What is the molar mass of magnesium carbonate ($MgCO_3$)?

The molar mass of $MgCO_3$ is approximately 84.31 g/mol (Mg = 24.31, C = 12.01, O = 16.00 × 3).

How many moles of $MgCO_3$ are present in 7.27 grams?

Number of moles = 7.27 g / 84.31 g/mol ≈ 0.0863 mol.

What is the molar ratio between $MgCO_3$ and HCl in the reaction?

The balanced equation shows a 1:2 ratio, meaning 1 mole of $MgCO_3$ reacts with 2 moles of HCl.

How do you calculate the volume of HCl needed once

you know the moles required?

Use the formula: Volume (L) = moles of HCl / molarity. Since molarity is given as 0.409 M, multiply the moles of HCl by 1000 to convert to mL after dividing by 0.409.

What is the final volume of 0.409 M HCl needed to completely react with 7.27 g of $MgCO_3$?

Moles of HCl needed = 2 × 0.0863 mol ≈ 0.1726 mol. Volume = 0.1726 mol / 0.409 mol/L ≈ 0.422 L or 422 mL.

Additional Resources

Hydrochloric Acid (HCl) Volume Calculation

Introduction

In the realm of chemical reactions, precise measurements are paramount, especially when dealing with acid-base reactions involving compounds like magnesium carbonate ($MgCO_3$). Whether you're a seasoned chemist, a student, or an enthusiast engaging in laboratory experiments, understanding how to accurately determine the volume of hydrochloric acid (HCl) required for complete reaction is essential. This article delves into the detailed process of calculating the volume of 0.409 M HCl necessary to react fully with 7.27 grams of $MgCO_3$, presented with clarity, depth, and expert insights.

Understanding the Chemical Context

The Reactants: Magnesium Carbonate and Hydrochloric Acid

Magnesium carbonate ($MgCO_3$) is a common carbonate mineral, often used in various industrial and laboratory applications. When it reacts with hydrochloric acid, it produces magnesium chloride, carbon dioxide, and water:

$$
\mathrm{MgCO_3 (s) + 2 HCl (aq) \rightarrow MgCl_2 (aq) + CO_2 (g) + H_2O (l)}
$$

This balanced chemical equation tells us that one mole of magnesium carbonate reacts with two moles of hydrochloric acid.

The Goal: Precise Volume Calculation

Given:

- Mass of $MgCO_3$ = 7.27 grams
- Concentration of HCl = 0.409 molar (M), which indicates moles per liter

Our objective:

- To find out how many milliliters (mL) of 0.409 M HCl are needed for complete reaction with 7.27 g of $MgCO_3$.

Step 1: Calculating the Moles of $MgCO_3$

Why Moles Matter

Chemical reactions are governed by molar ratios, not just raw mass. To determine how much HCl is needed, we first need to convert the given mass of $MgCO_3$ into moles.

Molar Mass of $MgCO_3$

Calculating the molar mass is straightforward by summing the atomic masses:

Element	Atomic Mass (amu)	Quantity	Total Mass (amu)
Magnesium (Mg)	24.305	1	24.305
Carbon (C)	12.011	1	12.011
Oxygen (O)	16.00	3	48.00

Total molar mass of $MgCO_3$ = 24.305 + 12.011 + 48.00 = 84.316 g/mol

Convert Mass to Moles

Using the formula:

$$
\text{Moles of MgCO}_3 = \frac{\text{Mass}}{\text{Molar mass}}
$$

$$
= \frac{7.27\, \text{g}}{84.316\, \text{g/mol}} \approx 0.0862\, \text{mol}
$$

Step 2: Using the Balanced Equation to Find Moles of HCl Needed

From the chemical equation:

\[

$$
\mathrm{MgCO_3 + 2\ HCl \rightarrow MgCl_2 + CO_2 + H_2O}
$$

the molar ratio of $MgCO_3$ to HCl is 1:2.

Calculating Moles of HCl Required

$$
\text{Moles of HCl} = 2 \times \text{Moles of MgCO}_3
$$

$$
= 2 \times 0.0862\, \text{mol} \approx 0.1724\, \text{mol}
$$

This is the total amount of HCl needed for complete reaction.

Step 3: Calculating the Volume of HCl Solution Needed

Understanding Molarity

Molarity (M) is defined as moles of solute per liter of solution:

$$
\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{volume in liters}}
$$

Rearranged to find volume:

$$
\text{Volume (L)} = \frac{\text{moles of solute}}{\text{Molarity}}
$$

Plugging in the Values

$$
\text{Volume (L)} = \frac{0.1724\, \text{mol}}{0.409\, \text{mol/L}} \approx 0.4218\, \text{L}
$$

Convert to Milliliters

Since 1 L = 1000 mL:

$$
0.4218\, \text{L} \times 1000 = 421.8\, \text{mL}
$$

Thus, approximately 422 mL of 0.409 M HCl is required for complete reaction

with 7.27 g of $MgCO_3$.

Additional Considerations

Precision and Experimental Variability

While the calculation provides a theoretical volume, in practical applications, slight variations may occur due to:

- Purity of reagents
- Measurement inaccuracies
- Reaction conditions (temperature, pressure)

Therefore, it’s recommended to add HCl gradually, monitoring the reaction progress, especially if performing titrations.

Safety Precautions

Handling concentrated acids like HCl necessitates:

- Wearing appropriate personal protective equipment (PPE)
- Working in a well-ventilated area or fume hood
- Properly disposing of chemical waste

Final Summary

Step	Calculation	Result
Moles of $MgCO_3$	7.27 g / 84.316 g/mol	0.0862 mol
Moles of HCl needed	2 × moles of $MgCO_3$	0.1724 mol
Volume of HCl (L)	0.1724 mol / 0.409 mol/L	0.422 L
Volume of HCl (mL)	0.422 L × 1000	422 mL

Therefore, approximately 422 milliliters of 0.409 M hydrochloric acid are necessary to completely react with 7.27 grams of magnesium carbonate.

Conclusion

Accurate chemical calculations such as this are fundamental in laboratory settings, ensuring reactions proceed to completion without excess reagent waste or unintended side effects. By understanding the molar relationships, molar mass calculations, and solution concentrations, chemists and students alike can confidently determine the precise volume of reagents needed for their experiments. This detailed process underscores the importance of fundamental chemical principles applied meticulously to real-world scenarios,

exemplifying the essence of expert-level chemical analysis.

Note: Always double-check calculations and consider experimental adjustments to accommodate real-world conditions.

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