A 25.0 ML Sample Of Ba (OH)2 Solution Was Neutralized By 45.3 ML Of 0.150 N HCl. What Is The Normality

A 25.0 ML Sample Of Ba (OH)2 Solution Was Neutralized By 45.3 ML Of 0.150 N HCl. What Is The Normality

Understanding the concept of normality in acid-base chemistry is essential for accurately determining the concentration of solutions involved in titrations. In this article, we will explore the process of calculating the normality of a Barium hydroxide ($Ba(OH)_2$) solution based on titration data involving Hydrochloric acid (HCl). We will go through the relevant chemical principles, step-by-step calculations, and provide clarity on related concepts to ensure a comprehensive understanding.

Introduction to Normality and Titration Concepts

What Is Normality?

Normality (N) is a measure of concentration that expresses the number of equivalents of solute per liter of solution. It is particularly useful in acid-base, oxidation-reduction, and precipitation reactions because it accounts for the reactive capacity of a substance, rather than just the molar amount.

Definition:
Normality = Equivalents of solute / Liters of solution

Equivalents:
The amount of substance that reacts with or supplies one mole of hydrogen ions (H^+) or electrons.

Understanding Titration in Acid-Base Reactions

Titration is a laboratory technique used to determine the concentration of an unknown solution by reacting it with a solution of known concentration (the titrant). In an acid-base titration, the titrant is an acid or base, and the analyte is the unknown solution.

Key concepts:
- The equivalence point is reached when the amount of acid equals the amount of base reacting, based on their stoichiometry.
- The volume of titrant used at the equivalence point allows calculation of the unknown

concentration.

Chemical Reactions Involved

Reaction Between $Ba(OH)_2$ and HCl

The reaction between Barium hydroxide and Hydrochloric acid is a typical acid-base neutralization:

$$\mathrm{Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O}$$

Stoichiometry:
- 1 mole of $Ba(OH)_2$ reacts with 2 moles of HCl.

Implication:
- The reaction involves a 1:2 molar ratio between $Ba(OH)_2$ and HCl.

Understanding Equivalents in the Reaction

Given that normality accounts for equivalents, we observe:

- For $Ba(OH)_2$:
- Each mole provides 2 equivalents of OH^- ions (since there are 2 hydroxide ions per formula unit).
- For HCl:
- Each mole provides 1 equivalent of H^+ ions.

Step-by-Step Calculation of Normality of $Ba(OH)_2$ Solution

To find the normality of the $Ba(OH)_2$ solution, we'll analyze the titration data systematically.

Step 1: Determine the Equivalents of HCl Used

Given data:

- Volume of HCl, $V_{HCl} = 45.3\, \text{mL} = 0.0453\, \text{L}$
- Normality of HCl, $N_{HCl} = 0.150\, \text{N}$

Calculate:

$$
\text{Equivalents of HCl} = N_{HCl} \times V_{HCl}
$$

$$
= 0.150\, \frac{\text{eq}}{\text{L}} \times 0.0453\, \text{L} = 0.006795\, \text{eq}
$$

Step 2: Determine the Equivalents of $Ba(OH)_2$ Neutralized

Since the reaction ratio between $Ba(OH)_2$ and HCl is 1:2:

$$
\mathrm{Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O}
$$

- 1 equivalent of $Ba(OH)_2$ reacts with 2 equivalents of HCl.
- Therefore, the equivalents of $Ba(OH)_2$ in the sample are:

$$
\text{eq of Ba(OH)}_2 = \frac{\text{eq of HCl}}{2} = \frac{0.006795}{2} = 0.0033975\, \text{eq}
$$

Step 3: Calculate the Normality of $Ba(OH)_2$ Solution

Given:

- Volume of $Ba(OH)_2$ solution, $V_{Ba(OH)_2} = 25.0\, \text{mL} = 0.025\, \text{L}$

Normality is:

$$
N_{Ba(OH)_2} = \frac{\text{Equivalents of Ba(OH)}_2}{V_{Ba(OH)_2}}
$$

$$
= \frac{0.0033975\, \text{eq}}{0.025\, \text{L}} = 0.1359\, \text{N}
$$

Final answer:

\[
\boxed{

\text{The normality of the Ba(OH)}_2 \text{ solution is approximately } 0.136\, \text{N}
}
\]

Additional Considerations and Clarifications

Why Use Normality Instead of Molarity?

Normality simplifies calculations where the reactive capacity of a solution is more relevant than its molar concentration. For example, in titrations involving acids and bases, normality directly relates to the number of reactive species involved.

Common Mistakes to Avoid

- Confusing molarity and normality:
Remember that normality accounts for the number of equivalents, which depends on the reaction.

- Incorrect stoichiometric ratios:
Always verify the balanced chemical equation before calculations.

- Unit errors:
Convert all volume measurements to liters before calculations to maintain consistency.

Practical Applications

Understanding and calculating normality is vital in various fields such as:

- Pharmacology for preparing solutions.
- Environmental chemistry for analyzing water samples.
- Industrial processes involving titrations for quality control.

Conclusion

In summary, calculating the normality of $Ba(OH)_2$ from titration data involves understanding the reaction stoichiometry, calculating equivalents of titrant used, and applying the relationship between equivalents and normality. The process demonstrates how chemical principles translate into quantitative analyses, enabling chemists to determine unknown concentrations accurately. The normality of the $Ba(OH)_2$ solution in this scenario is approximately 0.136 N, reflecting its reactive capacity in the neutralization process with HCl.

FAQs

- **What is the significance of normality in titrations?**
  Normality directly relates to the reactive capacity of a solution, simplifying stoichiometric calculations in acid-base reactions.

- **Can normality be used interchangeably with molarity?**
  Not directly; normality considers equivalents, which depend on the reaction. Molarity measures moles per liter, regardless of reactivity.

- **How does reaction stoichiometry affect the calculation of normality?**
  It determines the ratio of equivalents between reactants, which is crucial for accurate calculations.

By mastering these concepts and calculations, students and professionals alike can confidently analyze titration data and determine solution concentrations for various chemical applications.

Frequently Asked Questions

How do you determine the normality of $Ba(OH)_2$ in the given solution?

Normality is determined by using the titration data with HCl, considering the equivalent points and the relation between equivalents of acid and base. Specifically, N of HCl × volume of HCl = N of $Ba(OH)_2$ × volume of $Ba(OH)_2$, adjusted for their equivalents.

What is the significance of the volume and normality of HCl in calculating the normality of $Ba(OH)_2$?

The volume and normality of HCl allow us to find the number of equivalents of acid reacted, which can then be used to determine the equivalents of $Ba(OH)_2$ in the sample, leading to the calculation of its normality.

How do you calculate the normality of $Ba(OH)_2$ from the titration data?

Use the equation: $N_1V_1 = N_2V_2$, where N_1 and V_1 are the normality and volume of HCl, and N_2 and V_2 are those of $Ba(OH)_2$. Rearranged, $N_2 = (N_1 \times V_1) / V_2$.

What is the molarity of $Ba(OH)_2$ if the normality is known?

Since $Ba(OH)_2$ is a diprotic base, its molarity equals half of its normality, because each molecule provides two hydroxide ions, but normality already accounts for equivalents, so molarity = normality / 2.

How does the reaction between $Ba(OH)_2$ and HCl proceed in terms of equivalents?

$Ba(OH)_2$ reacts with HCl in a 1:2 molar ratio because each $Ba(OH)_2$ provides two hydroxide ions, which neutralize two equivalents of HCl.

What is the step-by-step calculation to find the normality of $Ba(OH)_2$ from the given data?

First, calculate the equivalents of HCl: 0.150 N × 45.3 mL = 0.150 Eq/mL × 45.3 mL = 6.795 equivalents. Since 1 mol $Ba(OH)_2$ neutralizes 2 equivalents of HCl, the equivalents of $Ba(OH)_2$ = 6.795 / 2 = 3.3975 equivalents. Then, normality of $Ba(OH)_2$ = equivalents / volume in liters: 3.3975 / 0.025 L = 135.9 N.

What is the final normality of $Ba(OH)_2$ solution based on the titration data?

The normality of $Ba(OH)_2$ is approximately 135.9 N, calculated from the titration data provided.

Additional Resources

A 25.0 mL Sample Of $Ba(OH)_2$ Solution Was Neutralized By 45.3 mL Of 0.150 N HCl. What Is The Normality?

Introduction

In the realm of analytical chemistry, titration remains an indispensable technique for determining the concentration of unknown solutions. When examining the neutralization of a base by an acid, understanding the concept of normality becomes crucial, especially for reactions involving polyprotic acids or bases. This article delves into an investigative analysis of a titration experiment where a 25.0 mL sample of barium hydroxide ($Ba(OH)_2$) solution is neutralized by a measured volume of hydrochloric acid (HCl) of known normality. The core objective is to determine the normality of the $Ba(OH)_2$ solution based on the titration data provided.

Background: The Chemistry of $Ba(OH)_2$ and HCl

Barium hydroxide ($Ba(OH)_2$) is a strong, soluble base that dissociates completely in aqueous solution:

$$ \mathrm{Ba(OH)_2} \rightarrow \mathrm{Ba^{2+}} + 2 \mathrm{OH^-} $$

This dissociation results in two hydroxide ions (OH^-) per formula unit, making $Ba(OH)_2$ a diprotic base in terms of hydroxide ion release.

Hydrochloric acid (HCl) is a strong acid that dissociates fully:

$$ \mathrm{HCl} \rightarrow \mathrm{H^+} + \mathrm{Cl^-} $$

In titration, HCl reacts with hydroxide ions as follows:

$$ \mathrm{H^+} + \mathrm{OH^-} \rightarrow \mathrm{H_2O} $$

Given the stoichiometry, the neutralization reaction between $Ba(OH)_2$ and HCl involves the following overall reaction:

$$ \mathrm{Ba(OH)_2} + 2 \mathrm{HCl} \rightarrow \mathrm{BaCl_2} + 2 \mathrm{H_2O} $$

This indicates that one mole of $Ba(OH)_2$ reacts with two moles of HCl.

Understanding Normality in Acid-Base Titrations

Normality (N) is defined as the number of equivalents of solute per liter of solution. For acids and bases:

- For HCl, which provides one proton per molecule, the normality equals molarity (assuming monoprotic acid).
- For $Ba(OH)_2$, which provides two hydroxide ions per molecule, the normality is twice its molarity because each molecule supplies two equivalents of hydroxide.

In titrations involving strong acids and bases, the equivalence point is reached when the equivalents of acid equal the equivalents of base.

The Data and Its Implications

The experiment provides the following data:

- Volume of $Ba(OH)_2$ solution: 25.0 mL
- Volume of HCl used for neutralization: 45.3 mL
- Normality of HCl: 0.150 N

The key question is: What is the normality of the $Ba(OH)_2$ solution?

Step-by-Step Calculation of the Normality of $Ba(OH)_2$

Step 1: Convert all volumes to liters

- $Ba(OH)_2$: $25.0\, \mathrm{mL} = 0.0250\, \mathrm{L}$
- HCl: $45.3\, \mathrm{mL} = 0.0453\, \mathrm{L}$

Step 2: Calculate equivalents of HCl used

Since normality (N) × volume (L) gives equivalents:

$$\text{Equivalents of HCl} = N_{HCl} \times V_{HCl}$$

$$= 0.150\, \mathrm{eq/L} \times 0.0453\, \mathrm{L} = 0.006795\, \text{equivalents}$$

Step 3: Determine the equivalents of $Ba(OH)_2$

From the stoichiometry of the neutralization reaction:

$$\mathrm{Ba(OH)_2} + 2 \mathrm{HCl} \rightarrow \mathrm{BaCl_2} + 2 \mathrm{H_2O}$$

One mole of $Ba(OH)_2$ reacts with two equivalents of HCl. Therefore:

$$\text{Equivalents of Ba(OH)}_2 = \frac{\text{Equivalents of HCl}}{2}$$

$$= \frac{0.006795}{2} = 0.0033975\, \text{equivalents}$$

Step 4: Calculate the normality of $Ba(OH)_2$

Normality is equivalents per liter:

$$N_{Ba(OH)_2} = \frac{\text{Equivalents of Ba(OH)_2}}{V_{Ba(OH)_2}}$$

$$= \frac{0.0033975}{0.0250\, \mathrm{L}} \approx 0.1359\, \mathrm{N}$$

Interpretation and Significance

The calculation reveals that the normality of the $Ba(OH)_2$ solution is approximately 0.136 N.

This value indicates the concentration of reactive hydroxide equivalents present in the solution, which is essential for various applications, including titration accuracy, reagent preparation, and stoichiometric calculations.

Understanding the normality is particularly important when dealing with reactions involving polyprotic acids or bases, where the number of equivalents directly influences the stoichiometry and the titration endpoint. In industrial and research settings, such precise determination ensures proper reagent quantification and process control.

Additional Considerations

- Accuracy of Measurements: The precision of volume measurements influences the calculated normality. Using calibrated pipettes and burettes minimizes errors.
- Reaction Completion: The assumption here is that both solutions fully reacted, which is valid given the strength of the acids and bases involved.
- Polyprotic Nature: Since $Ba(OH)_2$ supplies two hydroxide ions per molecule, the normality calculation reflects this diprotic character, distinguishing it from molarity.

Conclusion

Through a detailed analysis of titration data, it is evident that the normality of the $Ba(OH)_2$ solution is approximately 0.136 N. This determination underscores the importance of understanding stoichiometry and normality in analytical chemistry, especially when quantifying solutions involving polyprotic species. The ability to accurately calculate normality ensures reliable experimental outcomes, facilitates quality control, and promotes a deeper comprehension of acid-base interactions.

References

1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2017). Fundamentals of Analytical Chemistry. Cengage Learning.
2. Harris, D. C. (2015). Quantitative Chemical Analysis. Macmillan Higher Education.
3. Atkins, P., & de Paula, J. (2014). Physical Chemistry. Oxford University Press.

Acknowledgments

The author appreciates the foundational principles of titration and stoichiometry that underpin this analysis, as well as the importance of precise measurement in chemical investigations.

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