Calculate The PH Of A Solution Obtained By Mixing 477 ML Of 0.17 M Hydrochloric Acid With 253 ML Of M

Calculate The pH Of A Solution Obtained By Mixing 477 ML Of 0.17 M Hydrochloric Acid With 253 ML Of M

Understanding how to calculate the pH of a solution resulting from the mixing of acids and bases is fundamental in chemistry. This process involves determining the concentration of hydrogen ions (H^+) in the final solution, which directly influences its acidity or alkalinity. In this article, we will explore the detailed steps involved in calculating the pH of a solution obtained by mixing 477 mL of 0.17 M hydrochloric acid (HCl) with a certain volume of a different solution (denoted as "M"). Although the original problem states "253 mL Of M," the concentration of M is not specified, so we will assume M represents a known concentration of a solution, and the calculations will be generalized accordingly.

Understanding the Basics of pH and Acid-Base Reactions

What is pH?

pH is a logarithmic measure of the concentration of hydrogen ions (H^+) in a solution. It is defined as:

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

- pH scale: Ranges from 0 (most acidic) to 14 (most basic), with 7 being neutral.
- Acidic solutions: pH < 7
- Basic solutions: pH > 7

Properties of Hydrochloric Acid (HCl)

Hydrochloric acid is a strong acid, meaning it dissociates completely in aqueous solution:

$HCl \rightarrow H^+ + Cl^-$

Therefore, the concentration of HCl directly translates to the concentration of H^+ ions in the solution.

Step-by-Step Calculation of the Final pH

To determine the pH of the mixed solution, follow these essential steps:

1. Calculate the moles of HCl in the initial solution.
2. Determine the moles of the other solution (M).
3. Establish the total volume of the final mixture.
4. Calculate the total moles of H^+ ions after mixing.
5. Compute the concentration of H^+ in the final solution.
6. Determine the pH from the hydrogen ion concentration.

Let's proceed with each step in detail.

1. Calculating Moles of Hydrochloric Acid (HCl)

Given data:

- Volume of HCl solution, V_1 = 477 mL = 0.477 L
- Concentration of HCl, C_1 = 0.17 M

Moles of HCl:

$$n_1 = C_1 \times V_1 = 0.17 \text{ mol/L} \times 0.477 \text{ L} \approx 0.08109 \text{ mol}$$

Since HCl is a strong acid, it dissociates completely, providing 0.08109 mol of H^+ ions.

2. Determining Moles of the M Solution

The problem states 253 mL of solution M. Since the concentration of M is not specified, we will denote:

- Volume of M, V_2 = 253 mL = 0.253 L
- Concentration of M, C_2 = ? (Unknown, but needed for calculations)

For demonstration, let's assume that M is a solution of a base or acid with a known concentration. For example, if M is a base with concentration C_2, then:

- Moles of M:

$$n_2 = C_2 \times V_2$$

Note: The exact calculation depends on the concentration of M. For this example, let's assume M is a 0.10 M NaOH solution, commonly used in such calculations.

Thus:

- $C_2 = 0.10$ M

Moles of M:

$n_2 = 0.10 \text{ mol/L} \times 0.253 \text{ L} = 0.0253 \text{ mol}$

The M solution's role depends on whether it is an acid or base. For this example, let's assume the M solution is a base (NaOH), which will neutralize some of the HCl.

3. Establishing the Total Volume of the Final Mixture

Total volume:

$V_{total} = V_1 + V_2 = 0.477 \text{ L} + 0.253 \text{ L} = 0.73 \text{ L}$

4. Calculating the Moles of H^+ and OH^- After Mixing

- Moles of H^+ initially from HCl: 0.08109 mol
- Moles of OH^- from NaOH: 0.0253 mol

Since NaOH is a strong base, it will neutralize an equivalent amount of H^+:

- Moles of H^+ remaining after neutralization:

$n_{H^+, remaining} = n_1 - n_2 = 0.08109 \text{ mol} - 0.0253 \text{ mol} \approx 0.05579 \text{ mol}$

- Moles of OH^- remaining:

Since the base was less than the acid, all of the base is consumed, and excess H^+ remains.

If the base were in excess, the calculation would be different.

5. Calculating the Hydrogen Ion Concentration in the Final Solution

Remaining moles of H^+:

$n_{H^+} \approx 0.05579 \text{ mol}$

Total volume:

$V_{total} = 0.73 \text{ L}$

Concentration of H^+:

$[H^+] = n_{H^+} / V_{total} \approx 0.05579 \text{ mol} / 0.73 \text{ L} \approx 0.0764 \text{ M}$

6. Calculating the pH

Using the formula:

$pH = -\log [H^+] \approx -\log 0.0764 \approx 1.117$

Therefore, the final pH of the solution is approximately 1.12, indicating a strongly acidic solution.

Important Considerations and Variations

- Concentration of M: The calculation hinges on knowing the concentration of solution M. If M is an acid, the pH calculation will involve different steps.
- Type of solution M: Whether M is an acid or base affects the neutralization process.
- Multiple neutralization steps: In more complex scenarios, multiple acids or bases may be involved, requiring sequential calculations.
- Dilution effects: Ensure volumes are accurately converted to liters for molarity calculations.

Additional Tips for Accurate pH Calculation

Use of Exact Concentrations

Always verify the exact concentrations of all solutions involved before calculations.

Accounting for Complete Dissociation

For strong acids and bases like HCl and NaOH, assume complete dissociation; for weak acids/bases, use their dissociation constants (Ka or Kb).

Handling Different Volumes and Concentrations

When mixing solutions, always account for the total volume to accurately compute molarities.

Utilizing pH Calculators and Software

For complex mixtures, pH calculators or chemistry software can streamline calculations.

Final Words

Calculating the pH of a mixed solution involves understanding the initial concentrations, neutralization reactions, and the final volume of the mixture. By carefully calculating moles, considering the stoichiometry of reactions, and applying logarithmic formulas, chemists can accurately determine the acidity or alkalinity of the resulting solution. Whether you're a student studying acid-base chemistry or a professional working with solutions, mastering these calculations is essential for ensuring precise pH control in laboratory and industrial settings.

Frequently Asked Questions

How do you calculate the pH of a solution obtained by mixing hydrochloric acid and another solution?

To calculate the pH, determine the moles of HCl in each solution, sum them up, find the total concentration in the combined volume, and then use pH = -log[H+].

What is the initial concentration of hydrochloric acid before mixing?

The initial concentration is 0.17 M in 477 mL of HCl solution.

How do you find the total moles of HCl after mixing?

Calculate moles in each solution: moles = molarity × volume in liters; then add them together for total moles.

What is the total volume of the mixture after combining the solutions?

Total volume = 477 mL + 253 mL = 730 mL or 0.73 L.

How do you determine the pH of the mixture once you have the total moles of HCl and total volume?

Calculate the concentration of H+ ions: [H+] = total moles of HCl / total volume in liters, then pH = -log[H+].

What is the significance of the molarity of the solutions in pH calculation?

Molarity indicates the concentration of H+ ions in the solution, which directly affects the pH value.

Can the pH of the mixture be acidic, neutral, or basic? How do you determine this?

Since hydrochloric acid is a strong acid, the mixture will be acidic, and the pH will be less than 7 based on the calculated H+ concentration.

Additional Resources

Calculate The pH Of A Solution Obtained By Mixing 477 ML Of 0.17 M Hydrochloric Acid With 253 ML Of M

Understanding how to determine the pH of a solution resulting from the mixing of different substances is a fundamental concept in chemistry, especially in acid-base chemistry. In this comprehensive review, we will explore the detailed process involved in calculating the pH of a solution formed by combining 477 mL of 0.17 M hydrochloric acid (HCl) with 253 mL of another solution, denoted as M. We will analyze each step carefully, discuss the underlying principles, and examine the factors influencing the final pH value. Whether you're a student, educator, or someone interested in chemical solutions, this article aims to clarify the process and provide a thorough understanding.

Understanding the Components and Initial Data

Hydrochloric Acid (HCl) Characteristics

Hydrochloric acid is a strong, monoprotic acid that dissociates completely in aqueous solutions. Given its molarity and volume, it provides a straightforward way to calculate the number of moles of HCl present.

- Molarity (M): 0.17 mol/L
- Volume: 477 mL = 0.477 L

The total moles of HCl initially present are calculated by:

\[\text{moles of HCl} = \text{Molarity} \times \text{Volume (L)} \]

\[\text{moles of HCl} = 0.17 \times 0.477 \approx 0.08109 \text{ mol} \]

This quantity will be central in determining the acidity after mixing.

Understanding Solution M

The problem mentions mixing with "253 mL of M," but the nature of solution M is unspecified. For the purpose of this calculation, we need to assume what M represents:

- If M is another acid or base, the calculation varies.
- If M is a neutral solution, the pH would primarily depend on the HCl.
- If M is a basic solution, it could neutralize some of the acid, affecting the final pH.

Assumption: To proceed with a meaningful calculation, let's assume M is a solution with a known molarity and type. For illustration, suppose M is a sodium hydroxide (NaOH) solution with a concentration of 0.1 M, which is common in titration problems.

- Volume of M: 253 mL = 0.253 L
- Molarity of M (NaOH): 0.1 mol/L

The moles of NaOH are:

$$ 0.1 \times 0.253 = 0.0253 \text{ mol} $$

Calculating the Final Concentration After Mixing

Determining Total Volume

The total volume after mixing:

$$ V_{\text{total}} = 477 \text{ mL} + 253 \text{ mL} = 730 \text{ mL} = 0.730 \text{ L} $$

This is crucial because concentrations depend on the total volume of the mixture.

Assessing the Reaction: Acid-Base Neutralization

Since HCl is a strong acid and NaOH is a strong base, they will react in a 1:1 molar ratio:

$$ \text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} $$

Number of moles of HCl: 0.08109 mol

Number of moles of NaOH: 0.0253 mol

Comparison:

- HCl: 0.08109 mol
- NaOH: 0.0253 mol

The NaOH will neutralize an equivalent amount of HCl:

$$ \text{Moles of HCl remaining} = 0.08109 - 0.0253 = 0.05579 \text{ mol} $$

Since NaOH is limiting, the reaction will consume all NaOH and leave excess HCl.

Calculating the Final pH

Remaining Acid Concentration

Concentration of remaining HCl in the mixture:

$$ [\text{HCl}] = \frac{\text{moles remaining}}{\text{total volume}} = \frac{0.05579}{0.730} \approx 0.0764 \text{ M} $$

Because HCl is a strong acid, it dissociates completely, and the concentration of hydrogen ions (H^+) equals the molarity of the remaining HCl:

$$ [\text{H}^+] = 0.0764 \text{ M} $$

Thus, the pH can be calculated as:

$$ \text{pH} = -\log [\text{H}^+] = -\log 0.0764 \approx 1.12 $$

This indicates a strongly acidic solution.

Key Features and Considerations

- The calculation hinges on the initial amounts, molarity, and the assumption regarding the nature of solution M.
- If M was a neutral solution (e.g., water), the pH would be determined solely by the initial acid.
- If M is a base like NaOH, the neutralization significantly affects the pH.
- The molarity of the initial solutions and the reaction stoichiometry are crucial for accurate

calculations.

Potential Variations and Their Impact

Depending on the actual nature of solution M, the final pH calculation could vary:

- If M is an acid (e.g., H_2SO_4): The pH would be even lower, indicating a more acidic solution.
- If M is a basic solution with higher molarity: The solution might reach neutral or basic pH after neutralization.
- If M is a buffer solution: The pH calculation would involve buffer equations.

Pros and Cons of the Calculation Method

Pros:

- Uses straightforward stoichiometry and molarity principles.
- Applicable for strong acid-strong base neutralizations.
- Provides a clear understanding of how volume and molarity influence pH.

Cons:

- Assumes complete dissociation, which may not be valid for weak acids or bases.
- Requires knowledge of the nature and concentration of solution M.
- Simplifies complex interactions; real-world solutions may involve activity coefficients.

Conclusion and Final Remarks

Calculating the pH of a solution created by mixing acids and bases involves understanding the initial concentrations, the volume of each component, and the stoichiometry of reactions. In the scenario where 477 mL of 0.17 M HCl is mixed with 253 mL of 0.1 M NaOH, the neutralization leaves excess HCl, resulting in a strongly acidic final solution with an estimated pH of approximately 1.12.

This process underscores the importance of precise measurements and assumptions in chemical calculations. Always consider the specific properties of the solutions involved, including dissociation, activity coefficients, and whether the acids or bases are weak or strong. Accurate pH calculations are essential in various applications, from laboratory experiments to industrial processes, and understanding these principles enhances the ability to manipulate and predict solution behaviors effectively.

In summary, calculating the pH after mixing solutions requires careful consideration of molarity, volume, reaction stoichiometry, and the nature of the substances involved. When applied correctly, these calculations provide valuable insights into the acidity or alkalinity of complex solutions, vital for both academic and practical purposes.

Calculate The Ph Of A Solution Obtained By Mixing 477 Ml Of 0 17 M Hydrochloric Acid With 253 Ml Of M

Calculate The Ph Of A Solution Obtained By Mixing 477 Ml Of 0 17 M Hydrochloric Acid With 253 Ml Of M

Related Articles

- During Aerobic Respiration, Electrons Travel Downhill In Which Sequence?a) Food Citric Acid Cycle ATP
- Enter Your Answer In The Provided Box. A Sample Of 7.73 G Of Naphthalene (c10h8) Is Dissolved In 85.9
- Determine The Intervals Of Continuity For The Following Function. -1 1 2 3 4 5 6 7 -1 1 2 3 4 5 6 7 8

Back to Home