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Understanding the pH change resulting from mixing solutions of different concentrations is fundamental in chemistry. Specifically, when sodium hydroxide (NaOH) and hydrochloric acid (HCl) are combined, they undergo a neutralization reaction, leading to a solution with a particular pH. This article explores the detailed process of calculating the pH of the resulting mixture when 200 mL of 2.0 M NaOH is added to 500 mL of 1.0 M HCl. We'll analyze the reactions, determine the limiting reagent, and calculate the final pH step by step.

Understanding the Components of the Mixture

Before delving into calculations, it's essential to understand the properties of the solutions involved.

NaOH Solution

- Concentration: 2.0 M (moles per liter)
- Volume: 200 mL (0.2 liters)
- Moles of NaOH:
$\text{Moles} = \text{Concentration} \times \text{Volume}$
$= 2.0\, \text{mol/L} \times 0.2\, \text{L} = 0.4\, \text{mol}$

HCl Solution

- Concentration: 1.0 M
- Volume: 500 mL (0.5 liters)
- Moles of HCl:
$1.0\, \text{mol/L} \times 0.5\, \text{L} = 0.5\, \text{mol}$

Reaction Between NaOH and HCl

The fundamental chemical reaction is:

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

This is a straightforward acid-base neutralization with a 1:1 molar ratio. The key steps involve comparing the moles of acid and base to determine whether the mixture will be acidic, basic, or neutral after the reaction.

Calculating the Moles of Reactants and Determining the Limiting Reagent

Given:
- Moles of NaOH: 0.4 mol
- Moles of HCl: 0.5 mol

Since the reaction proceeds in a 1:1 molar ratio:
- NaOH will neutralize 0.4 mol of HCl.
- Remaining HCl after neutralization:
$0.5\, \text{mol} - 0.4\, \text{mol} = 0.1\, \text{mol}$

Thus:
- All NaOH is consumed.
- Excess HCl remains, making the solution acidic.

Calculating the Final Volume of the Mixture

Total volume after mixing:
- Volume of NaOH solution: 200 mL
- Volume of HCl solution: 500 mL
- Total volume:
$200\, \text{mL} + 500\, \text{mL} = 700\, \text{mL}$ (or 0.7 liters)

Determining the Final Concentration of Remaining HCl

Remaining HCl:
- Moles: 0.1 mol
- Total volume: 0.7 L

Concentration of HCl after reaction:
$$\text{[HCl]} = \frac{\text{Remaining moles}}{\text{Total volume}} = \frac{0.1\, \text{mol}}{0.7\, \text{L}} \approx 0.143\, \text{M}$$

Since the excess HCl remains unreacted, the solution is acidic, and the pH is determined primarily by this residual HCl.

Calculating the pH of the Mixture

The pH of a solution is calculated using:
$$ \text{pH} = -\log [\text{H}^+] $$

Assuming complete dissociation of HCl (a strong acid), the concentration of hydrogen ions $[\text{H}^+]$ is approximately equal to the HCl concentration:
$$ [\text{H}^+] \approx 0.143\, \text{M} $$

Thus:
$$ \text{pH} = -\log(0.143) $$

Calculating:
$$ \text{pH} \approx -\log(0.143) \approx 0.84 $$

Final pH of the Mixture

The pH of the resulting mixture after adding 200 mL of 2.0 M NaOH to 500 mL of 1.0 M HCl is approximately 0.84. This indicates a strongly acidic solution, as expected because there is excess unreacted HCl after the neutralization process.

Additional Considerations and Tips

- Neutralization Point: The mixture is not at the neutral point because HCl is in excess.
- Equivalent Volumes: To reach neutrality, equal moles of acid and base are necessary; here, 0.4 mol of NaOH neutralizes 0.4 mol of HCl.
- pH Near Zero: When excess acid dominates, the pH approaches zero, indicating high acidity.
- Safety Precautions: Always handle strong acids and bases with appropriate safety gear, including gloves and eye protection.

Summary of Key Calculations

1. Moles of NaOH: 0.4 mol
2. Moles of HCl: 0.5 mol
3. Remaining HCl after neutralization: 0.1 mol
4. Final total volume: 0.7 L
5. Concentration of residual HCl: approximately 0.143 M
6. Final pH: approximately 0.84

Conclusion

Mixing 200 mL of 2.0 M NaOH with 500 mL of 1.0 M HCl results in a solution with a pH of about 0.84 due to the excess HCl remaining after neutralization. This calculation illustrates fundamental principles of acid-base titration, molarity, and pH determination, providing valuable insights for students and professionals working with chemical solutions.

FAQs

What happens if more NaOH is added?

- If additional NaOH is added beyond 0.4 mol, the solution will become basic, and the pH will increase accordingly.

How does volume affect pH in such reactions?

- Total volume impacts the concentration of remaining reactants; larger volumes dilute the solution, affecting pH calculations.

Why is understanding pH important?

- pH influences chemical reactivity, biological systems, and industrial processes, making accurate calculations crucial in various fields.

By mastering these calculations and concepts, you can confidently determine the pH of complex mixtures resulting from acid-base reactions, essential in laboratory experiments, industrial applications, and environmental chemistry.

Frequently Asked Questions

What is the pH of the mixture when 200 mL of 2.0 M NaOH is added to 500 mL of 1.0 M HCl?

The pH of the resulting mixture is approximately 13.0, indicating a strongly basic solution.

How do you determine the pH after mixing NaOH and HCl solutions?

Calculate the moles of NaOH and HCl, find the excess moles after neutralization, then use the concentration of the remaining species to find the pH.

What is the initial number of moles of NaOH and HCl before mixing?

NaOH: 0.4 mol (200 mL × 2.0 M), HCl: 0.5 mol (500 mL × 1.0 M).

Which reactant is in excess after mixing, and what does that imply about the pH?

NaOH is in excess (0.4 mol NaOH vs. 0.5 mol HCl), so the mixture is basic, resulting in a high pH.

How do you calculate the pH of the mixture after neutralization?

Determine the remaining moles of NaOH after neutralization (0.4 mol - 0.5 mol = 0.1 mol NaOH remaining), then divide by total volume and apply pH = 14 - pOH.

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

The total volume is 700 mL (200 mL + 500 mL).

Why is the pH of the mixture significantly higher than 7?

Because there is an excess of NaOH after neutralization, making the solution basic with a pH around 13.

Additional Resources

When 200 ml of 2.0 M NaOH(aq) is Added to 500 ml of 1.0 M HCl(aq), the pH of the Resulting Mixture Is

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Introduction

The interaction between acids and bases is a fundamental concept in chemistry, serving as the foundation for understanding titrations, buffer solutions, and many industrial processes. The simple yet profound reaction between sodium hydroxide (NaOH) and hydrochloric acid (HCl) epitomizes acid-base chemistry, providing insight into neutralization, solution pH changes, and stoichiometric calculations.

In this article, we explore a typical acid-base neutralization scenario: adding 200 ml of 2.0 M NaOH to 500 ml of 1.0 M HCl. Our goal is to analyze the resulting pH of the mixture, elucidate the underlying chemical principles, and examine the factors influencing the final pH. This investigation is relevant for students, educators, and laboratory professionals seeking to understand the quantitative aspects of acid-base reactions.

Understanding the Components of the Mixture

Sodium Hydroxide (NaOH)

NaOH is a strong base that dissociates completely in aqueous solution:

$$ \mathrm{NaOH} \rightarrow \mathrm{Na^+} + \mathrm{OH^-} $$

- Molarity: 2.0 M
- Volume added: 200 ml (0.200 L)

Hydrochloric Acid (HCl)

HCl is a strong acid that also dissociates completely:

$$ \mathrm{HCl} \rightarrow \mathrm{H^+} + \mathrm{Cl^-} $$

- Molarity: 1.0 M
- Volume: 500 ml (0.500 L)

Calculating the Moles of Reactants

Understanding the number of moles involved is critical for predicting the extent of neutralization and the resulting pH.

Moles of NaOH Added

$$
\text{Moles of NaOH} = \text{Concentration} \times \text{Volume} = 2.0\, \mathrm{mol/L} \times 0.200\, \mathrm{L} = 0.4\, \mathrm{mol}
$$

Moles of HCl Present Initially

$$
\text{Moles of HCl} = 1.0\, \mathrm{mol/L} \times 0.500\, \mathrm{L} = 0.5\, \mathrm{mol}
$$

Reaction Stoichiometry and Extent of Neutralization

The core reaction is:

$$ \mathrm{HCl} + \mathrm{NaOH} \rightarrow \mathrm{NaCl} + \mathrm{H_2O} $$

This is a 1:1 molar neutralization.

- Moles of HCl initially: 0.5 mol
- Moles of NaOH added: 0.4 mol

Analysis:

- Since NaOH is the limiting reagent, it will neutralize an equivalent amount of HCl:

$$
\text{HCl neutralized} = 0.4\, \mathrm{mol}
$$

- Remaining unreacted HCl:

$$
0.5\, \mathrm{mol} - 0.4\, \mathrm{mol} = 0.1\, \mathrm{mol}
$$

- Moles of NaOH after reaction:

$$
0\, \mathrm{mol} \quad (\text{all NaOH is consumed})
$$

Implication: The mixture contains unreacted HCl, making it acidic.

Determining the Final Concentration of HCl

The total volume of the mixture:

$$
V_{total} = 200\, \mathrm{ml} + 500\, \mathrm{ml} = 700\, \mathrm{ml} = 0.700\, \mathrm{L}
$$

The remaining unneutralized HCl:

$$
\text{Concentration of HCl} = \frac{\text{Unreacted moles}}{\text{Total volume}} = \frac{0.1\, \mathrm{mol}}{0.700\, \mathrm{L}} \approx 0.143\, \mathrm{M}
$$

Calculating the pH of the Mixture

Since the mixture contains unreacted HCl, which is a strong acid, the pH can be directly calculated from the concentration of H^+ ions:

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

Given:

$$
[\mathrm{H^+}] \approx 0.143\, \mathrm{M}
$$

Thus,

$$
\mathrm{pH} = -\log(0.143) \approx 0.84
$$

Conclusion: The pH of the resulting mixture is approximately 0.84, indicating a strongly acidic solution.

Factors Influencing the Final pH

While the straightforward calculation suggests a pH of about 0.84, several factors can influence this value in practical scenarios:

1. Temperature Effects

- Elevated temperatures can slightly alter dissociation constants and reaction rates, but since both reactants are strong electrolytes, the impact on pH is minimal in this context.

2. Impurities and Carbon Dioxide Absorption

- Exposure to atmospheric CO_2 can lead to the formation of carbonic acid, slightly lowering pH.
- Impurities in reagents might also influence the acidity.

3. Accuracy of Concentrations and Volumes

- Slight deviations in molarity or volume measurements can lead to variations in pH.

4. Complete Dissociation Assumption

- Assumed complete dissociation of strong acids/bases; in reality, high ionic strength can cause minor deviations.

Additional Considerations: Titration and Equivalence Point

This scenario resembles a partial titration, where NaOH is added to HCl:

- Equivalence point: When moles of NaOH added equal moles of HCl initially present (0.5 mol).
- Current state: NaOH is insufficient to reach equivalence (only 0.4 mol added).

If more NaOH were added to reach the equivalence point, the pH would shift dramatically from acidic to neutral (around pH 7) at the equivalence point, and beyond, into basic territory.

Implications for Laboratory Practice and Educational Contexts

Understanding how to calculate the pH after partial neutralization is essential for:

- Designing titration experiments
- Preparing buffer solutions
- Analyzing reaction stoichiometry

This scenario serves as a practical illustration of the importance of molar ratios, solution volumes, and reaction completeness in acid-base chemistry.

Summary

Adding 200 ml of 2.0 M NaOH to 500 ml of 1.0 M HCl results in a mixture with an approximate pH of 0.84. This is due to the incomplete neutralization of HCl, leaving unreacted acid in solution. The key steps in arriving at this conclusion include calculating initial moles, assessing the limiting reagent, determining the remaining unneutralized acid, and translating that into hydrogen ion concentration to find the pH.

The analysis underscores the significance of stoichiometry in predicting solution pH and highlights how quantitative calculations inform practical laboratory procedures.

References

- Atkins, P., & de Paula, J. (2014). Physical Chemistry. Oxford University Press.
- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.

- Brown, T. L., LeMay, H. E., Bursten, B. E., & Murphy, C. J. (2014). Chemistry: The Central Science. Pearson.

Author's Note:
This detailed examination aims to clarify the principles governing acid-base reactions and their quantitative analysis, providing a comprehensive understanding suitable for academic and laboratory contexts.

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