

Enter A Balanced Equation For The Complete Combustion Of Liquid C₃H₇SH. Express Your Answer As A

Enter A Balanced Equation For The Complete Combustion Of Liquid C₃H₇SH. Express Your Answer As A this chemical reaction involves understanding the combustion process of thiol compounds, specifically propanethiol (C₃H₇SH). Combustion reactions are fundamental in chemistry, especially in fields like energy production, environmental science, and chemical manufacturing. Achieving a balanced equation is crucial because it ensures the conservation of mass, indicating that the number of atoms for each element remains constant on both sides of the equation. In this article, we will explore the step-by-step process of balancing the complete combustion of liquid C₃H₇SH, understanding the underlying principles, and providing the final balanced chemical equation.

Understanding Complete Combustion

What Is Complete Combustion?

Complete combustion occurs when a hydrocarbon or sulfur-containing compound reacts fully with oxygen (O₂), producing carbon dioxide (CO₂), water (H₂O), and sulfur dioxide (SO₂). This process releases energy in the form of heat and light and is characterized by a clean flame with no soot or carbon monoxide formation. For hydrocarbons, complete combustion results in CO₂ and H₂O, but when sulfur is present, sulfur oxides are also produced.

Products of Complete Combustion of C₃H₇SH

The products depend on the elements present:

- Carbon (C) forms CO₂
- Hydrogen (H) forms H₂O
- Sulfur (S) forms SO₂ (sulfur dioxide)

The general reaction involves the oxidation of the organic part (C₃H₇SH) and sulfur, with oxygen as the reactant.

Chemical Composition of C₃H₇SH

Before balancing, it's important to analyze the molecular formula:

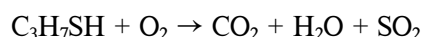
- Carbon atoms: 3
- Hydrogen atoms: 7
- Sulfur atom: 1
- The molecule is a thiol (mercaptan), specifically propanethiol.

This molecular structure influences the combustion products and the balancing process.

Step-by-Step Process to Balance the Combustion Equation

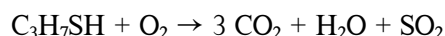
Step 1: Write the Unbalanced Equation

The unbalanced combustion of C₃H₇SH can be expressed as:



Step 2: Balance Carbon Atoms

Since there are 3 carbon atoms in C₃H₇SH, the products will have 3 CO₂ molecules:



Step 3: Balance Hydrogen Atoms

There are 7 hydrogen atoms in C₃H₇SH, so we need 3.5 H₂O molecules:



To avoid fractional coefficients, multiply the entire equation by 2 later.

Step 4: Balance Sulfur Atoms

There is 1 sulfur atom in C₃H₇SH, producing 1 SO₂ molecule:



Step 5: Balance Oxygen Atoms

Count the oxygen atoms on the right side:

- From 3 CO₂: $3 \times 2 = 6$ O
- From 3.5 H₂O: $3.5 \times 1 = 3.5$ O
- From SO₂: 2 O

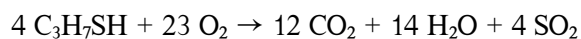
Total oxygen atoms needed: $6 + 3.5 + 2 = 11.5$ O

On the left side, oxygen molecules (O₂) contribute 2 O atoms each. Let's set the coefficient of O₂ as x:

$$2x = 11.5$$

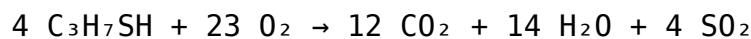
$$x = 5.75$$

To eliminate fractions, multiply the entire equation by 4:



Final Balanced Equation

After multiplying through by 4 to clear fractions, the balanced molecular equation is:



This equation indicates:

- 4 molecules of propanethiol react with 23 molecules of oxygen.
- The products are 12 molecules of carbon dioxide, 14 molecules of water, and 4 molecules of sulfur dioxide.

Significance of the Balanced Equation

Environmental Considerations

Understanding the complete combustion of C₃H₇SH is essential for environmental management. Complete combustion minimizes harmful emissions like carbon monoxide and unburned hydrocarbons. However, sulfur dioxide produced can lead to acid rain if not properly scrubbed.

Industrial Applications

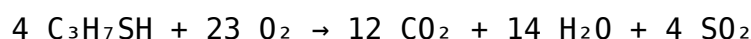
Propane thiols are used in various industries, including flavorings, pharmaceuticals, and as chemical intermediates. Knowledge of their combustion helps in designing safe combustion systems and pollution control measures.

Additional Insights and Tips

- Always balance carbon atoms first, then hydrogen, then sulfur, followed by oxygen.
- Multiplying through by the smallest common factor ensures whole number coefficients.
- Understanding the products helps in environmental impact assessments and process optimization.

Conclusion

Balancing the complete combustion of liquid $\text{C}_3\text{H}_7\text{SH}$ involves careful analysis of the molecular composition and systematic balancing of each element. The final balanced equation:



represents a complete and accurate depiction of the chemical process, vital for both theoretical understanding and practical applications in environmental science and chemical engineering. Properly balancing such equations not only reflects the conservation of mass but also informs us about the environmental impact of burning sulfur-containing hydrocarbons.

Frequently Asked Questions

What is the chemical formula for the complete combustion of liquid $\text{C}_3\text{H}_7\text{SH}$?

The complete combustion of $\text{C}_3\text{H}_7\text{SH}$ (propane-1-thiol) produces carbon dioxide (CO_2), water (H_2O), and sulfur dioxide (SO_2). The balanced equation is: $2 \text{ C}_3\text{H}_7\text{SH} + 11 \text{ O}_2 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + 2 \text{ SO}_2$.

How do you balance the complete combustion equation of C₃H₇SH as a word equation?

The combustion of C₃H₇SH in oxygen produces carbon dioxide, water, and sulfur dioxide, written as: Propane-1-thiol reacts with oxygen to form carbon dioxide, water, and sulfur dioxide.

What are the products of the complete combustion of C₃H₇SH?

The products are carbon dioxide (CO₂), water (H₂O), and sulfur dioxide (SO₂).

How many moles of oxygen are needed to completely combust 1 mole of C₃H₇SH?

Based on the balanced equation, 11/2 moles of O₂ are needed per mole of C₃H₇SH, i.e., 5.5 moles of O₂.

Why is it important to balance the combustion equation of C₃H₇SH?

Balancing ensures the law of conservation of mass is obeyed, showing that the number of atoms of each element is the same on both sides of the equation.

Can you express the balanced combustion equation of C₃H₇SH as a molecular equation?

Yes. The balanced molecular equation is: $2 \text{C}_3\text{H}_7\text{SH} + 11 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + 2 \text{SO}_2$.

What is the significance of expressing the combustion equation as a balanced chemical equation?

It allows for accurate calculation of reactants and products involved in the reaction, essential for stoichiometry and chemical engineering applications.

In the complete combustion of C₃H₇SH, what role does sulfur play?

Sulfur in C₃H₇SH is oxidized to sulfur dioxide (SO₂) during combustion, which is a product of sulfur oxidation in the reaction.

Additional Resources

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Understanding the Complete Combustion of $\text{C}_3\text{H}_7\text{SH}$: A Detailed Explanation

In the realm of organic chemistry and combustion processes, understanding how different compounds burn is fundamental. Today, we focus on a specific molecule: n-propyl mercaptan ($\text{C}_3\text{H}_7\text{SH}$), a sulfur-containing organic compound often used for its distinctive odor in natural gas detection and various industrial applications. Our goal is to write and balance the complete combustion equation of this compound, expressed as A.

The Significance of Balancing Combustion Equations

Before diving into the specifics of $\text{C}_3\text{H}_7\text{SH}$, it's essential to understand why balancing combustion equations is crucial:

- **Conservation of Mass:** A fundamental principle in chemistry states that matter cannot be created or destroyed in a chemical reaction. Balancing ensures the same number of atoms of each element appear on both sides of the equation.
- **Quantitative Analysis:** Properly balanced equations allow chemists to calculate reaction yields, understand energy release, and determine pollutant emissions.
- **Industrial Applications:** In energy production, accurate combustion equations facilitate efficient fuel use and emission control.

Chemical Structure and Composition of $\text{C}_3\text{H}_7\text{SH}$

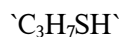
To accurately write the combustion equation, we first analyze the molecular structure:

- $\text{C}_3\text{H}_7\text{SH}$ is a mercaptan (thiol), consisting of:
 - A propyl group (C_3H_7-)
 - A thiol group ($-\text{SH}$)

This implies that the molecule has:

- 3 carbon atoms
- 8 hydrogen atoms (7 from the alkyl chain + 1 from the thiol group)
- 1 sulfur atom

Expressed as:



The Concept of Complete Combustion

Complete combustion occurs when a hydrocarbon or related compound burns in an excess of oxygen, producing:

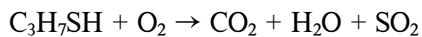
- Carbon dioxide (CO₂) for carbon content
- Water (H₂O) for hydrogen content
- Sulfur dioxide (SO₂) if sulfur is present and oxygen is sufficient

In this context, since the compound contains sulfur, the combustion will produce sulfur dioxide (SO₂), assuming complete combustion with enough oxygen.

Step-by-Step Derivation of the Combustion Equation

Step 1: Write the Unbalanced Equation

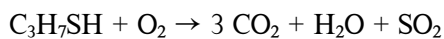
The unbalanced combustion of C₃H₇SH can be represented as:



Step 2: Balance Carbon Atoms

- The molecule has 3 carbons, so:

3 C atoms on the reactant side → 3 CO₂ molecules on the product side:



Step 3: Balance Hydrogen Atoms

- The molecule has 8 hydrogens:

8 H atoms → 4 H₂O molecules:



Step 4: Balance Sulfur Atoms

- One sulfur atom in the reactant:

1 S atom $\rightarrow$ 1 SO₂ molecule:



Step 5: Balance Oxygen Atoms

Now, count the oxygen atoms on the right:

- 3 CO₂ molecules: $3 \times 2 = 6$ oxygens

- 4 H₂O molecules: $4 \times 1 = 4$ oxygens

- 1 SO₂ molecule: 2 oxygens

Total oxygen atoms on the right:

$$6 + 4 + 2 = 12$$

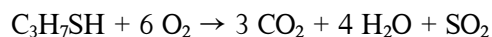
On the left, oxygen is supplied as O₂ molecules. Let the coefficient of O₂ be x:

Oxygen atoms on the left: 2x

Set up the balance:

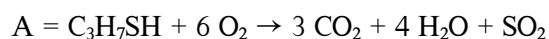
$$2x = 12 \rightarrow x = 6$$

Final Balanced Equation:



Expressing the Balanced Equation as A

The problem specifies the answer should be expressed as A. Thus, we can write:



This balanced equation fully captures the complete combustion of liquid C₃H₇SH.

Additional Insights: Energy and Environmental Implications

Energy Release

- Combustion reactions are exothermic, releasing heat energy.
- The energy released depends on the bond energies of reactants and products.
- While not calculated here, such equations are foundational for thermodynamic calculations related to fuel efficiency and power generation.

Environmental Impact

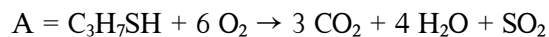
- Complete combustion minimizes pollutants like carbon monoxide (CO) and particulate matter.
- The formation of SO₂ can lead to acid rain, highlighting the importance of emission controls when burning sulfur-containing compounds.

Practical Applications and Safety Considerations

- Industrial processes involving propane, natural gas, and sulfur compounds require precise combustion control based on balanced equations.
- Mercaptans like C₃H₇SH are used as odorants for natural gas detection, but their combustion must be managed carefully to prevent harmful emissions.
- Safety protocols demand understanding of combustion equations to design appropriate ventilation and emission filtration systems.

Summary

In conclusion, the complete combustion of liquid C₃H₇SH (n-propyl mercaptan) in excess oxygen is accurately represented by the balanced chemical equation:



This equation demonstrates the conservation of atoms and provides a basis for calculating energy release, pollutant formation, and process efficiency in practical applications ranging from energy generation to environmental management.

Understanding the intricacies of combustion reactions like this not only advances chemical knowledge but also underscores the importance of precise chemical calculations in safeguarding our environment and optimizing industrial processes.

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