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Understanding chemical reactions and stoichiometry is fundamental in chemistry, especially when it comes to calculating the amounts of reactants needed to produce a desired amount of product. In this article, we will explore how to determine the number of grams of hydrogen gas (H_2) required to produce exactly 1.15 moles of ammonia (NH_3) based on the reaction:

$N_2 + 3H_2 \rightarrow 2NH_3$

This problem involves the application of molar ratios, molar mass calculations, and stoichiometric conversions. Let's delve into the step-by-step process to solve this problem efficiently.

Understanding the Reaction and Its Stoichiometry

The Balanced Chemical Equation

The given reaction is:

$N_2 + 3H_2 \rightarrow 2NH_3$

This equation indicates:

- 1 mole of nitrogen gas (N_2) reacts with
- 3 moles of hydrogen gas (H_2) to produce
- 2 moles of ammonia (NH_3).

Key Stoichiometric Relationships

From the balanced equation, the molar ratio between H_2 and NH_3 is:

3 moles H_2 : 2 moles NH_3

This ratio tells us that for every 2 moles of NH_3 produced, 3 moles of H_2 are consumed.

Calculating the Moles of H_2 Needed

Step 1: Determine the Moles of NH_3 Required

The problem states that we want to produce exactly 1.15 moles of NH_3. This is straightforward:

- Moles of NH_3 = 1.15 mol

Step 2: Use the Mole Ratio to Find Moles of H_2

Using the stoichiometric ratio:

- 2 mol NH_3 : 3 mol H_2

We can set up a proportion:

$$
\frac{3\, \text{mol H}_2}{2\, \text{mol NH}_3} = x\, \text{mol H}_2 / 1.15\, \text{mol NH}_3
$$

Solving for x:

$$
x = \frac{3}{2} \times 1.15 = 1.725\, \text{mol H}_2
$$

Therefore, 1.725 moles of H_2 are needed to produce 1.15 moles of NH_3.

Converting Moles of H_2 to Grams

Step 1: Find the Molar Mass of H_2

The molar mass of hydrogen gas (H_2):

- Atomic mass of hydrogen (H) ≈ 1.008 g/mol

- Molecular mass of H_2 = 2 × 1.008 = 2.016 g/mol

Step 2: Calculate the Mass of H_2 Required

Using the number of moles:

$$
\text{Mass} = \text{moles} \times \text{molar mass}
$$

$$
\text{Mass of H}_2 = 1.725\, \text{mol} \times 2.016\, \text{g/mol} \approx 3.48\, \text{g}
$$

Answer: Approximately 3.48 grams of H_2 are needed to produce 1.15 moles of NH_3.

Additional Considerations in Stoichiometry Calculations

Purity of Reactants

The calculations above assume complete purity of reactants. In real-world scenarios, impurities or reaction inefficiencies may require adjustments or excess reactants.

Reaction Conditions

The reaction for ammonia synthesis typically requires high temperature and pressure, and catalysts like iron. These conditions influence yield but do not affect the stoichiometric calculations.

Practical Applications

Understanding these calculations is crucial in industrial processes such as the Haber-Bosch process, which synthesizes ammonia on a large scale for fertilizer production.

Summary of the Calculation Process

- Identify the molar ratio from the balanced equation: 3 mol H_2 : 2 mol NH_3
- Determine the moles of NH_3 needed: 1.15 mol
- Calculate the moles of H_2 required: (3/2) × 1.15 = 1.725 mol
- Find the molar mass of H_2: 2.016 g/mol
- Calculate the grams of H_2: 1.725 mol × 2.016 g/mol ≈ 3.48 g

Thus, approximately 3.48 grams of hydrogen gas are necessary to produce 1.15 moles of ammonia under ideal conditions.

Final Thoughts

Mastering stoichiometric conversions like this is essential for chemists, chemical engineers, and students alike. By understanding the molar ratios and applying basic molar mass calculations, one can accurately determine the amounts of reactants needed for any chemical synthesis. Whether you're working in a laboratory or an industrial setting, these skills enable efficient and cost-effective resource management.

If you need further assistance with chemical calculations, reaction mechanisms, or industrial applications of chemistry, consider reviewing additional resources or consulting with professionals in the field. Accurate stoichiometry not only enhances your understanding of chemical reactions but also plays a vital role in optimizing production processes and ensuring safety and efficiency in chemical manufacturing.

Frequently Asked Questions

How do you determine the number of grams of H_2 needed to produce 1.15 moles of NH_3 in the reaction $N_2 + 3H_2 \rightarrow 2NH_3$?

First, note the molar ratio: 3 mol H_2 produce 2 mol NH_3. To produce 1.15 mol NH_3, calculate the required H_2 as (1.15 mol NH_3) × (3 mol H_2 / 2 mol NH_3) = 1.725 mol H_2. Then, convert moles of H_2 to grams using its molar mass (2.02 g/mol): 1.725 mol × 2.02 g/mol ≈ 3.49 grams of H_2.

What is the molar mass of H_2, and how is it used to convert moles to grams in this calculation?

The molar mass of H_2 is approximately 2.02 grams per mole. It is used to convert moles of H_2 into grams by multiplying the number of moles by 2.02 g/mol, allowing you to find the mass needed for the reaction.

If the reaction is 100% efficient, how many grams of H_2 are required to produce 1.15 moles of NH_3?

Assuming 100% efficiency, the required grams of H_2 are approximately 3.49 grams, calculated based on the molar ratio and molar mass as explained earlier.

How would the calculation change if the yield of the reaction was only 80%?

If the yield is 80%, you need to produce more H_2 to compensate for inefficiency. Calculate the theoretical amount (about 3.49 g), then divide by 0.80: 3.49 g / 0.80 ≈ 4.36 grams of H_2 needed to produce 1.15 moles of NH_3 at 80% yield.

Why is it important to understand the molar ratio in stoichiometry problems like this?

The molar ratio indicates the relationship between reactants and products in a chemical reaction. It is essential for accurately calculating the amount of

reactants needed to produce a specific amount of product, ensuring precise and efficient chemical calculations.

Additional Resources

Given The Reaction: $N_2 + 3H_2 \rightarrow 2NH_3$ How Many Grams Of H_2 Are Needed To Produce Exactly 1.15 Moles Of NH_3?

When working with chemical reactions, one of the fundamental tasks is to determine how much of a reactant is needed to produce a specific amount of product. In this guide, we'll analyze the problem: Given the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, how many grams of H_2 are needed to produce exactly 1.15 moles of NH_3? This scenario involves stoichiometry—the calculation of reactant and product quantities based on a balanced chemical equation. Understanding this process is essential for students, chemists, and anyone involved in laboratory or industrial chemical processes.

Understanding the Chemical Reaction

Before diving into calculations, it's vital to understand the reaction at hand:

$N_2 + 3H_2 \rightarrow 2NH_3$

This reaction represents the synthesis of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2). It is a classic example of a balanced chemical equation, which indicates the molar ratios between reactants and products.

Key points:
- Reactants: Nitrogen gas (N_2) and hydrogen gas (H_2)
- Product: Ammonia (NH_3)
- Stoichiometric ratio:
- 1 mol of N_2 reacts with 3 mol of H_2
- Produces 2 mol of NH_3

Step 1: Identify the Known and Unknown Variables

In this problem:

- Known:
- Moles of NH_3 produced: 1.15 mol
- Unknown:
- Grams of H_2 required

Our goal is to find the mass of H_2 needed to produce exactly 1.15 mol of NH_3.

Step 2: Set Up the Mole Ratio from the Balanced Equation

The balanced equation provides the molar ratio:

- $NH_3 : H_2 = 2 : 3$

This ratio implies that for every 2 moles of ammonia produced, 3 moles of hydrogen are consumed.

Step 3: Use Mole Ratios to Find Moles of H_2 Needed

To determine the moles of H_2 required for 1.15 mol of NH_3:

$$
\text{Moles of } H_2 = \left(\frac{3\, \text{mol } H_2}{2\, \text{mol } NH_3} \right) \times 1.15\, \text{mol } NH_3
$$

Calculating:

$$
\text{Moles of } H_2 = 1.15 \times \frac{3}{2} = 1.15 \times 1.5 = 1.725\, \text{mol } H_2
$$

Thus, 1.725 moles of H_2 are needed to produce 1.15 moles of NH_3.

Step 4: Convert Moles of H_2 to Grams

To find the mass, we need the molar mass of H_2:

- Hydrogen atom (H): approximately 1.008 g/mol
- H_2 molecule: 2 × 1.008 g/mol = 2.016 g/mol

Now, multiply the moles of H_2 by its molar mass:

$$
\text{Mass of } H_2 = 1.725\, \text{mol} \times 2.016\, \text{g/mol} \approx 3.48\, \text{g}
$$

Answer: Approximately 3.48 grams of H_2 are required to produce exactly 1.15 moles of NH_3.

Additional Considerations

While the calculation above provides a clear answer, several factors should be considered in real-world applications:

1. Reaction Efficiency
- Industrial processes rarely achieve 100% conversion efficiency.
- Actual H_2 needed might be higher due to losses or side reactions.

2. Purity of Reactants
- Impurities can affect the amount of H_2 required.
- Purity levels should be factored into precise calculations.

3. Temperature and Pressure Conditions
- The reaction conditions influence yield and rate but not the stoichiometric

calculations directly.
- For actual industrial optimization, these parameters are critical.

Summary of the Calculation Process

Here's a step-by-step summary:

1. Identify the balanced chemical equation and molar ratios.
2. Use the molar ratio to relate moles of product to moles of reactant.
3. Calculate the necessary moles of reactant based on the desired amount of product.
4. Convert moles of reactant to grams using molar mass.

Final Thoughts

In chemical stoichiometry, understanding the relationship between reactants and products through the balanced equation is crucial. This specific example, calculating how many grams of H_2 are needed to produce a given amount of NH_3, serves as an excellent illustration of applying molar ratios and unit conversions in practical chemistry problems. Whether you're preparing for exams, designing industrial processes, or simply exploring chemical calculations, mastering these steps ensures accuracy and efficiency in your work.

Remember, always double-check your molar ratios and unit conversions to avoid common errors. With practice, these calculations become second nature, empowering you to solve a wide range of stoichiometric problems confidently.

In conclusion, approximately 3.48 grams of H_2 are necessary to produce 1.15 moles of NH_3 in the given reaction, following the principles of stoichiometry and molecular mass calculations.

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