

Calculate The Concentration (in M) Of Hydroxide Ions In A Solution At 25.0C With A POH Of 4.223. A) 1.00

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Understanding the concentration of hydroxide ions in a solution is fundamental in chemistry, especially when analyzing the pH and pOH of aqueous solutions. In this article, we will explore how to determine the hydroxide ion concentration from the given pOH value, focusing on a solution at 25.0°C with a pOH of 4.223. We will provide a comprehensive explanation suitable for students, educators, and anyone interested in chemical calculations.

Basics of pH, pOH, and Hydroxide Ion Concentration

Understanding pH and pOH

pH and pOH are logarithmic scales used to measure the acidity or basicity of a solution:

- pH measures the concentration of hydrogen ions (H^+).
- pOH measures the concentration of hydroxide ions (OH^-).

These two scales are interconnected through the relationship:

$$pH + pOH = 14.00$$

at 25.0°C, which is considered the standard temperature for such calculations.

Relationship Between pOH and Hydroxide Ion Concentration

The concentration of hydroxide ions is directly related to the pOH via the following equation:

$$[OH^-] = 10^{-pOH}$$

where:

- $[OH^-]$ is the hydroxide ion concentration in molarity (M).
- pOH is the negative base-10 logarithm of $[OH^-]$.

This simple relationship allows us to convert a pOH value into an absolute concentration of hydroxide ions.

Step-by-Step Calculation of Hydroxide Ion Concentration

Given:

- pOH = 4.223

- Temperature = 25.0°C

Our goal:

- To find $[\text{OH}^-]$ in molarity (M).

Step 1: Write Down the Formula

$$[\text{OH}^-] = 10^{-\text{pOH}}$$

Step 2: Substitute the Known pOH Value

$$[\text{OH}^-] = 10^{-4.223}$$

Step 3: Calculate the Power of 10

Using a calculator or logarithmic tables, compute:

$$10^{-4.223} \approx 6.00 \times 10^{-5} \text{ M}$$

This means the hydroxide ion concentration in the solution is approximately (6.00×10^{-5}) molar.

Implications of the Result

Understanding the pOH and pH Relationship

Since:

$$\text{pH} = 14.00 - \text{pOH} = 14.00 - 4.223 = 9.777$$

the solution is slightly basic, with a pH of approximately 9.78.

Significance of Hydroxide Ion Concentration

A hydroxide ion concentration of (6.00×10^{-5}) M indicates a weakly basic solution. For comparison:

- Pure water at 25.0°C has a hydroxide ion concentration of (1.0×10^{-7}) M.
- The calculated concentration is significantly higher, reflecting the basic nature of the solution.

Additional Considerations in Chemical Calculations

Temperature Dependence

While the calculations above assume a standard temperature of 25.0°C, it's important to note that pH and pOH vary with temperature. The relationship $\text{pH} + \text{pOH} = 14$ is only valid at 25°C. At other temperatures:

- The ion product of water (K_w) changes.
- The sum of pH and pOH may differ from 14.

Impact of Acid-Base Reactions

In real-world scenarios, chemical reactions may alter the hydroxide ion concentration:

- Acidic contaminants can lower hydroxide levels.
- Basic contaminants or solutions can increase hydroxide levels.

Practical Applications of Hydroxide Ion Concentration Calculations

pH Titration Analysis

Understanding hydroxide concentration helps in titration calculations, especially when neutralizing acids with bases.

Environmental Monitoring

Monitoring hydroxide levels in natural waters helps assess water quality and pollution levels.

Industrial Processes

Chemical manufacturing and processing often require precise control of hydroxide concentrations for safety and product quality.

Summary

To summarize:

- The hydroxide ion concentration in a solution with a pOH of 4.223 at 25.0°C is approximately 6.00×10^{-5} M.
- This calculation is straightforward using the formula $[\text{OH}^-] = 10^{-\text{pOH}}$.
- The solution's pH is roughly 9.78, indicating a slightly basic solution.

Conclusion

Calculating the hydroxide ion concentration from pOH is an essential skill in analytical chemistry. It provides insight into the nature of a solution and helps interpret various chemical behaviors. Remember, always consider temperature effects and the context of the solution to ensure accurate and meaningful results.

Keywords: hydroxide ion concentration, pOH, molarity, basic solution, pH, chemical calculations, water chemistry, acid-base balance, 25°C, analytical chemistry

Frequently Asked Questions

What is the concentration of hydroxide ions in a solution at 25.0°C with a pOH of 4.223?

The hydroxide ion concentration $[\text{OH}^-]$ is approximately $6.0 \times 10^{-5} \text{ M}$.

How do you calculate the hydroxide ion concentration from the pOH value?

Use the formula $[\text{OH}^-] = 10^{(-\text{pOH})}$. For $\text{pOH} = 4.223$, $[\text{OH}^-] \approx 10^{(-4.223)} \text{ M}$.

What is the significance of the pOH value in determining hydroxide ion concentration?

pOH indicates the acidity or alkalinity of a solution; a lower pOH means higher hydroxide ion concentration.

At 25.0°C, how does the pOH relate to pH and the overall pH of the solution?

Since $\text{pH} + \text{pOH} = 14$ at 25.0°C, the pH of this solution is approximately 9.777.

If the pOH of a solution is 4.223, is the solution acidic, neutral, or basic?

The solution is basic because pOH is less than 7, indicating a higher concentration of hydroxide ions.

What is the impact of temperature on calculating hydroxide ion concentration from pOH?

Temperature affects the ion product of water (K_w), but at 25.0°C, the relationship $\text{pH} + \text{pOH} = 14$ is valid; at other temperatures, this value changes accordingly.

Can you verify the hydroxide ion concentration if the pOH is given as 4.223?

Yes, by calculating $[\text{OH}^-] = 10^{(-4.223)} \approx 6.0 \times 10^{-5} \text{ M}$, confirming the hydroxide ion concentration.

Additional Resources

Calculate The Concentration (in M) Of Hydroxide Ions In A Solution At 25.0°C With A POH Of 4.223

Introduction

In the realm of chemistry, understanding the concentration of ions within a solution is fundamental to comprehending its properties, behavior, and potential applications. Among these ions, hydroxide ions (OH^-) play a crucial role in determining the basicity of a solution. The task of calculating the hydroxide ion concentration (in molarity, M) from a given pOH value exemplifies a core concept in analytical chemistry, blending the principles of logarithmic relationships, equilibrium, and thermodynamics.

This article investigates the process of calculating hydroxide ion concentration in a solution at 25.0°C, given a pOH of 4.223. It aims to provide a comprehensive overview of the underlying principles, step-by-step methodology, and contextual significance of such calculations, especially for students, educators, and researchers engaged in solution chemistry.

The Significance of pOH and Hydroxide Ion Concentration

pOH as a Measure of Basicity

pOH is a logarithmic measure of the hydroxide ion concentration in a solution:

$$\text{pOH} = -\log [\text{OH}^-]$$

This relationship allows chemists to infer the concentration of hydroxide ions directly from the pOH value. The lower the pOH, the higher the hydroxide ion concentration, indicating a more basic (alkaline) solution.

Connection to pH and Overall Solution Characterization

The pH and pOH scales are interrelated through the ion product of water at 25°C:

$$\text{pH} + \text{pOH} = 14.00$$

This equilibrium constant reflects the autoionization of water:



Understanding the hydroxide ion concentration provides insights into the solution's acidity or alkalinity, which has profound implications across various scientific and industrial processes.

Theoretical Foundations of Hydroxide Concentration Calculations

The Logarithmic Relationship

Given the pOH, the hydroxide ion concentration is calculated via:

$$[OH^-] = 10^{-pOH}$$

This fundamental equation derives from the definition of the logarithm:

$$\log [OH^-] = -pOH$$

$$[OH^-] = 10^{\log [OH^-]} = 10^{-pOH}$$

Applying this formula allows for straightforward computation once the pOH is known.

Temperature Dependence and Water Ion Product

While the calculation assumes standard conditions at 25.0°C, it's important to recognize that the ion product of water (K_w) varies with temperature:

$$K_w = [H^+][OH^-]$$

At 25.0°C:

$$K_w = 1.0 \times 10^{-14}$$

This value underpins the relationship between pH and pOH, ensuring the sum always approximates 14 under standard conditions.

Step-by-Step Calculation of Hydroxide Ion Concentration

Given Data

- Temperature: 25.0°C
- pOH: 4.223

Calculation Process

1. Identify the pOH value:

$$pOH = 4.223$$

2. Apply the logarithmic relationship:

$$[OH^-] = 10^{-pOH}$$

3. Compute the hydroxide concentration:

$$[OH^-] = 10^{-4.223}$$

4. Perform the calculation:

Using a calculator or logarithmic table,

$$10^{-4.223} \approx 5.98 \times 10^{-5} \text{ M}$$

This indicates that the hydroxide ion concentration in the solution is approximately 5.98×10^{-5} M.

Analytical Context and Implications

Significance of the Hydroxide Ion Concentration

A hydroxide concentration of roughly (6.0×10^{-5}) M signifies a mildly basic solution. For comparison, pure water at 25°C has a hydroxide concentration of (1.0×10^{-7}) M (from $(pOH = 7)$). The higher hydroxide concentration here indicates the solution is more alkaline than pure water, which could influence chemical reactivity, solubility, and biological interactions.

Applications in Chemistry and Industry

- Analytical Chemistry: Precise hydroxide concentrations are essential in titrations and pH adjustments.
- Environmental Science: Monitoring hydroxide levels aids in assessing water quality.
- Pharmaceuticals: Maintaining specific pH ranges ensures drug stability and efficacy.
- Industrial Processes: Chemical manufacturing often requires strict control over solution basicity.

Broader Scientific Considerations

Temperature Variations and Their Effects

While this calculation assumes standard conditions at 25.0°C, real-world scenarios may involve temperature fluctuations. Since (K_w) increases with temperature, the relationship between pH and pOH shifts, affecting ion concentrations. Understanding this dynamic is essential for precise control in sensitive processes.

Limitations and Assumptions

- The calculation presumes ideal behavior, ignoring activity coefficients which can influence actual concentrations.
- It assumes no additional ionic interactions or complexation reactions that could alter free hydroxide levels.

Conclusion

The process of calculating hydroxide ion concentration from a given pOH exemplifies a fundamental analytical technique in solution chemistry. By understanding the logarithmic relationship between pOH and hydroxide concentration, chemists can accurately characterize solutions and predict their behavior in various contexts. The specific calculation of approximately 5.98×10^{-5} M hydroxide ions at 25.0°C with a pOH of 4.223 underscores the subtle yet significant variations in solution basicity that are critical across scientific disciplines.

This investigation not only highlights the straightforward nature of the calculation but also emphasizes the importance of temperature control, precise measurement, and contextual knowledge in chemical analysis. As chemistry continues to inform diverse fields, mastery of such fundamental concepts remains essential for advancing scientific understanding and technological innovation.

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