

Context ONE: Cooking with Natural Gas

1. Natural gas contains a colourless gas called methane (CH_4) and is used in many homes for cooking or heating. When a student was at home, they used a saucepan to boil some water to cook pasta - they noticed that the flame was blue, and initially, some water condensed on the outer surface of the pot. An air quality monitor showed increasing levels of carbon dioxide.



carbon dioxide levels

From the context above and the resource sheet, identify the following:

The observations	They noticed a blue flame, moisture condensing around surface of the pot, air quality monitor shows increasing carbon dioxide levels
The reactants	Methane (CH_4) and Oxygen (O_2)
The products	Carbon dioxide (CO_2) and water (H_2O)
Word equation	Methane + Oxygen \rightarrow Carbon dioxide + water
Balanced chemical equation	$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

2. Identify the type of reaction this is and the predictable pattern

Generic equation from the resource sheet	Type of reaction complete combustion.
Carbon compound + Oxygen (excess) \rightarrow Carbon dioxide + water.	

Explanation

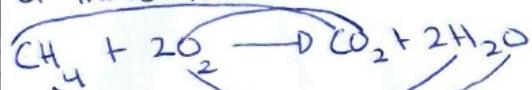
It fits the predictable pattern of complete combustion because a carbon compound (methane) combusts in excess oxygen to produce carbon dioxide and water.

3. Explain how the balanced chemical equation shows that **mass is conserved** by considering how the reactants turn into the products.

You should discuss:

- The types of atoms present.
- The number of atoms of each type (this can be shown by a table or diagram).
- How all of the atoms originally present in the reactants are rearranged to form the products.

The Law of Conservation of Mass states that matter cannot be created nor destroyed, therefore mass of reactants must equal to mass of products. In this combustion reaction, $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$, methane combusts in sufficient oxygen to produce carbon dioxide and water. From the reactants, C, H, O rearrange into new combinations to create the products. The 1C from CH_4 combines with 2O in 2O_2 to create the 1C in CO_2 . Similarly, the 4H in CH_4 combine with 2O from 2O_2 to produce the 4H in $2\text{H}_2\text{O}$. In the reactants, C, H, O simply rearrange into new combinations, showing that mass has been conserved. This shows that there are the same type and number of atoms in products, as they were in reactants. The total mass of carbon dioxide and water is equivalent to total mass of methane and oxygen. Therefore, shows that law of conservation of mass has been conserved.



Reactants:	products:
C = 1	C = 1
H = 4	H = 4
O = 4	O = 4

4. Using the **observations** from the information above and the **predictable pattern**, explain how this reaction links to the context.

You may also include **observations from laboratory experiments** if these will help your explanation.

In this reaction, you can see that $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$, a colourless gas methane combusts in colourless gas oxygen to produce and water. This is complete combustion because observations such as blue flame, moisture condensing on outer surface of test, and colourless gas given off during the reaction (turns lime water cloudy which is a positive test for CO_2 , during lab experiments).

- The blue flame indicates sufficient supply of oxygen, indicating complete combustion.
- The colourless liquid was identified as water. It turns blue cobalt chloride paper pink during lab experiments).

These observations are consistent with the predictable pattern of complete combustion.

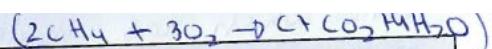
5. Due to their kitchen being renovated, the student's parents decided to cook in their garage and shifted the stove and other cooking materials to the small enclosed garage, which did not have any windows. They also noticed that the bottom of the saucepan was "dirty" and left a black solid on a cloth when it was cleaned and the flame was yellow. The equation for this reaction is



2 : 3

1 = 1.5 per methane molecule

a. Discuss how **conservation of mass** explains the observed differences in the products between this reaction and the one described in question 1.



b. Compare and contrast the consequences for people and the home environment between using a blue or yellow flame for cooking or heating.

Use the predictable patterns, observations and equations to help you do this.

The law of conservation of mass states that matter cannot be created nor destroyed. (mass of reactants must equal to mass of products). The products depend on how many O_2 are available to react. When there were 3O_2 available per methane molecule, all H atoms initially reacted with any available O_2 to produce H_2O . Then, C reacted with any remaining O_2 to produce carbon dioxide. However, when there were 1.5 O_2 molecules per methane molecule, all H atoms firstly reacted with available O_2 to produce H_2O . Any remaining O_2 reacted with C to produce CO_2 , but there were more C than O_2 , and since the supply of oxygen was insufficient than O_2 , and since the supply of oxygen was insufficient, some carbon atoms remained unreacted as carbon/soot. The unburnt carbon glows yellow/orange in the flame when heated.

Similarities:

In both complete and incomplete combustion, all H atoms will initially react with available O_2 , to produce H_2O . (If the supply of oxygen is insufficient for that to happen, then no combustion reaction will take place at all).

- both complete and incomplete combustion produce heat energy.
- the H_2O produced contributes to damp houses, promotes mold growth, and even allergic reactions etc.

→ The supply of oxygen was sufficient

The supply of oxygen was insufficient.

Differences:

- The complete combustion in q.t produces a hotter blue flame, which has shorter cooking times and is more energy efficient.
- The incomplete combustion in q.s produces a cooler yellow flame, which has longer cooking times and is less energy efficient, using more fuel.
- One of the products produced in incomplete combustion is carbon soot, which can lead to:
 - can cause health issues related to lungs/breathing
 - cause discolouration of pots and walls.
 - reduce the amount of photosynthesis taking place, as it blocks leaves from receiving sunlight, which can lead to less oxygen being produced.

~~QUESTION~~

Grade: Excellence

For Excellence, the student needs to interpret chemical reactions in context.

This involves discussing the implications of conservation of mass in the context of each chemical reaction, with reference to predictable patterns, observations, and equations.

This student has discussed an implication of conservation of mass related to the combustion context of cooking with natural gas. The student used conservation of mass to discuss the observation of soot forming on the outside of the pot when there was a decrease in the amount of oxygen available to react with methane. This is linked to predictable patterns, observations, and equations (both complete and incomplete combustion). Similar evidence for two other different reaction types is required for an overall grade of Excellence.