Combustion of Methane: How do molecules rearrange in a chemical reaction?

The students make a model to show that in a chemical reaction the atoms of the reactants rearrange to form the products.

Question to Investigate: Where do the atoms in the products of a chemical reaction come from?

Materials

- Atom model cut-outs: carbon, oxygen, and hydrogen (attached)
- Sheet of colored paper or construction paper
- Colored pencils
- Scissors
- Glue or tape

Combustion of methane: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

Procedure

Prepare the Atoms

1. Color the carbon atoms black, the oxygen atoms red, and leave the hydrogen atoms white.
2. Use scissors to carefully cut out the atoms.

Build the Reactants

1. On a sheet of paper, place the atoms together to make the molecules of the reactants on the left side of the chemical equation for the combustion of methane.
2. Write the chemical formula under each molecule of the reactants. Also draw a + sign between the reactants.

Build the Products

1. Draw an arrow after the second oxygen molecule to show that a chemical reaction is taking place.
2. Rearrange the atoms in the reactants to make the molecules in the products on the right side of the arrow.
3. Write the chemical formula under each molecule of the products. Also draw a + sign between the products.

Represent the Chemical Equation

1. Use their remaining atoms to make the reactants again to represent the chemical reaction as a complete chemical equation.
2. Glue or tape the atoms to the paper to make a more permanent chemical equation of the combustion of methane.
3. Count up the number of atoms on each side of the equation. And record in the table on the next page:

Combustion of methane: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

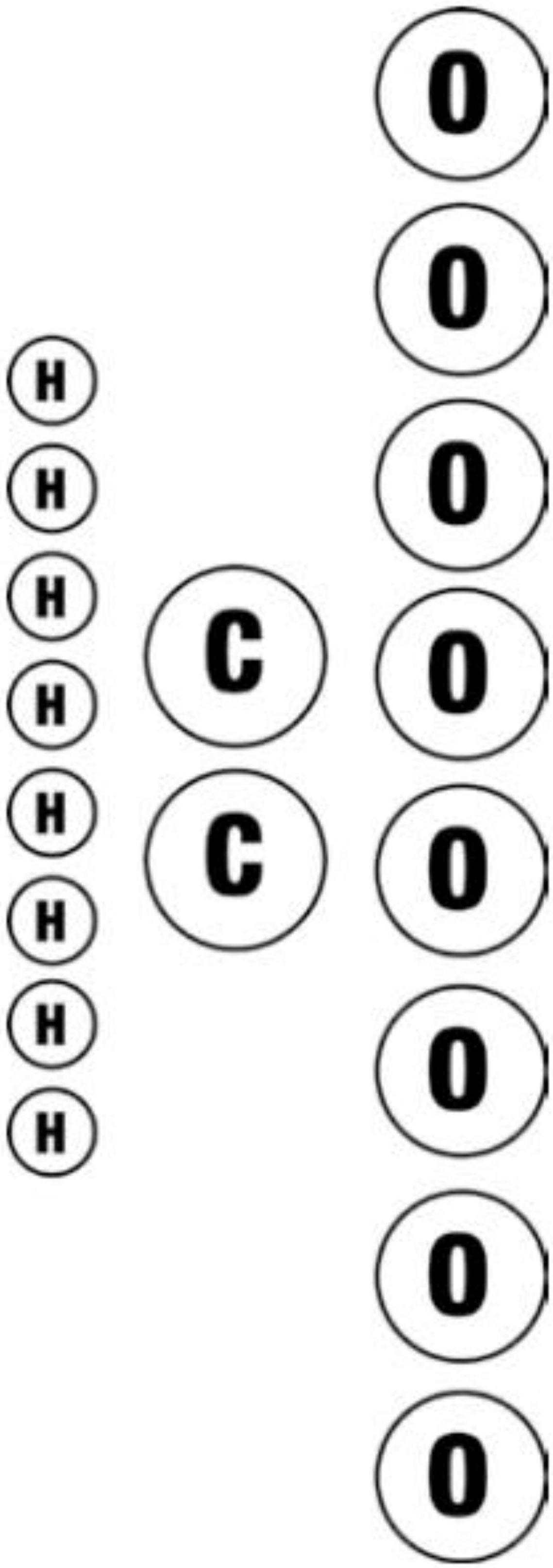
Atoms	Reactant Side	Product Side
Carbon		
Hydrogen		
Oxygen		

Answer the following questions using your model after viewing the animation of methane combustion

How many carbon, hydrogen, and oxygen atoms are in the reactants compared to the number of carbon, hydrogen, and oxygen atoms in the products?

Are atoms created or destroyed in a chemical reaction? Explain how you know.

In a physical change, like changing state from a solid to a liquid, the substance itself doesn't really change. How is a chemical change different from a physical change?


H
H
H
H
H
H
H
H
C
C
O
O
O
O
O
O
O
O

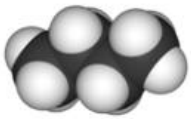
TAKE IT FURTHER: Molecules made up of only carbon and hydrocarbons.

CH_4
methane

Fuel in gas stoves in many home kitchens

C_3H_8
propane

Fuel in outdoor gas grills



C_4H_{10}
butane

Fuel in disposable lighters

Count the number of carbon, hydrogen, and oxygen atoms in the reactants and products of each equation to see if the equation is balanced. Record the number of each type of atom in each chart.

Combustion of Propane: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_20$

Atoms	**Reactant Side**	**Product Side**
Carbon		
Hydrogen		
Oxygen		

Combustion of Butane: $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

Atoms	**Reactant Side**	**Product Side**
Carbon		
Hydrogen		
Oxygen		

Teacher Resources:

Build the Reactants:

After you are sure that students have made and written the formula for the reactant molecules, tell students that they will re-arrange the atoms in the reactants to form the products.

Build the Products:

After students build the products, tell students that in a chemical reaction, the atoms in the reactants come apart, rearrange, and make new bonds to form the products.

Project the animation Moving Chemical Equation for the Combustion of Methane.

After students have made their models and counted up reactants and products show the animation linked above and explain the following:

Show students that the atoms in methane and oxygen need to come apart just like in their models. Also point out that the atoms arrange themselves differently and bond again to form new products. This is also like their model. Be sure that students realize that the atoms in the products only come from the reactants. There are no other atoms available. No new atoms are created and no atoms are destroyed. This is the law of conservation of mass Explain to students that chemical reactions are more complicated than the simplified model shown in the animation. The animation shows that bonds between atoms in the reactants are broken, and that atoms rearrange and form new bonds to make the products. In reality, the reactants need to collide and interact with each other in order for their bonds to break and rearrange. Also, the animation shows all of the atoms in the reactants coming apart and rearranging to form the products. But in many chemical reactions, only some bonds are broken, and groups of atoms stay together as the reactants form the products.

How many carbon, hydrogen, and oxygen atoms are in the reactants compared to the number of carbon, hydrogen, and oxygen atoms in the products?

Show students how to use the big number (coefficient) in front of the molecule and the little number after an atom of the molecule (subscript) to count the atoms on both sides of the equation. Explain to students that the subscript tells how many of a certain type of atom are in a molecule. The coefficient tells how many of a particular type of molecule there are. So if there is a coefficient in front of the molecule and a subscript after an atom, you need to multiply the coefficient times the subscript to get the number of atoms.

For example, in the products of the chemical reaction there are $2H_2O$. The coefficient means that there are two molecules of water. The subscript means that each water molecule has two hydrogen atoms. Since each water molecule has two hydrogen atoms and there are two water molecules, there must be 4 (2×2) hydrogen atoms.

Note: The coefficients actually indicate the ratios of the numbers of molecules in a chemical reaction. It is not the actual number as in two molecules of oxygen and one molecule of methane since there are usually billions of trillions of molecules reacting. The coefficient shows that there are twice as many oxygen molecules as methane molecules reacting. It would be correct to say that in this reaction there are two oxygen molecules for every methane molecule.

Explain that mass is conserved in a chemical reaction.

Are atoms created or destroyed in a chemical reaction?

No.

How do you know?

There are the same number of each type of atom on both the reactant side and the product side of the chemical equation we explored.

In a physical change, like changing state from a solid to a liquid, the substance itself doesn't really change. How is a chemical change different from a physical change?

In a chemical change, the molecules in the reactants interact to form new substances. In a physical change, like a state change or dissolving, no new substance is formed.

Explain that another way to say that no atoms are created or destroyed in a chemical reaction is to say, "Mass is conserved."

<u>Project the image Balanced Equation.</u>

Explain that the balance shows the mass of methane and oxygen on one side exactly equals the mass of carbon dioxide and water on the other. When an equation of a chemical reaction is written, it is "balanced" and shows that the atoms in the reactants end up in the products and that no new atoms are created and no atoms are destroyed.