What Mass Of Carbon Dioxide Is Formed In The Combustion Of 78. 7 G Of Acetone?.

What Mass Of Carbon Dioxide Is Formed In The Combustion Of 78. 7 G Of Acetone?

Understanding the combustion of organic compounds such as acetone is fundamental in chemistry, especially when calculating the amount of gases produced during combustion reactions. In this comprehensive guide, we will explore the process of determining the mass of carbon dioxide (CO_2) generated when 78.7 grams of acetone (C_3H_6O) undergoes complete combustion. This analysis involves understanding the chemical reaction, mole calculations, and applying stoichiometry principles to arrive at an accurate result.

Introduction to Acetone and Its Combustion

What Is Acetone?

Acetone, with the chemical formula C_3H_6O, is a common organic solvent used in various industrial and household applications. It is a colorless, volatile, and flammable liquid that belongs to the ketone family. Due to its widespread use, understanding its combustion is important for safety and environmental considerations.

The Combustion Reaction of Acetone

The complete combustion of acetone involves its reaction with oxygen (O_2) to produce carbon dioxide (CO_2) and water (H_2O). The general reaction can be written as:

$C_3H_6O + O_2 \rightarrow CO_2 + H_2O$

However, to balance this reaction properly, we need to determine the coefficients that satisfy the law of conservation of mass.

Balancing the Combustion Equation

Step-by-Step Balancing

Let's balance the combustion of acetone:

1. Write the unbalanced equation:

$C_3H_6O + O_2 \rightarrow CO_2 + H_2O$

2. Balance the carbon atoms:

$C_3H_6O + O_2 \rightarrow 3\ CO_2 + H_2O$

3. Balance the hydrogen atoms:

$C_3H_6O + O_2 \rightarrow 3\ CO_2 + 3\ H_2O$

4. Balance the oxygen atoms:

- Left side: C_3H_6O has 1 oxygen atom.
- Right side: 3 CO_2 has 3×2=6 oxygen atoms, and 3 H_2O has 3 oxygen atoms, totaling 9 oxygen atoms.

- Total oxygen atoms on the right: 9
- On the left: 1 (from C_3H_6O) + x (from O_2 molecules)

To balance oxygen:

$1 + 2x = 9$

$2x = 8$

$x = 4$

Thus, the balanced chemical equation is:

$C_3H_6O + 4\ O_2 \rightarrow 3\ CO_2 + 3\ H_2O$

Calculating the Moles of Acetone

Determining Molar Mass of Acetone

To convert grams to moles, we need the molar mass of acetone:

- Carbon (C): 12.01 g/mol
- Hydrogen (H): 1.008 g/mol
- Oxygen (O): 16.00 g/mol

Calculating:

(3 × 12.01) + (6 × 1.008) + (1 × 16.00) = 36.03 + 6.048 + 16.00 = 58.078 g/mol

Converting Grams to Moles

Given mass: 78.7 g

Number of moles of acetone:

$$
\text{Moles of C}_3\text{H}_6\text{O} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{78.7\, \text{g}}{58.078\, \text{g/mol}} \approx 1.355\, \text{mol}
$$

Using Stoichiometry to Find CO_2 Produced

The Stoichiometric Relationship

From the balanced chemical equation:

$C_3H_6O + 4\ O_2 \rightarrow 3\ CO_2 + 3\ H_2O$

- 1 mol of acetone produces 3 mol of CO_2.

Therefore, the moles of CO_2 produced from 1.355 mol of acetone:

$$
\text{Moles of CO}_2 = 1.355\, \text{mol} \times 3 = 4.065\, \text{mol}
$$

Calculating the Mass of CO_2

The molar mass of CO_2:

- Carbon: 12.01 g/mol
- Oxygen: 16.00 g/mol (×2)

Total:

12.01 + (2 × 16.00) = 12.01 + 32.00 = 44.01 g/mol

Now, the mass of CO_2 formed:

$$
\text{Mass of CO}_2 = 4.065\, \text{mol} \times 44.01\, \text{g/mol} \approx 178.8\, \text{g}
$$

\]

Final Result and Interpretation

Based on the calculations, when 78.7 grams of acetone undergoes complete combustion, approximately 178.8 grams of carbon dioxide are produced.

Key Takeaways:

1. The combustion of acetone results in the formation of CO_2 and H_2O, following a balanced chemical reaction.
2. Stoichiometric calculations involve converting grams to moles, applying mole ratios, and converting moles back to grams.
3. The amount of CO_2 produced is roughly 2.27 times the initial mass of acetone, highlighting the significant increase in gas volume and mass during combustion.

Factors Affecting the Accuracy of the Calculation

While the above calculation provides a theoretical value, several practical factors can influence the actual amount of CO_2 produced:

Purity of Acetone

Impurities in acetone may reduce the amount of combustion products formed.

Complete Combustion Assumption

This calculation assumes complete combustion; in real-world scenarios, incomplete combustion may occur, producing CO and other byproducts.

Environmental Conditions

Temperature and pressure can affect gas volumes, especially if considering gaseous measurements rather than mass.

Applications and Environmental Implications

Understanding how much CO_2 is produced during acetone combustion is essential for:

- Environmental impact assessments, especially regarding greenhouse gas emissions.
- Industrial safety planning for processes involving acetone burning.
- Designing better combustion systems to minimize CO_2 and other pollutants.

Conclusion

In summary, the combustion of 78.7 grams of acetone results in approximately 178.8 grams of carbon dioxide, assuming complete combustion. This calculation underscores the importance of stoichiometry in chemical reactions and illustrates the significant environmental considerations associated with organic solvent combustion. Mastery of these calculations is vital for chemists, environmental scientists, and engineers working towards safer and greener chemical processes.

References:

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Petrucci, R. H., Herring, F. G., Madura, J. D., & Bissonnette, C. (2017). General Chemistry: Principles & Modern Applications. Pearson.
- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics. CRC Press.

Note: Always double-check calculations and consider real-world variables when applying theoretical results to practical scenarios.

Frequently Asked Questions

What is the chemical formula of acetone?

The chemical formula of acetone is C_3H_6O.

How do you determine the molar mass of acetone?

The molar mass of acetone is calculated as (3 × 12.01) + (6 × 1.008) + (16.00) = 58.08 g/mol.

What is the balanced chemical equation for the combustion of acetone?

The balanced combustion reaction is: $C_3H_6O + 4\ O_2 \rightarrow 3\ CO_2 + 3\ H_2O$.

How do you calculate the moles of acetone in 78.7 g?

Moles of acetone = 78.7 g ÷ 58.08 g/mol ≈ 1.355 mol.

What is the molar ratio of acetone to carbon dioxide in the combustion reaction?

From the balanced equation, 1 mol of acetone produces 3 mol of CO_2.

How do you find the mass of CO_2 produced from 1.355 mol of acetone?

Mass of CO_2 = 1.355 mol × 3 mol CO_2/mol acetone × 44.01 g/mol ≈ 178.7 g.

What is the final mass of carbon dioxide formed in the combustion of 78.7 g of acetone?

Approximately 178.7 grams of CO_2 are formed.

Why is understanding molar ratios important in combustion calculations?

Molar ratios allow accurate conversion between reactants and products, ensuring precise mass calculations in chemical reactions.

Can the combustion of acetone be considered complete in this context?

Yes, assuming ideal conditions, the combustion of acetone is complete, producing carbon dioxide and water as the only products.

Additional Resources

What Mass Of Carbon Dioxide Is Formed In The Combustion Of 78.7 G Of Acetone?

Understanding the combustion process of organic compounds like acetone is fundamental in chemistry, especially when quantifying the amount of products formed. In this detailed exploration, we will analyze the steps involved in calculating the mass of carbon dioxide produced from the combustion of 78.7 grams of acetone (C_3H_6O). This involves delving into chemical formulas, molar masses, stoichiometry, and the combustion reaction mechanism.

Introduction to Acetone and Combustion Principles

Acetone, also known as propanone, is a common organic solvent with the chemical formula C_3H_6O. It is characterized by a carbonyl group (C=O) attached to a three-carbon chain, making it a simple ketone.

Key points:

- Chemical formula: C_3H_6O
- Molar mass: Approximately 58.08 g/mol
- Physical properties: Colorless, volatile, flammable liquid

Combustion is a chemical reaction where a substance reacts with oxygen, releasing energy in the form of heat and light. For organic compounds like acetone, combustion typically produces carbon dioxide (CO_2) and water (H_2O).

Understanding the Combustion Reaction of Acetone

The general combustion of an organic compound containing carbon, hydrogen, and possibly oxygen can be written as:

$$ \text{C}_x\text{H}_y\text{O}_z + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} $$

For acetone (C_3H_6O), the balanced combustion equation is derived as follows:

1. Write the unbalanced equation:

$$ \text{C}_3\text{H}_6\text{O} + O_2 \rightarrow CO_2 + H_2O $$

2. Balance carbon atoms:

$$ C_3H_6O + O_2 \rightarrow 3\, CO_2 + H_2O $$

3. Balance hydrogen atoms:

$$ C_3H_6O + O_2 \rightarrow 3\, CO_2 + 3\, H_2O $$

4. Balance oxygen atoms:

- On the right side, total oxygen atoms:

$$ (3 \times 2) + 3 = 6 + 3 = 9 $$

- On the left side, acetone provides 1 oxygen atom; the remaining oxygen atoms come from O_2 molecules.

- Total oxygen needed from O_2:

$$ 9 - 1 = 8 $$

- Since each O_2 molecule contains 2 oxygen atoms:

$$ \frac{8}{2} = 4 $$

- The balanced combustion equation:

$$ C_3H_6O + 4\, O_2 \rightarrow 3\, CO_2 + 3\, H_2O $$

Summary:

- 1 mole of acetone produces 3 moles of CO_2 upon complete combustion.

Calculating Moles of Acetone Consumed

Given the mass of acetone (78.7 g), the first step is to determine the number of moles:

$$ \text{Number of moles} = \frac{\text{Mass}}{\text{Molar mass}} $$

- Molar mass of acetone (C_3H_6O):

$$ (3 \times 12.01) + (6 \times 1.008) + (1 \times 16.00) = 36.03 + 6.048 + 16.00 = 58.078\, \text{g/mol} $$

- Moles of acetone:

$$ \frac{78.7\, \text{g}}{58.078\, \text{g/mol}} \approx 1.355\, \text{mol} $$

Stoichiometric Relationship Between Acetone and CO_2

From the balanced combustion equation:

$$ 1\, \text{mol} \text{ of acetone} \rightarrow 3\, \text{mol} \text{ of CO}_2 $$

Therefore, the total moles of CO_2 produced from 1.355 mol of acetone:

$$ 1.355\, \text{mol} \times 3 = 4.065\, \text{mol} $$

Calculating the Mass of Carbon Dioxide Formed

Next, we determine the mass of CO_2 produced using its molar mass:

- Molar mass of CO_2:

$$ (1 \times 12.01) + (2 \times 16.00) = 12.01 + 32.00 = 44.01\, \text{g/mol} $$

- Mass of CO_2:

$$ 4.065\, \text{mol} \times 44.01\, \text{g/mol} \approx 178.8\, \text{g} $$

Result:

Approximately 178.8 grams of carbon dioxide are formed when 78.7 grams of acetone undergo complete combustion.

Discussion of Key Factors and Assumptions

This calculation assumes ideal conditions and complete combustion, which is

often the case in theoretical chemistry calculations but may vary in practical scenarios.

Important considerations:

- Complete combustion: Ensures all carbon is converted to CO_2; in reality, incomplete combustion can produce CO or other carbon compounds.
- Purity of acetone: The calculation presumes pure acetone; impurities could affect the actual amount of CO_2 produced.
- Reaction conditions: Temperature and pressure influence reaction efficiency but do not alter molar ratios in ideal calculations.

Extensions and Related Concepts

1. Energy released during combustion:

- The heat of combustion of acetone is approximately -1660 kJ/mol.
- Total energy released:

$$ 1.355\, \text{mol} \times 1660\, \text{kJ/mol} \approx 2248\, \text{kJ} $$

2. Environmental implications:

- CO_2 is a greenhouse gas; understanding combustion outputs helps in assessing environmental impact.
- Efficient combustion reduces unburned hydrocarbons and pollutants.

3. Application in industry and laboratory:

- Calculating combustion products is crucial in chemical engineering for designing reactors and pollution control systems.

Conclusion

The combustion of 78.7 grams of acetone results in the formation of approximately 178.8 grams of carbon dioxide under ideal, complete combustion conditions. This calculation hinges on understanding the chemical formula, molar masses, balanced chemical equations, and stoichiometry principles. Such quantitative analyses are fundamental in both academic and industrial chemistry, aiding in energy calculations, environmental impact assessments, and process optimization.

Summary Table

Step	Description	Calculation	Result
1	Molar mass of acetone (C_3H_6O)	58.08 g/mol	–
2	Moles of acetone in 78.7 g	78.7 / 58.08	~1.355 mol
3	Moles of CO_2 produced	1.355 mol × 3	~4.065 mol
4	Mass of CO_2	4.065 mol × 44.01 g/mol	~178.8 g

This comprehensive overview provides a clear pathway from initial data to final quantification, illustrating the practical application of stoichiometry in chemical reactions.

What Mass Of Carbon Dioxide Is Formed In The Combustion Of 78 7 G Of Acetone

What Mass Of Carbon Dioxide Is Formed In The Combustion Of 78 7 G Of Acetone

Related Articles

- PLSSS HELPPPPP MEEEEE 20 POINTSSmake Ur Own Sentences Using The Word Aspire
- State The Law Of Conservation Of Linear Momentum And Describe Its Consequences.
- How Many Amino Acids Would The Follow Strand Of MRNA Code For?UGCCGAUAA9632

Back to Home