How To Balance This Equation NH4OH+H3PO4=(NH4)3PO4+H2O With Explainatio Please

How To Balance This Equation NH4OH+H3PO4=(NH4)3PO4+H2O With Explanation Please

Balancing chemical equations is a fundamental skill in chemistry that ensures the law of conservation of mass is maintained—the number of atoms for each element remains the same on both sides of the equation. In this article, we will guide you through the step-by-step process of balancing the chemical equation:

$NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$

Understanding how to balance this specific equation is essential for students and enthusiasts alike, especially when studying acid-base reactions, salt formations, and aqueous solutions. We'll break down each step, explain the underlying concepts, and provide helpful tips to master the process.

Understanding the Chemical Equation

Before diving into balancing, it's important to understand the components of the equation and what the reaction represents.

Reactants

- NH_4OH (Ammonium hydroxide): A weak base, often used as an ammonia solution.
- H_3PO_4 (Phosphoric acid): A triprotic acid commonly used in fertilizers and food additives.

Products

- $(NH_4)_3PO_4$ (Ammonium phosphate): A salt formed from ammonium and phosphate ions.
- H_2O (Water): A common byproduct of acid-base reactions.

This reaction involves an acid-base neutralization where ammonium hydroxide reacts with phosphoric acid to form ammonium phosphate and water.

Step-by-Step Guide to Balancing the Equation

Balancing involves adjusting coefficients (numbers in front of compounds) to ensure the same number of each atom appears on both sides. Let's proceed systematically.

Step 1: Write the Unbalanced Equation

The initial unbalanced chemical equation is:

$NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$

Step 2: List the Number of Atoms of Each Element

- Left side (Reactants):
- N: 1 (from NH_4OH)
- H: 5 (4 from NH_4 + 1 from OH) + 3 (from H_3PO_4) = 8
- P: 1 (from H_3PO_4)
- O: 1 (from NH_4OH) + 4 (from H_3PO_4) = 5

- Right side (Products):
- N: 3 (from $(NH_4)_3PO_4$)
- H: 12 (from 3 NH_4 groups) + 2 (from H_2O) = 14
- P: 1 (from $(NH_4)_3PO_4$)
- O: 4 (from $(NH_4)_3PO_4$) + 1 (from H_2O) = 5

Note that initially, atoms are unbalanced, especially nitrogen and hydrogen.

Step 3: Balance Elements Other Than Hydrogen and Oxygen First

- Nitrogen (N): 1 on the left, 3 on the right.
- To balance N, place a coefficient of 3 before NH_4OH:

$3\ NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$

- Now, check N: 3 on both sides.

Step 4: Balance Phosphorus (P)

- P: 1 on both sides, already balanced.

Step 5: Balance Hydrogen (H)

- Left side:
- N: 3 × 4 = 12 H (from 3 NH_4OH)
- H in NH_4OH: 4 (from NH_4) + 1 (from OH) = 5 H per molecule, but considering total:
- 3 × (4 + 1) = 3 × 5 = 15 H
- H_3PO_4: 3 H atoms
- Total H on the left: 15 + 3 = 18

- Right side:
- $(NH_4)_3PO_4$: 3 × 4 = 12 H
- H_2O: 2 H atoms per molecule, number unknown

To balance H, determine the coefficient for H_2O. Let's denote it as x.

Total H on the right: 12 + 2x

Set equal to total H on the left:

18 = 12 + 2x

Solve for x:

2x = 6 → x = 3

Add coefficient 3 before H_2O:

3 NH_4OH + H_3PO_4 → $(NH_4)_3PO_4$ + 3 H_2O

Step 6: Balance Oxygen (O)

- Left side:
- NH_4OH: 1 O per molecule, 3 molecules → 3 O
- H_3PO_4: 4 O
- Total O: 3 + 4 = 7

- Right side:
- $(NH_4)_3PO_4$: 4 O
- 3 H_2O: 3 O
- Total O: 4 + 3 = 7

Oxygen atoms are balanced.

Final Balanced Equation

After verifying all elements, the balanced chemical equation is:

$3\ NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + 3\ H_2O$

This equation now has the same number of each atom on both sides, respecting the law of conservation of mass.

Key Points to Remember When Balancing Equations

- Start with elements that appear in only one reactant and product.
- Balance polyatomic ions as a whole when they appear unchanged on both sides.
- Adjust coefficients systematically, avoiding changing subscripts.
- Always verify the atom count after each adjustment.
- Balance hydrogen and oxygen last, as they are often in multiple compounds.

Additional Tips for Balancing Chemical Equations

- Use fractional coefficients temporarily if needed, then clear denominators.
- Keep coefficients in the simplest whole-number ratio.
- Practice with various equations to develop intuition.
- Understand the reaction type—acid-base, redox, precipitation—to anticipate product formation.

Why Is Balancing Equations Important?

Balancing chemical equations is crucial because it reflects the actual proportions of reactants and products in a chemical reaction. Accurate balancing enables chemists to:

- Calculate yields and reactant requirements.
- Understand reaction mechanisms.
- Ensure safety and efficiency in industrial processes.
- Communicate chemical information precisely.

Conclusion

Balancing the chemical equation:

$NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$

may seem challenging at first, but by following a systematic approach—balancing elements one at a time, verifying atom counts, and understanding the reaction's nature—you can master the process. Remember to check your work thoroughly, and with practice, balancing equations will become an intuitive part of your chemistry skill set.

By understanding each step and applying these principles, you can confidently balance this and other complex chemical equations, contributing to a deeper comprehension of chemical reactions and stoichiometry.

Meta Description: Learn how to balance the chemical equation $NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$ with detailed explanation and step-by-step guidance. Perfect for students and chemistry enthusiasts aiming to master stoichiometry.

Frequently Asked Questions

How do I start balancing the chemical equation NH4OH + H3PO4 = (NH4)3PO4 + H2O?

Begin by identifying the number of each atom type on both sides of the equation. Balance the elements step-by-step, starting with those that appear in the fewest compounds, such as phosphorus (P).

What is the first step to balance the equation NH4OH + H3PO4 = (NH4)3PO4 + H2O?

The first step is to balance phosphorus (P), which appears only in H3PO4 and (NH4)3PO4. Since there is 1 P on both sides, P is already balanced.

How do I balance the nitrogen (N) atoms in the equation?

On the left, there are 1 N in NH4OH; on the right, 3 N in (NH4)3PO4. To balance N, multiply NH4OH by 3, making it 3 NH4OH, so that nitrogen is balanced with 3 N on both sides.

How can I balance hydrogen (H) atoms in this equation?

Count the H atoms on both sides: left has 3 N in NH4OH (which contains 4 H) and 3 H in H3PO4, totaling 3×4 + 3 = 15 H; right has 4×3 H in 3 NH4 (which is in (NH4)3PO4) plus H2O. Adjust coefficients accordingly to match the total H atoms on both sides.

Where do I place coefficients to balance the equation

correctly?

Set coefficients to balance atoms: start with nitrogen, then phosphorus, hydrogen, and oxygen. For instance, 3 NH4OH + H3PO4 = (NH4)3PO4 + H2O, then adjust H2O as needed to balance hydrogen and oxygen atoms.

What is the balanced chemical equation for NH4OH + H3PO4?

The balanced equation is 3 NH4OH + H3PO4 = (NH4)3PO4 + 3 H2O. This ensures all elements are balanced on both sides.

Why is it important to check the atom counts after balancing the equation?

Checking ensures that the number of each type of atom is the same on both sides, confirming that the equation is properly balanced and obeys the law of conservation of mass.

Can you explain why water (H2O) is produced in this reaction?

Water is produced from the combination of hydrogen atoms from ammonium hydroxide and other hydrogen sources during the formation of the ammonium phosphate compound, balancing the hydrogen and oxygen atoms in the reaction.

Additional Resources

How To Balance This Equation NH4OH + H3PO4 = (NH4)3PO4 + H2O: A Comprehensive Guide with Explanation

Balancing chemical equations is a fundamental skill in chemistry that ensures the law of conservation of mass is upheld. When dealing with equations involving acids, bases, and salts, like the one between ammonium hydroxide and phosphoric acid, understanding the underlying chemistry is crucial. This article provides a detailed, step-by-step approach to balance the equation:

NH4OH + H3PO4 → (NH4)3PO4 + H2O

along with in-depth explanations to enhance your comprehension.

Understanding the Reactants and Products

Before attempting to balance, it’s essential to understand what each chemical species represents and their roles in the reaction.

Reactants:

- NH_4OH (Ammonium hydroxide):
- An aqueous solution of ammonia (NH_3) dissolved in water.
- Acts as a weak base, providing ammonium ions (NH_4^+) and hydroxide ions (OH^-).
- In solution, it exists in equilibrium: $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$.

- H_3PO_4 (Phosphoric acid):
- A triprotic acid, capable of donating three protons (H^+).
- When reacting with bases, it often forms salts called phosphates.

Products:

- $(NH_4)_3PO_4$ (Ammonium phosphate):
- A salt formed from ammonium ions and phosphate ions.
- The formula indicates 3 ammonium ions per phosphate ion.

- H_2O (Water):
- The typical byproduct of acid-base neutralizations involving hydroxide ions.

Understanding the Reaction Type

This reaction is a typical acid-base neutralization:

- Ammonium hydroxide (a base) reacts with phosphoric acid (an acid).
- They produce a salt (ammonium phosphate) and water.

The general pattern for such reactions is:

acid + base → salt + water

This understanding guides how to balance the equation.

Step-by-Step Process to Balance the Equation

Balancing complex equations involves careful counting of atoms and understanding the stoichiometry.

Step 1: Write Down the Unbalanced Equation

Start with the skeleton:

$NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$

Step 2: Determine the Number of Atoms for Each Element

- Left Side (Reactants):
- N: 1 (from NH_4OH)
- H: 4 (NH_4OH) has 4 H, and H_3PO_4 has 3 H, totaling 7 H initially.
- O: 1 (NH_4OH) + 4 (H_3PO_4) = 5 O total.
- P: 1 (H_3PO_4)

- Right Side (Products):
- N: 3 ($(NH_4)_3PO_4$)
- H: 12 ($(NH_4)_3PO_4$: 3×4 H) + 2 (H_2O) = 14 H
- P: 1 ($(NH_4)_3PO_4$)
- O: 4 ($(NH_4)_3PO_4$) + 1 (H_2O) = 5 O

This initial count shows atoms are not balanced, especially nitrogen and hydrogen.

Step 3: Balance Nitrogen (N)

- The product has 3 N atoms in $(NH_4)_3PO_4$.
- The reactant NH_4OH contains only 1 N atom.
- To supply 3 N atoms, we need 3 equivalents of NH_4OH.

Update:

$NH_4OH \rightarrow 3\ NH_4OH$

Now, nitrogen is balanced:

- Left: 3 N
- Right: 3 N

Step 4: Balance Hydrogen (H)

- Left side:
- 3 NH4OH: 3×4 H = 12 H
- H3PO4: 3 H
- Total H: 12 + 3 = 15 H

- Right side:
- (NH4)3PO4: 3×4 H = 12 H
- H2O: 2 H
- Total H: 12 + 2 = 14 H

Hydrogen atoms are not balanced; 15 on the left vs. 14 on the right.

To fix this, notice that the water molecule accounts for 2 H. To balance hydrogen, we can adjust the coefficients.

Step 5: Balance Water (H2O)

- Since the number of H atoms is one more on the reactant side (15) than on the product side (14), we can add a coefficient to H2O to balance.

- Let's try increasing the H2O coefficient to 1:

H2O: 1

- Now, total H on the right: 12 + 2 = 14 H, still not matching 15.

- Alternatively, if we increase the water coefficient to 2:

2 H2O: 4 H

Total H on the right: 12 + 4 = 16, overshoot.

- Since 15 is odd, but water has an even number of H, it suggests that a better approach is to balance the hydrogen via the coefficients for NH4OH.

Therefore, the initial assumption of 3 NH4OH molecules might be adjusted.

Step 6: Reassess the Coefficients

Instead of fixing N first, consider the following:

- Since the ammonium ion (NH_4^+) appears in both reactant and product, and the phosphate ion (PO_4^{3-}) appears in the salt, the reaction involves:

$NH_4OH + H_3PO_4 \rightarrow (NH_4)_3PO_4 + H_2O$

- Recognize that:

- Each NH_4OH provides 1 NH_4^+ and 1 OH^-.
- The acid H_3PO_4 can donate 3 H^+.

- When reacting, the hydroxide ions (OH^-) from NH_4OH neutralize H^+ from H_3PO_4, forming water.

Alternative Approach: Use the Concept of Acid-Base Neutralization

The reaction proceeds as:

- H_3PO_4 (triprotic acid) reacts with NH_4OH (weak base).
- The three protons (H^+) from H_3PO_4 are neutralized by hydroxide ions (OH^-) from NH_4OH.
- The ammonium ions (NH_4^+) combine with phosphate ions (PO_4^{3-}) to form ammonium phosphate.

Step 1: Write the net ionic reaction:

$H_3PO_4 + 3\ NH_4OH \rightarrow (NH_4)_3PO_4 + 3\ H_2O$

Step 2: Verify atom balance:

- Nitrogen (N):
Left: 3 (from 3 NH_4OH)
Right: 3 (from $(NH_4)_3PO_4$) — balanced.

- Hydrogen (H):
Left:
- 3 NH_4OH: 3×4 = 12 H
- H_3PO_4: 3 H
- Total: 15 H

Right:
- $(NH_4)_3PO_4$: 3×4 = 12 H
- Water: 3 H (from 3 H_2O)
- Total: 15 H — balanced.

- Phosphorus (P):
1 on each side — balanced.

- Oxygen (O):

Left:
- H3PO4: 4 O
- 3 NH4OH: 3 O
- Total: 7 O

Right:
- (NH4)3PO4: 4 O
- 3 H2O: 3 O
- Total: 7 O — balanced.

This confirms the coefficients:

Coefficient for NH4OH: 3

Coefficient for H3PO4: 1

Coefficient for (NH4)3PO4: 1

Coefficient for H2O: 3

Final Balanced Equation

NH4OH + H3PO4 → (NH4)3PO4 + H2O

becomes

3 NH4OH + H3PO4 → (NH4)3PO4 + 3 H2O

This is the balanced chemical equation.

Additional Insights and Explanation

Why does this balancing work?

- The triprotic acid H3PO4 supplies three protons (H^+) per molecule.
- Each NH4OH supplies one NH_4^+ and one OH^-.
- To neutralize all three protons, three NH4OH molecules are

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