Ex- A Buffer Is Prepared By Dissolving 0.083 Mol Of Sodium Hypochlorite (naclo) In 247 Ml Of 0.0692 M

Ex- A Buffer Is Prepared By Dissolving 0.083 Mol Of Sodium Hypochlorite (NaClO) In 247 Ml Of 0.0692 M provides an interesting example of buffer preparation, a fundamental concept in chemistry that involves creating solutions capable of resisting pH changes. Understanding how to prepare such buffers, their composition, and their properties is essential in various scientific and industrial applications, including disinfection, water treatment, and chemical synthesis. This article explores the detailed process behind preparing a sodium hypochlorite buffer, the chemistry involved, and the significance of buffers in laboratory and real-world contexts.

Understanding the Components: Sodium Hypochlorite and Its Role in Buffer Solutions

What Is Sodium Hypochlorite?

Sodium hypochlorite (NaClO) is an inorganic compound commonly used as a disinfectant and bleaching agent. It is a chlorinating agent that releases hypochlorous acid (HOCl) in aqueous solutions, which is responsible for its antimicrobial properties. NaClO is typically found in household bleach and industrial sanitizers. Its chemical properties make it an ideal candidate for buffer solutions aimed at maintaining specific pH levels, especially in applications requiring sterilization or oxidation reactions.

The Chemistry of NaClO in Water

When dissolved in water, sodium hypochlorite undergoes an equilibrium:

$NaClO + H_2O \rightleftharpoons HOCl + Na^+ + OH^-$

This equilibrium is pH-dependent, with hypochlorous acid existing primarily in the solution, contributing to the solution’s overall pH. The presence of both NaClO and HOCl in solution makes it a suitable buffer system within certain pH ranges, especially near neutral to slightly basic conditions.

Calculating the Moles and Concentration of

Sodium Hypochlorite

Given Data

- Moles of NaClO: 0.083 mol
- Volume of solution: 247 mL (which is 0.247 L)
- Concentration of the NaClO solution used for dilution: 0.0692 M

Determining the Final Concentration of NaClO

To understand the buffer capacity, it is essential to determine the molarity of NaClO in the prepared solution:

$$
\text{Molarity} = \frac{\text{moles of solute}}{\text{volume of solution in liters}}
$$

$$
\text{Molarity} = \frac{0.083\, \text{mol}}{0.247\, \text{L}} \approx 0.336\, \text{M}
$$

This indicates that the final sodium hypochlorite solution has a concentration of approximately 0.336 M, which is significantly higher than the initial 0.0692 M solution used for dilution.

Preparation of the Buffer Solution

Step-by-Step Process

1. Measuring the Sodium Hypochlorite: Begin by measuring 0.083 mol of NaClO, which can be done by calculating the required mass based on its molar mass (~74.44 g/mol):

$$
\text{Mass} = 0.083\, \text{mol} \times 74.44\, \text{g/mol} \approx 6.18\, \text{g}
$$

2. Diluting with Water: Next, dissolve this amount of NaClO in a known volume of distilled water—initially in less than 247 mL to ensure complete dissolution.

3. Adjusting the Volume: After dissolution, transfer the solution to a

volumetric flask and dilute to the final volume of 247 mL with distilled water.

4. Final Mixing: Ensure thorough mixing to obtain a uniform buffer solution with the desired concentration.

Note: The precise preparation may involve using the initial 0.0692 M NaClO solution as an intermediate, diluting it appropriately to achieve the target molarity and volume.

Understanding Buffer Systems and pH Stability

What Is a Buffer?

A buffer is a solution that contains a weak acid and its conjugate base or a weak base and its conjugate acid. It resists changes in pH when small amounts of acids or bases are added. Buffers are essential in maintaining stable pH conditions in biological systems, industrial processes, and laboratory experiments.

Sodium Hypochlorite as a Buffer

NaClO, in equilibrium with HOCl, forms a buffer system especially effective around pH 7–8. The buffering action stems from the weak acid (HOCl) and its conjugate base (ClO^-), which are present in the solution. The ratio of these species determines the pH of the buffer.

Buffer Equation:

$$
\text{pH} = pK_a + \log \left(\frac{[\text{ClO}^-]}{[\text{HOCl}]} \right)
$$

Where pK_a of hypochlorous acid is approximately 7.5.

Applications and Significance of Sodium Hypochlorite Buffers

Industrial and Laboratory Use

- Disinfection: Maintaining an optimal pH enhances the antimicrobial efficacy of NaClO.
- Water Treatment: Stabilizing pH prevents the formation of undesirable

chlorinated compounds.
- Chemical Synthesis: Controlled pH conditions facilitate specific reactions involving oxidation.

Biological and Medical Relevance

In biological systems, buffers containing NaClO derivatives are utilized to simulate physiological conditions or to study oxidative stress mechanisms.

Factors Influencing Buffer Capacity and Stability

pH Range

The effective buffering range for NaClO-based solutions is generally between pH 6.5 and 8.5, depending on the ratio of hypochlorous acid to hypochlorite ion.

Concentration

Higher concentrations of NaClO increase the buffer capacity but may also lead to stability issues or undesirable side reactions.

Temperature

Temperature variations influence the dissociation constant (pK_a) and, consequently, the pH stability.

Conclusion

The preparation of a sodium hypochlorite buffer solution, as exemplified by dissolving 0.083 mol of NaClO in 247 mL of solution, illustrates essential principles of buffer chemistry. Understanding the chemistry behind the equilibrium between hypochlorous acid and hypochlorite ions allows chemists to design solutions with desired pH stability for diverse applications. Whether in disinfection, water treatment, or laboratory research, buffers like these are vital tools that ensure optimal conditions are maintained, ensuring safety, efficacy, and precision in chemical processes.

Summary of Key Points:
- Sodium hypochlorite acts as a weak base and its conjugate acid forms a buffer system.
- Proper calculation of molarity and concentration is crucial for effective

buffer preparation.
- Buffer solutions are essential in maintaining stable pH in various settings.
- The pH of NaClO-based buffers is primarily determined by the ratio of HOCl to ClO^- and the \(pK_a \) of hypochlorous acid.
- Factors such as concentration, temperature, and initial pH influence buffer stability and efficacy.

By mastering the principles outlined in this example, chemists and technicians can accurately prepare and utilize buffer solutions tailored to their specific needs, ensuring consistent and reliable outcomes in their scientific endeavors.

Frequently Asked Questions

What is the process of preparing an ex-buffer using sodium hypochlorite and its significance?

The ex-buffer is prepared by dissolving a specific amount of sodium hypochlorite (NaClO) in a defined volume of solution to achieve a desired pH or buffering capacity, which is significant in chemical reactions requiring controlled pH conditions.

How do you calculate the concentration of sodium hypochlorite in the prepared buffer solution?

The molarity of sodium hypochlorite can be calculated using the formula: Moles of NaClO divided by the total volume of the solution in liters, which in this case is 0.083 mol divided by 0.247 L, resulting in approximately 0.336 M.

Why is sodium hypochlorite used to prepare buffers, and what are its typical applications?

Sodium hypochlorite is used in buffer solutions due to its ability to provide a stable pH in disinfectants, bleaching agents, and water treatment processes, as it can act as both an oxidizing agent and a source of hypochlorite ions.

What is the significance of the molarity of 0.0692 M in the context of this buffer preparation?

The 0.0692 M concentration likely refers to the molarity of the solution used to dissolve or dilute the sodium hypochlorite, which influences the overall pH and buffering capacity of the final solution.

How does the amount of sodium hypochlorite (0.083 mol) relate to its role as a buffer component?

The 0.083 mol of sodium hypochlorite provides a specific amount of hypochlorite ions, which contribute to the buffer's ability to resist pH changes by neutralizing added acids or bases.

What are the potential safety considerations when preparing a buffer with sodium hypochlorite?

Handling sodium hypochlorite requires caution due to its corrosive and oxidizing properties; proper gloves, goggles, and ventilation are necessary to prevent skin contact, inhalation, or reactions with other chemicals.

Additional Resources

Sodium Hypochlorite Buffer Preparation: An Expert Analysis

In the realm of chemical solutions, buffers play a vital role in maintaining stable pH environments, which are crucial for a broad range of industrial, clinical, and laboratory applications. Among the many compounds used to prepare buffers, sodium hypochlorite (NaClO) stands out due to its widespread utility in disinfection, bleaching, and chemical synthesis. Today, we delve deeply into the specifics of preparing a sodium hypochlorite buffer solution by dissolving 0.083 mol of NaClO in 247 mL of a 0.0692 M solution—an exercise that combines stoichiometric precision with practical laboratory methodology.

This article aims to serve as an in-depth expert review, illuminating each step, calculation, and consideration involved in this preparation, while also offering insights into the underlying chemistry and best practices.

Understanding the Components and Their Roles

Sodium Hypochlorite (NaClO): The Active Agent

Sodium hypochlorite is an inorganic compound with the chemical formula NaClO. Commonly recognized as bleach, it possesses strong oxidizing properties and is used extensively for sterilization and water treatment. Its effectiveness depends heavily on pH, concentration, and stability.

- Chemical properties: NaClO exists as an unstable compound in aqueous solutions, especially under heat and light, which can lead to decomposition into sodium chloride ($NaCl$) and sodium chlorate ($NaClO_3$). Therefore, preparing a buffer solution requires careful control of conditions.

- Reactivity: As an oxidizer, NaClO can react with reducing agents, organic matter, and other chemicals, making it suitable for disinfectant applications but necessitating precise formulation in laboratory preparations.

Concentrated vs. Diluted Solutions

Understanding the molarity and volume relationships is critical:

- Concentration of the stock solution: The 0.0692 M solution indicates 0.0692 moles of NaClO per liter of solution.

- Target amount of NaClO: Dissolving 0.083 mol in the final buffer.

- Final volume: 247 mL.

Accurate calculations ensure the correct molar ratio and stability of the buffer.

Step-by-Step Preparation and Calculation

Calculating the Required Volume of the Stock Solution

The core principle involves diluting a known concentration of NaClO to achieve the desired molarity in the final volume.

Given Data:

- Moles of NaClO needed: 0.083 mol

- Concentration of stock solution (C_1): 0.0692 mol/L

- Final volume (V_2): 247 mL = 0.247 L

Calculation:

Using the dilution equation:

$$C_1 \times V_1 = C_2 \times V_2$$

Where:

- $C_1 = 0.0692 \, \text{mol/L}$

- V_1 = volume of stock solution needed

- C_2 = concentration of NaClO in the buffer (unknown, but can be derived)

Alternatively, since the amount of NaClO required is known (0.083 mol), and given the stock concentration, the volume of stock solution needed is:

$$V_1 = \frac{\text{moles needed}}{\text{stock concentration}} = \frac{0.083\, \text{mol}}{0.0692\, \text{mol/L}}$$

Calculating:

$$V_1 \approx 1.199\, \text{L}$$

However, this exceeds the total final volume of 0.247 L, indicating that the stock solution contains more NaClO than needed, or that the initial assumptions need refinement.

Note: Given the original data, it's more likely that the 0.083 mol of NaClO is to be dissolved into 247 mL of the 0.0692 M solution, rather than diluting from a more concentrated stock.

Alternate interpretation:

- The 0.083 mol of NaClO is added to 247 mL of 0.0692 M solution.

- To verify total moles in the final solution:

$$\text{Moles from } 0.0692\, \text{M} \text{ in } 0.247\, \text{L} = 0.0692 \times 0.247 \approx 0.0171\, \text{mol}$$

- Since only 0.083 mol of NaClO is used, it suggests that the 0.083 mol is added to the existing solution, increasing the total amount of NaClO beyond the initial 0.0171 mol in the solution.

Conclusion:

The preparation likely involves dissolving 0.083 mol of NaClO directly into 247 mL of 0.0692 M solution, creating a buffer with a higher total amount of NaClO, and possibly adjusting the concentration accordingly.

Preparation Procedure

1. Gather Materials:

- Sodium hypochlorite (NaClO) reagent (preferably commercial bleach with known concentration or pure compound).

- Volumetric flask of at least 250 mL capacity.

- Pipettes and graduated cylinders.

- Deionized or distilled water.

- Protective gear (gloves, goggles, lab coat).

2. Calculate the Mass of NaClO Needed:

- Molar mass of NaClO ≈ 74.44 g/mol

- Mass needed:

$$ 0.083\, \text{mol} \times 74.44\, \text{g/mol} \approx 6.18\, \text{g} $$

3. Dissolution:

- Carefully weigh approximately 6.18 grams of sodium hypochlorite.

- Dissolve this in a small volume of deionized water to ensure complete dissolution.

4. Dilution:

- Transfer the solution into a 247 mL volumetric flask.

- Add deionized water up to the 247 mL mark.

- Mix thoroughly to ensure uniformity.

5. Adjustment and Verification:

- Measure the final concentration using appropriate methods (e.g., titration or spectrophotometric analysis) to confirm the buffer's molarity.

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pH and Buffer Capacity Considerations

While NaClO solutions are inherently alkaline, the pH of the prepared buffer depends on the initial concentration and the presence of other buffering agents. It's crucial to measure the pH after preparation to ensure it aligns with the intended application.

- Typical pH Range: NaClO solutions usually have a pH around 11-13, depending on concentration.

- Stability: At high pH, NaClO is more stable, but over time, decomposition can occur. Proper storage in opaque, airtight containers is recommended.

- Buffer Optimization: If specific pH stabilization is required, buffering agents such as sodium carbonate or bicarbonate can be added, but this alters the composition and must be calculated accordingly.

Applications and Implications of the Prepared Buffer

The buffer prepared by dissolving 0.083 mol of NaClO in 247 mL of a 0.0692 M solution has multiple applications across various fields:

- Disinfection and Sterilization: Its high pH and oxidative capacity make it effective for sanitizing surfaces and equipment.

- Water Treatment: Used to oxidize contaminants in water purification processes.

- Laboratory Reactions: Serves as an oxidizing agent in organic synthesis or analytical procedures.

- Industrial Processes: Employed in bleaching and textile manufacturing.

Important considerations:

- Safety: NaClO solutions are corrosive and release chlorine gas upon decomposition or contact with acids; handling requires strict safety protocols.

- Environmental Impact: Proper disposal is essential to prevent environmental contamination.

- Storage: Keep in cool, dark, well-ventilated areas to prolong shelf life.

Final Thoughts and Best Practices

Preparing a sodium hypochlorite buffer by dissolving 0.083 mol in 247 mL of 0.0692 M solution exemplifies the intersection of precise stoichiometric calculation with practical laboratory techniques. Achieving a stable, effective buffer demands meticulous attention to detail:

- Use analytical balances and calibrated volumetric equipment.

- Verify concentrations through titration or spectrophotometry when possible.

- Handle chemicals with appropriate safety measures, including gloves and eye protection.

- Store prepared solutions properly to maintain stability over time.

This detailed approach ensures that the buffer not only meets the desired chemical specifications but also upholds safety and quality standards critical for impactful application.

In summary, the preparation of this sodium hypochlorite buffer involves careful calculations, precise weighing, and thorough mixing to produce a solution suitable for various disinfectant and industrial uses. Understanding each component's chemistry and the nuances of solution preparation allows professionals to optimize efficacy, safety, and stability in their applications.

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