21.10g Of NaOH And Ba3(OH)2 Mixture Is Dissolved Water To Prepare 1.0dm Solution. To Neutralize 25.OO

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Understanding the preparation and neutralization of alkaline solutions is fundamental in chemistry, especially when dealing with strong bases like sodium hydroxide (NaOH) and barium hydroxide ($Ba(OH)_2$). In this article, we delve into the process of dissolving a mixture of 21.10 grams of NaOH and $Ba_3(OH)_2$ in water to prepare a 1.0 dm^3 solution, and explore how this solution interacts with a specific amount of acid, focusing on neutralization principles, calculations, and practical applications.

Introduction to Alkali Solutions and Their Significance

Alkali solutions, primarily composed of hydroxides of alkali and alkaline earth metals, are widely used in industries ranging from manufacturing to laboratory testing. Sodium hydroxide (NaOH), also known as caustic soda, and barium hydroxide ($Ba(OH)_2$), are both strong bases capable of fully dissociating in water, releasing hydroxide ions (OH^-).

The neutrality and pH of such solutions determine their reactivity and suitability for various applications, such as titrations, pH adjustments, and chemical syntheses. Preparing precise concentrations of these solutions is crucial for achieving accurate and reliable results in experimental and industrial processes.

Preparation of the NaOH and $Ba(OH)_2$ Mixture Solution

Calculating the Moles of NaOH and $Ba(OH)_2$

The initial step involves calculating the number of moles of each component in the mixture.

- Sodium hydroxide (NaOH):

- Molar mass of NaOH = 23 (Na) + 16 (O) + 1 (H) = 40 g/mol

- Moles of NaOH = 21.10 g / 40 g/mol = 0.5275 mol

- Barium hydroxide ($Ba(OH)_2$):

- Molar mass of $Ba(OH)_2$ = 137 (Ba) + 2×16 (O) + 2×1 (H) = 137 + 32 + 2 = 171 g/mol

- Moles of $Ba(OH)_2$ = (Remaining mass in the mixture) / 171 g/mol

Given the total mixture weighs 21.10 g, and the NaOH component is 21.10 g, it appears that the entire mixture is NaOH. However, for the purpose of illustrating the calculation, suppose the mixture contains both NaOH and $Ba(OH)_2$.

Let's assume the mixture contains x grams of $Ba(OH)_2$, then:

- Total mass: 21.10 g = mass of NaOH + mass of $Ba(OH)_2$

- Mass of NaOH = 21.10 g – x g

- Moles of NaOH = (21.10 – x) / 40

- Moles of $Ba(OH)_2$ = x / 171

Alternatively, if the problem states a mixture of 21.10 g total, including both compounds, and we need to determine their individual contributions, further info is required. For simplicity, assume the mixture is composed of known amounts, or focus on the total molarity calculation assuming the entire mass is NaOH.

Preparing the 1.0 dm^3 Solution

To prepare a solution of 1.0 dm^3 (which is equivalent to 1 liter), the total molar concentration (molarity) is:

- Molarity (M) = total moles / volume in liters

Using the moles of NaOH and $Ba(OH)_2$, the total concentration can be calculated as:

- NaOH contribution:

- Molarity of NaOH = 0.5275 mol / 1 L = 0.5275 M

- $Ba(OH)_2$ contribution:

- Suppose the mixture contains x grams of $Ba(OH)_2$, then:

- Moles of $Ba(OH)_2$ = x / 171 mol

- Molarity of $Ba(OH)_2$ = (x / 171) / 1 L

This mixture results in a combined alkaline solution with specific hydroxide ion concentrations, which can be used for titration or neutralization experiments.

Neutralization with Acid: The Concept and Calculations

Understanding Neutralization Reactions

Neutralization involves reacting an acid with a base to produce salt and water. The strength and molarity of the solutions influence the amount of acid or base needed for complete neutralization.

For strong bases like NaOH and $Ba(OH)_2$, their reactions with acids are straightforward:

- NaOH:

- $NaOH + H^+ \rightarrow Na^+ + H_2O$

- $Ba(OH)_2$:

- $Ba(OH)_2 + 2H^+ \rightarrow Ba^{2+} + 2H_2O$

The molar ratios are critical; NaOH reacts with 1 mol of acid, while $Ba(OH)_2$ reacts with 2 mols of acid per mol of $Ba(OH)_2$.

Calculating the Volume of Acid Needed to Neutralize the Solution

Suppose the goal is to neutralize 25.00 mL of the prepared solution. To determine the amount of acid required, follow these steps:

1. Determine the total moles of hydroxide ions in the solution:

- Moles of NaOH = 0.5275 mol (assuming entire mixture is NaOH)

- Moles of $Ba(OH)_2$ (if present) can be added similarly

2. Calculate the total hydroxide concentration:

- For NaOH: 0.5275 mol in 1 L (or 1000 mL)

- Hydroxide concentration = 0.5275 M

3. Determine the moles of hydroxide in 25.00 mL:

- Moles of OH^- = 0.5275 mol/L × 0.025 L = 0.01319 mol

4. Calculate the moles of acid needed:

- For a monoprotic acid (e.g., HCl), the molar ratio is 1:1 with hydroxide ions.

- Moles of acid required = 0.01319 mol

5. Calculate the volume of acid solution needed:

- If the acid solution has concentration C mol/L,

- Volume V = moles / concentration = 0.01319 mol / C

For example, if the acid solution is 0.1 M HCl:

- V = 0.01319 mol / 0.1 mol/L = 0.1319 L = 131.9 mL

This calculation illustrates the importance of knowing solution concentrations and molar ratios for precise neutralization.

Practical Applications and Safety Considerations

Industrial and Laboratory Uses

Solutions of NaOH and $Ba(OH)_2$ are essential in various contexts:

- Chemical manufacturing: pH adjustments, soap making, and production of barium salts.

- Laboratory titrations: Determining unknown acid concentrations through standardization.

- Water treatment: Neutralizing acidic or basic pollutants.

Safety Precautions

Handling strong bases requires strict safety measures:

- Use of personal protective equipment (PPE) such as gloves, goggles, and lab coats.

- Proper storage in labeled, corrosion-resistant containers.

- Immediate neutralization and cleanup of spills.

- Awareness of the corrosive nature of these chemicals to prevent skin burns and eye injuries.

Environmental Impact and Disposal

Disposing of alkaline solutions must adhere to environmental regulations:

- Neutralize solutions with appropriate acids before disposal.

- Avoid releasing untreated bases into water bodies, which can harm aquatic life.

- Follow local guidelines for hazardous waste management.

Conclusion

Preparing a solution by dissolving 21.10 grams of NaOH and $Ba(OH)_2$ in water to make a 1.0 dm^3 solution involves understanding molar calculations, solution concentration, and the chemistry of hydroxide ions. The neutralization process with acids depends on molar ratios and solution concentrations, critical for both laboratory experiments and industrial applications. Proper safety and disposal practices ensure safe handling of these strong bases, making them valuable yet hazardous chemicals. Mastery of these concepts enables chemists and technicians to perform precise titrations, develop products, and maintain safe laboratory environments.

Keywords: NaOH, $Ba(OH)_2$, solution preparation, molarity, neutralization, titration, strong bases, chemical safety, hydroxide ions, acid-base reaction

Frequently Asked Questions

What is the purpose of dissolving 21.10 g of NaOH and $Ba(OH)_2$ in water?

The purpose is to prepare a 1.0 dm^3 solution with a specific concentration for neutralization purposes.

How do you determine the total molarity of the mixture containing NaOH and $Ba(OH)_2$?

Calculate moles of each compound separately using their molar masses and divide by the total volume to find their individual molarities, then sum them for total molarity.

What volume of the 1.0 dm^3 NaOH and $Ba(OH)_2$ solution is needed to neutralize 25.00 mL of an acid?

The volume can be determined using titration calculations based on the molarity of the mixture and the acid, applying the neutralization reaction equations.

What is the molar mass of NaOH and $Ba(OH)_2$?

NaOH has a molar mass of approximately 40 g/mol, while $Ba(OH)_2$ has a molar mass of about 171.34 g/mol.

How do you calculate the moles of NaOH and $Ba(OH)_2$ in 21.10 g of the mixture?

Divide the mass of each compound by its molar mass: moles of NaOH = 21.10 g × (portion of NaOH) / molar mass; similarly for $Ba(OH)_2$, based on their respective amounts in the mixture.

What is the neutralization reaction between NaOH, $Ba(OH)_2$, and the acid?

NaOH and $Ba(OH)_2$ are strong bases that react with acids through neutralization, producing water and corresponding salts; for example, NaOH reacts with HCl to form NaCl and water.

How do you determine the amount of acid neutralized by the mixture?

Calculate the equivalents based on the molarities and volumes of the base mixture and compare with the acid's equivalents to find the amount neutralized.

What factors affect the accuracy of preparing this neutralization solution?

Factors include precise measurement of mass, proper dissolution, accurate volume measurement, and complete mixing of the solution.

Why is it important to consider the mixture of NaOH and $Ba(OH)_2$ separately when preparing the solution?

Because they have different molar masses and dissociation properties, which affect the total molarity and neutralization capacity of the mixture.

Additional Resources

21.10g Of NaOH And Ba3(OH)2 Mixture Is Dissolved Water To Prepare 1.0dm Solution. To Neutralize 25.00

Introduction

The preparation of standardized solutions is a fundamental aspect of analytical chemistry, ensuring accurate titrations, calibrations, and chemical analyses. Among these, solutions of sodium hydroxide (NaOH) and barium hydroxide ($Ba(OH)_2$) are frequently employed due to their strong alkaline nature and utility in titrations. This article investigates the process of preparing a 1.0 dm^3 (liter) solution from a mixture of 21.10 grams of NaOH and $Ba_3(OH)_2$, analyzing the chemical principles involved, and assessing the solution's capacity to neutralize a specific amount of acid—namely, 25.00 mL of a standard acid solution.

Background and Context

The Chemistry of NaOH and $Ba(OH)_2$

NaOH and $Ba(OH)_2$ are both strong bases, dissociating completely in aqueous solutions:

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

Their high solubility makes them ideal for preparing solutions with known molarity. The mixture of these two hydroxides can be used for titrations involving acids, especially where the differing molar masses and hydroxide ion contributions affect the neutralization process.

Relevance of Neutralization and Titration

Neutralization reactions are fundamental in analytical chemistry to determine unknown concentrations of acids or bases. The neutralization capacity of a base depends on its molar concentration and the number of hydroxide ions available to react with hydrogen ions (H^+). Understanding the precise composition of the mixture allows chemists to calculate the exact amount of acid that the solution can neutralize, which is critical for standardization purposes.

Calculating the Composition of the Mixture

Step 1: Determine the Moles of NaOH

Given:
Mass of NaOH = 21.10 g
Molar mass of NaOH ≈ 40.00 g/mol

Number of moles of NaOH:
$n\_NaOH = 21.10$ g / 40.00 g/mol = 0.5275 mol

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

Given:
Mass of $Ba_3(OH)_2$ = 21.10 g (assuming the entire 21.10 g is a mixture, or specifically the mass of $Ba_3(OH)_2$, as per the problem statement)

However, the initial statement suggests a mixture of NaOH and $Ba_3(OH)_2$ totaling 21.10 g, but the exact individual masses are not specified. For the purpose of this review, we will assume:

- The total mixture weight = 21.10 g
- The mixture contains x grams of NaOH and (21.10 - x) grams of $Ba_3(OH)_2$

Alternatively, if the problem states that 21.10 g is the combined mass of NaOH and $Ba_3(OH)_2$, and that the mixture is prepared accordingly, then we need to find specific molar contributions.

For simplicity, assume that:

- The entire 21.10 g of NaOH is used (which is unlikely but simplifies calculations for this review).

Alternatively, if the mixture contains both substances, then the molar calculations must account for the molar ratios.

Step 3: Molar Mass of $Ba_3(OH)_2$

- Ba: 137.33 g/mol
- O: 16.00 g/mol
- H: 1.008 g/mol

Molar mass of $Ba_3(OH)_2$:
= (3 × 137.33) + (2 × (16.00 + 1.008))
= 411.99 + (2 × 17.008)
= 411.99 + 34.016
= 446.006 g/mol

Step 4: Calculating Moles of $Ba(OH)_2$ in the Mixture

Suppose the mixture contains m grams of $Ba_3(OH)_2$.
Number of moles:
$n\_Ba(OH)_2$ = m / 446.006

The total mass constraint:
m + x = 21.10 g

Without specific proportions, an exact calculation isn't possible. However, for the purpose of this analysis, let's assume that:

- 10 grams of NaOH
- 11.10 grams of $Ba_3(OH)_2$

This assumption allows us to proceed with approximate calculations.

Calculations under these assumptions:

- Moles of NaOH:
n_NaOH = 10 g / 40.00 g/mol = 0.25 mol

- Moles of $Ba_3(OH)_2$:
$n\_Ba(OH)_2$ = 11.10 g / 446.006 g/mol ≈ 0.0249 mol

Step 5: Total Hydroxide Ion Content

- NaOH provides 0.25 mol OH^-
- $Ba(OH)_2$ provides 2 × 0.0249 mol = 0.0498 mol OH^-

Total hydroxide ions:

= 0.25 + 0.0498 ≈ 0.2998 mol

Preparing the 1.0 dm^3 Solution

The total hydroxide molarity (M) of the solution is:

$$ M_{OH^-} = \frac{\text{Total moles of OH}^-}{\text{Volume in liters}} $$

Since the total volume is 1.0 dm^3 (which equals 1 liter):

$$ M_{OH^-} = 0.2998\, \text{mol} / 1\, \text{L} = 0.2998\, \text{M} $$

This means the solution contains approximately 0.30 mol/L hydroxide ions.

Neutralization Capacity and Acid Titration

Step 1: Acid-Neutralization Reaction

Assuming the acid is a standard strong acid, such as HCl:

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

The molar ratio is 1:1. Therefore, the amount of acid needed to neutralize the hydroxide ions in 1 liter of solution is equivalent to the total moles of OH^- present.

Given:

- Hydroxide ions in solution: 0.2998 mol
- Acid volume: 25.00 mL (0.02500 L)
- Acid molarity needed for neutralization:

$$ M_{acid} = \frac{\text{moles of OH}^-}{\text{volume of acid in liters}} $$

$$ M_{acid} = \frac{0.2998\, \text{mol}}{0.02500\, \text{L}} = 11.992\, \text{M} $$

This is a very high molarity, indicating that the acid used for titration is highly concentrated, or the initial assumptions may need adjustment.

Step 2: Practical Implications

In practice, titrations involve acids of known, manageable molarity (e.g., 0.1 M or 1 M HCl). The high molarity calculated suggests that:

- The initial mixture's hydroxide concentration is significant but manageable.
- The 25.00 mL of acid needed for neutralization indicates a strong acid, possibly with a molarity aligned with standard titration practices.

Critical Analysis and Observations

The Importance of Accurate Composition

The precise composition of the NaOH and $Ba(OH)_2$ mixture critically influences the neutralization capacity. Variations in the mixture ratio alter the total hydroxide ion concentration, affecting titration calculations.

The Impact of Mixture Ratios

- A higher proportion of NaOH increases the hydroxide concentration significantly.
- $Ba(OH)_2$, being less soluble than NaOH, contributes less hydroxide per unit mass, but each mole provides twice the hydroxide ions due to its dissociation.

Practical Challenges

- Ensuring complete dissolution of $Ba(OH)_2$ can be challenging due to its lower solubility.
- Accurate weighing and thorough mixing are vital to prepare a solution with known molarity.

Safety Considerations

Handling strong bases like NaOH and $Ba(OH)_2$ requires appropriate safety measures, including gloves, goggles, and proper ventilation due to their corrosive nature.

Conclusions

This detailed investigation underscores the importance of precise calculation and understanding of chemical properties when preparing and analyzing solutions:

- Based on assumed proportions, 21.10 g of a mixture containing NaOH and $Ba(OH)_2$ can produce a hydroxide solution with approximately 0.30 M concentration.
- This solution can neutralize approximately 0.30 mol of H^+ ions, which, in a 1.0 dm^3 solution, corresponds to a significant titration capacity.

- To neutralize 25.00 mL of acid, the required acid molarity depends heavily on the exact hydroxide concentration, emphasizing the necessity of accurate mixture preparation.

Ultimately, this analysis highlights the intricate balance between theoretical calculations and practical laboratory procedures. Proper standardization and careful measurement ensure that such solutions serve their intended analytical purposes effectively.

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