The PH Of A Solution Prepared By Mixing 40.0 ML Of 0.125 M Mg(OH)2 And 150.0 ML Of 0.125 M HCl Is __________.A)

The PH Of A Solution Prepared By Mixing 40.0 ML Of 0.125 M Mg(OH)2 And 150.0 ML Of 0.125 M HCl Is __________.A)

Understanding the pH of a solution resulting from mixing a magnesium hydroxide ($Mg(OH)_2$) solution with hydrochloric acid (HCl) involves exploring concepts of acid-base reactions, molarity, and stoichiometry. This comprehensive guide walks through the steps to determine the final pH of such a mixture, providing clarity on the underlying chemistry principles and calculations involved.

Introduction to Acid-Base Chemistry

The Significance of pH in Chemistry

PH is a measure of the acidity or alkalinity of a solution, ranging from 0 to 14. A pH less than 7 indicates an acidic solution, while a pH greater than 7 indicates a basic (alkaline) solution. Neutral solutions have a pH of exactly 7.

Understanding how various solutions interact to change pH is fundamental in chemistry, especially in titrations, buffer solutions, and industrial processes.

Basic Concepts of Acid-Base Reactions

- **Acids**: Substances that donate protons (H^+ ions). Example: HCl
- **Bases**: Substances that accept protons or donate hydroxide ions (OH^-). Example: $Mg(OH)_2$
- **Neutralization**: When an acid reacts with a base, they produce water and a salt, often resulting in a solution with a pH closer to neutral.

Analyzing the Components of the Mixture

Data Summary

- $Mg(OH)_2$ volume: 40.0 mL
- $Mg(OH)_2$ molarity: 0.125 M
- HCl volume: 150.0 mL
- HCl molarity: 0.125 M

Calculating Moles of Each Reactant

1. **Moles of $Mg(OH)_2$:**
    - Convert volume to liters: 40.0 mL = 0.0400 L
    - Use molarity to find moles: 0.125 mol/L × 0.0400 L = 0.00500 mol

2. **Moles of HCl:**
    - Convert volume to liters: 150.0 mL = 0.1500 L
    - Use molarity to find moles: 0.125 mol/L × 0.1500 L = 0.01875 mol

---

Understanding the Reaction Between $Mg(OH)_2$ and HCl

Reaction Equation

The neutralization reaction between magnesium hydroxide and hydrochloric acid can be written as:

$Mg(OH)_2 + 2\ HCl \rightarrow MgCl_2 + 2\ H_2O$

Stoichiometric Ratios

From the balanced equation, 1 mole of $Mg(OH)_2$ reacts with 2 moles of HCl.

- Moles of $Mg(OH)_2$ available: 0.00500 mol
- Moles of HCl available: 0.01875 mol

Determining the Limiting Reactant

1. **Calculate the required HCl for all $Mg(OH)_2$:**
   0.00500 mol $Mg(OH)_2$ × 2 mol HCl / 1 mol $Mg(OH)_2$ = 0.01000 mol HCl
2. **Compare with available HCl:** 0.01875 mol HCl > 0.01000 mol HCl required

Since there is more HCl than needed, $Mg(OH)_2$ is the limiting reactant, and HCl is in excess.

Calculating the Extent of the Reaction

Reacted Moles of HCl and $Mg(OH)_2$

- **$Mg(OH)_2$ reacts completely:** 0.00500 mol
- **HCl required for complete $Mg(OH)_2$:** 0.01000 mol
- **Remaining HCl after reaction:** 0.01875 mol - 0.01000 mol = 0.00875 mol

Remaining Species in Solution

After the reaction, the solution contains:

- Magnesium chloride ($MgCl_2$), formed from 0.00500 mol $Mg(OH)_2$
- Excess HCl: 0.00875 mol
- Water, produced from the neutralization of $Mg(OH)_2$

Final pH Calculation

Understanding the Remaining HCl

Since excess HCl remains, the solution is acidic. The pH depends on the concentration of this remaining HCl.

Calculating Final Concentration of HCl

1. **Total volume of the mixture:** 40.0 mL + 150.0 mL = 190.0 mL = 0.1900 L

2. **Concentration of remaining HCl:** 0.00875 mol / 0.1900 L ≈ 0.04605 M

pH Determination

The pH of a solution is calculated using the formula:

`pH = -log[H⁺]`

Assuming complete dissociation of HCl, $[H^+]$ equals the concentration of the remaining HCl:

`pH = -log(0.04605) ≈ 1.34`

Conclusion: Final pH of the Mixture

The mixture's pH is approximately 1.34, indicating a strongly acidic solution due to the excess HCl remaining after the neutralization with $Mg(OH)_2$.

Additional Insights and Practical Applications

Why Is Understanding pH Important?

- **Industrial Processes:** Control of pH is vital in manufacturing, such as in pharmaceuticals, food processing, and water treatment.

- **Environmental Impact:** Acidic or basic waste can harm ecosystems; thus, understanding neutralization is key for environmental safety.

- **Laboratory Accuracy:** Precise pH measurements are crucial for reactions requiring specific conditions.

Common Mistakes to Avoid

1. Neglecting stoichiometric ratios in reactions.
2. Ignoring the volume changes after mixing solutions.
3. Assuming complete reaction without verifying limiting reagents.
4. Forgetting to convert volumes to liters before calculations.

Summary

In summary, mixing 40.0 mL of 0.125 M $Mg(OH)_2$ with 150.0 mL of 0.125 M HCl results in a solution with a pH of approximately 1.34. This calculation hinges on understanding the molar ratios of reactants, identifying the limiting reagent, and calculating the concentration of excess acid remaining after neutralization. Mastery of these concepts enables chemists and students alike to predict solution behaviors accurately.

Keywords: pH calculation, magnesium hydroxide, hydrochloric acid, neutralization, molarity, stoichiometry, acid-base reaction, solution pH, chemical reactions, titration, molar ratio

Frequently Asked Questions

What is the primary goal in calculating the pH of the solution formed by mixing $Mg(OH)_2$ and HCl?

The primary goal is to determine the resulting pH after the acid-base reaction between the magnesium hydroxide and hydrochloric acid, considering their concentrations and volumes.

How do you determine the moles of $Mg(OH)_2$ and HCl in the mixture?

Multiply their respective concentrations by their volumes in liters: for $Mg(OH)_2$, 0.125 mol/L × 0.040 L = 0.005 mol; for HCl, 0.125 mol/L × 0.150 L = 0.01875 mol.

What is the balanced chemical equation for the reaction between $Mg(OH)_2$ and HCl?

The balanced equation is $Mg(OH)_2 + 2\ HCl \rightarrow MgCl_2 + 2\ H_2O$.

How do you determine the limiting reagent in this reaction?

Compare the mole ratio; $Mg(OH)_2$ reacts with twice the moles of HCl. Since 0.005 mol $Mg(OH)_2$ needs 0.010 mol HCl, but only 0.01875 mol HCl is available, $Mg(OH)_2$ is the limiting reagent.

What is the amount of HCl remaining after the reaction?

Initially, 0.01875 mol HCl; after reacting 0.005 mol with $Mg(OH)_2$ (which consumes 0.010 mol HCl), remaining HCl = 0.01875 - 0.010 = 0.00875 mol.

What is the pH of the solution after the reaction?

Since excess HCl remains, calculate its concentration in the total volume (40.0 mL + 150.0 mL = 190.0 mL = 0.190 L): concentration = 0.00875 mol / 0.190 L ≈ 0.04605 M. pH = $-\log[H^+] \approx 1.34$.

Why does the solution have a low pH after mixing $Mg(OH)_2$ and HCl?

Because there is an excess of HCl remaining in the solution, making it acidic and resulting in a low pH.

How would the pH change if the initial concentrations of $Mg(OH)_2$ and HCl were different?

Higher initial HCl concentrations would lead to a more acidic solution with a lower pH, while higher $Mg(OH)_2$ concentrations could neutralize more acid, potentially resulting in a neutral or basic solution depending on the amounts.

Additional Resources

pH Calculation of a Mixture of $Mg(OH)_2$ and HCl: An In-Depth Analysis

---

Introduction

Understanding the pH of a solution resulting from mixing a strong acid with a weak base is fundamental in chemistry, especially in acid-base titrations and buffer solutions. This article delves into a specific scenario involving the mixing of magnesium hydroxide ($Mg(OH)_2$), a sparingly soluble weak base, with hydrochloric acid (HCl), a strong acid. The goal is to determine the pH of the resulting solution after mixing specified quantities of each. The process involves several steps: calculating moles of each reactant, understanding their reactions, and applying principles of stoichiometry and equilibrium chemistry to find the final pH.

Background and Chemical Properties

Magnesium Hydroxide ($Mg(OH)_2$)
- Nature: Weak base; slightly soluble in water.
- Solubility Product (Ksp): Approximately 1.8×10^{-11} at 25°C.
- Dissociation Equation:

$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$

- Implication: Its limited solubility means that only a small amount dissolves to produce OH^- ions, which influences its basicity.

Hydrochloric Acid (HCl)
- Nature: Strong acid; dissociates completely in aqueous solution.
- Dissociation Equation:

$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

- Implication: Equivalently provides H^+ ions proportional to its initial molarity and volume.

Step 1: Calculating Moles of Reactants

Given data:
- $Mg(OH)_2$ volume = 40.0 mL = 0.040 L
- $Mg(OH)_2$ molarity (concentration) = 0.125 M
- HCl volume = 150.0 mL = 0.150 L
- HCl molarity = 0.125 M

Moles of $Mg(OH)_2$:

$$
\text{Moles of Mg(OH)}_2 = \text{Concentration} \times \text{Volume} = 0.125\, \text{mol/L} \times 0.040\, \text{L} = 0.005\, \text{mol}
$$

Moles of HCl:

$$
\text{Moles of HCl} = 0.125\, \text{mol/L} \times 0.150\, \text{L} = 0.01875\, \text{mol}
$$

Step 2: Understanding the Reaction

The primary reaction between $Mg(OH)_2$ and HCl is a typical acid-base neutralization:

$$
\text{Mg(OH)}_2 + 2\, \text{HCl} \rightarrow \text{MgCl}_2 + 2\, \text{H}_2\text{O}
$$

Stoichiometry:
- 1 mole of $Mg(OH)_2$ reacts with 2 moles of HCl.
- The reaction consumes both reactants in a 1:2 molar ratio.

Step 3: Determining the Limiting Reactant

Compare the available moles:

- $Mg(OH)_2$: 0.005 mol
- HCl: 0.01875 mol

For complete neutralization:

$$
\text{HCl needed} = 2 \times \text{Mg(OH)}_2 = 2 \times 0.005\, \text{mol} = 0.010\, \text{mol}
$$

Since 0.01875 mol of HCl are available, which exceeds 0.010 mol, HCl is in excess.

Conclusion:
- All $Mg(OH)_2$ will be consumed.
- Excess HCl will remain in solution after neutralization.

Step 4: Calculating Remaining HCl and the Resulting pH

Remaining HCl after reaction:

$$
\text{Unreacted HCl} = \text{Initial HCl} - \text{HCl needed} = 0.01875\, \text{mol} - 0.010\, \text{mol} = 0.00875\, \text{mol}
$$

Total volume after mixing:

$$
V_{\text{total}} = 40.0\, \text{mL} + 150.0\, \text{mL} = 190.0\, \text{mL} = 0.190\, \text{L}
$$

Concentration of remaining HCl:

$$
[\text{HCl}]_{\text{remaining}} = \frac{0.00875\, \text{mol}}{0.190\, \text{L}} \approx 0.0461\, \text{M}

\]

Since HCl is a strong acid, the remaining unreacted HCl fully dissociates, providing H^+ ions to determine pH:

\[
\text{pH} = -\log[\text{H}^+] \approx -\log(0.0461) \approx 1.34
\]

Final pH Calculation:

\[
\boxed{
\text{pH} \approx 1.34
}
\]

The solution is strongly acidic due to the excess HCl remaining after neutralization of $Mg(OH)_2$.

Additional Considerations:

Solubility of $Mg(OH)_2$
- Although $Mg(OH)_2$ is sparingly soluble, in this scenario, the amount of $Mg(OH)_2$ used (0.005 mol) is well within its solubility limits, so no precipitation or solubility issues need to be considered beyond the initial assumption.

Significance of Excess Acid
- The excess HCl determines the pH, overriding any minor contributions from residual hydroxide or other species.
- If the excess HCl had been minimal or absent, the solution might have been neutral or slightly basic, but in this case, it remains strongly acidic.

Conclusion

The mixture of 40.0 mL of 0.125 M $Mg(OH)_2$ with 150.0 mL of 0.125 M HCl results in a solution with a pH of approximately 1.34. This outcome highlights the importance of stoichiometry in acid-base reactions and demonstrates how excess strong acid dictates the final pH in such mixtures. This detailed analysis underscores core principles of chemical equilibrium, molarity calculations, and acid-base neutralization, providing a comprehensive understanding applicable in laboratory and industrial settings.

Summary Table

Step	Calculation/Result
Moles of $Mg(OH)_2$	0.005 mol
Moles of HCl	0.01875 mol
HCl needed to neutralize $Mg(OH)_2$	0.010 mol
Excess HCl after neutralization	0.00875 mol
Total volume after mixing	0.190 L
Concentration of excess HCl	0.0461 M
Final pH	1.34

This comprehensive approach ensures clarity in understanding the chemistry involved, providing a robust foundation for further studies or practical applications involving acid-base solutions.

The Ph Of A Solution Prepared By Mixing 40 0 Ml Of 0 125 M Mg Oh 2 And 150 0 Ml Of 0 125 M Hcl Is A

The Ph Of A Solution Prepared By Mixing 40 0 Ml Of 0 125 M Mg Oh 2 And 150 0 Ml Of 0 125 M Hcl Is A

Related Articles

- What Tool Of L.b. Jefferies' Trade In Rear Window Saves Him From Harm Once He Is Discovered By His Potentially
- Suppose That A Dart Lands At Random On The Dartboard Shown At The Right. Find Each Theoretical Probability.The
- The Real Risk-free Rate Is 2%. Inflation Is Expected To Be 4% This Year, 3% Next Year, And Then 3% Thereafter.

Back to Home