Chemistry Help!How Much 1.50 M H3PO4, In ML, Would You Need To Add To 50.00 ML Of 3.50 M Ca(OH)2 In Order

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Understanding how to determine the volume of an acid needed to neutralize a base is a fundamental concept in chemistry, especially in titration experiments. In this article, we'll explore step-by-step how to calculate the volume of 1.50 M phosphoric acid (H_3PO_4) required to completely react with a given volume of 3.50 M calcium hydroxide ($Ca(OH)_2$). Whether you're a student preparing for exams or a chemistry enthusiast seeking clarity, this comprehensive guide will help you master the calculation process with clarity and confidence.

Understanding the Chemical Reaction

Before diving into calculations, it’s essential to comprehend the underlying chemical reaction between phosphoric acid and calcium hydroxide.

The Balanced Chemical Equation

The reaction between phosphoric acid and calcium hydroxide can be represented as:

$$ 2 \mathrm{H}_3\mathrm{PO}_4 + 3 \mathrm{Ca(OH)}_2 \rightarrow \mathrm{Ca}_3(\mathrm{PO}_4)_2 + 6 \mathrm{H}_2\mathrm{O} $$

This equation indicates that:

- 2 moles of phosphoric acid react with 3 moles of calcium hydroxide.
- The products are calcium phosphate ($Ca_3(PO_4)_2$) and water.

The Mole Ratio

From the balanced equation, the molar ratio is:

$$ \frac{\text{H}_3\mathrm{PO}_4}{\mathrm{Ca(OH)}_2} = \frac{2}{3} $$

This ratio is fundamental in calculating how much acid is needed for a given amount of base.

Given Data and What We Need to Find

Let's list the known quantities:

- Concentration of phosphoric acid, $C_{H_3PO_4}$ = 1.50 M
- Volume of phosphoric acid to find, $V_{H_3PO_4}$ in mL
- Concentration of calcium hydroxide, $C_{Ca(OH)_2}$ = 3.50 M
- Volume of calcium hydroxide, $V_{Ca(OH)_2}$ = 50.00 mL

Objective: Calculate the volume of 1.50 M H_3PO_4 needed to neutralize 50.00 mL of 3.50 M $Ca(OH)_2$.

Step-by-Step Calculation Process

Below are the detailed steps to perform the calculation:

1. Convert the Volume of $Ca(OH)_2$ to Liters

Since molarity is expressed in mol/L, convert 50.00 mL to liters:

$$V_{Ca(OH)_2} = 50.00\, \mathrm{mL} \times \frac{1\, \mathrm{L}}{1000\, \mathrm{mL}} = 0.05000\, \mathrm{L}$$

2. Calculate Moles of $Ca(OH)_2$

Using molarity:

$$\text{moles of } Ca(OH)_2 = C_{Ca(OH)_2} \times V_{Ca(OH)_2}$$

$$= 3.50\, \mathrm{mol/L} \times 0.05000\, \mathrm{L} = 0.175\, \mathrm{mol}$$

3. Determine Moles of H_3PO_4 Needed

From the balanced equation, the mole ratio of H_3PO_4 to $Ca(OH)_2$ is 2:3.

Expressed as:

$$\text{moles of } H_3PO_4 = \frac{2}{3} \times \text{moles of } Ca(OH)_2$$

$$= \frac{2}{3} \times 0.175\, \mathrm{mol} \approx 0.1167\, \mathrm{mol}$$

4. Calculate Volume of H_3PO_4 Required

Using the molarity of H_3PO_4:

$$V_{H_3PO_4} = \frac{\text{moles of } H_3PO_4}{C_{H_3PO_4}}$$

$$= \frac{0.1167\, \mathrm{mol}}{1.50\, \mathrm{mol/L}} \approx 0.0778\, \mathrm{L}$$

Convert liters back to milliliters:

$$V_{H_3PO_4} = 0.0778\, \mathrm{L} \times 1000\, \mathrm{mL/L} \approx 77.8\, \mathrm{mL}$$

Final Answer and Interpretation

You need approximately 77.8 mL of 1.50 M H_3PO_4 to completely neutralize 50.00 mL of 3.50 M $Ca(OH)_2$.

This calculation ensures precise titration, preventing excess acid or base and optimizing the neutralization process.

Additional Considerations for Accurate Titration

While the calculation provides a theoretical volume, real-world titrations may require adjustments due to factors like:

- Measurement uncertainties

- Incomplete reactions
- Indicator choice and endpoint detection

Always perform titrations carefully and consider performing multiple trials for accuracy.

Summary of Key Steps in the Calculation

1. Convert given volume of base to moles using molarity.
2. Use the balanced chemical equation to determine the molar ratio.
3. Calculate the moles of acid needed based on the molar ratio.
4. Convert moles of acid to volume using molarity.

Following these steps ensures a systematic approach to titration calculations and enhances your understanding of acid-base reactions.

Conclusion

Mastering the calculation of required acid volume is crucial in chemistry for titration experiments, lab analysis, and understanding reaction stoichiometry. By carefully analyzing the balanced chemical equation, converting units appropriately, and applying molarity concepts, you can confidently determine the exact amount of acid needed to neutralize a specific base volume. Whether preparing solutions or conducting experiments, these skills form the foundation of accurate and effective chemical analysis.

Remember: Always double-check your calculations, consider experimental factors, and practice regularly to solidify your understanding of titration chemistry.

If you want more help with other titration problems or chemical calculations, explore additional resources or consult your chemistry instructor for personalized guidance.

Frequently Asked Questions

How do I calculate the volume of 1.50 M H3PO4 needed to neutralize 50.00 mL of 3.50 M Ca(OH)2?

Use the molarity and volume relationship from the balanced chemical equation: H3PO4 + 3Ca(OH)2 → Ca3(PO4)2 + 6H2O. First, find moles of Ca(OH)2: 3.50 mol/L × 0.050 L = 0.175 mol. Since 1 mol H3PO4 reacts with 3 mol Ca(OH)2, moles of H3PO4 needed = 0.175 mol / 3 ≈ 0.05833 mol. Then, calculate volume of H3PO4: 0.05833 mol / 1.50 mol/L ≈ 0.03889 L or 38.89 mL.

What is the balanced chemical equation for the reaction between phosphoric acid and calcium hydroxide?

The balanced equation is: H3PO4 + 3Ca(OH)2 → Ca3(PO4)2 + 6H2O.

How many milliliters of 1.50 M H3PO4 are needed to neutralize 50 mL of 3.50 M Ca(OH)2?

Approximately 38.89 mL of 1.50 M H3PO4 is required to react completely with 50 mL of 3.50 M Ca(OH)2.

Why do we divide the moles of Ca(OH)2 by 3 when calculating the amount of H3PO4 needed?

Because the balanced chemical equation shows that 1 mole of H3PO4 reacts with 3 moles of Ca(OH)2, so we divide the moles of Ca(OH)2 by 3 to find the required moles of H3PO4.

Can I use a shortcut to find the volume of acid needed without calculating moles explicitly?

Yes, you can set up a ratio based on molarity and volume: (M1 × V1) = (M2 × V2) / the molar ratio from the balanced equation. For this reaction, V1 = (M2 × V2 × 1) / (M1 × 3). Plug in the values to find V1 directly.

What common mistakes should I avoid when calculating titration volumes like this?

Avoid mixing units, ensure the chemical equation is correctly balanced, and remember to account for the molar ratio. Double-check calculations and convert all volumes to liters before applying molarity.

Additional Resources

Chemistry Help! How Much 1.50 M H3PO4, In ML, Would You Need To Add To 50.00 ML Of 3.50 M Ca(OH)2 In Order — this is a classic titration problem that combines concepts of molarity, stoichiometry, and acid-base reactions. Whether you're a student preparing for an exam or a chemistry enthusiast tackling real-world titrations, understanding how to calculate the volume of acid needed to neutralize a base is fundamental. In this guide, we'll walk through the step-by-step process to determine how much 1.50 M H_3PO_4 you need to add to 50.00 mL of 3.50 M $Ca(OH)_2$, ensuring you grasp the underlying principles and calculations involved.

Understanding the Problem

Before diving into calculations, let's clarify what the problem asks and the key concepts involved:

- You have 50.00 mL of 3.50 M $Ca(OH)_2$ (calcium hydroxide), a base.
- You want to add 1.50 M H_3PO_4 (phosphoric acid) to neutralize the base.
- The question: How many milliliters of this acid are needed?

This is a typical acid-base titration problem where the goal is to find the volume of acid required to completely react with the given amount of base.

Step 1: Write the Balanced Chemical Equation

The first step in any stoichiometry problem involving reactions is to write the balanced chemical equation.

Calcium hydroxide reacting with phosphoric acid:

$$ \text{Ca(OH)}_2 + \text{H}_3\text{PO}_4 \rightarrow \text{CaHPO}_4 + \text{H}_2\text{O} $$

However, phosphoric acid is a triprotic acid, capable of donating three protons:

$$ \text{H}_3\text{PO}_4 \rightarrow 3 \text{H}^+ + \text{PO}_4^{3-} $$

Similarly, calcium hydroxide is a strong base that dissociates:

$$ \text{Ca(OH)}_2 \rightarrow \text{Ca}^{2+} + 2 \text{OH}^- $$

The neutralization involves the reaction:

$$ 3 \text{H}^+ + 3 \text{OH}^- \rightarrow 3 \text{H}_2\text{O} $$

But since calcium hydroxide provides 2 hydroxide ions per formula unit, and phosphoric acid can provide up to 3 protons, the stoichiometry is more complex.

Simplifying to the net reaction:

The balanced reaction between calcium hydroxide and phosphoric acid is:

$$ 2 \text{Ca(OH)}_2 + \text{H}_3\text{PO}_4 \rightarrow \text{Ca}_2\text{HPO}_4 + 2 \text{H}_2\text{O} $$

But to be precise, considering the full neutralization process, the complete balanced equation is:

$$ 2 \text{Ca(OH)}_2 + 2 \text{H}_3\text{PO}_4 \rightarrow 2 \text{CaHPO}_4 + 2 \text{H}_2\text{O} $$

Alternatively, considering the triprotic nature of phosphoric acid, the general neutralization involves a 1:2 molar ratio of H_3PO_4 to $Ca(OH)_2$:

- Each mole of H_3PO_4 can neutralize 2 moles of $Ca(OH)_2$ because of the multiple protons.

Key Point: The molar ratio between H_3PO_4 and $Ca(OH)_2$ is 1:2.

Step 2: Calculate Moles of $Ca(OH)_2$ in the Solution

Given data:

- Volume of $Ca(OH)_2$ solution = 50.00 mL = 0.05000 L
- Molarity of $Ca(OH)_2$ = 3.50 M

Number of moles of $Ca(OH)_2$:

$$
\text{Moles of Ca(OH)}_2 = \text{Molarity} \times \text{Volume (L)} = 3.50\, \text{mol/L} \times 0.05000\, \text{L} = 0.175\, \text{mol}
$$

So, 0.175 mol of $Ca(OH)_2$ are present.

Step 3: Determine Moles of H_3PO_4 Needed

Using the balanced chemical equation, the molar ratio between H_3PO_4 and $Ca(OH)_2$ is 1:2:

$$
\text{H}_3\text{PO}_4 : \text{Ca(OH)}_2 = 1 : 2
$$

Thus, the moles of H_3PO_4 required:

$$
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$$
\text{Moles of H}_3\text{PO}_4 = \frac{1}{2} \times \text{moles of Ca(OH)}_2 = \frac{1}{2} \times 0.175\, \text{mol} = 0.0875\, \text{mol}
$$

Key insight: To neutralize 0.175 mol of $Ca(OH)_2$, you need 0.0875 mol of H_3PO_4.

Step 4: Calculate the Volume of 1.50 M H_3PO_4 Needed

Given:

- Molarity of H_3PO_4 = 1.50 M

Number of moles needed = 0.0875 mol

Using molarity:

$$
\text{Volume of H}_3\text{PO}_4 = \frac{\text{moles}}{\text{molarity}} = \frac{0.0875\, \text{mol}}{1.50\, \text{mol/L}} \approx 0.05833\, \text{L}
$$

Convert to milliliters:

$$
0.05833\, \text{L} \times 1000\, \text{mL/L} \approx 58.33\, \text{mL}
$$

Final Answer:

You would need approximately 58.33 mL of 1.50 M H_3PO_4 to completely neutralize 50.00 mL of 3.50 M $Ca(OH)_2$.

Additional Considerations and Practical Tips

1. Significance of Stoichiometry

Understanding the molar ratios in chemical reactions is crucial. In this problem, recognizing that phosphoric acid's triprotic nature and the calcium hydroxide's divalent nature lead to a 1:2 molar ratio is key to accurate calculations.

2. Dilution and Concentration

Always ensure that the units are consistent, especially converting volumes into liters when working with molarity.

3. Titration Practicalities

In laboratory settings, it’s wise to add the acid gradually and observe the pH change, especially near the equivalence point. The calculated volume provides a theoretical estimate, but experimental titrations may vary slightly due to factors like solution purity, temperature, and measurement precision.

4. Safety Precautions

Handling acids and bases requires proper safety measures:

- Wear safety goggles and gloves.
- Work in a well-ventilated area.
- Add acid to water slowly to prevent splashing.

5. Extensions and Variations

This approach can be extended to different concentrations or volumes:

- Adjust molarity or volume in calculations.
- Use similar principles for other acid-base titrations involving different acids or bases.
- Calculate pH at various points during titration for a comprehensive understanding.

Conclusion

Understanding how to determine the volume of a specific molarity acid needed to neutralize a known amount of base is a vital skill in chemistry. By carefully analyzing the balanced chemical equation, calculating moles, and applying molarity principles, you can confidently solve titration problems like "How much 1.50 M H_3PO_4, in mL, would you need to add to 50.00 mL of 3.50 M $Ca(OH)_2$?" With practice, these calculations become intuitive, empowering you to handle a wide range of acid-base chemistry challenges effectively.

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