

What Is The POH Of A Solution With A Hydrogen Ion Concentration Of 1×10^{-9} ?

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Understanding the pOH of a solution is fundamental in chemistry, especially when analyzing its acidity or alkalinity. When given the hydrogen ion concentration ($[H^+]$) of a solution, determining its pOH provides insight into its basicity. In this case, the hydrogen ion concentration is 1×10^{-9} mol/L, and calculating the pOH involves understanding the relationship between hydrogen ion concentration, pH, and pOH. This article explores the concept of pOH, the calculation process for this specific concentration, and the broader implications for chemical solutions.

Fundamentals of pH and pOH

What Is pH?

pH is a logarithmic measure of the hydrogen ion concentration in a solution. It quantifies the acidity or alkalinity, with the following general scale:

- pH < 7: Acidic solution
- pH = 7: Neutral solution
- pH > 7: Basic (alkaline) solution

The pH is calculated using the formula:

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

where $[H^+]$ is the molar concentration of hydrogen ions.

What Is pOH?

pOH is similarly a measure of the hydroxide ion concentration ($[OH^-]$) in a solution, with the scale typically ranging from 0 to 14 in aqueous solutions at 25°C. It is defined as:

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

The relationship between pH and pOH in water at 25°C is given by:

$$\text{pH} + \text{pOH} = 14$$

This fundamental relationship allows us to determine one value if the other is known.

Calculating the pOH for a Hydrogen Ion Concentration of 1×10^{-9}

Given the hydrogen ion concentration, $[\text{H}^+] = 1 \times 10^{-9} \text{ mol/L}$, the steps to find the pOH are as follows:

Step 1: Calculate the pH

Using the pH formula:

$$\text{pH} = -\log[\text{H}^+] = -\log(1 \times 10^{-9}) = 9$$

Thus, the solution has a pH of 9, indicating it is mildly basic.

Step 2: Determine the pOH

Using the relationship between pH and pOH:

$$\text{pOH} = 14 - \text{pH} = 14 - 9 = 5$$

Therefore, the pOH of the solution is 5.

Interpreting the Result: Is the Solution Acidic, Neutral, or Basic?

Since the pH is 9, which is greater than 7, the solution is basic. Correspondingly, the pOH of 5 indicates it is more alkaline than neutral.

Summary:

- Hydrogen ion concentration: $1 \times 10^{-9} \text{ mol/L}$
- pH: 9
- pOH: 5
- Nature of solution: Basic (alkaline)

Broader Implications of pOH Calculations in Chemistry

Understanding pOH is crucial in various fields, including biochemistry, environmental chemistry, and industrial processes. Here are some key applications:

1. Buffer Solutions

- pOH helps in designing buffer solutions that resist changes in pH.
- Knowing the pOH can inform the amount of acid or base needed to achieve desired pH levels.

2. Environmental Monitoring

- Water bodies' alkalinity or acidity impacts aquatic life.
- pOH readings assist in assessing pollution or contamination levels.

3. Industrial Processes

- Manufacturing of pharmaceuticals, food, and chemicals often requires precise pH and pOH control.
- pOH measurements guide adjustments in process chemistry.

Additional Factors Affecting pOH Calculations

While the straightforward calculation assumes ideal conditions, real-world scenarios may involve complexities such as:

1. Temperature Dependence

- The relationship $\text{pH} + \text{pOH} = 14$ holds strictly at 25°C.
- Changes in temperature can alter the ionization constant of water, shifting this balance.

2. Ionic Strength and Activity Coefficients

- High ionic strength solutions can affect activity coefficients, influencing the apparent pH and pOH.

3. Presence of Other Ions

- Additional ions in solution can interfere with hydrogen or hydroxide ion activity, impacting pOH calculations.

Conclusion

In summary, for a solution with a hydrogen ion concentration of 1×10^{-9} mol/L, the pH is 9, indicating a mildly basic solution. Applying the fundamental relationship between pH and pOH, the pOH of this solution is 5. Understanding this calculation is essential for chemists and scientists working across various disciplines, enabling precise control and measurement of solution properties. Whether in laboratory settings, environmental monitoring, or industrial applications, knowing how to determine the pOH from hydrogen ion concentration is a vital skill in the chemist's toolkit.

Frequently Asked Questions

What is the pOH of a solution with a hydrogen ion concentration of 1×10^{-9} M?

The pOH is 5 because $\text{pOH} = 14 - \text{pH}$ and $\text{pH} = -\log[\text{H}^+]$; thus, $\text{pH} = 9$, so $\text{pOH} = 14 - 9 = 5$.

How do you calculate the pOH of a solution with $[\text{H}^+] = 1 \times 10^{-9}$ M?

Calculate pH first as $-\log(1 \times 10^{-9}) = 9$, then determine pOH as $14 - \text{pH}$, which equals 5.

What does a pOH of 5 indicate about the basicity of the solution?

A pOH of 5 indicates the solution is slightly basic since pOH values above 7 are considered basic, but in this case, it suggests neutrality or very weak basicity due to the low $[\text{H}^+]$.

Is a pOH of 5 considered acidic, neutral, or basic?

A pOH of 5 is considered basic because pOH values less than 7 indicate a basic solution.

How is pOH related to pH and the concentration of hydrogen ions?

pOH is related to pH through the equation $\text{pH} + \text{pOH} = 14$, and it reflects the concentration of hydroxide ions, with $\text{pOH} = -\log[\text{OH}^-]$.

If the hydrogen ion concentration is very low, like 1×10^{-9} M,

what does that say about the solution's pH and pOH?

The low $[H^+]$ means the pH is high (around 9), indicating a basic solution, and the pOH is low (around 5), consistent with the basic nature.

Why is knowing the pOH important in understanding solution properties?

pOH helps determine the basicity or acidity of a solution, which is essential for chemical reactions, biological processes, and industrial applications.

Can you convert hydrogen ion concentration directly to pOH? If so, how?

Yes, by first calculating pH as $-\log[H^+]$, then subtracting pH from 14 to find pOH, since $pOH = 14 - pH$.

Additional Resources

Understanding the pOH of a Solution with a Hydrogen Ion Concentration of 1×10^{-9} M

When delving into the realm of aqueous solutions and their pH and pOH measurements, the concept of pOH plays a crucial role in characterizing the basicity or alkalinity of a solution. Specifically, understanding the pOH of a solution with a known hydrogen ion concentration provides insight into the solution's pH, its acidity or alkalinity, and its overall chemical behavior. In this comprehensive review, we will explore the concept of pOH in detail, focusing on a solution with a hydrogen ion concentration of 1×10^{-9} M, and examine the implications, calculations, and significance associated with this parameter.

Fundamentals of pH and pOH

Before diving into the specifics of the solution in question, it's essential to establish a solid understanding of the fundamental concepts surrounding pH and pOH.

What is pH?

- Definition: pH is a logarithmic measure of the hydrogen ion (H^+) concentration in a solution. It quantifies the acidity or alkalinity of a solution.

- Mathematical Expression:

$$pH = -\log [H^+]$$

- Range: Typically ranges from 0 (most acidic) to 14 (most basic), with 7 being neutral.

What is pOH?

- Definition: pOH is a measure of the hydroxide ion (OH^-) concentration in a solution.

- Mathematical Expression:

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

- Relationship with pH: The sum of pH and pOH in aqueous solutions at 25°C always equals 14:

$$\text{pH} + \text{pOH} = 14$$

Interrelationship and Significance

Understanding the relationship between pH and pOH allows chemists to determine the basicity or acidity of solutions, predict chemical behavior, and infer properties like reactivity and stability.

Hydrogen Ion Concentration and Its Role

The hydrogen ion concentration, denoted as $[\text{H}^+]$, is central to calculating pH and, indirectly, pOH.

Given Data: $[\text{H}^+] = 1 \times 10^{-9} \text{ M}$

- This indicates a very low concentration of hydrogen ions, characteristic of a solution that is weakly basic or nearly neutral.

- As the hydrogen ion concentration decreases, the solution becomes less acidic and potentially more basic.

Implications of a Hydrogen Ion Concentration of $1 \times 10^{-9} \text{ M}$

- The solution is slightly alkaline since $[\text{H}^+]$ is less than the neutral value of $1 \times 10^{-7} \text{ M}$.

- The pH of such a solution will be higher than 7, specifically close to 9, indicating a basic environment.

Calculating the pH of the Solution

Using the provided hydrogen ion concentration, the pH can be straightforwardly calculated:

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

$$\text{pH} = -\log (1 \times 10^{-9}) = -(-9) = 9$$

Result: The pH of the solution is 9.

Determining the pOH of the Solution

Having established the pH, calculating the pOH becomes a matter of applying the fundamental relationship between pH and pOH at 25°C:

$$\text{pH} + \text{pOH} = 14$$

$$\text{pOH} = 14 - \text{pH} = 14 - 9 = 5$$

Therefore, the pOH of the solution is 5.

Understanding the Significance of the pOH Value

A pOH of 5 indicates the solution is basic, but not strongly so. Let's explore what this means in practical terms:

Comparison to Neutral and Acidic Solutions

- Neutral solution: pH = 7, pOH = 7, [H⁺] and [OH⁻] are both 1×10⁻⁷ M.
- Basic solution: pH > 7, pOH < 7.
- In this case: pH = 9, pOH = 5, confirming the solution is mildly basic.

Hydroxide Ion Concentration

Using the pOH value, the hydroxide ion concentration can be calculated:

$$[\mathrm{OH}^-] = 10^{-\text{pOH}} = 10^{-5} = 1 \times 10^{-5} \text{ M}$$

This indicates that the hydroxide ion concentration is 10,000 times higher than the hydrogen ion concentration, reinforcing the basic nature of the solution.

Chemical and Practical Implications

Understanding the pOH and related parameters of this solution helps predict its behavior in various chemical contexts.

Buffer Capacity and pH Stability

- The solution's pH and pOH suggest it may act as a weak base or be part of a buffer system.
- Such solutions can resist drastic pH changes upon addition of small amounts of acids or bases.

Reactivity and Biological Significance

- Slightly basic solutions are common in biological systems, such as blood plasma, which has a pH around 7.4.
- The pOH of 5 indicates a relatively high hydroxide presence, which can influence reaction rates, enzyme activity, and solubility of certain compounds.

Environmental and Industrial Relevance

- Understanding pOH helps in environmental chemistry, such as assessing water quality and alkalinity.
- In industrial processes, controlling pOH is vital for reactions like soap making, water treatment, and chemical manufacturing.

Limitations and Considerations

While the calculations are straightforward at 25°C, some factors can influence the actual pOH:

- Temperature Dependence: The relationship $\text{pH} + \text{pOH} = 14$ holds strictly at 25°C. Deviations in temperature alter the ionization constants of water, changing the sum.
- Ionic Strength: High concentrations of ions can affect activity coefficients, slightly modifying the effective concentrations.
- Measurement Accuracy: Precise determination of $[\text{H}^+]$ or $[\text{OH}^-]$ requires careful calibration of pH meters and consideration of ionic strength.

Conclusion: The pOH of a Solution with $[\text{H}^+] = 1 \times 10^{-9} \text{ M}$

To summarize:

- The hydrogen ion concentration of $1 \times 10^{-9} \text{ M}$ indicates a solution that is mildly basic.
- The pH corresponding to this $[\text{H}^+]$ is 9.
- Using the fundamental relationship at 25°C, the pOH is 5.
- The hydroxide ion concentration is $1 \times 10^{-5} \text{ M}$, confirming the basic nature.
- Understanding the pOH provides insights into the solution's reactivity, biological relevance, and environmental impact.

This detailed analysis underscores the importance of pOH as a complementary measure to pH, offering a complete picture of a solution's acidity or alkalinity. Whether for academic purposes, industrial applications, or environmental assessments, knowing how to determine and interpret pOH values is fundamental in chemistry.

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