Chemical changes

Some form of evidence will always appear when a **chemical change** takes place. The evidence could be anything from a change in colour to a funny smell. The browned top of a baked cake and the black surface that forms on burnt toast are both evidence that a chemical change has taken place.

All substances are made up of **particles** (that are too small to see), called **atoms**. During a chemical change, the **chemical bonds** holding the particles together break or new **bonds** are formed. Sometimes both of these things happen.

Chemical reactions

Chemical reactions are chemical changes in which a new substance is formed. For example, the steel wool used to scrub saucepans can change to form a new substance — rust. It is often very difficult, if not impossible, to reverse chemical reactions.

Rusting is a chemical reaction.

Oxygen in the air is a **molecule** — that is, it is made up of groups of two oxygen atoms joined together. The iron atoms in steel wool react with oxygen in the air. When iron and oxygen come in contact in damp conditions, the chemical bonds between the iron atoms break. The bonds in the oxygen molecules also break. New bonds form between oxygen atoms and iron atoms, and rust forms.

Rust is a **compound** because it contains more than one type of **element** chemically bonded together.

Where's the evidence?

Some of the clues that tell you if a chemical reaction has taken place are:

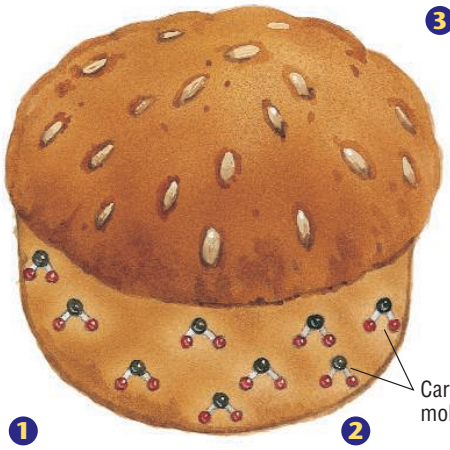
- a solid appears or disappears
- a smell is given off
- bubbles appear
- the temperature goes up or down
- a flame or light appears
- a change in colour occurs.

However, the only way to be sure a chemical reaction has taken place is to identify one or more new chemical products.

HOW IT WORKS

Chemical changes in baking

When an **acid** is added to bicarbonate of soda, a new substance — carbon dioxide gas — is produced. This process is a chemical change and is used in cakes to help them rise during the cooking process. Baking powder is a **mixture** of bicarbonate of soda and cream of tartar. When baking powder is added to cakes, the cream of tartar **dissolves** in the liquids of the cake and forms tartaric acid. This acid is then available to react with the bicarbonate of soda. Self-raising flour contains baking powder, so when a recipe includes self-raising flour and a liquid, you know that the cooking process will involve a chemical change. The carbon dioxide gas produced during this chemical change rises through the cake mixture as it cooks and helps to aerate it.



1 *Bicarbonate of soda is made up of molecules of sodium, hydrogen, carbon and oxygen. Tartaric acid is made up of molecules of hydrogen, carbon and oxygen.*

2 *When we combine them with liquid in a cake, and apply heat, the chemical bonds holding the atoms together break and new bonds are formed.*

3 *The atoms re-form into molecules of water, a salt and carbon dioxide gas. The carbon dioxide gas is the important product of this chemical change because it aerates the cake.*

Go to worksheet 4.4:
Bouncing eggs

How can you tell a chemical reaction has taken place?

You will need:

500 mL beaker	220 °C thermometer
electronic balance	heatproof mat
110 g sugar	half a spatula of bicarbonate of soda
150 mL cold water	measuring cylinder
2 teaspoons of golden syrup	test tube
half a spatula of cream of tartar	patty pans
hotplate	laboratory coat and safety glasses.
stirring rod	

- Mix the sugar, cold water, golden syrup and cream of tartar in the beaker.
- Gently heat and stir the mixture over the hotplate until the sugar has completely dissolved.
- Stop stirring the mixture when it boils.
- Allow the mixture to reach 154 °C, then remove it from the hotplate.

!CAUTION: The beaker and the mixture are very hot. Remove them from the hotplate with care.

- Dissolve the bicarbonate of soda in 1–2 mL of warm tap water in the test tube. Pour the dissolved bicarbonate of soda into the sugar mixture, stirring gently.
- Pour the hot mixture into patty pans.
- Allow to cool before examining.

What evidence is there that a chemical reaction has taken place?

Writing chemical equations

The chemicals present at the beginning of a chemical reaction are called **reactants**. The new chemicals that are produced are called the **products**. The products can be elements or they can be compounds. All chemical reactions can be written as **chemical word equations**. The reactants are written on the left-hand side of an arrow. The products are written on the right-hand side of an arrow. For example, the chemical equation for rusting is:

$$\text{iron} + \text{water} + \text{oxygen} \longrightarrow \text{hydrated iron oxide (rust)}.$$

Some chemicals react as soon as they come into contact with each other. Other chemicals need energy, like heat or a spark of electricity, to get the reaction started. In a chemical word equation, the type of energy needed is written above the arrow. This shows that this type of energy is necessary for the reaction to take place. An example is the burning of natural gas (methane) on a gas stove. A flame is needed to start the reaction:

$$\text{methane} + \text{oxygen} \xrightarrow{\text{heat}} \text{carbon dioxide} + \text{water}.$$

Sometimes scientists will simplify chemical word equations by using chemical symbols instead. For example, if chemical symbols were used in the above equation, it would become:

$$CH_4 + 2O_2 \xrightarrow{\text{heat}} CO_2 + 2H_2O$$

where O is oxygen, H is hydrogen and C is carbon.

Activities

REMEMBER

1. What always happens to the particles of a substance when a chemical change takes place?
2. List four observations that indicate that a chemical reaction may have taken place.
3. What is the only way to be sure a chemical reaction has taken place?
4. The rusting of iron is a chemical reaction.
   (a) What are the reactants?
   (b) What is the product?

THINK

5. The burning of natural gas requires heating before the reaction takes place. Why is heat not shown in the chemical word equation as a reactant?
6. Using carbon dioxide gas to aerate a cake is an example of a chemical change. Is it an example of a chemical reaction? Explain your answer.
7. Write word equations for the following chemical reactions:
   (a) Vinegar and baking powder react to form salt, water and carbon dioxide.
   (b) Wood burns with oxygen to form carbon dioxide and water.

ICT

8. Use an appropriate Internet search engine to find out what chemical change produces the smell of toast.

learning

I CAN:

- ☐ explain the difference between a chemical change and a physical change
- ☐ find out if a chemical reaction has taken place
- ☐ write chemical word equations.

Combustion reactions

Air is a mixture of chemicals. One of the most important chemicals in air is oxygen. Humans breathe in oxygen from the air and, like most other living things, cannot survive without it. Oxygen is involved in many reactions, one of which is **combustion** or burning.

During many reactions involving oxygen, flames are present and energy is released. The **reactant** that burns with the oxygen is called a **fuel**. Burning is a **chemical reaction** called combustion. All **combustion reactions** release energy in the form of heat or light.

Cooking with gas

*When a gas stove is used to cook food, a combustion reaction takes place. Natural gas is a **fossil fuel**. Its chemical name is methane. Methane reacts with oxygen to form carbon dioxide and water. The heat needed to start the reaction is provided by a match or a spark. The energy released during this reaction is what heats the food.*

*The **chemical word equation** for this reaction is:*

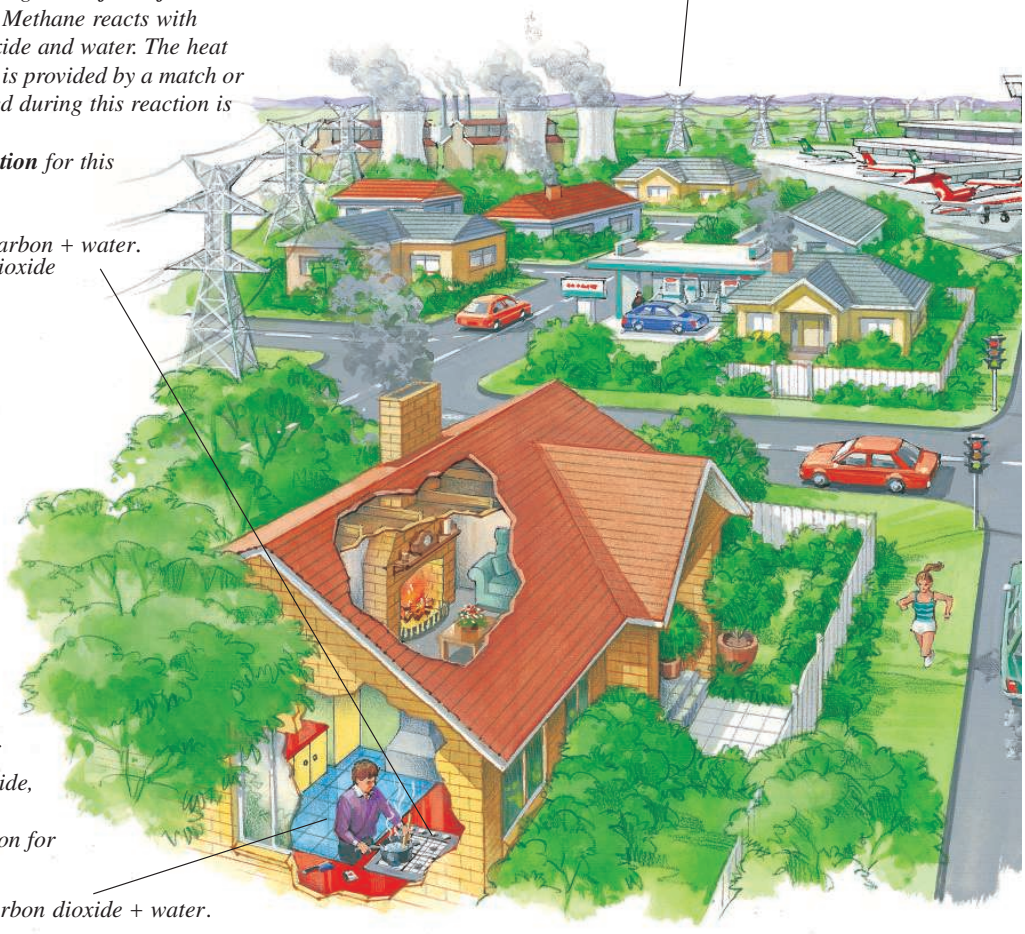
$$\text{methane + oxygen} \xrightarrow{\text{heat}} \text{carbon dioxide + water.}$$

Large-scale energy

*Fossil fuels such as coal and natural gas are burnt in power stations. Carbon dioxide and water are two of the products of the combustion of coal. The released energy is used to heat water to produce **steam**. The steam turns the blades inside giant turbines. The moving blades are used to produce electricity.*

The chemical word equation for the combustion of coal is:

$$\text{coal + oxygen} \xrightarrow{\text{heat}} \text{carbon dioxide + water.}$$



Bodily reactions

*A chemical reaction called **respiration** takes place in every cell of your body. Respiration is a slow combustion reaction that releases energy from the food you eat. During respiration, glucose from your food reacts with oxygen in the air that you breathe in. The **products** of respiration are carbon dioxide, water and energy.*

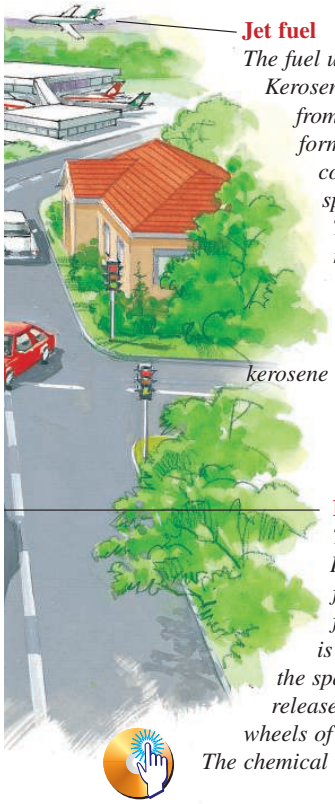
The chemical word equation for this reaction is:

$$\text{glucose + oxygen} \longrightarrow \text{carbon dioxide + water.}$$

The energy used to send a shuttle into space comes from combustion reactions. The reaction that powers the main rocket engines occurs between hydrogen and oxygen. The product of the reaction is water.

The chemical word equation for this reaction is:

$$\text{hydrogen} + \text{oxygen} \xrightarrow{\text{heat}} \text{water}.$$



Jet fuel

The fuel used in jet aircraft is kerosene. Kerosene is a liquid fossil fuel. The vapour from this liquid reacts with oxygen to form carbon dioxide and water. This is a combustion reaction. An electrical spark is used to start the reaction. The energy released during the reaction is used to move the aircraft. The chemical word equation for this reaction is:

$$\textit{kerosene} + \textit{oxygen} \xrightarrow{\textit{electricity}} \textit{carbon dioxide} + \textit{water}.$$

Energy to go

*The fuel used in most cars is **octane**. It is a liquid fossil fuel. The vapour from this liquid reacts with oxygen to form carbon dioxide and water. This is a combustion reaction. A spark from the spark plug starts the reaction. Energy released during the reaction turns the wheels of the car.*

The chemical word equation for this reaction is:

$$\textit{octane} + \textit{oxygen} \xrightarrow{\textit{electricity}} \textit{carbon dioxide} + \textit{water}.$$

Activities

REMEMBER

1. What do all combustion reactions have in common?
2. On a gas stove, where does the heat to start the reaction between methane and oxygen come from?
3. Respiration is a chemical reaction that takes place in your cells.
   (a) What are the reactants?
   (b) What are the products?
4. Which chemical product do all of the combustion reactions involving fossil fuels have in common?
5. List five examples of fuels.

THINK

6. What is the fuel in the combustion reaction that takes place in every cell of your body?
7. Hydrogen and oxygen are cooled down to turn them into liquid fuels for the space shuttle. Why is water, the product of the reaction, produced as a gas?
8. Write word equations for the following reactions.
   (a) Sugar burns with oxygen to form carbon, carbon dioxide and water.
   (b) Baking powder reacts with vinegar to form carbon dioxide, water and salt.

INVESTIGATE

9. Find out what fossil fuels are and what problems are associated with their use.
10. How are each of the following fossil fuels formed and treated before use?
    (a) Methane
    (b) Kerosene
    (c) Octane

CREATE

11. Create a poster that shows how the burning of coal is used to generate electricity. Include the chemical equation for the combustion of coal on your poster. Also include information about where the reactants come from and what happens to the products.

learning

I CAN:

- ☐ describe a number of combustion reactions
- ☐ explain what happens to a fuel during a combustion reaction
- ☐ describe uses for the energy that is produced in combustion reactions.