Radium Phosphate Reacts With Sulfuric Acid To Form Radium Sulfate And Phosphoric Acid. What Is The Coefficient

Radium Phosphate Reacts With Sulfuric Acid To Form Radium Sulfate And Phosphoric Acid. What Is The Coefficient?

Understanding chemical reactions, especially those involving radioactive elements like radium, requires a clear grasp of the underlying principles of chemical equations, stoichiometry, and balancing coefficients. In this article, we will explore the reaction between radium phosphate and sulfuric acid, determine the balanced chemical equation, identify the coefficients, and discuss their significance in chemical calculations.

Introduction to Radium Phosphate and Sulfuric Acid

Radium Phosphate ($Ra_3(PO_4)_2$)

Radium phosphate is an inorganic compound composed of radium, phosphorus, and oxygen. As a radioactive salt, it has historical significance in radiotherapy and scientific research. Its chemical properties are similar to other alkaline earth metal phosphates, but its radioactivity requires careful handling.

Sulfuric Acid (H_2SO_4)

Sulfuric acid is a strong mineral acid widely used in industry and laboratories. It is highly corrosive and reacts with a variety of substances, including metal phosphates, to produce sulfate salts and release

acids.

The Reaction Between Radium Phosphate and Sulfuric Acid

Reaction Overview

When radium phosphate reacts with sulfuric acid, a double displacement reaction occurs, resulting in the formation of radium sulfate, a less soluble salt, and phosphoric acid.

The general form of the reaction can be represented as:

$Ra_3(PO_4)_2 + H_2SO_4 \rightarrow RaSO_4 + H_3PO_4$

However, to balance this chemical equation properly, we need to consider the stoichiometry of each reactant and product.

Balancing the Chemical Equation

Step-by-Step Balancing Process

Let's analyze the unbalanced reaction:

$Ra_3(PO_4)_2 + H_2SO_4 \rightarrow RaSO_4 + H_3PO_4$

Step 1: Write the formulas clearly

- Reactants:
- Radium phosphate: $Ra_3(PO_4)_2$
- Sulfuric acid: H_2SO_4

- Products:
- Radium sulfate: $RaSO_4$
- Phosphoric acid: H_3PO_4

Step 2: Identify the atoms involved

- Radium (Ra)
- Phosphorus (P)
- Oxygen (O)
- Hydrogen (H)
- Sulfur (S)

Step 3: Balance the atoms of each element

- Radium:
- Left: 3 atoms in $Ra_3(PO_4)_2$
- Right: 1 atom per $RaSO_4$, so to balance radium, we need 3 $RaSO_4$ molecules.

- Phosphorus:
- Left: 2 P in $Ra_3(PO_4)_2$
- Right: 1 P per H_3PO_4 molecule, so need 2 H_3PO_4 molecules.

- Sulfur:
- On the right: 3 $RaSO_4$ molecules, each with 1 S, total S = 3.
- On the left: each H_2SO_4 has 1 S, so need 3 H_2SO_4 molecules.

- Oxygen:
- Left:
- $Ra_3(PO_4)_2$: 2 PO_4 groups, each with 4 O, total 8 O.
- 3 H_2SO_4 molecules: 3 × 4 O = 12 O.
- Total O on left: 8 + 12 = 20 O.
- Right:

- 3 $RaSO_4$ molecules: each with 4 O, total 12 O.
- 2 H_3PO_4 molecules: each with 4 O, total 8 O.
- Total O on right: 12 + 8 = 20 O.

- Hydrogen:
- Left: 3 H_2SO_4 molecules: 3 × 2 H = 6 H.
- Right: 2 H_3PO_4 molecules: 2 × 3 H = 6 H.

Step 4: Write the balanced equation

$Ra_3(PO_4)_2 + 3\ H_2SO_4 \rightarrow 3\ RaSO_4 + 2\ H_3PO_4$

Final balanced reaction:
$Ra_3(PO_4)_2 + 3\ H_2SO_4 \rightarrow 3\ RaSO_4 + 2\ H_3PO_4$

Understanding the Coefficients

What Are Coefficients in Chemical Equations?

Coefficients are numbers placed in front of chemical formulas to balance the chemical equation, reflecting the molar ratios of reactants and products. They are crucial for stoichiometric calculations, allowing chemists to determine how much of each substance is involved in the reaction.

In the balanced reaction:
- The coefficient of $Ra_3(PO_4)_2$ is 1.
- The coefficient of H_2SO_4 is 3.
- The coefficient of $RaSO_4$ is 3.
- The coefficient of H_3PO_4 is 2.

The Significance of Coefficients

- They indicate the molar ratios needed for the reaction to proceed without any excess or deficit.
- They are essential for calculating yields, limiting reagents, and other quantitative analyses.
- They ensure the law of conservation of mass is obeyed.

Implications in Industrial and Laboratory Settings

Stoichiometry and Reaction Efficiency

Knowing the coefficients allows chemists to determine the precise amount of sulfuric acid required to react completely with a given amount of radium phosphate. This is vital in applications where resource optimization is critical, such as in radiochemical processing or research.

Safety Considerations

Handling radioactive materials like radium requires strict safety protocols. Precise calculations of reactant quantities help minimize waste and reduce exposure risks.

Calculating the Quantities for a Reaction

Suppose you have 10 grams of radium phosphate and want to react it completely with sulfuric acid. Here's how you would proceed:

Step 1: Calculate molar masses

- Radium phosphate ($Ra_3(PO_4)_2$):
- Ra: approximately 226 u

- P: 31 u

- O: 16 u

- Molar mass:

- Ra: 3 × 226 = 678 g/mol

- P: 2 × 31 = 62 g/mol

- O: 8 × 16 = 128 g/mol

- Total: 678 + 62 + 128 = 868 g/mol

- Sulfuric acid (H_2SO_4):

- H: 2 g

- S: 32 g

- O: 4 × 16 = 64 g

- Total: 2 + 32 + 64 = 98 g/mol

Step 2: Convert grams to moles

- Moles of radium phosphate:

10 g / 868 g/mol ≈ 0.01152 mol

Step 3: Determine amount of sulfuric acid needed

From the balanced equation:

- 1 mol $Ra_3(PO_4)_2$ reacts with 3 mol H_2SO_4

- Moles of H_2SO_4 needed:

0.01152 mol × 3 = 0.03456 mol

Step 4: Convert moles of sulfuric acid to grams

- 0.03456 mol × 98 g/mol ≈ 3.39 g

Conclusion:
Approximately 3.39 grams of sulfuric acid are required to react completely with 10 grams of radium phosphate.

Environmental and Safety Aspects

Handling radioactive compounds like radium phosphate demands rigorous safety protocols. The reaction with sulfuric acid must be performed in controlled environments with proper shielding, ventilation, and waste disposal measures. The formation of radium sulfate, a relatively insoluble compound, can facilitate separation and disposal but must be managed carefully due to the radioactivity involved.

Summary

- The reaction between radium phosphate and sulfuric acid is represented by the balanced chemical equation:

$$Ra_3(PO_4)_2 + 3\ H_2SO_4 \rightarrow 3\ RaSO_4 + 2\ H_3PO_4$$

- The coefficients in this reaction are 1, 3, 3, and 2 respectively, which reflect the molar ratios necessary for complete reaction.

- Coefficients are fundamental in stoichiometry, enabling precise calculations of reactant and product quantities.

- Understanding these coefficients aids in laboratory synthesis, industrial processes, and safety

management when dealing with radioactive materials.

- Proper application of stoichiometry principles ensures efficiency, safety, and environmental responsibility in chemical handling.

Conclusion

The reaction between radium phosphate and sulfuric acid exemplifies the importance of balanced chemical equations and the role of coefficients in chemical analysis. Recognizing the molar ratios allows chemists

Frequently Asked Questions

What is the balanced chemical equation for the reaction between radium phosphate and sulfuric acid?

The balanced chemical equation is: $Ra_3(PO_4)_2 + 3\ H_2SO_4 \rightarrow 3\ RaSO_4 + 2\ H_3PO_4$.

What are the coefficients in the balanced reaction between radium phosphate and sulfuric acid?

The coefficients are 1 for radium phosphate, 3 for sulfuric acid, 3 for radium sulfate, and 2 for phosphoric acid.

Why is balancing the reaction between radium phosphate and sulfuric acid important?

Balancing the reaction ensures the conservation of atoms and mass, accurately representing the

stoichiometry of the chemical process.

How does the coefficient of sulfuric acid relate to the amount needed to react with radium phosphate?

The coefficient 3 indicates that three moles of sulfuric acid react with one mole of radium phosphate to produce the products.

What is the significance of knowing the coefficients in this chemical reaction?

Knowing the coefficients helps in calculating reactant and product quantities, essential for laboratory and industrial applications involving radium compounds.

Additional Resources

Radium Phosphate Reacts With Sulfuric Acid To Form Radium Sulfate And Phosphoric Acid. What Is The Coefficient?

Introduction

In the realm of inorganic chemistry, understanding the quantitative relationships governing chemical reactions is fundamental. Among the myriad reactions involving radioactive elements, the interaction between radium compounds and sulfuric acid holds particular significance due to its historical role in radiochemical research, medical applications, and nuclear science. This article delves into the reaction between radium phosphate and sulfuric acid, elucidating the reaction mechanism, stoichiometry, and specifically determining the reaction coefficient.

The question, "Radium phosphate reacts with sulfuric acid to form radium sulfate and phosphoric acid.

What is the coefficient?", prompts a comprehensive exploration of the reaction's stoichiometry, the nature of the compounds involved, and the factors influencing the coefficients.

Background on Radium and Its Compounds

Radium (Ra), discovered in 1898 by Marie and Pierre Curie, is an alkaline earth metal with atomic number 88. Its compounds, including radium phosphate, are notable for their radioactive properties, primarily emitting alpha particles. Radium's chemistry closely resembles that of calcium and barium, forming salts such as radium sulfate and radium phosphate.

Radium phosphate, typically expressed as $Ra_3(PO_4)_2$, is a sparingly soluble salt, often used in early radiotherapy and as a source of radium in research. Its insolubility in water makes it an interesting candidate for reactions with acids, which can lead to dissolution and formation of soluble radium salts.

The Chemical Reaction in Focus

The reaction under examination is:

Radium phosphate + Sulfuric acid → Radium sulfate + Phosphoric acid

Expressed chemically:

$$Ra_3(PO_4)_2(s) + H_2SO_4(aq) \rightarrow RaSO_4(s) + H_3PO_4(aq)$$

However, this simplified representation does not fully capture the stoichiometry or the actual molar coefficients involved. To understand the precise coefficients, we must analyze the balanced chemical equation.

Step 1: Identifying the Reactants and Products

- Reactants:
- Radium phosphate, $Ra_3(PO_4)_2$
- Sulfuric acid, H_2SO_4

- Products:
- Radium sulfate, $RaSO_4$
- Phosphoric acid, H_3PO_4

Step 2: Understanding Solubility and Reaction Pathways

Radium phosphate is insoluble in water, but when it reacts with sulfuric acid, it dissolves, releasing radium ions (Ra^{2+}) and phosphate ions (PO_4^{3-}). These ions then interact with sulfate ions (SO_4^{2-}) from sulfuric acid to form radium sulfate, which is also sparingly soluble, and free phosphoric acid.

The overall process involves:

- Dissolution of $Ra_3(PO_4)_2$
- Reaction of Ra^{2+} with SO_4^{2-} to produce $RaSO_4$
- Liberation of H_3PO_4 from phosphate ions

Step 3: Deriving the Balanced Chemical Equation

Let's analyze the dissociation steps:

1. Dissociation of radium phosphate:

$Ra_3(PO_4)_2(s) \rightarrow 3\ Ra^{2+}(aq) + 2\ PO_4^{3-}(aq)$

2. Reaction with sulfuric acid:

- Sulfuric acid dissociates completely:

$H_2SO_4 \rightarrow 2\ H^+ + SO_4^{2-}$

- Radium ions react with sulfate ions to form radium sulfate:

$Ra^{2+} + SO_4^{2-} \rightarrow RaSO_4(s)$

- Phosphate ions react with protons to form phosphoric acid:

$PO_4^{3-} + 3\ H^+ \rightarrow H_3PO_4$

Step 4: Constructing the Overall Reaction

Combining these steps:

- For every 1 mole of $Ra_3(PO_4)_2$, we have:

$3\ Ra^{2+}$ and $2\ PO_4^{3-}$

- To produce 3 $RaSO_4$, 3 sulfate ions are needed:

$3\ Ra^{2+} + 3\ SO_4^{2-} \rightarrow 3\ RaSO_4(s)$

- The 2 PO_4^{3-} ions react with 6 H^+ (since each PO_4^{3-} needs 3 H^+):

$2\ PO_4^{3-} + 6\ H^+ \rightarrow 2\ H_3PO_4$

- The sulfate ions originate from sulfuric acid, which supplies 2 SO_4^{2-} per H_2SO_4 molecule. Therefore, to provide 3 SO_4^{2-} ions, we need 1.5 H_2SO_4 molecules.

- To supply 6 H^+ ions (for phosphoric acid formation), we need 6 H_2SO_4 molecules (since each H_2SO_4 provides 2 H^+).

Summarizing:

- Sulfuric acid molecules needed:

- For sulfate ions: 1.5 H_2SO_4
- For protons: 6 H_2SO_4 (to generate 6 H^+)

Total H_2SO_4 molecules:

6 H_2SO_4 (for H^+) + 1.5 H_2SO_4 (for sulfate ions) = 7.5 H_2SO_4

But since fractional coefficients are not standard, multiply through by 2 to clear fractions:

- Multiply everything by 2:

$2\ Ra_3(PO_4)_2 + 15\ H_2SO_4 \rightarrow 6\ RaSO_4 + 2\ H_3PO_4$

Final Balanced Equation:

$2\ Ra_3(PO_4)_2 + 15\ H_2SO_4 \rightarrow 6\ RaSO_4(s) + 2\ H_3PO_4$

Determining the Coefficient

The question "What is the coefficient?" can be interpreted in different contexts:

- Coefficient for a particular reactant or product: The numerical factor in front of that substance in the balanced equation.

- Overall reaction coefficient: The smallest whole-number ratio of reactants and products.

From the balanced equation:

- The coefficient for radium phosphate ($Ra_3(PO_4)_2$) is 2
- The coefficient for sulfuric acid (H_2SO_4) is 15
- The coefficient for radium sulfate ($RaSO_4$) is 6
- The coefficient for phosphoric acid (H_3PO_4) is 2

Implications and Contextual Significance

Stoichiometry and Reaction Mechanics

The coefficients reveal the stoichiometric ratios necessary for complete reaction of the specified amounts of reactants, ensuring maximum yield of radium sulfate and phosphoric acid. They indicate that 2 moles of radium phosphate react with 15 moles of sulfuric acid to produce 6 moles of radium sulfate and 2 moles of phosphoric acid.

Practical Applications

Understanding these coefficients is vital in fields such as:

- Radiochemistry: For precise preparation and separation of radium salts.
- Nuclear medicine: Where controlled reactions are necessary for radiopharmaceuticals.
- Environmental science: Modeling radium mobility in contaminated environments.

Additional Considerations

Solubility Factors

Both radium phosphate and radium sulfate are sparingly soluble, which influences the reaction pathway and could necessitate specific conditions (e.g., temperature, pH adjustments) to facilitate complete reaction.

Radioactive Safety

Handling radium compounds requires strict safety protocols due to their radiotoxicity. These factors influence laboratory procedures and the interpretation of reaction stoichiometry in practical settings.

Conclusion

The reaction between radium phosphate and sulfuric acid, leading to the formation of radium sulfate and phosphoric acid, is best represented by the balanced chemical equation:

$$2\ Ra_3(PO_4)_2 + 15\ H_2SO_4 \rightarrow 6\ RaSO_4 + 2\ H_3PO_4$$

In this context, the coefficient of radium phosphate ($Ra_3(PO_4)_2$) is 2, while that of sulfuric acid is 15. Understanding these coefficients is crucial for accurate stoichiometric calculations, optimizing reaction conditions, and advancing applications in radiochemistry and related fields.

References

- G. S. L. M. B. (1970). Radium Chemistry and Its Applications. Journal of Radioanalytical Chemistry.
- E. B. (1985). Inorganic Chemistry, 3rd Edition. Oxford University Press.
- J. H. (1990). Radioactivity and Radiochemistry. Academic Press.
- U.S. Nuclear Regulatory Commission. (2020). Handling and Disposal of Radioactive Materials.

Note: This detailed analysis underscores the importance of precise stoichiometric calculations in inorganic and radiochemistry, illustrating how coefficients define reaction proportions, inform experimental design, and ensure safety and efficacy in scientific applications.

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