The Number Of Moles Of Cu(oh)2 Needed To Completely React 2.0 Moles Of H3po4?

The Number Of Moles Of $Cu(OH)_2$ Needed To Completely React 2.0 Moles Of H_3PO_4?

Understanding the stoichiometry of chemical reactions is essential for chemists, students, and anyone involved in chemical manufacturing or laboratory experiments. When dealing with reactions involving copper hydroxide ($Cu(OH)_2$) and phosphoric acid (H_3PO_4), calculating the exact amount of reactants needed ensures efficiency and safety. This article explores in detail how to determine the number of moles of $Cu(OH)_2$ required to fully react with 2.0 moles of H_3PO_4, including an in-depth look at the reaction mechanisms, balanced equations, and key concepts in molar calculations.

Understanding the Reactants and Their Properties

What is Copper Hydroxide ($Cu(OH)_2$)?

Copper hydroxide, $Cu(OH)_2$, is an insoluble, blue-green solid commonly used in various chemical applications, including as a precursor for copper compounds and in educational demonstrations. Its chemical structure consists of copper ions coordinated with hydroxide ions, and it reacts with acids to produce soluble copper salts and water.

What is Phosphoric Acid (H_3PO_4)?

Phosphoric acid is a triprotic acid, meaning it can donate three protons (H^+) per molecule. It is widely used in fertilizers, food flavorings, and in laboratory chemistry. As a triprotic acid, it reacts with bases and metal hydroxides to produce corresponding salts and water.

Balancing the Chemical Reaction Between $Cu(OH)_2$ and H_3PO_4

Step 1: Write the Unbalanced Equation

The general reaction between a metal hydroxide and an acid produces a salt and water. For $Cu(OH)_2$ reacting with H_3PO_4, the unbalanced reaction is:

$$ \text{Cu(OH)}_2 + \text{H}_3\text{PO}_4 \rightarrow \text{Copper phosphate salt} + \text{H}_2\text{O} $$

The key is to determine the correct stoichiometric coefficients to balance the equation.

Step 2: Identify the Products

Copper phosphate salts can be mono-, di-, or tri-phosphate, but typically, when reacting with phosphoric acid, the salt formed is copper(II) phosphate, specifically $Cu_3(PO_4)_2$. The balanced reaction leading to this salt is:

$$ 3\,\text{Cu(OH)}_2 + 2\,\text{H}_3\text{PO}_4 \rightarrow \text{Cu}_3(\text{PO}_4)_2 + 6\,\text{H}_2\text{O} $$

Step 3: Confirm the Balance of Atoms and Charge

- Copper (Cu): 3 on both sides
- Phosphorus (P): 2 on both sides
- Oxygen (O): 8 in reactants (from 3 $Cu(OH)_2$ and 2 H_3PO_4) and 8 in products (from $Cu_3(PO_4)_2$ and water)
- Hydrogen (H): 6 in reactants (from 2 H_3PO_4) and 6 in water molecules

The balanced chemical equation is:

Balanced Reaction:

$$ 3\,\text{Cu(OH)}_2 + 2\,\text{H}_3\text{PO}_4 \rightarrow \text{Cu}_3(\text{PO}_4)_2 + 6\,\text{H}_2\text{O} $$

Calculating the Moles of $Cu(OH)_2$ Needed for 2.0 Moles of H_3PO_4

Step 1: Understand the Reaction Stoichiometry

From the balanced equation:

- 2 moles of H_3PO_4 react with 3 moles of $Cu(OH)_2$.

This gives a molar ratio:

$$ \text{Cu(OH)}_2 : \text{H}_3\text{PO}_4 = 3 : 2 $$

or equivalently,

\[1\, \text{mol of H}_3\text{PO}_4 \text{ reacts with } \frac{3}{2} \text{

mol of Cu(OH)}_2 \]

Step 2: Set Up the Calculation for 2.0 Moles of H_3PO_4

Given:

- Moles of H_3PO_4 = 2.0 mol

Using the molar ratio:

\[\text{Moles of Cu(OH)}_2 = 2.0\, \text{mol H}_3\text{PO}_4 \times \frac{3\, \text{mol Cu(OH)}_2}{2\, \text{mol H}_3\text{PO}_4} \]

Calculating:

\[\text{Moles of Cu(OH)}_2 = 2.0 \times \frac{3}{2} = 3.0\, \text{mol} \]

Therefore, 3.0 moles of $Cu(OH)_2$ are needed to completely react with 2.0 moles of H_3PO_4.

Key Points to Remember in Molar Calculations

- Always identify the correct balanced chemical equation.
- Use the molar ratio derived from the coefficients in the balanced equation.
- Convert given moles of one reactant to the required moles of the other reactant.
- Be cautious of units and ensure ratios are in moles, not mass or volume unless conversions are made.

Additional Considerations in Reaction Calculations

1. Limiting Reactant

In practical scenarios, one reactant may be in excess, and the other limits the reaction. Accurate calculations help determine the limiting reagent and the maximum amount of product formed.

2. Reaction Yield

Theoretical calculations assume 100% reaction efficiency. Actual yields may be lower due to side reactions or incomplete reactions, so consider this when planning experiments or industrial processes.

3. Safety Precautions

Handling chemicals like $Cu(OH)_2$ and H_3PO_4 requires proper safety measures, including gloves, goggles, and proper ventilation.

Conclusion

To summarize, the amount of $Cu(OH)_2$ required to fully react with 2.0 moles of H_3PO_4 is 3.0 moles, based on the stoichiometry of the balanced chemical equation:

$$ 3\,\text{Cu(OH)}_2 + 2\,\text{H}_3\text{PO}_4 \rightarrow \text{Cu}_3(\text{PO}_4)_2 + 6\,\text{H}_2\text{O} $$

Understanding this calculation is fundamental in chemical lab work, industrial synthesis, and academic studies. Accurate molar calculations ensure efficient use of reactants, help predict product yields, and facilitate safe chemical handling.

FAQs

1. **How do I determine the molar ratio in a chemical reaction?**

   By balancing the chemical equation, the coefficients directly provide the molar ratio between reactants and products.

2. **Can I use this method for other reactions?**

   Yes, the approach of balancing equations and using molar ratios applies universally to chemical reactions.

3. **What if I have a different amount of H_3PO_4?**

   Adjust the calculation proportionally using the molar ratio from the balanced equation.

By mastering these concepts, you'll be well-equipped to perform precise chemical calculations involving molar amounts and reaction stoichiometry.

Frequently Asked Questions

What is the balanced chemical equation for the

reaction between $Cu(OH)_2$ and H_3PO_4?

The balanced equation is $3Cu(OH)_2 + 2H_3PO_4 \rightarrow Cu_3(PO_4)_2 + 6H_2O$.

How many moles of $Cu(OH)_2$ are needed to react completely with 2.0 moles of H_3PO_4?

According to the balanced equation, 3 moles of $Cu(OH)_2$ react with 2 moles of H_3PO_4, so for 2.0 moles of H_3PO_4, you need (3/2) × 2.0 = 3.0 moles of $Cu(OH)_2$.

What is the molar ratio between $Cu(OH)_2$ and H_3PO_4 in the reaction?

The molar ratio is 3:2, meaning 3 moles of $Cu(OH)_2$ react with 2 moles of H_3PO_4.

If I have 4 moles of $Cu(OH)_2$, how much H_3PO_4 can I react with completely?

Using the molar ratio, 3 moles $Cu(OH)_2$ react with 2 moles H_3PO_4. So, 4 moles $Cu(OH)_2$ will react with (2/3) × 4 = approximately 2.67 moles of H_3PO_4.

What is the significance of balancing the chemical equation in this calculation?

Balancing ensures the mole ratios are correct, allowing accurate calculation of how many moles of $Cu(OH)_2$ are needed to react with a given amount of H_3PO_4.

Can the amount of $Cu(OH)_2$ needed vary if the reaction conditions change?

The theoretical amount required remains based on stoichiometry, but actual amounts may vary slightly due to reaction efficiency or incomplete reactions.

What is the practical application of calculating the moles of $Cu(OH)_2$ needed for a given amount of H_3PO_4?

Such calculations are essential in titrations, chemical manufacturing, and ensuring proper reagent quantities in laboratory and industrial processes.

Is it necessary to consider purity or molarity when calculating the moles of reactants needed?

Yes, if reagents are not pure or are in solution, their actual molar amounts may differ, so adjustments based on purity or molarity are necessary for precise calculations.

Additional Resources

The Number Of Moles Of $Cu(OH)_2$ Needed To Completely React 2.0 Moles Of H_3PO_4?

Understanding the precise quantities of reactants required in chemical reactions is fundamental in both academic chemistry and industrial applications. Today, we explore a classic acid-base reaction involving copper hydroxide and phosphoric acid, focusing on calculating the exact number of moles of copper hydroxide [$Cu(OH)_2$] needed to completely neutralize a given amount of phosphoric acid [H_3PO_4]. This inquiry showcases the importance of stoichiometry—a cornerstone concept that bridges chemical equations with practical laboratory and manufacturing processes.

Foundations of the Reaction: Reactants and Products

Before diving into calculations, it’s essential to understand the nature of the reactants involved and the expected products.

Copper Hydroxide [$Cu(OH)_2$]:
- An insoluble, weak base often used in laboratory synthesis and as a precipitate for removal of contaminants.
- Its structure contains copper in the +2 oxidation state bound to hydroxide groups.

Phosphoric Acid [H_3PO_4]:
- A triprotic acid, meaning it has three ionizable hydrogen atoms.
- Commonly used in fertilizers, food additives, and industrial processes.

Reaction Overview:
When $Cu(OH)_2$ reacts with H_3PO_4, a neutralization occurs where the hydroxide ions of copper hydroxide react with the hydrogen ions from phosphoric acid to form water, and the remaining parts form a salt.

Balancing the Chemical Equation

The core of any stoichiometric calculation begins with a correctly balanced chemical equation. Let’s derive and analyze the reaction step-by-step.

Step 1: Write the unbalanced equation

$$\text{Cu(OH)}_2 + \text{H}_3\text{PO}_4 \rightarrow \text{Products}$$

Step 2: Predict the products

Given the acid-base nature, the products are expected to be a copper phosphate salt and water:

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

But to confirm, we need to balance the equation properly.

Step 3: Balance the copper and phosphate

- Copper from $Cu(OH)_2$: Each unit contains 1 Cu^{2+} ion; the salt formed is copper phosphate.
- Phosphate from H_3PO_4: Contains one phosphate group per molecule.

Step 4: Determine the molar ratios

Copper phosphate has the formula $Cu_3(PO_4)_2$, indicating that three Cu^{2+} ions combine with two PO_4^{3-} ions.

Step 5: Write the balanced equation

To form $Cu_3(PO_4)_2$, three $Cu(OH)_2$ units are needed, providing the three Cu^{2+} ions, and two H_3PO_4 molecules provide the two PO_4^{3-} groups:

$$ 3\, \text{Cu(OH)}_2 + 2\, \text{H}_3\text{PO}_4 \rightarrow \text{Cu}_3(\text{PO}_4)_2 + 6\, \text{H}_2\text{O} $$

Final balanced equation:

$3\ Cu(OH)_2 + 2\ H_3PO_4 \rightarrow Cu_3(PO_4)_2 + 6\ H_2O$

Key stoichiometric ratios:

- 3 moles of $Cu(OH)_2$ react with 2 moles of H_3PO_4.

Calculating the Moles of $Cu(OH)_2$ Needed

Given the balanced equation, the next step is to determine how much $Cu(OH)_2$ is required to react completely with 2.0 moles of H_3PO_4.

Step 1: Use the molar ratio from the balanced equation

From the equation:

$$ 2\, \text{H}_3\text{PO}_4 \quad \leftrightarrow \quad 3\, \text{Cu(OH)}_2 $$

Thus, for every 2 moles of H_3PO_4, 3 moles of $Cu(OH)_2$ are needed.

Step 2: Set up the proportion

$$
\text{Moles of Cu(OH)}_2 = \left(\frac{3\, \text{moles Cu(OH)}_2}{2\, \text{moles H}_3\text{PO}_4} \right) \times \text{moles of H}_3\text{PO}_4
$$

Given:

$$
\text{moles of H}_3\text{PO}_4 = 2.0
$$

Calculating:

$$
\text{Moles of Cu(OH)}_2 = \left(\frac{3}{2} \right) \times 2.0 = 3.0\, \text{moles}
$$

Result:

3.0 moles of $Cu(OH)_2$ are required to completely react with 2.0 moles of H_3PO_4.

Implications and Practical Significance

This stoichiometric calculation is more than an academic exercise; it has real-world implications in fields such as materials synthesis, environmental chemistry, and manufacturing.

Industrial Applications:
- Proper reactant proportions are crucial in producing high-purity copper phosphate salts, which are used in fertilizers and pigments.
- Precise calculations prevent waste, reduce costs, and ensure safety.

Laboratory Context:
- When conducting titrations or synthesis, knowing the exact amount of reactants ensures the reaction proceeds to completion without excess reagents, which could interfere with analysis or subsequent steps.

Environmental Considerations:
- Proper stoichiometry minimizes the generation of waste and environmental impact, especially when dealing with metal compounds and acids.

Additional Considerations in Real-World Scenarios

While the theoretical calculation provides a clear answer, real-world conditions might introduce complexities:

- Purity of Reactants: Impurities can affect stoichiometry and reaction efficiency.
- Reaction Conditions: Temperature, pH, and mixing influence reaction completeness.
- Solubility: $Cu(OH)_2$ is sparingly soluble; hence, the reaction may be limited by solubility constraints in aqueous media.
- Measurement Accuracy: Precise weighing and measurement are vital to match theoretical calculations.

Summary and Conclusion

In conclusion, understanding the chemical reaction between copper hydroxide and phosphoric acid reveals that 3 moles of $Cu(OH)_2$ are needed to react completely with 2 moles of H_3PO_4. This calculation hinges on the balanced chemical equation, which accurately reflects the molar ratios of reactants and products.

This insight exemplifies the power of stoichiometry—a fundamental tool that allows chemists and industry professionals to predict reactant quantities, optimize processes, and minimize waste. Whether in laboratory synthesis or large-scale manufacturing, precise calculations like these ensure reactions are efficient, cost-effective, and environmentally responsible.

By mastering such fundamental concepts, professionals can confidently design experiments, scale up processes, and innovate with chemical reactions that meet the demands of modern science and industry.

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