We Mix 79 ML Of 0.211 M Nitric Acid With 38 ML Of 0.207 M Calcium Hydroxide. Both Solutions Are Initially

We Mix 79 ML Of 0.211 M Nitric Acid With 38 ML Of 0.207 M Calcium Hydroxide. Both Solutions Are Initially in separate containers before the process of mixing begins. This common laboratory procedure involves combining an acid and a base, which results in a chemical reaction that produces a salt and water. Understanding the details of this mix, including the calculations, reaction mechanisms, and potential outcomes, is essential for students, educators, and professionals working in chemistry. This article explores the process thoroughly, offering insights into the chemistry behind the reaction, step-by-step calculations, and practical considerations for laboratory experimentation.

Understanding the Components of the Mixture

Nitric Acid (HNO_3): Properties and Concentration

Nitric acid is a strong, highly corrosive acid commonly used in laboratories and industrial processes. In this scenario, it is present at a concentration of 0.211 molar (M), meaning each liter of solution contains 0.211 moles of nitric acid.

- **Volume:** 79 milliliters (mL) or 0.079 liters (L)
- **Concentration:** 0.211 mol/L
- **Initial moles of HNO_3:** Calculated as volume × concentration

Calcium Hydroxide ($Ca(OH)_2$): Properties and Concentration

Calcium hydroxide, also known as slaked lime, is a strong base used in various chemical applications. It dissociates completely in water to produce calcium ions and hydroxide ions.

- **Volume:** 38 mL or 0.038 L
- **Concentration:** 0.207 mol/L
- **Initial moles of $Ca(OH)_2$:** Volume × Concentration

Calculations of Moles of Reactants

Determining Moles of Nitric Acid

To understand the reaction, first, calculate the number of moles of nitric acid:

1. Convert volume to liters: 79 mL = 0.079 L
2. Calculate moles: 0.079 L × 0.211 mol/L = 0.016669 mol

Approximately 0.01667 moles of nitric acid are present initially.

Determining Moles of Calcium Hydroxide

Similarly, calculate the moles of calcium hydroxide:

1. Convert volume to liters: 38 mL = 0.038 L
2. Calculate moles: 0.038 L × 0.207 mol/L = 0.007866 mol

Approximately 0.00787 moles of calcium hydroxide are present initially.

Reaction Between Nitric Acid and Calcium Hydroxide

Balanced Chemical Equation

The reaction between nitric acid and calcium hydroxide is a typical acid-base neutralization:

$$2 \, \mathrm{HNO_3} + \mathrm{Ca(OH)_2} \rightarrow \mathrm{Ca(NO_3)_2} + 2\, \mathrm{H_2O}$$

This indicates that 2 moles of nitric acid react with 1 mole of calcium hydroxide to produce calcium nitrate and water.

Calculating the Limiting Reactant

To determine which reactant limits the reaction, compare the molar ratios:

- Moles of HNO_3 needed: 2×0.007866 mol = 0.015732 mol
- Moles of HNO_3 available: 0.016669 mol

Since 0.016669 mol of nitric acid is slightly more than the 0.015732 mol needed to fully react with calcium hydroxide, nitric acid is in excess, and calcium hydroxide is the limiting reactant.

Predicting the Products and Residual Reactants

Extent of Reaction

- The limiting reactant ($Ca(OH)_2$) is entirely consumed.
- The amount of nitric acid that reacts: 0.007866 mol.
- The remaining nitric acid: $0.016669 - (2 \times 0.007866) = 0.000937$ mol.

Final Concentrations of Products and Reactants

- Calcium nitrate $\mathrm{Ca(NO_3)_2}$: formed from 0.007866 mol of calcium hydroxide

$$ \text{Moles of } \mathrm{Ca(NO_3)_2} = 0.007866 \text{ mol} $$

- Remaining nitric acid: 0.000937 mol

- Water formed: equal to the moles of calcium hydroxide reacted:

$$ 0.007866 \text{ mol} \times 2 = 0.015732 \text{ mol} $$

The final solution contains residual nitric acid, calcium nitrate, and water.

Calculations of Final Concentrations

Volume of the Mixture

Initial volumes:

- Nitric acid: 79 mL
- Calcium hydroxide: 38 mL

Total volume after mixing:

$$ 79\, \mathrm{mL} + 38\, \mathrm{mL} = 117\, \mathrm{mL} $$
or 0.117 liters.

Concentrations of Products and Remaining Reactants

- Residual nitric acid:

$$ \text{Concentration} = \frac{\text{Remaining moles}}{\text{Total volume}} = \frac{0.000937\, \text{mol}}{0.117\, \text{L}} \approx 0.00801\, \mathrm{M} $$

- Calcium nitrate:

$$ \frac{0.007866\, \text{mol}}{0.117\, \text{L}} \approx 0.0672\, \mathrm{M} $$

- Water:

$$ \frac{0.015732\, \text{mol}}{0.117\, \text{L}} \approx 0.1344\, \mathrm{M} $$

These concentrations are important for understanding the solution's properties post-reaction, including pH and conductivity.

Practical Implications and Laboratory Considerations

Safety Precautions

Handling nitric acid and calcium hydroxide requires strict safety measures, including wearing gloves, goggles, and working in a fume hood. Both solutions are corrosive, and proper disposal protocols should be followed.

Experimental Procedure

- Measure precise volumes of each solution using calibrated pipettes or burettes.
- Mix solutions carefully to observe the reaction.
- Use indicators or pH meters to determine the endpoint, especially if titration is involved.
- Record temperature changes, if any, as exothermic reactions can occur.

Potential Applications

- Producing calcium nitrate for fertilizer applications.
- Studying acid-base titrations and reaction stoichiometry.
- Educational demonstrations of neutralization reactions.

Conclusion

Mixing 79 mL of 0.211 M nitric acid with 38 mL of 0.207 M calcium hydroxide involves a straightforward acid-base neutralization, leading to the formation of calcium nitrate and water. Through careful calculation, it is evident that calcium hydroxide is the limiting reactant, dictating the amount of salt produced and the residual acid present. This process exemplifies fundamental principles of stoichiometry, solution chemistry, and chemical reactions, providing valuable insights for students and professionals alike. Proper understanding and execution of such mixing procedures are essential for effective laboratory work, safe handling of chemicals, and achieving desired chemical outcomes.

Frequently Asked Questions

What is the net reaction when mixing 79 mL of 0.211 M nitric acid with 38 mL of 0.207 M calcium hydroxide?

The reaction is between nitric acid (HNO_3) and calcium hydroxide ($Ca(OH)_2$), producing calcium nitrate and water: $2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$.

How do you determine the limiting reactant in this acid-base neutralization reaction?

Calculate the moles of each reactant: for nitric acid, 0.211 mol/L × 0.079 L; for calcium hydroxide, 0.207 mol/L × 0.038 L. The reactant with fewer moles limits the reaction.

What is the pH of the solution after mixing these two solutions?

The pH depends on the extent of neutralization. If excess acid or base remains, the solution will be acidic or basic respectively. Calculating remaining moles after reaction determines the final pH.

How do you calculate the amount of calcium nitrate formed in this

reaction?

Identify the limiting reactant, then use its initial moles to determine the moles of calcium nitrate produced, since the molar ratio is 1:1 between calcium hydroxide and calcium nitrate.

What safety precautions should be taken when mixing nitric acid and calcium hydroxide solutions?

Wear appropriate personal protective equipment, such as gloves and goggles, work in a well-ventilated area, and add acid to water slowly to prevent splashing and vigorous reactions.

Additional Resources

We Mix 79 ML Of 0.211 M Nitric Acid With 38 ML Of 0.207 M Calcium Hydroxide. Both Solutions Are Initially

In the realm of chemistry, understanding how different solutions interact is fundamental to mastering the principles of acid-base reactions. Today, we explore a specific scenario involving the mixing of nitric acid and calcium hydroxide—two common laboratory chemicals—each prepared at precise molarities and volumes. This case presents an excellent opportunity to delve into the intricacies of neutralization reactions, stoichiometry, and solution behavior.

Understanding the Initial Conditions

Before exploring the reaction dynamics, it is crucial to understand the initial parameters:

- Nitric Acid (HNO_3): 79 milliliters of a 0.211 molar solution.

- Calcium Hydroxide ($Ca(OH)_2$): 38 milliliters of a 0.207 molar solution.

Both solutions are aqueous and prepared at specific concentrations, setting the stage for a classic acid-base neutralization. The question that follows is: what are the resulting chemical changes when these two solutions are combined? Specifically, what is the nature of the neutralization, the amount of reactants consumed, and the properties of the resulting solution?

Calculating the Moles of Reactants

The first step involves determining the number of moles of each reactant present initially. Moles are foundational in stoichiometry, allowing us to predict the extent of the reaction and the final composition of the mixture.

Moles of Nitric Acid

Using the molarity formula:

\[\text{Moles of HNO}_3 = \text{Molarity} \times \text{Volume (L)} \]

Convert 79 mL to liters:

\[79\,\text{mL} = 0.079\,\text{L} \]

Calculate:

\[0.211\,\text{mol/L} \times 0.079\,\text{L} = 0.016669\,\text{mol} \]

So, approximately 0.01667 mol of nitric acid are present initially.

Moles of Calcium Hydroxide

Similarly, for calcium hydroxide:

Convert 38 mL to liters:

$$ 38\,\text{mL} = 0.038\,\text{L} $$

Calculate:

$$ 0.207\,\text{mol/L} \times 0.038\,\text{L} = 0.007866\,\text{mol} $$

Approximately 0.00787 mol of calcium hydroxide are present initially.

The Chemical Reaction: Neutralization in Focus

The core reaction occurs between nitric acid and calcium hydroxide:

$$
2\,\text{HNO}_3 + \text{Ca(OH)}_2 \rightarrow \text{Ca(NO}_3)_2 + 2\,\text{H}_2\text{O}
$$

This balanced equation indicates that:

- 2 moles of nitric acid react with 1 mole of calcium hydroxide.

- The products are calcium nitrate ($\text{Ca(NO}_3)_2$) and water.

Implication: The reaction is a typical acid-base neutralization, forming a soluble salt and water.

Stoichiometric Analysis

Using the initial molar amounts:

- Moles of nitric acid: 0.01667 mol

- Moles of calcium hydroxide: 0.00787 mol

Calculate the limiting reactant:

$$
\text{Required moles of HNO}_3 \text{ for complete Ca(OH)}_2 = 2 \times 0.00787\,\text{mol} = 0.01574\,\text{mol}
$$

Compare with available moles:

- Available nitric acid: 0.01667 mol (more than needed)

- Calcium hydroxide: 0.00787 mol

Since 0.01574 mol of nitric acid are needed to fully react with the calcium hydroxide, and we have more than that, calcium hydroxide is the limiting reactant.

Conclusion:

- All 0.00787 mol of calcium hydroxide will be consumed.

- The amount of nitric acid that reacts:

$$
2 \times 0.00787\,\text{mol} = 0.01574\,\text{mol}
$$

Remaining nitric acid:

$$
0.01667\,\text{mol} - 0.01574\,\text{mol} = 0.00093\,\text{mol}
$$

Approximately 0.00093 mol of nitric acid remains unreacted.

Final Composition of the Mixture

Reacted Moles:

- Calcium hydroxide: 0.00787 mol (completely reacted)

- Nitric acid: 0.01574 mol reacted, 0.00093 mol unreacted

Products formed:

- Calcium nitrate ($\text{Ca(NO}_3)_2$):

$$
\text{Moles} = 0.00787\,\text{mol}
$$

- Water:

$$
\text{Moles} = 2 \times 0.00787\,\text{mol} = 0.01574\,\text{mol}
$$

- Unreacted nitric acid:

$$
0.00093\,\text{mol}
$$

Total volume of the mixture:

$$
79\,\text{mL} + 38\,\text{mL} = 117\,\text{mL} = 0.117\,\text{L}
$$

Calculating Final Concentrations

To understand the properties of the final solution, we calculate the molarities of each component:

- Calcium Nitrate ($\text{Ca(NO}_3)_2$):

$$
\text{Molarity} = \frac{0.00787\,\text{mol}}{0.117\,\text{L}} \approx 0.0673\,\text{M}
$$

- Unreacted Nitric Acid:

$$
\frac{0.00093\,\text{mol}}{0.117\,\text{L}} \approx 0.00795\,\text{M}
$$

- Remaining Nitric Acid (initial):

Initially, the nitric acid was at 0.211 M; after reaction, the residual concentration is approximately 0.00795 M, indicating that most of the acid has been neutralized.

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pH and Solution Properties

The pH of the final solution is primarily dictated by the remaining nitric acid, which is a strong acid:

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

Since nitric acid is strong and dissociates completely, the hydrogen ion concentration is roughly equal to its molarity:

$$
\text{pH} \approx - \log 0.00795 \approx 2.10
$$

This pH indicates a mildly acidic solution, characteristic of residual nitric acid presence. The calcium nitrate, being a neutral salt derived from a strong acid and base, does not significantly influence the pH.

Broader Implications and Practical Considerations

The detailed analysis of this mixing process provides insights into various practical and theoretical aspects:

- Neutralization Efficiency: The fact that calcium hydroxide is limiting means that the reaction proceeds almost to completion with some excess acid remaining.

- Salt Formation: Calcium nitrate forms as a soluble salt, and its concentration could be relevant in applications like fertilizer production or in laboratory synthesis.

- pH Adjustment: In industrial or laboratory settings, understanding the residual acidity after neutralization informs decisions on whether further pH adjustments are necessary.

- Safety and Handling: Both acids and bases require careful handling due to their corrosive nature; understanding the reaction extent helps in managing waste and safety protocols.

- Environmental Impact: Disposal of such solutions must consider their residual contents to prevent environmental harm, especially in cases where nitrates are involved.

Educational and Scientific Significance

This scenario exemplifies core principles in chemistry education:

- Stoichiometry: Precise calculations of reactant amounts and product formation.

- Acid-Base Reactions: Understanding the behavior of strong acids and bases in aqueous solutions.

- Solution Chemistry: Analyzing how concentration, volume, and molar ratios influence reaction outcomes.

- Analytical Techniques: Employing molarity and molar calculations to predict the final solution properties.

Conclusion

The mixing of 79 mL of 0.211 M nitric acid with 38 mL of 0.207 M calcium hydroxide illustrates the fundamental principles of acid-base chemistry and stoichiometry. Through careful calculation, we observe that calcium hydroxide acts as the limiting reagent, leading to the formation of calcium nitrate and residual nitric acid. The final solution exhibits a mildly acidic pH, dominated by unreacted nitric acid, showcasing the importance of molar ratios in predicting reaction outcomes.

Understanding such interactions is vital across scientific disciplines—from laboratory research to industrial applications—highlighting the importance of precise measurements, balanced equations, and analytical reasoning in chemistry. As we continue to explore chemical reactions, scenarios like these reinforce the foundational concepts that underpin modern science and industry.

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