

Using Some Of The Following Reagents, Describe The Preparation Of 500 ML, Ph 7 Citric Acid 1.8 M Citric

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Preparing a 500 mL solution of citric acid at a concentration of 1.8 M and a pH of 7 requires careful consideration of the chemical properties of citric acid, the selection of appropriate reagents, and precise procedural steps. Citric acid ($C_6H_8O_7$) is a weak triprotic acid commonly used in laboratory and industrial applications, including buffering, food stabilization, and biochemical research. Achieving a specific pH and molarity involves understanding acid-base equilibria, solubility, and the role of buffering agents. In this article, we will explore the detailed process of preparing such a solution, utilizing various reagents and techniques to ensure accuracy and reproducibility.

Understanding the Components and Requirements

Key Parameters and Their Significance

Before delving into the preparation steps, it is essential to understand the critical parameters:

- **Volume:** 500 mL
- **Concentration:** 1.8 M (moles per liter)
- **pH:** 7 (neutral pH)

Achieving these parameters requires precise calculation and adjustment, primarily because citric acid is a weak acid and does not readily produce a neutral pH in solution. The solution's pH will be influenced by the amount of citric acid and the addition of a base to neutralize excess acidity.

Properties of Citric Acid and Buffering Capacity

Citric acid has three acidic protons with dissociation constants (pKa

values):

- $\text{pK}_{\text{a}1} \approx 3.13$
- $\text{pK}_{\text{a}2} \approx 4.76$
- $\text{pK}_{\text{a}3} \approx 6.40$

To attain a pH near 7, the solution must be carefully balanced with a base to neutralize part of the acid, leveraging the buffering capacity of citric acid's conjugate bases.

Materials and Reagents Needed

Essential Reagents

- **Citric Acid Monohydrate ($\text{C}_6\text{H}_8\text{O}_7 \cdot \text{H}_2\text{O}$):** Primary source of citric acid; provides the acid component.
- **Sodium Hydroxide (NaOH):** Strong base used to neutralize citric acid and adjust pH to 7.
- **Distilled Water:** Solvent to prepare the solution, ensuring purity and consistency.

Optional Reagents

- **pH Meter or Indicator Solution:** For precise pH measurement during adjustment.
- **Analytical Balance:** For accurate weighing of reagents.

Step-by-Step Procedure for Preparation

1. Calculating the Required Amount of Citric Acid

To prepare 500 mL (0.5 L) of a 1.8 M solution:

1. Calculate moles of citric acid needed:

$$\circ \text{ moles} = \text{molarity} \times \text{volume} = 1.8 \text{ mol/L} \times 0.5 \text{ L} = 0.9 \text{ mol}$$

2. Determine the mass of citric acid monohydrate:

$$\circ \text{ Molecular weight of citric acid monohydrate} \approx 210.14 \text{ g/mol}$$

$$\circ \text{ Mass} = 0.9 \text{ mol} \times 210.14 \text{ g/mol} \approx 189.13 \text{ g}$$

Note: Since citric acid is a triprotic acid, consider that all three protons may not dissociate fully at pH 7, and the preparation involves neutralization with NaOH to reach the desired pH.

2. Dissolving the Citric Acid

1. Weigh approximately 189.13 g of citric acid monohydrate using an analytical balance.
2. Transfer the citric acid to a clean, dry 1-liter volumetric flask or a suitable container.
3. Add about 250-300 mL of distilled water to dissolve the acid thoroughly, stirring continuously with a glass rod or magnetic stirrer.
4. Ensure complete dissolution, which may take several minutes.

3. Preparing the Buffer Solution to Achieve pH 7

Since citric acid alone in solution tends to produce a pH below 7, neutralization with a strong base like NaOH is essential.

1. Prepare a sodium hydroxide solution (e.g., 0.1 M NaOH):
 - Dissolve 4 g of NaOH in 1 L of distilled water.
2. Using a pH meter calibrated with standard buffers, measure the pH of the citric acid solution.
3. Titrate the citric acid solution with the NaOH solution:
 - Slowly add NaOH while stirring.
 - Continuously monitor pH.

- Stop titration when the pH reaches 7.

4. Record the volume of NaOH used; this allows for calculation of the exact amount of base needed.

Note: Since the theoretical amount of NaOH needed can be estimated based on molar ratios, precise titration ensures accurate pH adjustment.

4. Final Volume Adjustment

1. Transfer the titrated solution to a 500 mL volumetric flask.

2. Add distilled water up to the 500 mL mark to ensure the final volume is accurate.

3. Mix thoroughly to ensure uniformity.

Quality Control and Verification

Measuring pH

- Use a calibrated pH meter to verify the pH of the prepared solution.

- If the pH deviates from 7, make minor adjustments by adding small amounts of NaOH or citric acid solution, then re-measure.

Ensuring Concentration Accuracy

- Confirm molarity by calculating based on the amount of citric acid used and the final volume.

- Optionally, perform titration with a standard base to verify the amount of free acid.

Additional Considerations and Troubleshooting

Solubility Issues

- Citric acid is highly soluble in water; ensure complete dissolution before proceeding.

- If undissolved particles remain, slightly warm the solution (not exceeding 40°C) to aid solubility.

pH Adjustment Precision

- Use a high-quality, calibrated pH meter.
- Add NaOH slowly to prevent overshoot and maintain control over pH.

Maintaining Sterility (if required)

- For laboratory or biological applications, sterilize the solution via filtration or autoclaving if compatible.

Summary of the Key Steps

- Calculate the amount of citric acid required for 1.8 M concentration in 500 mL.
- Dissolve the citric acid in distilled water.
- Prepare a NaOH solution for titration.
- Titrate the acid solution with NaOH until pH 7 is reached.
- Adjust the final volume to 500 mL with distilled water.
- Verify the pH and concentration, making minor adjustments as necessary.

Conclusion

Preparing a 500 mL solution of citric acid at 1.8 M and pH 7 involves meticulous calculation, precise titration, and careful handling of reagents. By understanding the acid-base chemistry of citric acid, selecting appropriate reagents such as NaOH for neutralization, and employing accurate measurement techniques, one can produce a reliable, reproducible buffer solution suitable for various scientific applications. This process exemplifies fundamental principles of solution preparation, including molarity calculations, pH adjustment, and solution homogeneity, essential skills in chemical laboratory practice.

Frequently Asked Questions

How do you prepare 500 mL of 1.8 M citric acid solution at pH 7 using citric acid as a reagent?

To prepare 500 mL of 1.8 M citric acid at pH 7, first calculate the required amount of citric acid monohydrate (molecular weight approximately 210.14 g/mol): $1.8 \text{ mol/L} \times 0.5 \text{ L} \times 210.14 \text{ g/mol} \approx 189.13 \text{ g}$. Dissolve this in less than 500 mL of distilled water, then adjust the pH to 7 by adding small amounts of a suitable base, such as sodium hydroxide, while continuously monitoring the pH with a pH meter. Finally, make up the solution to 500 mL with distilled water.

Which reagents are necessary for preparing a 1.8 M citric acid solution at pH 7, and what are their roles?

The main reagent is citric acid monohydrate, which provides the citric acid molecules. To adjust the pH to 7, a base such as sodium hydroxide (NaOH) is used. Distilled water is required to dilute and adjust the final volume. The citric acid provides the buffer capacity, while NaOH adjusts the pH to the desired neutral level.

What are the key steps involved in adjusting the pH to 7 during the preparation of citric acid solution?

After dissolving the citric acid in water to create a concentrated solution, slowly add small portions of NaOH solution while continuously stirring and monitoring the pH with a pH meter. Continue until the pH reaches exactly 7. Then, dilute the solution to the final volume of 500 mL with distilled water, ensuring thorough mixing.

How do you ensure the correct molarity and pH when preparing the citric acid solution?

Calculate the precise amount of citric acid needed based on molarity and volume, then carefully dissolve it in water. Use a calibrated pH meter to monitor pH changes during base addition. Add NaOH gradually until the pH stabilizes at 7. Confirm the total volume after adjustments, and dilute if necessary to reach 500 mL, ensuring the solution's molarity remains at 1.8 M.

What precautions should be taken when preparing a pH 7 citric acid solution with specific molarity?

Use accurate measuring instruments for weighing chemicals and measuring liquids. Always add NaOH slowly to prevent overshooting the pH. Wear

appropriate personal protective equipment, such as gloves and eye protection. Ensure the pH meter is calibrated correctly before use. Work in a well-ventilated area, and handle chemicals with care to prevent accidents.

Can you modify this preparation method for different pH levels or molarities? If so, how?

Yes, the method can be adapted for other pH levels or molarities by adjusting the amount of citric acid and the volume of NaOH added. For higher molarities, increase the amount of citric acid proportionally. For different pH targets, fine-tune the amount of NaOH added during pH adjustment, always monitoring with a pH meter to achieve the desired value before final dilution.

Additional Resources

Preparation of 500 mL of 1.8 M Citric Acid Solution at pH 7 Using Citric Acid

Creating a precise citric acid solution at a specified molarity and pH involves careful planning, accurate measurement, and thorough understanding of the chemistry involved. This detailed guide explores the step-by-step process, underlying principles, and considerations necessary to prepare 500 mL of 1.8 M citric acid solution with a pH of 7.

Understanding the Fundamentals of Citric Acid Solutions

Citric Acid Properties and Characteristics

- Chemical Formula: $C_6H_8O_7$
- Molecular Weight: Approximately 192.12 g/mol
- Nature: Weak triprotic acid, capable of donating three protons
- Solubility: Highly soluble in water, forming clear, colorless solutions
- Applications: Food industry (as a preservative and flavoring agent), pharmaceuticals, biochemical research, and buffer solutions

Relevance of pH and Molarity in Solution Preparation

- Molarity (M): Indicates the concentration of citric acid in moles per liter
- pH: Measure of acidity or alkalinity; pH 7 denotes neutrality

- Buffering capacity: Citric acid's multiple proton dissociations allow it to serve as a buffer, stabilizing pH

Designing the Preparation: Key Considerations

Target Parameters

- Volume: 500 mL (0.5 L)
- Molarity: 1.8 M
- pH: Approximately 7 (neutral)

Implications for Preparation

- Since citric acid is a weak acid, preparing a solution at pH 7 requires adjusting the acid-base balance, typically by adding a base such as sodium hydroxide (NaOH).
- The goal is to create a solution where the citric acid is partially neutralized, achieving the desired pH while maintaining the specified molarity.

Approach Overview

- Dissolve an appropriate amount of citric acid monohydrate in water.
- Adjust the pH to 7 by titrating with a standard NaOH solution while monitoring pH.
- Dilute the solution to the final volume (500 mL).

Step-by-Step Preparation Procedure

1. Calculating the Required Amount of Citric Acid

- Moles of citric acid needed:

$$\text{Moles} = \text{Molarity} \times \text{Volume} = 1.8 \, \text{mol/L} \times 0.5 \, \text{L} = 0.9 \, \text{mol}$$

$\times 0.5$, $\text{L} = 0.9$, mol
]

- Mass of citric acid monohydrate:

Citric acid monohydrate ($\text{C}_6\text{H}_8\text{O}_7 \cdot \text{H}_2\text{O}$) has a molecular weight of approximately 210.14 g/mol.

[
 $\text{Mass} = 0.9$, $\text{mol} \times 210.14$, $\text{g/mol} \approx 189.13$,
 g
]

- Note: If anhydrous citric acid is used, the molecular weight is 192.12 g/mol, and calculations should be adjusted accordingly.

2. Weighing the Citric Acid

- Use an analytical balance capable of measuring to at least 0.1 g.
- Weigh approximately 189 g of citric acid monohydrate.

3. Dissolving Citric Acid

- Transfer the weighed citric acid into a clean, appropriately sized beaker or flask.
- Add about 300 mL of distilled or deionized water.
- Stir gently with a glass rod or magnetic stirrer until fully dissolved.
- The solution will be clear and homogeneous.

4. Adjusting the pH to 7

Since citric acid solutions are naturally acidic (pH typically around 2-3), neutralizing it to pH 7 involves adding a base:

- Preparation of NaOH Solution:

- Prepare a standard NaOH solution, say 0.1 M, by dissolving 4 g of NaOH pellets in 1 L of distilled water.
- Use a calibrated pH meter for precise measurement.

- Titration Process:

1. Place the citric acid solution in a titration vessel.
2. Add NaOH slowly while continuously stirring.
3. Monitor the pH with the pH meter.

4. When the pH approaches 7, add NaOH dropwise to avoid overshoot.
5. Stop titration once the pH stabilizes at 7.

- Calculating the Amount of NaOH Needed:

- Citric acid's dissociation at pH 7 involves partial neutralization.
- Approximate neutralization:

Since citric acid has three dissociable protons, and the solution is only partially neutralized to reach pH 7, an estimated amount of NaOH is needed based on the acid's dissociation constants (pKa values of approximately 3.13, 4.76, and 6.40).

- Typically, for pH 7, about 0.45–0.55 equivalents of base per mole of citric acid are required.

- Calculations:

- Moles of citric acid: 0.9 mol
- Approximate moles of NaOH to be added: $0.45\text{--}0.55 \times 0.9 \text{ mol} \approx 0.405\text{--}0.495 \text{ mol}$

- Corresponding mass of NaOH:

$$\text{Mass} = \text{moles} \times 40, \text{ g/mol}$$
$$\approx 0.45, \text{ mol} \times 40, \text{ g/mol} = 18, \text{ g}$$

- Practical Approach:

- Use a 0.1 M NaOH solution:

$$\text{Volume} = \frac{\text{moles}}{\text{concentration}} = \frac{0.45, \text{ mol}}{0.1, \text{ mol/L}} = 4.5, \text{ L}$$

- Since this volume is large, it's better to prepare a more concentrated NaOH solution (e.g., 1 M) for practical titration.

- In practice:

- Add NaOH incrementally, measuring pH after each addition.
- Record the amount of NaOH added once pH 7 is reached.

5. Final Dilution to 500 mL

- After adjusting the pH, transfer the neutralized solution to a 500 mL volumetric flask.
- Rinse the beaker with distilled water and add washings to the flask to ensure complete transfer.
- Fill the flask with distilled water up to the calibration mark, ensuring the total volume is exactly 500 mL.
- Mix thoroughly to ensure homogeneity.

Quality Control and Verification

pH Measurement

- Use a calibrated pH meter to verify the final solution's pH.
- Adjust if necessary by adding small amounts of NaOH or citric acid solution, then re-measure.

Concentration Confirmation

- To confirm molarity, perform an analytical titration or use spectrophotometric methods if applicable.
- Alternatively, accept calculated preparation unless high precision is required.

Storage Conditions

- Store the prepared solution in an airtight container, preferably glass, to prevent contamination and degradation.
- Label with concentration, pH, date of preparation, and expiration date.

Additional Considerations and Tips

- Purity of Reagents: Use high-purity citric acid monohydrate and analytical-grade NaOH for accurate results.
- Temperature Effects: Be aware that temperature influences pH; perform

titration at room temperature (~20-25°C).

- Safety Precautions:

- Wear appropriate personal protective equipment (PPE): gloves, goggles, lab coat.

- Handle NaOH with caution, as it is caustic.

- Dispose of waste solutions according to local regulations.

- Alternatives and Variations:

- If a different buffer pH is required, adjust the amount of NaOH accordingly.

- For more precise pH control, use a pH-stat titration system.

- Scaling Up or Down:

- Adjust quantities proportionally for different volumes.

- Ensure that titration steps are scaled accurately to maintain precision.

Conclusion

Preparing a 500 mL solution of 1.8 M citric acid at pH 7 is a meticulous process that combines stoichiometric calculations, precise measurement, and careful pH adjustment. While straightforward in principle, attention to detail ensures the solution's accuracy and suitability for subsequent applications, whether in biochemical research, buffer preparation, or industrial processes. Understanding the underlying chemistry, including

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