What Volume Of 0.1379 M Hcl Is Required To Neutralize 10.0 Ml Of 0.2789 M Naoh Soluation

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When working with acid-base reactions in the laboratory, determining the precise volume of acid needed to neutralize a given amount of base is essential for various applications, including titrations, pH calculations, and chemical analysis. In this article, we will explore the detailed process of calculating the volume of 0.1379 M hydrochloric acid (HCl) required to neutralize 10.0 mL of 0.2789 M sodium hydroxide (NaOH) solution. This calculation involves understanding molarity, molar ratios, and the principles of titration, providing a comprehensive understanding suitable for students, educators, and professionals alike.

Understanding the Basics: Molarity and Neutralization

Before diving into the calculation, it's important to grasp some fundamental concepts:

What Is Molarity?

- Molarity (M) refers to the concentration of a solution expressed as the number of moles of solute per liter of solution.
- For example, a 0.1379 M HCl solution contains 0.1379 moles of HCl per liter.

What Is Neutralization?

- Neutralization is a chemical reaction where an acid reacts with a base to produce water and a salt.
- The general reaction between hydrochloric acid and sodium hydroxide is:

$$
\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}
$$

- The molar ratio of HCl to NaOH in this reaction is 1:1.

Step-by-Step Calculation of Required HCl Volume

The process to find the required volume of HCl involves several steps:

1. Calculate the number of moles of NaOH in the given solution

Given:
- Volume of NaOH solution = 10.0 mL = 0.0100 L
- Molarity of NaOH = 0.2789 M

Using the formula:
$$
\text{moles of NaOH} = \text{molarity} \times \text{volume (in liters)}
$$

Calculating:
$$
\text{moles of NaOH} = 0.2789\, \text{mol/L} \times 0.0100\, \text{L} = 0.002789\, \text{mol}
$$

2. Determine the moles of HCl required for neutralization

Since the reaction ratio of HCl to NaOH is 1:1:
$$
\text{moles of HCl} = \text{moles of NaOH} = 0.002789\, \text{mol}
$$

3. Calculate the volume of HCl solution needed

Given:
- Molarity of HCl = 0.1379 M
- Moles of HCl needed = 0.002789 mol

Using the molarity formula rearranged for volume:
$$
\text{Volume of HCl} = \frac{\text{moles of HCl}}{\text{molarity of HCl}}
$$

Calculating:
$$
\text{Volume of HCl} = \frac{0.002789\, \text{mol}}{0.1379\, \text{mol/L}} \approx 0.0202\, \text{L}
$$

Converting to milliliters:
$$
0.0202\, \text{L} \times 1000\, \text{mL/L} = 20.2\, \text{mL}
$$

Answer: Approximately 20.2 mL of 0.1379 M HCl is required to neutralize 10.0 mL of 0.2789

M NaOH solution.

Additional Considerations for Accurate Titration

While the calculation above provides a theoretical volume, practical titrations involve several factors that can influence the actual volume required:

End Point Detection

- The titration endpoint is typically indicated by a color change using an appropriate pH indicator.
- Slight variations can occur due to the indicator’s sensitivity, so precise measurement may require multiple trials.

Concentration Accuracy

- Ensure that the molarity values for both solutions are accurately prepared and known.
- Slight deviations in concentration can significantly affect the volume calculations.

Temperature Effects

- Temperature can influence molarity and reaction rates; conducting titrations at controlled temperatures enhances accuracy.

Practical Applications of Acid-Base Neutralization Calculations

Understanding how to calculate the required volume of acid for neutralization has numerous practical applications:

- **Laboratory Titrations:** Precise determination of unknown concentrations.
- **Industrial Processes:** Ensuring proper neutralization in chemical manufacturing.
- **Environmental Testing:** Assessing acidity or alkalinity of water sources.
- **Educational Demonstrations:** Teaching concepts of molarity and stoichiometry.

Summary of Key Steps in the Calculation

1. Calculate moles of NaOH using its volume and molarity.
2. Use the molar ratio from the balanced chemical equation to find moles of HCl needed.
3. Divide the moles of HCl by its molarity to find the volume required.

Conclusion

In summary, to determine the volume of 0.1379 M HCl needed to neutralize 10.0 mL of 0.2789 M NaOH, the calculation involves straightforward stoichiometry based on molarity and molar ratios. The process results in approximately 20.2 mL of HCl solution being required for complete neutralization. Such calculations are fundamental in chemistry labs, industrial applications, and environmental science, underscoring the importance of understanding molarity, titration principles, and precise measurement techniques for accurate results. Whether for academic purposes or practical applications, mastering these calculations enhances one's ability to work confidently with acid-base reactions.

Frequently Asked Questions

How do you calculate the volume of HCl needed to neutralize a given volume of NaOH solution?

Use the neutralization formula $M_1V_1 = M_2V_2$, where M and V are the molarity and volume of each solution. Rearrange to find the unknown volume: $V_1 = (M_2 \times V_2) / M_1$.

What is the molarity of NaOH in the problem?

The molarity of NaOH is 0.2789 M.

What is the volume of NaOH solution provided in the problem?

The volume of NaOH solution is 10.0 mL.

How do you convert the volume of NaOH from milliliters to liters for calculation?

Divide the volume in milliliters by 1000: 10.0 mL = 0.0100 L.

What is the molarity of the HCl solution used in the calculation?

The molarity of HCl is 0.1379 M.

What is the calculated volume of 0.1379 M HCl required to neutralize 10.0 mL of 0.2789 M NaOH?

Using the formula $V_1 = (M_2 \times V_2) / M_1$, $V_1 = (0.2789 \text{ mol/L} \times 0.0100 \text{ L}) / 0.1379 \text{ mol/L} \approx 0.0202 \text{ L}$ or 20.2 mL.

Additional Resources

What Volume Of 0.1379 M Hcl Is Required To Neutralize 10.0 Ml Of 0.2789 M Naoh Solution is a classic example of a titration problem, which is fundamental to understanding acid-base chemistry. Such calculations are essential in various scientific fields, including analytical chemistry, environmental testing, and industrial processes. Determining the precise volume of a solution needed for neutralization not only demonstrates core principles of molarity and stoichiometry but also highlights the importance of accurate measurements in chemical reactions. This article provides an in-depth exploration of how to approach this problem, including the theoretical background, step-by-step calculations, and practical considerations.

Understanding the Basics of Acid-Base Titration

What Is Titration?

Titration is a laboratory technique used to determine the concentration of an unknown solution by adding a reagent of known concentration until a reaction reaches its endpoint. In acid-base titrations, a strong acid and a strong base react in a straightforward, predictable manner based on their molar ratios.

Core Concepts: Molarity and Stoichiometry

- Molarity (M): Represents moles of solute per liter of solution. For example, 0.1379 M HCl contains 0.1379 moles of HCl per liter.
- Stoichiometry: The calculation of reactants and products in chemical reactions. For acids and bases, the mole ratio is typically 1:1 unless otherwise specified.

Setting Up the Calculation

Given Data

- Molarity of HCl (acid): 0.1379 M
- Volume of NaOH (base): 10.0 mL (which is 0.0100 L)
- Molarity of NaOH: 0.2789 M

Reaction Equation

The neutralization reaction between hydrochloric acid and sodium hydroxide is:

$$ \text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} $$

This reaction proceeds on a 1:1 molar basis, meaning one mole of HCl reacts with one mole of NaOH.

Step-by-Step Calculation

1. Calculate moles of NaOH used

Using the molarity and volume of NaOH:

$$
\text{moles of NaOH} = M_{NaOH} \times V_{NaOH}
$$

$$
= 0.2789\, \text{mol/L} \times 0.0100\, \text{L} = 0.002789\, \text{mol}
$$

2. Determine moles of HCl required

Since the molar ratio is 1:1:

$$
\text{moles of HCl} = \text{moles of NaOH} = 0.002789\, \text{mol}
$$

3. Calculate the volume of HCl required

Using the molarity of HCl:

$$
V_{HCl} = \frac{\text{moles of HCl}}{M_{HCl}} = \frac{0.002789\, \text{mol}}{0.1379\, \text{mol/L}}
$$

$$
V_{HCl} \approx 0.02021\, \text{L}
$$

Converting to milliliters:

$$
V_{HCl} \approx 20.21\, \text{mL}
$$

Therefore, approximately 20.21 mL of 0.1379 M HCl is required to neutralize 10.0 mL of 0.2789 M NaOH.

Practical Features and Considerations of This Calculation

Accuracy Factors

- Precision in measurements: Using accurate volumetric instruments such as burettes ensures reliable results.
- Concentration accuracy: Ensuring the molarity of solutions is correctly prepared or calibrated is vital.
- Reaction completeness: Confirming the endpoint, especially in practical titrations, to avoid under- or over-titration.

Potential Errors and Their Impact

- Reading errors: Parallax or misreading burette scales can lead to inaccuracies.
- Solution contamination: Impurities or evaporation can alter concentrations.
- Temperature effects: Changes in temperature can slightly affect molarity and reaction rates.

Features and Pros/Cons of the Calculation Approach

Features:

- Based on fundamental stoichiometry principles applicable to many titrations.
- Straightforward calculation once all data are known.
- Reinforces understanding of molarity, molar ratio, and unit conversions.

Pros:

- Simple and quick to perform with basic data.
- Highly accurate if measurements are precise.
- Adaptable to different acid-base pairs with similar principles.

Cons:

- Assumes complete reaction without side reactions.
- Requires accurate initial data; errors in concentration or volume significantly affect results.
- Does not account for experimental factors like endpoint detection accuracy.

Extensions and Real-World Applications

Understanding how to calculate the required volume of acid to neutralize a base extends beyond academic exercises. In industry, it aids in:

- Manufacturing processes: Precise dosing of acids or bases for pH adjustments.
- Environmental testing: Determining pollutant levels by titration.
- Medical laboratory work: Acid-base balance assessments.

In each case, the principles remain the same but are adapted to specific contexts and safety protocols.

Conclusion

Calculating the volume of 0.1379 M HCl needed to neutralize 10.0 mL of 0.2789 M NaOH is a fundamental exercise in acid-base chemistry that demonstrates the application of molarity, mole concept, and stoichiometry. The key steps involve determining the moles of NaOH present, translating that into the required moles of HCl, and then calculating the corresponding volume of HCl solution. The result—about 20.21 mL—illustrates how

chemical principles translate into practical laboratory procedures. While the calculation is straightforward, attention to detail in measurement and awareness of potential errors are crucial for accuracy. Mastery of such titration calculations underpins many analytical techniques and is essential for students, researchers, and professionals working in chemistry-related fields.

In summary:
- The process relies on the molar ratios in the balanced chemical equation.
- Precise measurements and calibration are key to accuracy.
- The fundamental principles illustrated here are applicable across various chemical analyses and industrial applications.

By understanding and applying these principles, one can confidently perform titrations and interpret their results, ensuring reliability and consistency in chemical experimentation and analysis.

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