What Is The Mass Of Calcium Phosphate That Can Be Prepared From 1.08 G Of Na3po4?

What Is The Mass Of Calcium Phosphate That Can Be Prepared From 1.08 G Of Na3PO4?

Understanding the chemical relationships and stoichiometry involved in the synthesis of calcium phosphate from sodium phosphate (Na_3PO_4) is essential for students, chemists, and professionals working in fields like biochemistry, medicine, and materials science. This article provides a comprehensive guide to calculating the mass of calcium phosphate ($Ca_3(PO_4)_2$) that can be obtained from a given amount of sodium phosphate, specifically 1.08 grams. We will explore the relevant chemical reactions, molar calculations, and step-by-step procedures to arrive at the correct mass, ensuring clarity and depth for all readers.

Fundamental Concepts and Chemical Background

Understanding Sodium Phosphate (Na_3PO_4)

Sodium phosphate, with the chemical formula Na_3PO_4, is an inorganic compound often used in various industrial and laboratory applications. It contains three sodium ions (Na^+) and one phosphate ion (PO_4^{3-}). In aqueous solutions, it dissociates into these ions, making it reactive for precipitating other compounds such as calcium phosphate.

Calcium Phosphate ($Ca_3(PO_4)_2$)

Calcium phosphate is a significant compound in biological systems, especially in bones and teeth. Its chemical formula is $Ca_3(PO_4)_2$, indicating three calcium ions (Ca^{2+}) and two phosphate ions (PO_4^{3-}). It is often prepared in laboratory settings via reactions involving calcium salts and phosphate ions.

Relevant Chemical Reaction

The typical reaction for forming calcium phosphate from sodium phosphate and calcium chloride ($CaCl_2$) is as follows:

$$
2 \mathrm{Na}_3\mathrm{PO}_4 + 3 \mathrm{CaCl}_2 \rightarrow \mathrm{Ca}_3(\mathrm{PO}_4)_2 \downarrow + 6 \mathrm{NaCl}
$$

In this reaction:

- Two molecules of sodium phosphate react with three molecules of calcium

chloride.
- The insoluble calcium phosphate precipitates out.
- Sodium chloride remains in solution.

Note: For our calculation, we focus on the molar relationships and the amount of calcium phosphate that can theoretically be produced from a given amount of sodium phosphate, assuming complete reaction and no losses.

Step-by-Step Calculation Process

1. Determine the molar mass of Na_3PO_4

To convert grams to moles, we need the molar mass:

Element	Atomic Mass (g/mol)	Quantity in Na_3PO_4	Total Mass Contribution (g/mol)
Na	22.99	3	3 × 22.99 = 68.97
P	30.97	1	30.97
O	16.00	4	4 × 16.00 = 64.00

Total molar mass of Na_3PO_4:

$$
68.97 + 30.97 + 64.00 = 163.94\, \text{g/mol}
$$

2. Calculate moles of Na_3PO_4 in 1.08 grams

$$
\text{Moles of Na}_3\text{PO}_4 = \frac{\text{Mass}}{\text{Molar mass}} = \frac{1.08\, \text{g}}{163.94\, \text{g/mol}} \approx 0.00659\, \text{mol}
$$

3. Establish molar ratios from the balanced chemical equation

From the reaction:

$$
2 \mathrm{Na}_3\mathrm{PO}_4 \rightarrow 1 \mathrm{Ca}_3(\mathrm{PO}_4)_2
$$

This indicates:

- 2 moles of Na_3PO_4 produce 1 mole of calcium phosphate.

Therefore:

$$
\text{Moles of Ca}_3(\mathrm{PO}_4)_2 = \frac{1}{2} \times \text{moles of Na}_3\text{PO}_4
$$

Substituting our value:

$$
\text{Moles of Ca}_3(\mathrm{PO}_4)_2 = \frac{1}{2} \times 0.00659 \approx 0.003295\, \text{mol}
$$

4. Determine the molar mass of $Ca_3(PO_4)_2$

Calculate based on atomic masses:

Element	Atomic Mass (g/mol)	Quantity in $Ca_3(PO_4)_2$	Total Mass Contribution (g/mol)
Ca	40.08	3	3 × 40.08 = 120.24
P	30.97	2	2 × 30.97 = 61.94
O	16.00	8	8 × 16.00 = 128.00

Total molar mass of $Ca_3(PO_4)_2$:

$$
120.24 + 61.94 + 128.00 = 310.18\, \text{g/mol}
$$

5. Calculate the mass of calcium phosphate formed

Multiply the number of moles by the molar mass:

$$
\text{Mass of Ca}_3(\mathrm{PO}_4)_2 = 0.003295\, \text{mol} \times 310.18\, \text{g/mol} \approx 1.021\, \text{g}
$$

Result: Approximately 1.02 grams of calcium phosphate can be prepared from 1.08 grams of sodium phosphate, assuming complete reaction and ideal conditions.

Additional Considerations and Practical Implications

Yield and Purity

In laboratory or industrial settings, the actual yield of calcium phosphate may be less than the theoretical maximum due to:

- Incomplete reactions
- Side reactions
- Losses during filtration and washing
- Impurities in reactants

Typically, yields are expressed as a percentage of the theoretical amount. For example, with an 85% yield:

$$
\text{Actual yield} = 1.02\, \text{g} \times 0.85 \approx 0.87\, \text{g}
$$

Understanding these practical factors is crucial for accurate planning and resource management.

Applications of Calcium Phosphate

Calcium phosphate has numerous applications, including:

- Bone grafts and dental materials
- Food additives
- Pharmaceuticals
- Ceramic materials

Its biocompatibility and similarity to biological apatite make it especially valuable in medical fields.

Summary and Final Remarks

In conclusion, starting with 1.08 grams of sodium phosphate (Na_3PO_4), the maximum theoretical amount of calcium phosphate ($Ca_3(PO_4)_2$) that can be prepared is approximately 1.02 grams. This calculation hinges on understanding molar masses, balanced chemical equations, and molar ratios. Recognizing the difference between theoretical and practical yields allows chemists and students to plan experiments more effectively and understand the efficiencies involved.

Key Takeaways:

- Molar mass calculations are fundamental to stoichiometric conversions.
- Balanced chemical equations provide the molar ratios needed for accurate calculations.
- Real-world yields may be less than theoretical due to various practical factors.
- Knowledge of these calculations supports advancements in biomedical, industrial, and research applications involving calcium phosphate.

By mastering these concepts, learners and professionals can confidently determine product yields, optimize reactions, and understand the underlying chemistry of calcium phosphate synthesis.

Frequently Asked Questions

What is the main goal when calculating the mass of calcium phosphate from 1.08 g of Na_3PO_4?

The goal is to determine how much calcium phosphate can be produced when reacting 1.08 g of sodium phosphate (Na_3PO_4) with calcium ions, based on the stoichiometry of the chemical reaction.

What is the balanced chemical equation for the formation of calcium phosphate from Na_3PO_4?

The balanced equation is $3\ Ca^{2+} + 2\ PO_4^{3-} \rightarrow Ca_3(PO_4)_2(s)$. When Na_3PO_4 reacts with calcium salts, it forms calcium phosphate and sodium salts.

How do you determine the mole ratio between Na_3PO_4 and calcium phosphate?

From the balanced equation, 2 moles of Na_3PO_4 produce 1 mole of $Ca_3(PO_4)_2$, so the mole ratio is 2:1.

What is the molar mass of Na_3PO_4?

The molar mass of Na_3PO_4 is approximately 164 g/mol.

How do you calculate the moles of Na_3PO_4 in 1.08 g?

Moles of Na_3PO_4 = mass / molar mass = 1.08 g / 164 g/mol ≈ 0.00659 mol.

How do you find the moles of calcium phosphate formed from the moles of Na_3PO_4?

Using the mole ratio, moles of $Ca_3(PO_4)_2$ = 0.00659 mol Na_3PO_4 × (1 mol $Ca_3(PO_4)_2$ / 2 mol Na_3PO_4) ≈ 0.003295 mol.

What is the molar mass of calcium phosphate, $Ca_3(PO_4)_2$?

The molar mass of $Ca_3(PO_4)_2$ is approximately 310 g/mol.

How do you calculate the mass of calcium phosphate produced?

Mass of $Ca_3(PO_4)_2$ = moles × molar mass = 0.003295 mol × 310 g/mol ≈ 1.02 g.

What is the approximate mass of calcium phosphate that can be prepared from 1.08 g of Na_3PO_4?

Approximately 1.02 grams of calcium phosphate can be prepared.

Why is it important to consider molar ratios in such calculations?

Molar ratios ensure stoichiometric accuracy, allowing precise calculation of product mass based on reactant quantities according to the balanced chemical equation.

Additional Resources

Calcium Phosphate: A Comprehensive Calculation of Its Formation From Sodium Phosphate

Understanding the quantitative relationships in chemical reactions is fundamental for scientists, students, and professionals working in fields like biochemistry, materials science, and pharmaceuticals. One common area of interest involves calculating the amount of product formed from a given quantity of reactant. Today, we explore this concept through the specific example of determining the mass of calcium phosphate that can be prepared from 1.08 grams of sodium phosphate ($\mathrm{Na_3PO_4}$). This detailed analysis not only enhances conceptual understanding but also demonstrates practical application in laboratory and industrial settings.

Introduction to the Reaction and Its Significance

Calcium phosphate is an important inorganic compound with widespread applications, including in medical bone grafts, dental products, and as a key mineral component of bones and teeth. The synthesis of calcium phosphate often involves reacting calcium salts with phosphate ions. For this discussion, we focus on a simplified reaction where sodium phosphate reacts with calcium ions to produce calcium phosphate and sodium ions in solution.

Understanding how much calcium phosphate can be formed from a known amount of sodium phosphate is essential for:

- Designing efficient manufacturing processes
- Calculating reagent requirements in laboratory synthesis
- Estimating yields in research settings

Fundamental Concepts and Reaction Overview

Key Chemical Reaction

The reaction between sodium phosphate and calcium chloride (a common calcium source) to produce calcium phosphate can be represented as:

$$
2\, \mathrm{Na_3PO_4} + 3\, \mathrm{CaCl_2} \rightarrow \mathrm{Ca_3(PO_4)_2} + 6\, \mathrm{NaCl}
$$

This reaction illustrates the formation of calcium phosphate ($\mathrm{Ca_3(PO_4)_2}$), a precipitate, along with sodium chloride in solution.

Note: For the purpose of this calculation, we assume the reaction proceeds to completion and that sodium phosphate is the limiting reagent.

Step-by-Step Calculation Process

To determine the mass of calcium phosphate formed from 1.08 grams of sodium phosphate, we need to follow a systematic approach involving:

1. Calculating the molar mass of sodium phosphate ($\mathrm{Na_3PO_4}$)
2. Converting the given mass of sodium phosphate to moles
3. Using the stoichiometry of the balanced reaction to find moles of calcium phosphate produced
4. Calculating the mass of calcium phosphate from its molar mass and the number of moles produced

---

1. Calculating Molar Mass of Sodium Phosphate ($\mathrm{Na_3PO_4}$)

Let's examine the atomic masses:

- Sodium (Na): 22.99 g/mol
- Phosphorus (P): 30.97 g/mol
- Oxygen (O): 16.00 g/mol

Calculating molar mass:

$$
\mathrm{Na_3PO_4} = (3 \times 22.99) + 30.97 + (4 \times 16.00)
$$

$$
= 68.97 + 30.97 + 64.00 = 163.94\, \text{g/mol}
$$

---

2. Convert 1.08 g of $\mathrm{Na_3PO_4}$ to Moles

Number of moles:

$$
\text{Moles of Na}_3\text{PO}_4 = \frac{\text{Mass}}{\text{Molar mass}} = \frac{1.08\, \text{g}}{163.94\, \text{g/mol}} \approx 0.00659\, \text{mol}
$$

---

3. Determine Moles of Calcium Phosphate ($\mathrm{Ca_3(PO_4)_2}$) Formed

From the balanced reaction:

$$
2\, \mathrm{Na_3PO_4} \rightarrow 1\, \mathrm{Ca_3(PO_4)_2}
$$

This indicates a molar ratio:

$$
2\, \text{mol Na}_3\text{PO}_4 : 1\, \text{mol Ca}_3(\text{PO}_4)_2
$$

Calculating moles of calcium phosphate produced:

$$
\text{Moles of } \mathrm{Ca_3(PO_4)_2} = \frac{1}{2} \times \text{moles of Na}_3\text{PO}_4
$$

$$
= \frac{1}{2} \times 0.00659 \approx 0.003295\, \text{mol}
$$

---

4. Calculating the Mass of Calcium Phosphate

Next, determine the molar mass of calcium phosphate ($\mathrm{Ca_3(PO_4)_2}$):

Atomic masses:

- Calcium (Ca): 40.08 g/mol
- Phosphorus (P): 30.97 g/mol
- Oxygen (O): 16.00 g/mol

Calculating molar mass:

$$
\mathrm{Ca_3(PO_4)_2} = (3 \times 40.08) + (2 \times 30.97) + (8 \times 16.00)
$$

$$
= 120.24 + 61.94 + 128.00 = 310.18\, \text{g/mol}
$$

\]

Finally, calculate the mass:

\[
\text{Mass of } \mathrm{Ca_3(PO_4)_2} = \text{moles} \times \text{molar mass} = 0.003295 \times 310.18 \approx 1.02\, \text{g}
\]

Final Result and Practical Implications

Therefore, approximately 1.02 grams of calcium phosphate can be prepared from 1.08 grams of sodium phosphate, assuming complete reaction efficiency and ideal conditions.

This calculation highlights several key points:

- The ratio of reactants and products is critical in stoichiometry.
- Small changes in reactant amounts can significantly influence yields.
- Accurate molar mass calculations are essential for precise results.

Additional Considerations and Real-World Factors

While the theoretical yield is approximately 1.02 grams, real-world conditions often influence actual yields:

- Reaction Efficiency: Not all reactants may react completely, leading to lower yields.
- Purity of Reactants: Impurities can affect the reaction pathway and final product purity.
- Side Reactions: Other reactions could consume reactants or produce unwanted byproducts.
- Experimental Conditions: Temperature, pH, and mixing influence reaction completion and product crystallization.

Understanding these factors is crucial for translating theoretical calculations into practical laboratory or industrial processes.

Conclusion

In sum, starting with 1.08 grams of sodium phosphate, the maximum theoretical mass of calcium phosphate that can be prepared is approximately 1.02 grams. This detailed calculation exemplifies the power of stoichiometry in chemical synthesis, providing a foundation for designing experiments, optimizing

processes, and understanding material quantities in various applications.

Such precise, step-by-step approaches are invaluable for scientists and engineers striving for efficiency and accuracy in the development and production of inorganic compounds like calcium phosphate.

What Is The Mass Of Calcium Phosphate That Can Be Prepared From 1 08 G Of Na3po4

What Is The Mass Of Calcium Phosphate That Can Be Prepared From 1 08 G Of Na3po4

Related Articles

- Determine The Unknown Angle Measures Of DEF. Round To The Nearest Degree.mD = MF =
- How Do Interest Groups Expand The Range Of Issues That Come To Lawmakers' Attention?
- In Happiness Is Which Context Clue Can Help You Figure Out The Meaning Of Malcontent

Back to Home