From The Unbalanced Reaction: B2H6 + O2 ---> HBO2 + H2OHow Many Grams Of O2 (32g/mol) Will Be Needed

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Understanding the stoichiometry of chemical reactions is fundamental in chemistry, especially when it comes to calculating the precise amounts of reactants needed for a specific reaction. In this article, we will analyze the unbalanced chemical reaction between diborane (B_2H_6) and oxygen (O_2) to produce boric acid (HBO_2) and water (H_2O). Specifically, our focus is on determining how many grams of oxygen are required for this reaction, given its molar mass of 32 grams per mole.

This type of calculation is crucial in various fields such as industrial chemistry, environmental science, and laboratory synthesis, where precise reactant quantities impact yield, cost, and safety. By carefully balancing the chemical equation and applying stoichiometric principles, we can accurately determine the amount of oxygen necessary to complete the reaction.

Understanding the Reaction Components and Their Significance

1. The Reactants

- Diborane (B_2H_6): A boron hydride used in chemical synthesis and rocket propellants. It is a colorless, highly reactive gas with a molar mass of approximately 27.67 g/mol.
- Oxygen (O_2): An abundant diatomic gas essential for combustion and oxidation reactions, with a molar mass of 32 g/mol.

2. The Products

- Boric Acid (HBO_2): A compound used in antiseptics, insecticides, and as a precursor for other boron compounds.
- Water (H_2O): The universal solvent, vital in many chemical processes.

Step 1: Writing and Balancing the Chemical Equation

The initial unbalanced reaction is:

$$
\text{B}_2\text{H}_6 + \text{O}_2 \rightarrow \text{HBO}_2 + \text{H}_2\text{O}
$$

To determine the exact amount of oxygen needed, we first need to balance this equation properly.

2.1 Balancing the Reaction

Let's analyze the reaction step-by-step:

- Boron atoms: There are 2 boron atoms on the reactant side, so the product side should have 2 boron atoms. Since each HBO_2 molecule contains 1 boron atom, we need 2 HBO_2 molecules.

- Hydrogen atoms: B_2H_6 has 6 hydrogens; on the product side, hydrogens are present in HBO_2 (which has 1 H) and H_2O (which has 2 H). To balance hydrogens:

- Total hydrogens on reactant side: 6
- On product side: (2 × 1) from HBO_2 + (number of H_2O molecules × 2)

Let's denote the number of H_2O molecules as x.

$$
6 = 2 \times 1 + 2x \Rightarrow 6 = 2 + 2x \Rightarrow 2x = 4 \Rightarrow x = 2
$$

- Oxygen atoms: On the product side, oxygen atoms are in HBO_2 (2 per molecule) and H_2O (1 per molecule):

- HBO_2: $2 \times 2 = 4$ oxygen atoms
- H_2O: $2 \times 1 = 2$ oxygen atoms

Total oxygen atoms on the product side: 4 + 2 = 6

On the reactant side, oxygen comes from O_2 molecules. Each O_2 has 2 oxygen atoms. Let y be the number of O_2 molecules:

$$
2y = 6 \Rightarrow y = 3
$$

Final balanced reaction:

$$
\text{B}_2\text{H}_6 + 3\, \text{O}_2 \rightarrow 2\, \text{HBO}_2 + 2\, \text{H}_2\text{O}
$$

Step 2: Molar Masses and Stoichiometric Calculations

Having balanced the chemical equation, the next step involves calculating the molar ratios and quantities needed.

3.1 Molar Masses of Reactants and Products

Compound	Molar Mass (g/mol)	Calculation Details
B_2H_6	27.67 g/mol	(2×10.81 for B) + (6×1.008 for H)
O_2	32 g/mol	(2×16)
HBO_2	61.83 g/mol	(1×10.81 for B) + (1×1.008 for H) + (2×16 for O)
H_2O	18.02 g/mol	(2×1.008 for H) + (16 for O)

Note: The molar mass of B_2H_6 is approximately 27.67 g/mol, which aligns with standard references.

Step 3: Determining the Amount of B_2H_6 and O_2 Needed

Suppose we start with a certain amount of diborane, for example, 1 mole, and want to determine how much oxygen is required for complete reaction.

4.1 Calculating Moles of O_2 Needed

From the balanced equation:

$$
1\, \text{mol B}_2\text{H}_6 \quad \text{reacts with} \quad 3\, \text{mol O}_2
$$

Therefore, for 1 mole of B_2H_6, 3 moles of O_2 are needed.

Step 4: Converting Moles of O_2 to Grams

Given that each mole of O_2 weighs 32 grams, the total grams needed are:

$$
\text{Mass of O}_2 = \text{Number of moles} \times \text{Molar mass}
$$

For 3 moles:

$$
3 \text{ mol} \times 32\, \text{g/mol} = 96\, \text{g}
$$

Result: To react completely with 1 mole of B_2H_6, 96 grams of oxygen are required.

Step 5: General Calculation for Any Given Amount of B_2H_6

Suppose you have an arbitrary amount of B_2H_6, say n grams. To find out how many grams of O_2 are needed:

1. Convert grams of B_2H_6 to moles:

$$
\text{Moles of B}_2\text{H}_6 = \frac{n}{27.67}
$$

2. Determine moles of O_2 required:

$$
\text{Moles of O}_2 = 3 \times \left(\frac{n}{27.67} \right)
$$

3. Convert moles of O_2 to grams:

$$
\text{Grams of O}_2 = \text{Moles of O}_2 \times 32 = 3 \times \left(\frac{n}{27.67} \right) \times 32
$$

Simplify:

$$
\text{Grams of O}_2 = \frac{3 \times 32}{27.67} \times n \approx \frac{96}{27.67} \times n \approx 3.47 \times n
$$

Therefore:

$$
\boxed{
\text{Grams of O}_2 \approx 3.47 \times \text{grams of B}_2\text{H}_6
}
$$

This formula allows quick calculation of oxygen requirements based on the amount of diborane used.

Additional Considerations in Practical Applications

While theoretical calculations provide a precise amount of reactants needed, real-world reactions may require consideration of:

- Reaction efficiency: Not all reactions proceed to completion; adjustments may be necessary.
- Purity of reactants: Impurities can affect the amount of oxygen consumed.
- Safety precautions: Handling gases like diborane and oxygen requires specialized equipment due to their reactive nature.
- Environmental controls: Excess oxygen can pose fire hazards; proper ventilation and controls are essential.

Conclusion: Summarizing the Key Findings

- The balanced chemical equation for the reaction between diborane and oxygen is:

$$
\text{B}_2\text{H}_6 + 3\, \text{O}_2 \rightarrow 2\, \text{HBO}_2 + 2\, \text{H}_2\text{O}
$$

- For every mole of B_2H_6 (27.67 g), 3 moles of O_2 (96 g) are needed.
- In terms of practical calculations, approximately 3.47 grams of O_2 are required per gram

Frequently Asked Questions

What is the balanced chemical equation for the reaction between B2H6 and O2?

The balanced equation is B2H6 + 3 O2 → 2 HBO2 + 3 H2O.

How many grams of O2 are needed to fully react with a given amount of B2H6?

The amount of O2 required depends on the moles of B2H6 and the stoichiometric ratio from the balanced equation; use molar ratios to calculate grams needed.

If 10 grams of B2H6 are reacted, how many grams of O2 are required?

First, convert 10 g B2H6 to moles: 10 g / 27.73 g/mol ≈ 0.36 mol. Using the molar ratio (1 mol B2H6 : 3 mol O2), O2 needed = 0.36 × 3 = 1.08 mol. Convert to grams: 1.08 mol × 32 g/mol = 34.56 grams of O2.

What is the molar ratio of B2H6 to O2 in the reaction?

The molar ratio is 1 mol B2H6 : 3 mol O2, as indicated by the balanced equation.

How do you determine the amount of oxygen needed from the balanced reaction equation?

Identify the molar ratio between B2H6 and O2 from the balanced equation, then use the number of moles of B2H6 to calculate the required moles (and grams) of O2.

Why is it important to balance chemical reactions before calculating reactant quantities?

Balancing ensures the conservation of mass, allowing accurate calculation of reactant and product quantities based on stoichiometry.

Additional Resources

From The Unbalanced Reaction: B2H6 + O2 → HBO2 + H2O How Many Grams Of O2 (32g/mol) Will Be Needed

Understanding the stoichiometry behind chemical reactions is fundamental in both academic and industrial chemistry. When dealing with reactions such as the oxidation of diborane (B2H6), it's crucial to determine the exact amount of reagents required to produce desired products efficiently and safely. The question posed—"From The Unbalanced Reaction: B2H6 + O2 → HBO2 + H2O How Many Grams Of O2 (32g/mol) Will Be Needed"—serves as an excellent case study in applying stoichiometric principles to real-world chemical calculations.

In this detailed review, we will explore the process of balancing the reaction, calculating the required amount of oxygen, and understanding the broader implications of such calculations in chemical synthesis. By breaking down the reaction step-by-step and examining its features, pros, and cons, this article aims to deepen your understanding of stoichiometry and reaction planning.

Understanding the Reaction: B2H6 and O2

Before delving into calculations, it's essential to comprehend what is happening chemically. Diborane (B2H6) is a boron hydride used in various applications, including organic synthesis and as a reducing agent. Its oxidation with oxygen typically yields boron compounds such as boric acid or boron oxides, along with water.

The unbalanced chemical equation is:

B2H6 + O2 → HBO2 + H2O

However, this equation is not yet stoichiometrically meaningful. To determine the amount of oxygen needed, we must first balance it properly.

Balancing the Chemical Equation

Step 1: Write the unbalanced formula

B2H6 + O2 → HBO2 + H2O

Step 2: Balance boron atoms

- Left side: 2 B atoms (in B2H6)
- Right side: 1 B atom (in HBO2)

To balance boron:

B2H6 + O2 → 2 HBO2 + H2O

Step 3: Balance hydrogen atoms

- Left: 6 H atoms (in B2H6)
- Right: 2 H (in HBO2) + 2 H (in H2O) = 4 H

Thus, hydrogen is unbalanced; to match 6 H on the right:

- Add 3 H2O molecules:

B2H6 + O2 → 2 HBO2 + 3 H2O

Now, hydrogen:

- Left: 6 H
- Right: 2 H (HBO2) + 6 H (3 H2O) = 8 H

Hydrogen is overcounted; adjust accordingly.

Alternatively, starting with:

B2H6 + O2 → 2 HBO2 + 3 H2O

Hydrogen:

- Left: 6 H
- Right: 2 H (HBO2) + 6 H (3 H2O) = 8 H

To balance hydrogen, multiply HBO2 and H2O by appropriate factors or adjust coefficients.

Instead, let's proceed more systematically.

More systematic balancing

Let's assign coefficients:

a B2H6 + b O2 → c HBO2 + d H2O

Balance boron:

a 2 = c (since HBO2 has 1 B)

Balance hydrogen:

a 6 = 2d (since H2O has 2 H)

Balance oxygen:

On the right: c 2 (from HBO2) + d 1 (from H2O)

On the left: b 2 (since O2 has 2 O)

Now, express c and d in terms of a:

c = 2a

From hydrogen:

6a = 2d → d = 3a

Oxygen:

b 2 = c 2 + d = (2a)2 + 3a = 4a + 3a = 7a

Therefore, b = (7a)/2

To avoid fractions, choose a = 2:

a = 2

Then:

c = 4

d = 6

b = (7 2)/2 = 7

So, the balanced equation is:

2 B2H6 + 7 O2 → 4 HBO2 + 6 H2O

Calculating the Required Grams of O2

With the balanced equation:

2 B2H6 + 7 O2 → 4 HBO2 + 6 H2O

we can now determine how much oxygen is needed for a given amount of B2H6.

Suppose we start with a known mass of B2H6—say, 10 grams—and want to find out how many grams of O2 are required to fully react.

Step 1: Convert grams of B2H6 to moles

Molar mass of B2H6:

- Boron (B): 10.81 g/mol
- Hydrogen (H): 1.008 g/mol

Molar mass of B2H6:

= (2 × 10.81) + (6 × 1.008) = 21.62 + 6.048 = 27.668 g/mol

Number of moles in 10 g:

n = 10 g / 27.668 g/mol ≈ 0.3616 mol

Step 2: Use mole ratios from the balanced equation

From the balanced reaction:

2 mol B2H6 react with 7 mol O2

So, for 0.3616 mol B2H6:

Oxygen needed = (7/2) × 0.3616 mol ≈ 1.264 mol

Step 3: Convert moles of O2 to grams

Molar mass of O2 = 32 g/mol

Mass of O2 = 1.264 mol × 32 g/mol ≈ 40.45 grams

Result: Approximately 40.45 grams of O2 are needed to completely react with 10 grams of B2H6.

Broader Implications and Practical Considerations

Calculating the precise amount of oxygen needed for reactions involving diborane is critical for multiple reasons.

Industrial Significance

- Efficiency: Accurate calculations prevent wastage of costly reagents.
- Safety: Excess oxygen can lead to hazardous conditions, especially with reactive gases like B2H6.
- Environmental Impact: Proper stoichiometry minimizes by-products and waste.

Challenges in Real-World Applications

- Purity of reactants: Impurities can influence stoichiometry.
- Reaction conditions: Temperature, pressure, and catalysts affect reaction completion.
- Measurement accuracy: Precise weighing and measurement tools are essential.

Features, Pros, and Cons of the Calculation Method

Features:

- Based on fundamental stoichiometric principles.
- Uses balanced equations for accuracy.
- Easily adaptable to different reactant quantities.

Pros:

- Ensures precise reagent quantities.
- Facilitates safe and efficient reaction planning.
- Supports scale-up from laboratory to industrial processes.

Cons:

- Assumes complete reaction without side products.
- Real-world reactions may have inefficiencies.
- Requires accurate initial data (molar masses, purity).

Conclusion

Determining how many grams of O2 are needed for the oxidation of B2H6 hinges on accurately balancing the chemical equation and applying stoichiometric conversions. Starting from the unbalanced reaction, we derived the balanced equation:

> 2 B2H6 + 7 O2 → 4 HBO2 + 6 H2O

Using this, we calculated that approximately 40.45 grams of O2 are needed to react completely with 10 grams of B2H6. This process illustrates the importance of precise calculation in chemical reactions, ensuring efficiency, safety, and environmental responsibility.

Understanding such calculations not only enhances your grasp of chemical principles but also prepares you for practical applications in research, manufacturing, and environmental management. Whether handling small-scale laboratory reactions or large industrial processes, mastering the art of stoichiometry remains fundamental to successful chemistry.

In summary:

- Accurate balancing of chemical equations is vital.
- Converting between grams and moles allows for precise reagent planning.
- Real-world factors may influence theoretical calculations.
- Careful stoichiometric analysis leads to safer and more efficient chemical processes.

Embracing these principles ensures that chemists and engineers can optimize reactions, minimize waste, and uphold safety standards across various applications.

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