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Understanding the formation of water through chemical reactions is fundamental in chemistry. Specifically, the reaction between oxygen and hydrogen gases to produce water is a classic example illustrating the principles of chemical stoichiometry. In this article, we will explore the details of how 48 grams of oxygen react with 6 grams of hydrogen to form water and determine the amount of oxygen that combines with 2 grams of hydrogen. This comprehensive guide will help you grasp the concepts of chemical equations, molar ratios, and calculations involved in such reactions, making it easier for students, educators, and chemistry enthusiasts to understand and apply these principles effectively.

Understanding the Basics of Water Formation

The Chemical Reaction Between Hydrogen and Oxygen

The formation of water from hydrogen and oxygen gases involves a straightforward chemical reaction:

$$ 2H_2 + O_2 \rightarrow 2H_2O $$

This balanced chemical equation indicates that:

- Two molecules of hydrogen gas (H_2) react with one molecule of oxygen gas (O_2).
- The reaction produces two molecules of water (H_2O).

This reaction is exothermic, releasing energy in the form of heat, and is fundamental in various natural and industrial processes, including combustion and biological respiration.

Mass Relationships and the Law of Conservation of Mass

According to the Law of Conservation of Mass:

- The total mass of reactants equals the total mass of products.
- The atoms are neither created nor destroyed during the reaction.

This principle allows us to relate the masses of reactants to the masses of products, which is crucial for calculating unknown quantities in chemical reactions.

Calculating the Moles of Reactants

Determining Moles of Hydrogen

Given:
- Mass of hydrogen (H_2) = 6 grams

Molar mass of hydrogen gas:
- H_2 = 2 grams/mole

Calculations:
$$
\text{Moles of H}_2 = \frac{\text{Mass of H}_2}{\text{Molar mass of H}_2} = \frac{6\,g}{2\,g/\text{mol}} = 3\,\text{mol}
$$

Determining Moles of Oxygen

Given:
- Mass of oxygen (O_2) = 48 grams

Molar mass of oxygen gas:
- O_2 = 32 grams/mole

Calculations:
$$
\text{Moles of O}_2 = \frac{\text{Mass of O}_2}{\text{Molar mass of O}_2} = \frac{48\,g}{32\,g/\text{mol}} = 1.5\,\text{mol}
$$

Analyzing the Stoichiometric Ratios

Understanding the Mole Ratio

From the balanced chemical equation:

$$ 2H_2 + O_2 \rightarrow 2H_2O $$

The molar ratio of hydrogen to oxygen is:
- 2 mol H_2 : 1 mol O_2

In terms of the given quantities:

- Moles of hydrogen = 3 mol
- Moles of oxygen = 1.5 mol

Since:
$$
\text{Required oxygen for 3 mol H}_2 = \frac{1\,\text{mol O}_2}{2\,\text{mol H}_2} \times 3\,\text{mol H}_2 = 1.5\,\text{mol O}_2
$$

This matches the available oxygen exactly, indicating that:
- The reaction uses all the oxygen and hydrogen without any excess.

Calculating the Mass of Water Formed

Mass of Water Produced from the Reaction

Using the moles of hydrogen reacted:

- Moles of water produced:
$$
\text{From the balanced equation, } 2\,\text{mol H}_2 \Rightarrow 2\,\text{mol H}_2O
$$
- Therefore, for 3 mol H_2:
$$
\text{Moles of H}_2O = 3\,\text{mol}
$$

Molar mass of water:
- H_2O = 18 grams/mole

Calculations:
$$
\text{Mass of water} = 3\,\text{mol} \times 18\,g/\text{mol} = 54\,g
$$

This means that 54 grams of water are formed when 6 grams of hydrogen react completely with 48 grams of oxygen.

What Happens When Only 2 Grams of Hydrogen React?

Determining the Reactants' Limits

Suppose only 2 grams of hydrogen are involved in the reaction. Let's analyze how much oxygen is needed and how much water is produced.

Calculations:
- Moles of hydrogen:
$$
\frac{2\,g}{2\,g/\text{mol}} = 1\,\text{mol}
$$

- Using the molar ratio:
$$
2\,\text{mol H}_2 : 1\,\text{mol O}_2
$$
- Moles of oxygen required:
$$
\frac{1\,\text{mol O}_2}{2\,\text{mol H}_2} \times 1\,\text{mol H}_2 = 0.5\,\text{mol O}_2
$$

- Mass of oxygen needed:
$$
0.5\,\text{mol} \times 32\,g/\text{mol} = 16\,g
$$

Since we have 48 grams of oxygen available (from the original data), oxygen is in excess, and only 16 grams are needed for the reaction with 2 grams of hydrogen.

Mass of Water Produced from 2g of Hydrogen

- Moles of water:
$$
1\,\text{mol H}_2 \Rightarrow 1\,\text{mol H}_2\text{O}
$$
- Mass of water:
$$

$$1\,\text{mol} \times 18\,g/\text{mol} = 18\,g$$

Thus, when 2 grams of hydrogen react completely with the necessary oxygen, 18 grams of water are formed.

Summary of Key Calculations and Concepts

1. **Moles of Hydrogen:** 6 g / 2 g/mol = 3 mol
2. **Moles of Oxygen:** 48 g / 32 g/mol = 1.5 mol
3. **Reaction Stoichiometry:** 2 mol H_2 : 1 mol O_2
4. **Oxygen required for 3 mol H_2:** 1.5 mol (exact match)
5. **Water formed:** 3 mol H_2O, which equals 54 g
6. **For 2 g H_2:** 1 mol H_2 reacts with 0.5 mol O_2, producing 18 g water

Practical Applications and Relevance

Industrial Production of Water and Hydrogen

Understanding the stoichiometry of water formation is crucial in industries such as:

- Hydrogen fuel cell technology
- Water electrolysis processes
- Combustion engines and energy generation

Environmental and Safety Considerations

- Hydrogen is a clean fuel, but its storage and handling require safety precautions due to its flammability.

- The reaction releasing water is often harnessed in sustainable energy systems.

Conclusion

In conclusion, the reaction between hydrogen and oxygen gases to form water exemplifies fundamental principles of chemistry, including molar ratios, conservation of mass, and stoichiometry. When 48 grams of oxygen combine with 6 grams of hydrogen, they produce approximately 54 grams of water. When only 2 grams of hydrogen react, they produce about 18 grams of water, requiring only 16 grams of oxygen from the available supply. These calculations demonstrate the importance of molar ratios in predicting product formation in chemical reactions and highlight the practical significance of understanding these concepts in real-world applications.

By mastering these calculations and concepts, students and professionals can better design experiments, optimize industrial processes, and understand the chemical basis of many natural phenomena related to water formation.

Frequently Asked Questions

What is the chemical reaction involved when oxygen combines with hydrogen to form water?

The reaction is $2H_2 + O_2 \rightarrow 2H_2O$, where hydrogen reacts with oxygen to produce water.

How much water is formed when 48g of oxygen combines with 6g of hydrogen?

The total water formed is 54g, as the combined mass of oxygen and hydrogen (48g + 6g) equals 54g.

What is the ratio of hydrogen to oxygen in the formation of water based on the given data?

The ratio of hydrogen to oxygen in the reaction is 2:1 by mole, but by mass, 6g hydrogen combines with 48g oxygen.

If 48g of oxygen reacts with 6g of hydrogen to produce water, how much oxygen will react with 2g of

hydrogen?

Using the ratio, 6g hydrogen reacts with 48g oxygen; thus, 2g hydrogen will react with (48g/6g)×2g = 16g of oxygen.

How do you calculate the mass of oxygen needed to react with a certain amount of hydrogen?

Use the molar ratio from the balanced equation; for every 2 mol of H_2, 1 mol of O_2 reacts. Convert grams to moles, find the ratio, then convert back to grams.

Why is the mass of water formed equal to the combined masses of oxygen and hydrogen used?

Because chemical reactions conserve mass, the total mass of reactants equals the mass of products, so water formed has a mass of 54g in this case.

What is the significance of the given data in understanding the composition of water?

It illustrates the mass ratio of hydrogen to oxygen in water and helps determine how much of each gas combines during formation.

Can the amount of oxygen reacting with 2g of hydrogen be different in other conditions?

Yes, factors like reaction completeness, purity, or conditions could affect the actual amount, but theoretically, 16g of oxygen reacts with 2g of hydrogen.

What is the key concept demonstrated by this problem about chemical reactions?

It demonstrates the conservation of mass and the mole ratio in chemical reactions, specifically in the formation of water from hydrogen and oxygen.

How do you determine the mass of oxygen that combines with 2g of hydrogen in the reaction?

By using the molar ratio 2:1, convert 2g hydrogen to moles, find the corresponding moles of oxygen, then convert back to grams—resulting in 16g of oxygen.

Additional Resources

Water Is Formed When 48g Of Oxygen Combine With 6g Of Hydrogen. What Mass Of Oxygen Combines With 2g

In the realm of chemistry, few reactions are as fundamental and universally recognized as the formation of water. This simple yet profound process involves the combination of hydrogen and oxygen—two elemental gases—to produce a compound essential for life on Earth. Understanding the precise quantities involved in this reaction not only deepens our grasp of chemical principles but also exemplifies the importance of stoichiometry—the calculation of reactants and products in chemical reactions.

In this article, we will explore the question: If 48 grams of oxygen react with 6 grams of hydrogen to produce water, what mass of oxygen will combine with 2 grams of hydrogen? Through a detailed analysis, we will uncover the underlying principles, calculations, and implications of this problem, making it accessible to readers with a basic understanding of chemistry yet rich in technical depth.

The Fundamentals of Water Formation: The Chemical Equation

To understand the problem at hand, it’s essential to revisit the fundamental chemical reaction involved in water formation.

The Reaction: Hydrogen Combines With Oxygen

The formation of water is a classic example of a synthesis reaction, represented by the balanced chemical equation:

$$ 2H_2 + O_2 \rightarrow 2H_2O $$

This equation indicates that:

- Two molecules of diatomic hydrogen (H_2) react with one molecule of diatomic oxygen (O_2)
- To produce two molecules of water (H_2O)

In terms of moles:

- 2 moles of hydrogen gas combine with 1 mole of oxygen gas
- Yielding 2 moles of water

Atomic and Molecular Masses

Understanding the molar masses of the involved elements is crucial:

- Hydrogen (H): approximately 1 g/mol
- Molecular hydrogen (H_2): 2 g/mol
- Oxygen (O): approximately 16 g/mol
- Molecular oxygen (O_2): 32 g/mol
- Water (H_2O): 18 g/mol

This information allows us to translate between mass and moles, which is vital for stoichiometric calculations.

Initial Data and Its Significance

The problem states:

- 48 grams of oxygen combine with 6 grams of hydrogen to produce water
- The question: What mass of oxygen will combine with 2 grams of hydrogen

Before proceeding, it's important to clarify whether the initial data align with the stoichiometric ratio dictated by the balanced equation.

Checking the Original Reaction: Are the Reactant Amounts Consistent?

Using molar masses:

- Moles of oxygen in 48 g:

$$ \text{moles of } O_2 = \frac{48\, g}{32\, g/mol} = 1.5\, mol $$

- Moles of hydrogen in 6 g:

$$ \text{moles of } H_2 = \frac{6\, g}{2\, g/mol} = 3\, mol $$

According to the balanced reaction:

- For every 2 mol of H_2, 1 mol of O_2 is needed
- The ratio of hydrogen to oxygen in moles is:

$$ \frac{3\, mol\, H_2}{1.5\, mol\, O_2} = 2:1 $$

which perfectly aligns with the stoichiometric ratio of the reaction (2 mol

H_2 : 1 mol O_2).

This indicates that the initial quantities are consistent with complete reaction and that all the reactants are fully consumed to produce water.

Calculating the Mass of Oxygen That Reacts With 2 Grams of Hydrogen

The core of the problem involves determining how much oxygen would react with a different amount of hydrogen—specifically, 2 grams—based on the initial reaction data.

Step 1: Convert 2 grams of hydrogen to moles

Using the molar mass of H_2:

$$ \text{moles of } H_2 = \frac{2\, g}{2\, g/mol} = 1\, mol $$

Step 2: Determine the corresponding amount of oxygen based on stoichiometry

From the balanced equation:

- 2 mol H_2 react with 1 mol O_2

Thus, for 1 mol H_2:

$$ \text{moles of } O_2 = \frac{1\, mol\, H_2}{2} = 0.5\, mol $$

Step 3: Convert moles of oxygen to mass

Using the molar mass of O_2:

$$ \text{mass of } O_2 = 0.5\, mol \times 32\, g/mol = 16\, g $$

Therefore, 16 grams of oxygen will combine with 2 grams of hydrogen.

Implications and Broader Understanding

This calculation reveals a key aspect of chemical reactions: the stoichiometric relationships dictate the precise amounts of reactants needed for complete reactions. The initial data serve as a real-world example of how chemists determine proportions and predict yields.

Real-World Applications

Understanding these principles has numerous applications:

- Industrial synthesis of water and other compounds: Ensuring correct reactant ratios minimizes waste and maximizes efficiency.
- Environmental science: Calculating pollutant transformations or resource consumption.
- Educational purposes: Teaching students the importance of molar ratios and proportional reasoning.

Limitations and Considerations

While the calculations assume complete reactions without side processes, real-world scenarios might involve:

- Impurities
- Incomplete reactions
- External factors like temperature and pressure

However, for theoretical calculations and most controlled settings, the stoichiometric approach provides accurate predictions.

Summary and Key Takeaways

- The reaction for water formation involves hydrogen and oxygen in a fixed molar ratio: 2 mol H_2 to 1 mol O_2.
- The initial data (48 g oxygen and 6 g hydrogen) align perfectly with this ratio, confirming complete reaction.
- To find the oxygen amount that reacts with 2 g of hydrogen, we:

1. Convert 2 g of H_2 to moles (1 mol)
2. Apply the molar ratio to find 0.5 mol O_2
3. Convert moles of O_2 to mass (16 g)

- Consequently, 16 grams of oxygen will combine with 2 grams of hydrogen in a complete reaction.

This problem underscores the importance of stoichiometry in chemistry, illustrating how fundamental principles can be applied to real-world questions. Whether in laboratory settings or industrial processes, understanding the relationships between reactants enables precise control and prediction of chemical reactions, reinforcing chemistry's role as both a science and a practical tool.

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Author’s Note: Understanding stoichiometric relationships like these is foundational for anyone interested in chemistry, environmental science, or engineering. The ability to translate between mass, moles, and molecules allows scientists and engineers to design efficient processes, analyze reactions, and innovate solutions across myriad fields.

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