If The Concentration Of H3O+ In An Aqueous Solution Is 7.6 10-9 M, The Concentration Of OH- Is ________.A)

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Understanding the Relationship Between H3O+ and OH- in Aqueous Solutions

In aqueous chemistry, the concentrations of hydronium ions (H3O+) and hydroxide ions (OH-) are fundamental to understanding the acidity, alkalinity, and overall pH of a solution. These ions are connected through the concept of water autoionization and the water dissociation constant, Kw. When given the concentration of one ion, we can determine the concentration of the other, which is essential for various applications, including titrations, environmental analysis, and biochemical processes.

What Is the Water Dissociation Constant (Kw)?

The water dissociation constant, symbolized as Kw, is an equilibrium constant that describes the extent to which water dissociates into H3O+ and OH- ions:

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

Since H+ in aqueous solutions exists primarily as H3O+, the reaction is often written as:

$$ \mathrm{H_2O} \leftrightarrow \mathrm{H_3O^+} + \mathrm{OH^-} $$

At 25°C, Kw is a constant value:

$$ K_w = [\mathrm{H_3O^+}] \times [\mathrm{OH^-}] = 1.0 \times 10^{-14} $$

This means that at this temperature, the product of the concentrations of H3O+ and OH- ions in pure water is always 1.0×10^{-14}.

Calculating the Concentration of OH-

Given the concentration of H3O+ ions:

$$ [\mathrm{H_3O^+}] = 7.6 \times 10^{-9} \text{ M} $$

To find the concentration of OH- ions:

$$ [\mathrm{OH^-}] = \frac{K_w}{[\mathrm{H_3O^+}]} $$

Substituting the known values:

$$ [\mathrm{OH^-}] = \frac{1.0 \times 10^{-14}}{7.6 \times 10^{-9}} $$

Calculating:

$$ [\mathrm{OH^-}] = \frac{1.0 \times 10^{-14}}{7.6 \times 10^{-9}} = \frac{1.0}{7.6} \times 10^{-14 + 9} $$

$$ [\mathrm{OH^-}] = 0.1316 \times 10^{-5} $$

$$ [\mathrm{OH^-}] \approx 1.32 \times 10^{-6} \text{ M} $$

Thus, the concentration of hydroxide ions in the solution is approximately 1.32×10^{-6} M.

Understanding pH and pOH in This Context

The pH and pOH are logarithmic measures of the H3O+ and OH- concentrations, respectively. They provide insight into the acidity or alkalinity of a solution.

Calculating pH:

$$ \text{pH} = -\log [\mathrm{H_3O^+}] $$

Substituting:

$$ \text{pH} = -\log (7.6 \times 10^{-9}) $$

$$ \text{pH} = -(\log 7.6 + \log 10^{-9}) $$

$$ \text{pH} = -(0.8808 - 9) $$

$$ \text{pH} = 9 - 0.8808 = 8.1192 $$

Approximately, the pH is 8.12, indicating a slightly basic solution.

Calculating pOH:

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

$$ \text{pOH} = -\log (1.32 \times 10^{-6}) $$

$$ \text{pOH} = -(\log 1.32 + \log 10^{-6}) $$

$$ \text{pOH} = - (0.1206 - 6) $$

$$ \text{pOH} = 6 - 0.1206 = 5.8794 $$

The pOH is approximately 5.88.

Implications of the Calculated OH- Concentration

Knowing the hydroxide ion concentration has several important implications:

- pH and pOH Relationship: The sum of pH and pOH in aqueous solutions at 25°C is always approximately 14, aligning with the calculations above.
- Acidity or Basicity: Since the pH is above 7, the solution is basic, consistent with the low H_3O^+ concentration.
- Buffer Capacity: Such calculations are critical when designing buffer solutions that maintain pH stability.
- Environmental and Biological Relevance: The pH of natural waters and biological fluids influences chemical reactions, enzyme activity, and overall health.

Additional Considerations in Acid-Base Chemistry

Temperature Dependence of Kw

It's essential to recognize that Kw is temperature-dependent. While 1.0×10^{-14} is valid at 25°C, at higher temperatures, Kw increases, affecting ion concentrations and pH calculations.

Significance of Ion Concentrations

- Dilute Solutions: The calculated concentrations are very low, characteristic of dilute solutions.
- Real-World Applications: Accurate ion concentrations are vital in pharmaceuticals, environmental monitoring, and industrial processes.

Limitations and Assumptions

- Calculations assume ideal behavior and pure water conditions.
- Deviations may occur in complex solutions due to activity coefficients and other ionic interactions.

Conclusion

In summary, given the H_3O^+ concentration of 7.6×10^{-9} M in an aqueous solution, the hydroxide ion concentration is approximately 1.32×10^{-6} M. This calculation hinges on the fundamental water dissociation constant, Kw, and provides insights into the solution's pH, pOH, and overall acidity or alkalinity. Understanding these relationships is crucial for chemists, environmental scientists, and biochemists working with aqueous systems. Accurate ion concentration calculations enable better control and prediction of chemical behaviors across various scientific and industrial fields.

Meta Description:
Learn how to determine the hydroxide ion concentration in an aqueous solution when given the hydronium ion concentration. This comprehensive guide covers water ionization, Kw, pH, pOH, and practical applications.

Frequently Asked Questions

What is the relationship between H_3O^+ and OH^- concentrations in aqueous solutions?

In aqueous solutions, the product of H_3O^+ and OH^- concentrations is always 1.0×10^{-14} mol²/L², following the water dissociation constant (Kw).

Given the concentration of H_3O^+ as 7.6×10^{-9} M, how do you calculate the OH^- concentration?

Use the relation $[OH^-] = Kw / [H_3O^+]$. So, $[OH^-] = 1.0 \times 10^{-14} / 7.6 \times 10^{-9} \approx 1.32 \times 10^{-6}$ M.

Is the solution acidic, basic, or neutral given the H_3O^+ concentration of 7.6×10^{-9} M?

Since the H_3O^+ concentration is less than 1.0×10^{-7} M, the solution is basic.

What is the pH of the solution with H_3O^+ concentration of 7.6×10^{-9} M?

$pH = -\log[H_3O^+] = -\log(7.6 \times 10^{-9}) \approx 8.12$.

Why is understanding the concentration of OH^- important in aqueous chemistry?

Knowing the OH^- concentration helps determine the solution's pH, acidity/basicity, and the chemical behavior of substances in the solution.

Additional Resources

If the concentration of H_3O^+ in an aqueous solution is 7.6×10^{-9} M, the concentration of OH^- is _________.

Understanding the relationship between hydrogen ion (H_3O^+) and hydroxide ion (OH^-) concentrations in aqueous solutions is fundamental in chemistry, especially when analyzing the acidity or alkalinity of a solution. The given concentration of H_3O^+ allows us to explore the pH and pOH of the solution, providing insight into its acidic or basic nature. This article aims to thoroughly analyze how to determine the OH^- concentration based on the provided H_3O^+ concentration, along with a detailed discussion of related concepts, calculations, and applications.

Understanding the Role of H_3O^+ in Aqueous Solutions

In aqueous chemistry, the hydrogen ion (H^+) does not exist freely in significant amounts because it strongly interacts with water molecules, forming hydronium ions (H_3O^+). The concentration of H_3O^+ directly reflects the acidity of the solution. A high concentration indicates a strongly acidic solution, whereas a low concentration suggests a neutral or basic solution.

Key points:
- The concentration of H_3O^+ is a measure of the solution's acidity.
- The pH scale is logarithmic and defined as pH = -log [H_3O^+].
- The relationship between H_3O^+ and OH^- concentrations is governed by the ion product of water (Kw).

Fundamental Concepts: pH, pOH, and Kw

pH and pOH

- pH is a measure of acidity, calculated as pH = -log [H_3O^+].
- pOH measures alkalinity, calculated as pOH = -log [OH^-].
- For any aqueous solution at 25°C, the sum of pH and pOH is always 14, based on the ion product of water.

The Ion Product of Water (Kw)

- The product of the molar concentrations of H_3O^+ and OH^- in water at 25°C is constant:

$$Kw = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

- This relationship allows us to find the concentration of one ion if the other is known.

Calculating the OH^- Concentration from H_3O^+ Concentration

Given:
- $[H_3O^+] = 7.6 \times 10^{-9}$ M

Using the Kw relationship:

$$[OH^-] = Kw / [H_3O^+]$$

Substituting the known values:

$$[OH^-] = (1.0 \times 10^{-14}) / (7.6 \times 10^{-9})$$

Calculating:

$$[OH^-] = (1.0 / 7.6) \times 10^{-14} / 10^{-9} = (0.1316) \times 10^{-5} = 1.316 \times 10^{-6} \text{ M}$$

Result:
- The hydroxide ion concentration, $[OH^-]$, is approximately 1.32×10^{-6} M.

Determining the pH and pOH of the Solution

Knowing [H_3O^+], we can determine the pH:

pH = -log [H_3O^+] = -log (7.6×10^{-9})

Calculating:
- log (7.6×10^{-9}) = log 7.6 + log 10^{-9} ≈ 0.8808 - 9 = -8.1192

Therefore:

pH ≈ -(-8.1192) = 8.12

Similarly, the pOH:

pOH = 14 - pH ≈ 14 - 8.12 = 5.88

This indicates the solution is slightly alkaline since the pH is above 7.

Features and Implications of the Calculated Values

Features of the Solution:
- The pH of approximately 8.12 classifies the solution as weakly basic.
- The hydroxide concentration, 1.32×10^{-6} M, is relatively low but significant enough to influence the solution's basicity.
- The close relationship between pH and pOH demonstrates the balance of ions in pure water and dilute solutions.

Implications:
- Solutions with similar H_3O^+ concentrations are typical of weakly basic solutions.
- Understanding these concentrations helps in fields such as biochemistry, environmental science, and chemical manufacturing, where pH control is critical.

Practical Applications and Importance

Environmental Monitoring:
- pH values are vital for assessing water quality in lakes, rivers, and oceans.
- Slight deviations from neutral pH can significantly impact aquatic ecosystems.

Industrial Processes:
- Manufacturing of pharmaceuticals, food, and chemicals often requires precise pH control.
- Buffer solutions depend on the relationship between H_3O^+ and OH^-.

Laboratory Analysis:
- Accurate calculations of ion concentrations are essential for titrations, spectrophotometry, and other analytical techniques.

Biological Systems:
- Human blood maintains a narrow pH range (~7.35-7.45); understanding ion concentrations aids in diagnosing

and treating conditions like acidosis or alkalosis.

Pros and Cons of Using H_3O^+ and OH^- Concentrations for pH Analysis

Pros:
- Provides precise quantitative measures of acidity and alkalinity.
- Enables calculation of related ion concentrations for detailed solution characterization.
- Fundamental in designing chemical processes and understanding biological systems.

Cons:
- Requires accurate measurements, which can be challenging at very low concentrations.
- Assumes temperature remains constant (25°C); deviations affect Kw and ion concentrations.
- Complex mixtures may involve additional equilibria complicating straightforward calculations.

Conclusion

In summary, given the H_3O^+ concentration of 7.6×10^{-9} M, the hydroxide ion concentration in the solution is approximately 1.32×10^{-6} M. This calculation hinges upon the fundamental relationship of water's ion product, Kw, and the logarithmic nature of pH and pOH scales. Such quantitative analyses are indispensable in various scientific and industrial contexts, offering insights into the acidity or basicity of solutions and guiding practical applications. Whether in environmental monitoring, industrial manufacturing, or biological systems, understanding and manipulating ion concentrations are vital skills in chemistry, underpinning the broader understanding of solution chemistry and pH dynamics.

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