How Many ML Of 0.375M KOH Are Needed To Neutralize 185 ML Of 0.250M Hydrobromic Acid? (123 ML)

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Understanding the precise volume of a base required to neutralize a given volume of an acid is fundamental in chemistry, especially in titration procedures. In this article, we explore how to determine the volume of 0.375M potassium hydroxide (KOH) needed to neutralize 185 mL of 0.250M hydrobromic acid (HBr). We will explain the underlying principles, step-by-step calculations, and practical applications of this process.

Introduction to Acid-Base Neutralization

What is Neutralization?

Neutralization is a chemical reaction where an acid reacts with a base to produce water and a salt. The general reaction can be represented as:

\[\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water} \]

In the case of hydrobromic acid and potassium hydroxide:

\[\mathrm{HBr} + \mathrm{KOH} \rightarrow \mathrm{KBr} + \mathrm{H_2O} \]

Importance in Titration

Titration is a laboratory technique used to determine the concentration of an unknown solution by reacting it with a solution of known concentration. By using a suitable indicator, the endpoint of the reaction is observed, allowing for calculation of the unknown concentration or volume.

Understanding the Problem: Key Data and Goals

Before diving into calculations, let's identify the given data and what we need to find.

Given Data:

- Molarity of KOH (base): $M_{KOH} = 0.375\, \text{mol/L}$
- Volume of KOH needed: $V_{KOH} = ?\, \text{mL}$
- Molarity of hydrobromic acid (acid): $M_{HBr} = 0.250\, \text{mol/L}$
- Volume of hydrobromic acid: $V_{HBr} = 185\, \text{mL}$

What to Find:

- The volume of 0.375M KOH required to neutralize 185 mL of 0.250M HBr, which is given as 123 mL (answer to verify).

Step-by-Step Calculation of the Required KOH Volume

The core of the problem involves stoichiometry—the quantitative relationship between reactants and products.

Step 1: Convert Volumes to Liters

Since molarity is expressed in mol/L, convert the given volumes:

$$
V_{HBr} = 185\, \text{mL} = 0.185\, \text{L}
$$
$$
V_{KOH} = ?\, \text{mL}
$$

Step 2: Calculate Moles of Hydrobromic Acid

Number of moles of HBr:

$$
\text{Moles of HBr} = M_{HBr} \times V_{HBr} = 0.250\, \text{mol/L} \times 0.185\, \text{L} = 0.04625\, \text{mol}
$$

Step 3: Determine the Mole Ratio

The balanced chemical equation shows a 1:1 molar ratio:

$$
\mathrm{HBr} + \mathrm{KOH} \rightarrow \mathrm{KBr} + \mathrm{H_2O}
$$

This means 1 mole of HBr reacts with 1 mole of KOH.

Step 4: Calculate Moles of KOH Needed

Since the molar ratio is 1:1:

$$
\text{Moles of KOH} = \text{Moles of HBr} = 0.04625\, \text{mol}
$$

Step 5: Calculate the Volume of KOH Required

Using molarity:

$$
V_{KOH} = \frac{\text{Moles of KOH}}{M_{KOH}} = \frac{0.04625\, \text{mol}}{0.375\, \text{mol/L}} \approx 0.1233\, \text{L}
$$

Convert to milliliters:

$$
V_{KOH} \approx 0.1233\, \text{L} \times 1000\, \text{mL/L} \approx 123.3\, \text{mL}
$$

This aligns perfectly with the given answer of 123 mL.

Practical Implications and Applications

Understanding how to perform these calculations is essential in various fields such as:

- Chemical Manufacturing: Precise titration ensures correct formulation of products.
- Pharmaceutical Industry: Accurate neutralization is vital for drug development.
- Environmental Testing: Determining pollutant concentrations through titration.
- Educational Settings: Teaching fundamental stoichiometry principles.

Additional Considerations in Titration

Choice of Indicator

Selecting an appropriate indicator (e.g., bromothymol blue for acid-base titrations) ensures a clear endpoint.

Accuracy and Precision

- Use calibrated equipment.
- Repeat titrations to confirm results.
- Consider endpoint detection methods for better accuracy.

Limitations and Sources of Error

- Misreading buret levels.
- Impure reactants.
- Incomplete reactions or side reactions.

Summary of Key Steps in Neutralization Calculations

1. Convert all volumes to liters.
2. Calculate moles of the known reactant (acid).
3. Use the mole ratio from the balanced equation to find moles of the unknown reactant (base).
4. Calculate the volume of the unknown reactant using molarity.

By following these steps, you can accurately determine the volume of a titrant needed for any acid-base neutralization problem.

Conclusion

In this detailed exploration, we've demonstrated that to neutralize 185 mL of 0.250M hydrobromic acid, approximately 123 mL of 0.375M potassium hydroxide is required. This calculation hinges on understanding molarity, mole ratios, and basic stoichiometry principles. Mastery of these concepts enables chemists and students alike to perform accurate titrations, ensuring precise chemical measurements vital across scientific disciplines.

References and Further Reading

- Chemistry: The Central Science by Brown, LeMay, Bursten, Murphy
- Quantitative Chemical Analysis by Daniel C. Harris
- Online titration calculators and molarity tutorials
- Laboratory manuals on acid-base titration techniques

Remember: Always double-check your calculations and lab procedures to ensure safety and accuracy in your experiments!

Frequently Asked Questions

How do you calculate the volume of KOH needed to neutralize a given volume of hydrobromic acid?

Use the neutralization formula: $M_1V_1 = M_2V_2$, where M and V are molarity and volume. Rearranged to find the required volume of KOH: $V_2 = (M_1V_1) / M_2$.

What is the significance of the molarity values in calculating the required KOH volume?

Molarity indicates the concentration of the solutions. It helps determine the exact volume of KOH needed to provide the equivalent amount of hydroxide ions to neutralize the acid based on their molar ratios.

Why is the answer 123 mL for the volume of 0.375 M KOH needed to neutralize 185 mL of 0.250 M hydrobromic acid?

Applying the neutralization formula: V_KOH = (M_HBr V_HBr) / M_KOH = (0.250 185) / 0.375 ≈ 123 mL, which confirms the given answer.

How does the molarity of hydrobromic acid compare to that of KOH in this neutralization problem?

The hydrobromic acid has a molarity of 0.250 M, while the KOH solution has a higher molarity of 0.375 M, meaning less volume of the more concentrated KOH is needed for neutralization.

What is the purpose of using molarity and volume in titration calculations like this one?

They allow for precise determination of the amount of reactant needed to achieve neutralization, ensuring accurate and consistent chemical reactions in titration processes.

Additional Resources

KOH Neutralization Calculation: A Comprehensive Guide to Determining the Required Volume for Hydrobromic Acid

When it comes to chemical reactions involving acids and bases, understanding how to accurately determine the volume of one reagent needed to neutralize another is fundamental. Whether you're a student tackling a chemistry problem, a lab technician ensuring precise titrations, or a researcher designing experiments, mastering the calculation of reagent volumes is essential. In this article, we delve into a specific scenario: calculating how many milliliters of a 0.375 M potassium hydroxide (KOH) solution are required to neutralize 185 mL of a 0.250 M hydrobromic acid (HBr) solution. We'll present a step-by-step approach, explore the underlying principles, and clarify common pitfalls.

Understanding the Fundamentals of Acid-Base Neutralization

Before diving into calculations, it's crucial to comprehend the core concept: neutralization. Neutralization is a chemical reaction where an acid reacts with a base to produce water and a salt. The general form for a strong acid and strong base is:

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

In our specific case:

$$\mathrm{HBr} + \mathrm{KOH} \rightarrow \mathrm{KBr} + \mathrm{H_2O}$$

This reaction proceeds in a 1:1 molar ratio, meaning one mole of hydrobromic acid reacts with one mole of potassium hydroxide.

Key Variables and Data

Let's identify the known quantities:

- Concentration of KOH (Base): 0.375 M
- Volume of KOH needed (Unknown): To be calculated in milliliters (mL)
- Concentration of HBr (Acid): 0.250 M
- Volume of HBr (Acid): 185 mL
- Expected volume of KOH (from scenario): 123 mL (for context)

The goal is to verify or determine how much KOH is required, given the concentrations and volume of HBr.

Step-by-Step Calculation Process

1. Calculate the moles of hydrobromic acid (HBr)

Using molarity and volume:

$$
\text{Moles of HBr} = M_{HBr} \times V_{HBr}
$$

Where:

- $M_{HBr} = 0.250\, \text{mol/L}$
- $V_{HBr} = 185\, \text{mL} = 0.185\, \text{L}$

$$
\text{Moles of HBr} = 0.250\, \text{mol/L} \times 0.185\, \text{L} = 0.04625\, \text{mol}
$$

2. Determine the moles of KOH needed

Since the reaction is 1:1, the moles of KOH required are equal to the moles of HBr:

$$
\text{Moles of KOH} = 0.04625\, \text{mol}
$$

3. Calculate the volume of KOH solution required

Using the molarity of KOH:

$$
V_{KOH} = \frac{\text{Moles of KOH}}{M_{KOH}}

\]

$$
V_{KOH} = \frac{0.04625\, \text{mol}}{0.375\, \text{mol/L}} \approx 0.1233\, \text{L}
$$

Convert to milliliters:

$$
V_{KOH} \approx 0.1233\, \text{L} \times 1000\, \text{mL/L} = 123.3\, \text{mL}
$$

This matches the scenario's provided volume of approximately 123 mL, confirming the calculation's accuracy.

Interpreting the Results and Practical Implications

Theoretical Confirmation

The calculation demonstrates that about 123 mL of 0.375 M KOH is needed to neutralize 185 mL of 0.250 M HBr. This precise volume ensures complete neutralization, assuming ideal conditions and complete reaction.

Real-World Considerations

While calculations are straightforward, practical lab scenarios may introduce factors such as:

- Concentration inaccuracies: Slight deviations in molarity.
- Measurement errors: Pipettes and burettes have tolerances.
- Reaction completeness: Ensuring complete mixing and reaction.
- Temperature effects: Affecting molarities and reaction rates.

Application Contexts

This calculation is pivotal in various contexts:

- Titration experiments: Quantitative determination of unknown concentrations.
- Industrial processes: Precise reagent dosing.
- Educational demonstrations: Understanding stoichiometry.
- Chemical safety: Proper handling and disposal based on reagent quantities.

Common Pitfalls and Tips for Accurate Calculations

- Always convert volumes to liters when calculating molarity-based moles.
- Keep track of significant figures to maintain precision.
- Verify the reaction ratio: For reactions beyond 1:1, adjust calculations accordingly.
- Use consistent units throughout all steps.
- Double-check calculations: Small errors can lead to significant deviations in reagent volumes.

Additional Insights and Related Calculations

Adjusting for Different Concentrations

Suppose the KOH solution's molarity changes, or you have a different acid volume. The same calculation approach applies:

$$
V_{KOH} = \frac{M_{HBr} \times V_{HBr}}{M_{KOH}}
$$

Handling Weak or Polyprotic Acids

For acids with multiple dissociation steps or multiple reactive sites, the molar ratios differ, requiring adjusted calculations based on the number of protons or reactive sites involved.

Conclusion: Mastering Acid-Base Neutralization Calculations

In summary, determining the volume of KOH necessary to neutralize a given amount of hydrobromic acid hinges on understanding molarity, molar ratios, and careful unit conversions. The case study confirms that approximately 123 mL of 0.375 M KOH is needed for 185 mL of 0.250 M HBr, aligning perfectly with theoretical predictions. Mastery of these calculations empowers chemists, students, and professionals to perform precise titrations, ensure safety, and interpret experimental data reliably.

By following a systematic approach, double-checking each step, and considering practical nuances, you can confidently handle similar acid-base neutralization problems with accuracy and expertise.

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