What Is The PH Of The Final Solution When 25 ML Of 0.021 M HCl Has Been Added To 35 ML Of 0.036 M HCl

What Is The pH Of The Final Solution When 25 ML Of 0.021 M HCl Has Been Added To 35 ML Of 0.036 M HCl is a common question in acid-base chemistry, especially when dealing with dilute solutions and titration-like scenarios. Understanding how to determine the pH after mixing different volumes and concentrations of acids involves fundamental concepts of molarity, volume, and the acid dissociation properties. This article aims to thoroughly explain the process step-by-step, providing clarity on how to calculate the pH of the final solution in this specific case, while also offering insights into the underlying principles of acid-base chemistry.

Understanding the Basics: Molarity, Volume, and Acid Concentration

What is Molarity?

Molarity (M) is a measure of concentration expressed as moles of solute per liter of solution. In this context, it tells us how many moles of HCl are present in a given volume:
- 0.021 M HCl means 0.021 moles per liter.
- 0.036 M HCl means 0.036 moles per liter.

Calculating Moles of HCl

To determine the total amount of acid in each solution, we multiply the molarity by the volume (converted to liters):
- Moles of HCl = Molarity × Volume (in liters).

Step-by-Step Calculation of the Final pH

1. Determine the Moles of HCl in Each Solution

Let's calculate the moles of HCl in both solutions:

- Solution 1: 35 mL of 0.036 M HCl
- Convert volume to liters: 35 mL = 0.035 L
- Moles of HCl: 0.036 mol/L × 0.035 L = 0.00126 mol

- Solution 2: 25 mL of 0.021 M HCl
- Convert volume to liters: 25 mL = 0.025 L

- Moles of HCl: 0.021 mol/L × 0.025 L = 0.000525 mol

2. Determine the Total Moles of HCl After Mixing

Since both solutions are acids (HCl), and they are being mixed without any other reactants, their moles will simply add:
- Total moles of HCl = 0.00126 mol + 0.000525 mol = 0.001785 mol

3. Calculate the Total Volume of the Final Solution

The total volume is the sum of the individual volumes:
- 35 mL + 25 mL = 60 mL = 0.060 L

4. Find the Final Concentration of HCl

Molarity of the final solution:
- M = Total moles / Total volume
- M = 0.001785 mol / 0.060 L ≈ 0.02975 M

5. Determine the pH of the Final Solution

HCl is a strong acid, which dissociates completely in water. Therefore, the concentration of H_3O^+ ions is equal to the molarity of the acid:
- $[H_3O^+]$ ≈ 0.02975 M

Calculate pH:
- pH = -log $[H_3O^+]$
- pH ≈ -log(0.02975) ≈ 1.526

Therefore, the pH of the final solution is approximately 1.53.

Additional Considerations and Context

Is the Final Solution Acidic or Basic?

Since the pH is approximately 1.53, which is well below 7, the solution remains strongly acidic after mixing.

Effect of Dilution and Molarity

Dilution reduces the concentration of HCl, but in this case, the total moles of acid increase, leading to a relatively high concentration and a low pH.

Common Mistakes to Avoid

- Forgetting to convert volume to liters before calculating moles.
- Assuming molarity remains unchanged after mixing.
- Ignoring the complete dissociation of strong acids like HCl.

Visual Representation of the Process

To better understand the process, consider the following steps:

1. Calculate the moles of acid in each separate solution.

2. Add the moles to find the total amount of acid present.

3. Sum the volumes to find the total volume.

4. Divide total moles by total volume to get the final molarity.

5. Calculate the pH from the molarity of H_3O^+ ions.

Practical Applications and Real-World Relevance

Understanding how to calculate the pH after mixing acids is vital in various fields:
- Chemical manufacturing: Ensuring proper pH levels during production processes.
- Environmental science: Assessing acidity in water bodies after pollutant runoff.
- Laboratory experiments: Precise pH adjustments during titrations and reactions.
- Pharmaceuticals: Formulating solutions with correct acidity for medication stability.

Summary and Key Takeaways

In this scenario, adding 25 mL of 0.021 M HCl to 35 mL of 0.036 M HCl results in a combined solution with a molarity of approximately 0.02975 M. Since HCl dissociates completely, the concentration of hydrogen ions is equal to this molarity, leading to a final pH of about 1.53. This calculation emphasizes the importance of understanding molarity, volume conversion, and acid dissociation in accurately determining solution pH.

Conclusion

Calculating the pH of a final solution after mixing different acid solutions involves straightforward principles of molarity and molar calculations, combined with the understanding of acid dissociation. By carefully following each step — from calculating individual moles to deriving the final molarity — chemists and students can accurately determine the acidity of combined solutions. Mastery of these concepts not only enhances problem-solving skills but also provides a foundation for more complex titration and buffer calculations in advanced chemistry topics.

Frequently Asked Questions

What is the initial concentration and volume of HCl in the final solution after mixing 25 mL of 0.021 M HCl with 35 mL of 0.036 M HCl?

The total moles of HCl are (25 mL × 0.021 M) + (35 mL × 0.036 M) = (0.025 L × 0.021 mol/L) + (0.035 L × 0.036 mol/L) = 0.000525 mol + 0.00126 mol = 0.001785 mol. The total volume is 25 mL + 35 mL = 60 mL = 0.060 L. The final concentration is 0.001785 mol / 0.060 L ≈ 0.02975 M. Since HCl is a strong acid, the pH is approximately -log(0.02975) ≈ 1.53.

How do you calculate the pH of the final solution after mixing the two HCl solutions?

First, find the total moles of HCl from both solutions, then divide by the total volume to get the final concentration. Since HCl is a strong acid, the pH is calculated as -log of the final molarity: pH = -log([HCl]). Using the total moles and volume, the concentration is obtained, and then the pH is found accordingly.

What assumptions are made when calculating the pH of this mixture?

The calculation assumes that all the HCl dissociates completely (strong acid behavior), no volume change upon mixing (volume is additive), and that there are no other acids or bases present that could affect the pH.

Would the pH change significantly if a weak acid or base were involved instead of HCl?

Yes, if a weak acid or base were involved, the pH calculation would be more complex, requiring consideration of dissociation equilibria, and the pH might not be directly proportional to the concentration as with strong acids like HCl.

What is the significance of knowing the pH after mixing different concentrations of HCl solutions?

Understanding the pH helps in applications such as titrations, chemical reactions, and biological systems where acidity or alkalinity influence process outcomes, ensuring proper control and safety measures.

Additional Resources

What Is The pH Of The Final Solution When 25 mL Of 0.021 M HCl Has Been Added To 35 mL Of 0.036 M HCl

Understanding the pH of a solution resulting from mixing acids is fundamental in chemistry, especially in titrations and solution preparation. The question of determining the pH after combining two acid solutions involves concepts such as molarity, volume, and the behavior of acids in aqueous solutions. In this detailed analysis, we will explore how to calculate the pH of the final mixture when 25 mL of 0.021 M HCl is added to 35 mL of 0.036 M HCl, providing a comprehensive overview of the underlying principles, step-by-step calculations, and implications.

Understanding the Components of the Mixture

Before delving into the calculations, it is critical to understand the properties of the individual solutions involved:

- HCl (Hydrochloric Acid): A strong acid that dissociates completely in water, meaning the molarity of HCl directly translates into the concentration of hydrogen ions (H^+) in the solution.
- Initial solutions:
- 35 mL of 0.036 M HCl
- 25 mL of 0.021 M HCl

The total volume after mixing will be the sum of the two volumes, but since the acids are mixed, their moles of H^+ will combine, affecting the overall pH.

Calculating Moles of HCl in Each Solution

The first step in determining the final pH involves calculating the total number of moles of HCl present in each solution:

Moles of HCl in the initial 35 mL of 0.036 M solution

- Convert volume from mL to L:
35 mL = 0.035 L
- Use molarity:
Moles of HCl = Molarity × Volume (L)
= 0.036 mol/L × 0.035 L
= 0.00126 mol

Moles of HCl in the added 25 mL of 0.021 M solution

- Convert volume from mL to L:
25 mL = 0.025 L
- Use molarity:
Moles of HCl = 0.021 mol/L × 0.025 L

= 0.000525 mol

Combining the Moles and Calculating Total Moles of HCl

Since both solutions are acids and dissociate completely, their moles of HCl can be directly summed:

- Total moles of HCl = 0.00126 mol + 0.000525 mol
= 0.001785 mol

Total volume after mixing:

- 35 mL + 25 mL = 60 mL or 0.060 L

This total volume is essential for calculating the concentration of H^+ ions in the final solution.

Calculating the Final Concentration of Hydrogen Ions (H^+)

Given that HCl is a strong acid, it dissociates completely, so:

- Moles of H^+ in the final solution = total moles of HCl added
- Concentration of H^+ in the final solution = total moles of HCl / total volume in liters

Calculating:

- $[H^+]$ = 0.001785 mol / 0.060 L
= 0.02975 mol/L

Determining the Final pH

The pH is calculated from the hydrogen ion concentration:

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

Applying the value:

pH = -log(0.02975) ≈ 1.53

This means the final solution has a pH of approximately 1.53, indicating a strongly acidic environment.

Implications and Considerations

The calculation demonstrates that mixing two hydrochloric acid solutions results in a solution with a pH reflective of the combined molarities and volumes. The pH of approximately 1.53 indicates a highly acidic solution, which aligns with expectations considering the initial concentrations.

Features and Observations:

- Additive nature of strong acids: Since both solutions are strong acids, their moles simply add up without any neutralization or buffering effects.
- Volume effect: Increasing the total volume dilutes the concentration of H^+ ions, but in this case, the total moles of H^+ are additive, leading to a predictable pH.
- No neutralization or buffering: The solution remains strongly acidic, with no neutralization happening, as both acid solutions are in excess.

Potential Variations and Complexities

While the above calculation is straightforward for strong acids, real-world scenarios might involve additional complexities:

- Presence of weak acids or bases: Buffering capacity could alter the pH significantly.
- Dilution effects: Further dilution would decrease concentration, raising pH.
- Temperature effects: pH can vary slightly with temperature, although this is typically minimal for dilute solutions.

Pros and Cons of This Approach

Pros:

- Simple and direct: Based on molarity and volume, making calculations straightforward.
- Applicable to strong acids: When acids dissociate fully, adding moles directly translates to hydrogen ion concentration.
- Educational clarity: Demonstrates fundamental principles of solution chemistry.

Cons:

- Assumes complete dissociation: Not applicable for weak acids or bases.
- Ignores activity coefficients: Real solutions may have activity effects not captured by simple molarity.
- Does not account for impurities or side reactions: Real samples may contain other substances influencing pH.

Conclusion

In summary, when 25 mL of 0.021 M HCl is added to 35 mL of 0.036 M HCl, the resulting solution contains a total of 0.001785 mol of HCl in 60 mL of solution, leading to a concentration of approximately 0.02975 mol/L of H^+ ions. The calculated pH is roughly 1.53, indicating a strongly acidic environment. This calculation exemplifies the principles of solution chemistry, highlighting how molarity, volume, and the dissociation properties of acids influence the final pH. For students and practitioners, understanding these calculations is vital for designing experiments, preparing solutions, and interpreting chemical reactions involving acids and bases.

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