How Many Litres Of H2 Gas (at STP) Are Needed To Completelyreact With 5 Moles Of0gas?

How Many Litres Of H2 Gas (at STP) Are Needed To Completely React With 5 Moles Of O2 Gas?

Understanding the relationship between gases in chemical reactions is fundamental in chemistry, especially when dealing with gases at standard temperature and pressure (STP). If you're wondering how much hydrogen gas (H_2) is required to react completely with a given amount of oxygen gas (O_2), this article provides a comprehensive explanation. Specifically, we'll explore how many liters of H_2 gas at STP are needed to fully react with 5 moles of O_2 gas.

Fundamental Concepts in Gas Reactions

Before delving into calculations, it’s essential to understand some basic concepts:

- Standard Temperature and Pressure (STP):
Defined as a temperature of 0°C (273.15 K) and a pressure of 1 atm.
At STP, one mole of any ideal gas occupies approximately 22.4 liters.

- Mole Ratio in Chemical Equations:
The coefficients in balanced chemical equations indicate the molar ratio of reactants and products.

- Gas Volume and Moles Relationship:
Under constant temperature and pressure, the volume ratio of gases is directly proportional to their molar ratio.

Understanding the Balanced Chemical Equation

The reaction of hydrogen gas with oxygen gas to produce water is represented by the following balanced chemical equation:

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2 H₂ + O₂ → 2 H₂O
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Key points from the equation:

- 2 moles of hydrogen react with 1 mole of oxygen.
- The molar ratio of H_2 to O_2 is 2:1.

Calculating the Required Volume of Hydrogen Gas

Given that:

- You have 5 moles of O_2.
- The molar ratio of H_2 to O_2 in the reaction is 2:1.

Step 1: Determine the moles of H_2 needed

Since 1 mole of O_2 reacts with 2 moles of H_2:

$$
\text{Moles of H}_2 = 2 \times \text{Moles of O}_2
$$

$$
\text{Moles of H}_2 = 2 \times 5 = 10 \text{ moles}
$$

Step 2: Convert moles of H_2 to liters at STP

At STP: 1 mole of gas = 22.4 liters

$$
\text{Liters of H}_2 = \text{Moles of H}_2 \times 22.4
$$

$$
\text{Liters of H}_2 = 10 \times 22.4 = 224 \text{ liters}
$$

Result:
224 liters of H_2 gas at STP are needed to completely react with 5 moles of O_2 gas.

Additional Considerations and Practical

Applications

1. Gas Purity and Reaction Conditions

- Purity of gases can affect the amount needed, especially if impurities are present.
- Reaction conditions such as temperature and pressure deviations from STP can slightly alter gas volumes.

2. Real-world Scenarios

- In industrial settings, precise measurements are crucial.
- Safety precautions are essential when handling hydrogen and oxygen gases due to their flammability and explosive potential.

3. Extending the Concept

This calculation framework can be adapted for other gas reactions by adjusting the molar ratios based on the balanced chemical equation.

Summary of Key Points

- The reaction between hydrogen and oxygen to form water follows the balanced equation: $2\ H_2 + O_2 \rightarrow 2\ H_2O$.
- To react completely with 5 moles of O_2, 10 moles of H_2 are required.
- At STP, 10 moles of H_2 occupy 224 liters.
- Therefore, 224 liters of H_2 gas (at STP) are necessary to fully react with 5 moles of O_2.

Frequently Asked Questions (FAQs)

Q1: Can I use this calculation for gases at conditions other than STP?
A1: Yes. Adjust the volume calculations using the ideal gas law: PV = nRT. For gases not at STP, you need to account for the different temperature and pressure conditions.

Q2: What happens if the gases are not pure?
A2: Impurities can reduce the effective amounts of reactants, potentially requiring more gas or leading to incomplete reactions.

Q3: Is the volume ratio always 1:1 for gases at STP?
A3: No. The volume ratio depends on the molar coefficients in the balanced equation. For example, in this case, H_2 is twice as much volume as O_2 needed.

Conclusion

Determining how many liters of hydrogen gas are required to react completely with a specific amount of oxygen gas involves understanding the chemical reaction, molar ratios, and the relationship between moles and volume at STP. In this case, 5 moles of O_2 require 10 moles of H_2, which translates to 224 liters of hydrogen gas at STP. This fundamental calculation is vital in laboratory experiments, industrial processes, and safety planning involving gases.

Interested in learning more about gas reactions?
Explore topics like the ideal gas law, gas mixtures, and reaction stoichiometry to deepen your understanding of gases in chemistry.

Frequently Asked Questions

How many liters of H_2 gas at STP are required to react completely with 5 moles of O_2 gas?

10 liters of H_2 gas are needed to react with 5 moles of O_2 gas at STP, based on the reaction $2H_2 + O_2 \rightarrow 2H_2O$, where 2 moles of H_2 react with 1 mole of O_2.

What is the volume of hydrogen gas at STP needed to completely react with 5 moles of oxygen gas?

Since 2 moles of H_2 react with 1 mole of O_2, 5 moles of O_2 require 10 moles of H_2. At STP, 1 mole of gas occupies 22.4 liters, so 10 moles of H_2 occupy 224 liters.

If you have 5 moles of oxygen gas, how many liters of hydrogen gas are required at STP for complete reaction?

You need 10 moles of hydrogen gas, which equals 224 liters at STP, to fully react with 5 moles of oxygen gas.

How do you calculate the amount of H_2 gas needed to react with a given amount of O_2 gas at STP?

Use the stoichiometric ratio from the balanced equation $2H_2 + O_2 \rightarrow 2H_2O$. Convert moles of O_2 to moles of H_2 (multiply by 2), then multiply by 22.4 liters per mole to find the volume at

STP.

What is the molar volume of gases at STP, and how does it relate to calculating H_2 gas volume?

The molar volume of gases at STP is 22.4 liters per mole. It allows you to convert moles of H_2 needed into liters by multiplying the moles by 22.4.

Can you determine the volume of H_2 gas required to react with 5 moles of O_2 without using the molar volume?

No, the molar volume (22.4 liters per mole at STP) is essential for converting moles to volume. Without it, you cannot accurately determine the gas volume.

What is the significance of STP in calculating gas volumes in chemical reactions?

STP (Standard Temperature and Pressure) standardizes conditions (0°C and 1 atm), allowing consistent calculation and comparison of gas volumes using molar ratios and molar volume.

If the amount of O_2 gas changes, how do you adjust the H_2 gas volume needed at STP?

Adjust the moles of H_2 proportionally based on the stoichiometric ratio from the balanced equation. For example, for each mole of O_2, 2 moles of H_2 are needed; convert these moles to liters at STP accordingly.

Additional Resources

How Many Litres Of H_2 Gas (at STP) Are Needed To Completely React With 5 Moles Of O_2 Gas?

Understanding the precise quantities of gases involved in chemical reactions is fundamental for chemists, engineers, and students alike. Among the many reactions in chemical science, the combination of hydrogen gas (H_2) with oxygen gas (O_2) to produce water stands out as a classic example of a fundamental and highly relevant process. This reaction not only underpins energy production in fuel cells and combustion engines but also exemplifies the importance of stoichiometry in calculating reactant requirements.

In this article, we will explore the question: How many litres of H_2 gas (at Standard Temperature and Pressure, STP) are needed to completely react with 5 moles of O_2 gas? We will delve into the reaction's chemical principles, the concept of molar volume at STP, and the step-by-step calculation process to arrive at an accurate and comprehensive answer.

Understanding the Chemical Reaction: Hydrogen and Oxygen

The reaction between hydrogen and oxygen to form water can be represented by the balanced chemical equation:

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

This equation indicates that two moles of hydrogen gas react with one mole of oxygen gas to produce two moles of water (liquid). The coefficients in the balanced equation reflect the molar ratios of reactants and products, essential for stoichiometric calculations.

Key points:
- The ratio of H_2 to O_2 is 2:1.
- The reaction produces water in the liquid phase under standard conditions.

The Concept of Molar Volume at STP

Standard Temperature and Pressure (STP) is a reference condition often used in chemistry, defined as:

- Temperature: 0°C (273.15 K)
- Pressure: 1 atm (101.325 kPa)

Under STP, gases occupy a specific volume per mole, known as the molar volume. According to Avogadro’s Law:

One mole of any ideal gas occupies approximately 22.4 litres at STP.

This value allows us to convert between moles of gas and volume in litres, which is crucial for our calculations.

Step-by-Step Calculation: From Moles to Litres

1. Determine the Moles of O_2

Given:
- Moles of O_2 = 5 mol

Our goal:
- Find the volume of H_2 gas required to react completely with this amount of O_2.

2. Use the Reaction's Stoichiometry

From the balanced equation:
- 1 mol O_2 reacts with 2 mol H_2

Therefore:
- 5 mol O_2 will require:

2 mol H_2 / 1 mol O_2 × 5 mol O_2 = 10 mol H_2

3. Convert Moles of H_2 to Volume at STP

At STP:
- 1 mol H_2 occupies 22.4 L

Thus:
- 10 mol H_2 will occupy:

10 mol × 22.4 L/mol = 224 L

Answer:
Approximately 224 litres of hydrogen gas at STP are needed to completely react with 5 moles of oxygen gas.

Additional Considerations and Real-World Implications

While the calculation above is based on ideal gas behavior and standard conditions, many practical considerations can influence the actual volume needed:

- Non-ideal Gas Behavior: Real gases may deviate slightly from ideality, especially at high pressures or low temperatures.
- Purity of Gases: Impurities can affect reaction stoichiometry and gas volumes.
- Reaction Conditions: Variations from STP, such as temperature and pressure, will alter gas volumes according to the ideal gas law: PV=nRT.

Practical Applications of These Calculations

Understanding the precise volume of hydrogen required for reactions with oxygen has broad implications:

- Fuel Cell Technology: Ensuring accurate hydrogen supply for energy generation.
- Industrial Water Production: Optimizing reactant quantities to maximize efficiency.
- Safety Protocols: Managing explosive mixtures of hydrogen and oxygen with precision.
- Research and Development: Designing experiments that involve gas reactions.

Summary of Key Points

- The reaction between hydrogen and oxygen is $2\ H_2 + O_2 \rightarrow 2\ H_2O$.
- 1 mole of any ideal gas at STP occupies 22.4 litres.
- To react completely with 5 moles of oxygen, 10 moles of hydrogen are needed.
- Therefore, approximately 224 litres of H_2 gas at STP are required.

Final Thoughts

Calculating the amount of hydrogen gas needed to react with a given quantity of oxygen exemplifies the core principles of chemical stoichiometry and gas law relationships. This knowledge is vital not only in academic settings but also in industrial and environmental applications where efficient and safe handling of gases is paramount.

As we advance technological innovations such as hydrogen fuel cells and sustainable energy solutions, mastering these fundamental calculations becomes increasingly important. Accurate estimations of reactant volumes ensure safety, optimize processes, and contribute to the development of cleaner energy systems.

In conclusion, understanding the interplay between chemical equations, molar volumes, and stoichiometry provides the tools necessary to quantify gas requirements precisely. For the specific case of reacting 5 moles of oxygen, approximately 224 litres of hydrogen gas at STP are needed—a number that embodies the elegance and utility of fundamental chemical principles.

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