How Many Grams Of Methane,CH4, Are Produced From Thecomplete Reaction Of 5.15 Molesof Carbon Monoxide,

How Many Grams Of Methane, CH_4, Are Produced From The Complete Reaction Of 5.15 Moles Of Carbon Monoxide

Understanding the chemical transformation of carbon monoxide (CO) into methane (CH_4) is a fundamental concept in organic and inorganic chemistry. This process involves specific reactions that convert gaseous carbon monoxide into a more stable hydrocarbon form, methane, which is the simplest alkane. In this article, we will delve into the details of how to determine the amount of methane produced from a given quantity of carbon monoxide, emphasizing the importance of stoichiometry, reaction mechanisms, and practical applications.

Introduction to the Reaction Between Carbon Monoxide and Hydrogen

The production of methane from carbon monoxide primarily involves a process known as methanation, which is a chemical reaction where carbon monoxide reacts with hydrogen to produce methane and water.

The Sabatier Process

One of the most well-known methods for converting CO into methane is the Sabatier process. This industrial process involves catalyzed reactions at elevated temperatures and pressures, typically using nickel catalysts:

\[\mathrm{CO} + 3\mathrm{H}_2 \rightarrow \mathrm{CH}_4 + \mathrm{H}_2\mathrm{O} \]

This reaction is exothermic and highly efficient, making it valuable for applications like space missions, where carbon dioxide and monoxide are converted into useful hydrocarbons.

Understanding the Chemical Equation

Before calculating how much methane is produced, it’s crucial to understand the stoichiometry of the reaction:

\[\mathrm{CO} + 3\mathrm{H}_2 \rightarrow \mathrm{CH}_4 +

$$\mathrm{H}_2\mathrm{O}$$

- Reactants:
- 1 mole of carbon monoxide (CO)
- 3 moles of hydrogen gas (H_2)

- Products:
- 1 mole of methane (CH_4)
- 1 mole of water (H_2O)

This balanced equation indicates that for every mole of CO consumed, one mole of methane is produced, provided there is sufficient hydrogen.

Calculating the Moles of Methane Produced

Given the initial amount of carbon monoxide, which is 5.15 moles, the question arises: How many grams of methane can be produced from this amount?

Step 1: Determine the Moles of CH_4 Formed

Based on the reaction's molar ratio, 1 mole of CO produces 1 mole of CH_4:

$$\text{Moles of CH}_4 = \text{Moles of CO} = 5.15 \text{ moles}$$

Note: This assumes complete reaction and sufficient hydrogen availability.

Step 2: Find the Molar Mass of Methane (CH_4)

The molar mass of methane is calculated as:

Element	Atomic Mass (g/mol)	Quantity in CH_4	Total Mass (g)
Carbon (C)	12.01	1	12.01
Hydrogen (H)	1.008	4	4.032
Total			16.04 g/mol

Therefore, 1 mole of methane weighs approximately 16.04 grams.

Step 3: Calculate the Mass of Methane Produced

Using the molar mass:

$$\text{Mass of CH}_4 = \text{Moles of CH}_4 \times \text{Molar mass of CH}_4$$

$$ \text{Mass of CH}_4 = 5.15 \text{ mol} \times 16.04 \text{ g/mol} $$

$$ \text{Mass of CH}_4 \approx 82.59 \text{ grams} $$

Therefore, approximately 82.59 grams of methane are produced from the complete reaction of 5.15 moles of carbon monoxide, assuming excess hydrogen and ideal reaction conditions.

Additional Factors Influencing the Reaction

While the theoretical calculation provides an ideal amount of methane produced, real-world conditions can influence the actual yield:

1. Reaction Efficiency

- Catalysts and reaction conditions (temperature, pressure) affect the rate and completeness of the reaction.
- Side reactions may occur, reducing the amount of methane formed.

2. Hydrogen Availability

- Since the reaction requires 3 moles of hydrogen per mole of CO, the amount of available hydrogen determines whether the reaction proceeds to completion.
- Insufficient hydrogen will limit methane production, leading to partial conversion.

3. Purity of Reactants

- Impurities in the gases can inhibit catalyst activity or lead to side reactions.

Practical Applications and Significance

Understanding the stoichiometry and calculations involved in methane production from carbon monoxide has several practical implications:

- **Space Missions and Life Support:** Converting CO_2 and CO into methane and water to support life systems.
- **Industrial Gas Processing:** Methanation used in synthetic natural gas (SNG) production.
- **Environmental Control:** Mitigating carbon monoxide emissions by

converting harmful gases into useful hydrocarbons.

Summary and Key Takeaways

- The reaction between carbon monoxide and hydrogen produces methane and water, governed by a simple molar ratio of 1:1.
- From 5.15 moles of CO, approximately 82.59 grams of methane can be produced under ideal conditions.
- Accurate calculations depend on understanding the stoichiometry, molar masses, and reaction conditions.
- Real-world yields can vary based on catalysts, reactant purity, and operational parameters.

Final Thoughts

Calculating the amount of methane produced from a given mole of carbon monoxide is a fundamental exercise in chemical stoichiometry. It demonstrates the importance of understanding balanced reactions, molar ratios, and molar masses to predict product quantities accurately. Whether for industrial applications, environmental management, or scientific research, mastering these calculations is essential for chemists and engineers alike.

Remember: Always consider practical factors that might influence the theoretical yield, and strive for optimal reaction conditions to maximize efficiency and product output.

Frequently Asked Questions

How many grams of methane (CH_4) are produced from the complete reaction of 5.15 moles of carbon monoxide (CO)?

Approximately 36.6 grams of methane are produced from 5.15 moles of CO, based on the reaction: $2CO + 2H_2 \rightarrow CH_4 + CO_2$.

What is the balanced chemical equation involved in converting carbon monoxide to methane?

The balanced reaction is: $2CO + 4H_2 \rightarrow CH_4 + 2H_2O$.

How do you calculate the mass of methane produced from a given number of moles of carbon monoxide?

First, determine the molar ratio from the balanced equation, then multiply the moles of CO by the molar ratio (1 mol CH_4 per 2 mol CO), and finally multiply by the molar mass of CH_4 (16.04 g/mol).

What is the molar mass of methane (CH_4)?

The molar mass of methane (CH_4) is approximately 16.04 grams per mole.

If 5.15 moles of CO are reacted completely, how many moles of CH_4 are formed?

According to the reaction stoichiometry, 2 moles of CO produce 1 mole of CH_4, so 5.15 moles of CO produce approximately 2.575 moles of CH_4.

Can the amount of methane produced from 5.15 moles of CO be directly calculated using the molar ratio?

Yes, using the molar ratio from the balanced equation, you can directly calculate the moles of CH_4 produced from the moles of CO reacted.

What assumptions are made when calculating the grams of methane produced from CO?

Assumptions include complete reaction without side products, ideal stoichiometry, and that all reactants are pure and fully reacted.

Is the reaction between CO and H_2 the only pathway for methane formation in this context?

In this context, the reaction considered is the reduction of CO with H_2 to form methane; other pathways are not considered unless specified.

How can experimental conditions affect the theoretical calculation of methane grams from CO?

Factors like reaction efficiency, incomplete reactions, side reactions, and impurities can cause actual yields to be lower than the theoretical calculation.

Additional Resources

Methane Production from Carbon Monoxide: An In-Depth Analysis

Understanding the quantitative relationship between different chemical compounds is fundamental in industrial chemistry, environmental science, and energy production. Today, we delve into a specific yet significant calculation: How many grams of methane (CH_4) are produced from the complete reaction of 5.15 moles of carbon monoxide (CO)? This question not only involves stoichiometry but also highlights the importance of chemical equations, molar relationships, and practical applications in real-world processes.

Introduction to the Reaction Context

Before we proceed with the calculations, it’s essential to grasp the chemical background of methane formation from carbon monoxide. The process is typically associated with catalytic reactions such as the Sabatier reaction, where carbon monoxide reacts with hydrogen to produce methane:

Reaction Equation:

\[CO + 3H_2 \rightarrow CH_4 + H_2O \]

This reaction is significant in fields like space exploration (life support systems), renewable energy (power-to-gas technology), and industrial synthesis of methane.

Key points:

- The reaction involves carbon monoxide (CO) and hydrogen gas (H_2).
- The product of interest is methane (CH_4).
- Complete reaction implies that all the CO reacts as per the balanced chemical equation.

Understanding the Stoichiometry

To determine how many grams of methane are produced from a given amount of CO, we need to analyze the molar relationships dictated by the reaction.

Balanced Chemical Equation

The reaction is already balanced:

\[CO + 3H_2 \rightarrow CH_4 + H_2O \]

This indicates:

- 1 mole of CO produces 1 mole of CH_4.
- The molar ratio of CO to CH_4 is 1:1.

Implication for Calculations

Given the molar ratio, the amount of methane produced directly correlates to the amount of carbon monoxide consumed, assuming complete reaction conditions and 100% efficiency.

Step-by-Step Calculation

Let's systematically work through the calculation process.

1. Identify the moles of CO

The problem states:

- Moles of CO = 5.15 mol

2. Determine moles of CH_4 produced

From the molar ratio:

- 1 mol CO → 1 mol CH_4

Therefore:

- Moles of CH_4 = Moles of CO = 5.15 mol

3. Convert moles of CH_4 to grams

To find the mass of methane produced, multiply the moles by the molar mass of CH_4.

Molar mass of CH_4:

- Carbon (C): 12.01 g/mol

- Hydrogen (H): 1.008 g/mol

Calculations:

$$ M_{CH_4} = 12.01 + 4 \times 1.008 = 12.01 + 4.032 = 16.042\, \text{g/mol} $$

Mass of methane:

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

$$ \text{Mass of CH}_4 = 5.15\, \text{mol} \times 16.042\, \text{g/mol} \approx 82.66\, \text{g} $$

Additional Considerations

While the calculation appears straightforward, several practical factors influence the actual yield and process efficiency.

1. Reaction Conditions

- Temperature and Pressure: Both influence reaction completeness and yield.
- Catalysts: Typically, nickel catalysts are used to facilitate the Sabatier reaction.
- Purity of Reactants: Impurities may reduce the efficiency.

2. Side Reactions and Byproducts

- Not all reactions proceed with 100% efficiency; side reactions could produce other compounds, reducing the amount of methane obtained.
- In industrial settings, yields are often less than theoretical due to process limitations.

3. Energy and Cost Considerations

- The reaction requires specific energy inputs to maintain optimal conditions.
- Hydrogen availability and cost impact the feasibility of methane production.

Summary of Key Findings

Parameter	Value
Moles of CO supplied	5.15 mol
Moles of CH_4 produced	5.15 mol
Molar mass of CH_4	16.042 g/mol
Total grams of CH_4 produced	approximately 82.66 g

This calculation confirms that, under ideal conditions, 5.15 moles of carbon monoxide will produce approximately 82.66 grams of methane.

Implications and Applications

Understanding this stoichiometric relationship is critical in various applications:

- Renewable Energy Storage: Methane is used as a storable energy carrier; knowing production quantities aids in designing efficient systems.
- Space Missions: The Sabatier process enables astronauts to generate water and fuel from CO and H_2, making precise calculations vital for mission planning.
- Industrial Gas Synthesis: Scaling reactions from laboratory to industrial levels requires accurate molar conversions.

Final Remarks

The journey from a simple mole ratio to a tangible mass underscores the importance of stoichiometry in chemistry. Whether optimizing industrial processes, designing sustainable energy systems, or conducting academic research, such calculations form the backbone of precise and efficient chemical engineering.

In conclusion, complete reaction of 5.15 moles of carbon monoxide in a typical Sabatier process results in approximately 82.66 grams of methane under ideal conditions. Understanding these relationships not only enhances our grasp of chemical processes but also empowers advancements in energy, environmental management, and space exploration.

```
Note: Always consider real-world factors such as reaction efficiency, purity
of reactants, and operational conditions when applying these theoretical
calculations to practical scenarios.
```

How Many Grams Of Methane Ch4 Are Produced From Thecomplete Reaction Of 5 15 Molesof Carbon Monoxide

How Many Grams Of Methane Ch4 Are Produced From Thecomplete Reaction Of 5 15 Molesof Carbon Monoxide

Related Articles

- In A Certain Population Of Lizards, Some Of The Lizards Have Longer Legs Than Others. After A New Kind
- Football Player Joe Is Running Toward The Opponent's Goal Line With The Football, And Slows Down As He
- Hannah Has Two Bags Of Sweets.In The First Bag There Are 5 Red Sweets And 7 Green Sweets.In The Second

Back to Home