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Understanding the precise amount of sodium hydroxide (NaOH) required to completely neutralize a given quantity of a diprotic acid like H_2A is fundamental in chemistry, especially in titrations, laboratory experiments, and industrial applications. In this article, we will explore the detailed calculations involved in determining the exact amount of NaOH needed to react with 7.5 grams of a diprotic acid with a molecular weight of 150 g/mol. We'll also discuss the principles behind acid-base reactions, stoichiometry, and how to apply these concepts to real-world scenarios.

Understanding Diprotic Acids and Their Reactions with Sodium Hydroxide

What Is a Diprotic Acid?

A diprotic acid is an acid that can donate two protons (H^+ ions) per molecule in a chemical reaction. Common examples include sulfuric acid (H_2SO_4) and oxalic acid ($H_2C_2O_4$). The general structure of diprotic acids is represented as H_2A, indicating two ionizable hydrogen atoms.

Reaction of Diprotic Acids with NaOH

The neutralization of a diprotic acid with sodium hydroxide follows a two-step process:

1. First proton donation:
$$
\mathrm{H_2A} + \mathrm{NaOH} \rightarrow \mathrm{NaH\ A} + \mathrm{H_2O}
$$

2. Second proton donation:
$$
\mathrm{NaH\ A} + \mathrm{NaOH} \rightarrow \mathrm{Na_2A} + \mathrm{H_2O}
$$

Overall, the complete neutralization reaction is:
$$
\mathrm{H_2A} + 2\ \mathrm{NaOH} \rightarrow \mathrm{Na_2A} + 2\ \mathrm{H_2O}
$$

This indicates that one mole of diprotic acid reacts with two moles of NaOH to produce a salt and water.

Calculating the Moles of the Diprotic Acid (H_2A)

Before determining the amount of NaOH required, we need to calculate the number of moles of H_2A in 7.5 grams.

Step 1: Determine the number of moles of H_2A

Given data:
- Mass of H_2A = 7.5 grams
- Molecular weight (Mr) of H_2A = 150 g/mol

Using the formula:
$$
\text{Number of moles} = \frac{\text{Mass}}{\text{Molecular weight}}
$$

Calculation:
$$
\text{Moles of H}_2A = \frac{7.5\, \text{g}}{150\, \text{g/mol}} = 0.05\, \text{mol}
$$

Calculating the Required Amount of Sodium Hydroxide

Since the complete neutralization of H_2A involves 2 moles of NaOH per mole of H_2A, the total moles of NaOH needed are:

$$
\text{Moles of NaOH} = 2 \times \text{Moles of H}_2A
$$

Substituting the known value:
$$
\text{Moles of NaOH} = 2 \times 0.05\, \text{mol} = 0.10\, \text{mol}
$$

Step 2: Convert moles of NaOH to grams

The molecular weight of NaOH is approximately 40 g/mol.

Therefore, the mass of NaOH required:

$$
\text{Mass of NaOH} = \text{Moles} \times \text{Molecular weight}
$$

Calculation:
$$
\text{Mass of NaOH} = 0.10\, \text{mol} \times 40\, \text{g/mol} = 4\, \text{g}
$$

Conclusion:
To precisely react with 7.5 grams of the diprotic acid H_2A (Mr = 150), you need 4 grams of sodium hydroxide.

Practical Considerations in Titration and Laboratory Applications

Importance of Accurate Measurement

Precise measurement of reactants ensures the accuracy of titration experiments, which are vital in determining acid or base concentrations in unknown samples. Using the calculated 4 grams of NaOH allows for complete neutralization without excess or deficiency.

Procedure for Titration

- Prepare a solution of known concentration of NaOH.
- Weigh accurately 7.5 g of the diprotic acid.
- Slowly add NaOH solution to the acid while stirring.
- Observe the endpoint with a suitable indicator (e.g., phenolphthalein).
- Calculate the concentration of NaOH if unknown, or verify the amount needed as per calculations.

Factors Affecting the Reaction and Calculations

Purity of Chemicals

Impurities in reagents can alter the amount needed for complete neutralization.

Environmental Conditions

Temperature and pressure can influence reaction rates and solubility.

Measurement Accuracy

Precise weighing and volumetric measurements are crucial for reliable results.

Real-World Applications of Acid-Base Neutralization Calculations

Industrial Processes

- Wastewater treatment often involves neutralizing acidic effluents with bases like NaOH.
- Manufacturing of fertilizers and chemicals requires precise stoichiometric calculations.

Pharmaceuticals and Food Industry

- Ensuring correct pH levels during formulation.
- Calculating dosages of acids and bases in medicinal preparations.

Environmental Monitoring

- Assessing acidity levels in natural water bodies.
- Designing remediation strategies.

Summary of Key Points

1. Diprotic acids donate two protons per molecule, requiring two equivalents of NaOH for complete neutralization.

2. Calculations involve converting mass to moles, then applying stoichiometry to find the required amount of NaOH.

3. For 7.5 g of H_2A (Mr = 150), approximately 4 grams of NaOH are needed for complete reaction.

4. Accurate measurements and understanding reaction principles are essential in laboratory and industrial contexts.

Final Thoughts

Determining the exact amount of sodium hydroxide needed to react with a specific quantity of diprotic acid is a fundamental aspect of acid-base chemistry. By understanding the

stoichiometry involved, chemists can perform precise titrations, optimize industrial processes, and ensure safety in chemical handling. Remember that real-world factors such as purity, temperature, and measurement accuracy can influence these calculations, so always consider these variables in practical applications.

In summary, to react exactly with 7.5 grams of a diprotic acid with a molecular weight of 150 g/mol, approximately 4 grams of sodium hydroxide are required, based on the stoichiometry of the neutralization reaction. Mastery of these calculations enhances both theoretical understanding and practical skills in chemistry.

Frequently Asked Questions

How do you determine the amount of sodium hydroxide needed to react completely with 7.5g of a diprotic acid H_2A?

First, calculate the molar mass of H_2A (given as 150 g/mol), then find the number of moles of H_2A in 7.5g by dividing 7.5g by 150 g/mol. Since the acid is diprotic, it reacts with twice as many moles of NaOH. Use the mole ratio to determine the required NaOH amount.

What is the molar mass of the diprotic acid H_2A, and how does it influence the calculation?

The molar mass of H_2A is 150 g/mol. It helps to convert the mass of the acid to moles, which is essential for calculating the exact amount of NaOH needed for complete neutralization.

How do you calculate the moles of H_2A in 7.5g of the acid?

Divide the mass of the acid (7.5g) by its molar mass (150 g/mol): 7.5 / 150 = 0.05 moles of H_2A.

What is the stoichiometric ratio between H_2A and NaOH in the reaction?

Since H_2A is diprotic, each mole reacts with 2 moles of NaOH, so the ratio is 1:2 (H_2A:NaOH).

How much sodium hydroxide (NaOH) in grams is needed to react exactly with 7.5g of H_2A?

Calculate moles of NaOH needed: 0.05 moles H_2A × 2 = 0.10 moles NaOH. Then, multiply by NaOH's molar mass (40 g/mol): 0.10 × 40 = 4g. Therefore, 4 grams of NaOH are required.

Can the calculation vary if the molecular weight of H_2A changes?

Yes, if the molar mass of H_2A changes, the number of moles in 7.5g will change accordingly, affecting the calculated amount of NaOH needed.

What assumptions are made in this calculation regarding purity and reaction conditions?

The calculation assumes the acid is pure, reacts completely with NaOH, and there are no side reactions or losses during the process.

How would the calculation differ if the acid was monoprotic instead of diprotic?

If the acid were monoprotic, the mole ratio with NaOH would be 1:1 instead of 1:2, so the amount of NaOH needed would be half of what is calculated for the diprotic case.

What practical steps should be taken to ensure the exact amount of NaOH reacts with the acid in a lab setting?

Use precise weighing scales to measure NaOH, perform titrations with a suitable indicator, and ensure complete mixing to achieve accurate, stoichiometric neutralization.

Additional Resources

Which Amount Of Sodium Hydroxide Is Would React Exactly With 7.5g Of A Diprotic Acid, H2A (Mr = 150)?

Understanding the precise amount of sodium hydroxide (NaOH) required to neutralize a given mass of a diprotic acid like H_2A is essential in many laboratory and industrial applications. Whether you're preparing titrations, designing chemical processes, or studying acid-base reactions, calculating the exact quantity of reactants ensures efficiency, safety, and accuracy. This guide walks you through the detailed steps to determine which amount of sodium hydroxide is needed to react exactly with 7.5 grams of a diprotic acid, H_2A, with a molar mass of 150 g/mol.

Introduction to Acid-Base Reactions and the Importance of Precise Calculations

In chemistry, neutralization reactions involve an acid reacting with a base to produce water and a salt. For acids with multiple acidic protons, such as diprotic acids, the reaction complexity increases. Accurate stoichiometric calculations are vital because:

- They help in titrations to find unknown concentrations.

- They prevent wastage of chemicals.
- They ensure safety by avoiding over- or under-reacting reagents.
- They assist in designing industrial processes where exact reactant ratios are crucial.

In this context, understanding how many moles of NaOH are needed to neutralize 7.5 grams of H_2A provides a foundation for precise chemical management.

Understanding the Chemical Nature of H_2A (Diprotic Acid)

What Is a Diprotic Acid?

A diprotic acid is an acid capable of donating two protons (H^+) per molecule during dissociation. Its general dissociation can be represented as:

$H_2A \rightleftharpoons 2H^+ + A^{2-}$

This means each molecule of H_2A can react twice with a base like NaOH, which supplies hydroxide ions (OH^-) to neutralize the protons.

Key Properties of H_2A in This Scenario

- Molecular Weight (Mr): 150 g/mol
- Number of Protons per Molecule: 2
- Reaction Type: Double neutralization

Understanding these properties allows us to determine the molar amount of H_2A in the given sample and, subsequently, the amount of NaOH needed.

Step-by-Step Calculation Process

Step 1: Calculate the Moles of H_2A in 7.5g

Given the mass of the acid (m) and its molar mass (Mr):

- Mass (m): 7.5 grams
- Molar Mass (Mr): 150 g/mol

Number of moles (n) of H_2A:

$n = m / Mr = 7.5\ g / 150\ g/mol = 0.05\ mol$

Step 2: Determine the Total Number of Protons to be Neutralized

Since H_2A is diprotic:

- Each molecule supplies 2 protons.
- Total protons (H^+) in 0.05 mol:

Total H^+ = 0.05 mol × 2 = 0.10 mol

Step 3: Write the Neutralization Reaction

The neutralization involves NaOH donating OH^- to neutralize H^+:

$H_2A + 2NaOH \rightarrow Na_2A + 2H_2O$

This reaction shows that:

- 1 mole of H_2A reacts with 2 moles of NaOH.

Step 4: Calculate the Moles of NaOH Required

From the stoichiometry:

NaOH needed = 2 × moles of H_2A = 2 × 0.05 mol = 0.10 mol

Step 5: Convert Moles of NaOH to Mass

- Molar mass of NaOH ≈ 40 g/mol
- Mass of NaOH needed:

mass = moles × molar mass = 0.10 mol × 40 g/mol = 4 grams

Final Answer: The Exact Amount of Sodium Hydroxide Needed

To react exactly with 7.5 grams of the diprotic acid H_2A (Mr = 150), you would need approximately 4 grams of sodium hydroxide (NaOH).

Additional Considerations and Practical Tips

1. Purity of Reactants

Ensure both the acid and base are pure. Impurities can affect the actual amounts needed.

2. Concentration and Solution Preparation

If working with solutions rather than solid reagents, understand their molarity to determine volume requirements:

- For example, a 1 M NaOH solution contains 1 mol per liter.
- To get 0.10 mol, you'd need 0.10 L or 100 mL of 1 M NaOH.

3. Titration Method

In laboratory settings, titrating the acid with a known concentration of NaOH allows for

practical verification of these calculations.

4. pH Monitoring

Use pH indicators or pH meters to determine the endpoint, ensuring complete neutralization.

5. Safety Precautions

NaOH is caustic. Handle with appropriate protective gear, and add it slowly to avoid splashes or reactions that could cause harm.

Summary

Calculating the precise amount of sodium hydroxide required for neutralization involves understanding the chemical formula, stoichiometry, and molar relationships:

- Moles of acid: 0.05 mol (from 7.5 g / 150 g/mol)
- Moles of NaOH needed: 2 × 0.05 mol = 0.10 mol
- Mass of NaOH: 0.10 mol × 40 g/mol = 4 grams

Thus, approximately 4 grams of NaOH will react exactly with 7.5 grams of the diprotic acid H_2A.

Closing Remarks

Accurate stoichiometric calculations are fundamental in chemistry, ensuring reactions proceed as intended and resources are used efficiently. Whether you're conducting laboratory titrations, scaling up industrial processes, or just honing your understanding of acid-base chemistry, mastering these calculations provides a solid foundation for success. Always double-check your work, consider practical variables, and prioritize safety in all chemical procedures.

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