STEMscopedia: PHYSICAL AND CHEMICAL PROPERTIES AND CHANGES

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Reflect

What do ice cream, root beer, and carbon dioxide gas have in common? Not only do these ingredients combine to make a good treat on a hot summer day, but they are also made of matter.

Matter can be found in many different shapes, sizes, and forms. For example, the ice cream, the root beer, and the gas that makes the root beer fizz are all types of matter. Even your body is made of matter. What other things in your life contain matter?

What Is Matter?

Simply put, matter is the stuff that every physical thing is made of. Matter can be described and classified by its properties. A property is a characteristic or feature of a substance or an object. Matter has both physical properties and chemical properties.

Physical Properties

Physical properties can be observed and measured. Some physical properties of matter—such as size, color, and shape—can be observed using your senses. Measurements made using science tools can be used to describe other physical properties of matter. Most matter can be found in three phases; solid, liquid, or gas. Both melting points and boiling points are examples of physical properties.

Chemical Properties

A chemical property is how matter reacts or behaves when it undergoes a chemical change. Some examples of chemical properties are **flammability**, oxidation, and toxicity. A substance must undergo some kind of a chemical reaction to observe a chemical property. Some substances react with other substances—this is a chemical property called reactivity.

Different substances have different melting points; this is one way scientists can classify matter.

Flammability: the ability of a substance to burn or ignite

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What Do You Think?

Observe the following pictures. Can you list the physical properties about each substance? Research and find at least one chemical property of each substance.

Match
Physical properties:

Chemical properties:

Wood
Physical properties:

Chemical properties:

Rocks
Physical properties:

Chemical properties:

Vinegar
Physical properties:

Chemical properties:

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Look Out

Just like matter has physical and chemical properties, all forms of matter can undergo both physical and chemical changes. These two types of changes should not be confused because they are very different. Physical changes do not change the chemical makeup of a substance, but a chemical change is caused by a chemical reaction and it does change the substance into an entirely new substance with different chemical properties.

Anytime you change the physical properties of a substance, you are causing a physical change. The chemical makeup is the same. If you crush a can, you have changed its appearance, but it is still a can. When you melt an ice cube, you are changing the state of matter, but chemically it is still H_2O, or water.

On the other hand, chemical reactions cause a change that creates an entirely new form of matter. Burning wood is an example of a chemical change. When some sort of fuel is added to wood and then exposed to oxygen and heated to wood's combustibility temperature, the wood catches fire and begins to burn. As it burns, it is breaking down into ashes, and is no longer wood.

Reactant: a substance that takes part in and undergoes change during a reaction

Let's look at an example showing the difference. Suppose you have a glass of water and a spoonful of sugar. If you dissolve the sugar in the water, the resulting product seems different than the original **reactants**, but it is just a mixture of sugar and water. No new substance has formed. However, if you place antacid tablets in water, the tablets dissolve through a chemical reaction. This is readily observed by the bubbling of gas in the glass. The antacid tablets contain the substances sodium bicarbonate ($NaHCO_3$) and citric acid ($C_6H_8O_7$). When these substances are placed in water, the atoms rearrange and carbon dioxide gas is produced. The picture below shows the gas bubbles that you observe in the glass. The gas is an entirely new substance created during the chemical reaction.

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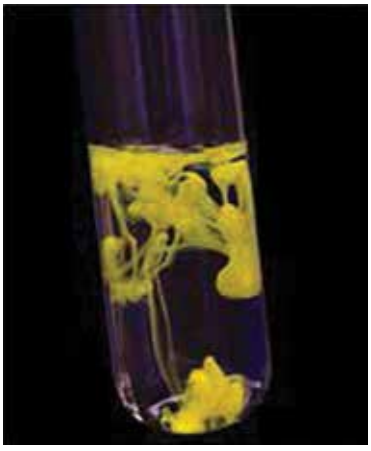
Evidence of Chemical Reactions
There are several ways you can observe whether or not a chemical change has occurred due to a reaction. You will always observe one or more of these changes in a chemical change.

Production of a Gas
As previously discussed, mixing antacids with water creates the gas carbon dioxide. Anytime molecules rearrange to form a gas as a by-product of a chemical reaction, you can be sure that a chemical change has occurred.

Production of Light
The burning of logs in a fireplace is the reaction of the wood and oxygen along with a heat initiation source. Wood is made of cellulose, a combination of different substances that contain carbon, hydrogen, and oxygen. When this reaction occurs, a large amount of energy is produced. This energy is in the form of both heat and light. This type of reaction is a combustion reaction. It is similar to the reaction that produces the bright light and heat in fireworks.

Change in Temperature
Chemical reactions can either give off heat or use heat. Perhaps you have had an injury and applied a chemical heat pack to the area. A chemical heat pack is an example of a reaction that produces heat. A common substance in a heat pack is magnesium sulfate ($MgSO_4$). When the heat pack is activated, the magnesium sulfate reacts with water. The result is the production of heat, which you use to soothe your injury. Chemical cold packs work in an opposite way to use heat when they mix with water. They may feel very cool to the touch. These temperature changes are evidence of a chemical reaction.

Formation of a Precipitate
A precipitate is a solid substance that forms and separates from a solution. A precipitate often settles to the bottom of a liquid reaction. One common chemical reaction that forms a precipitate is the reaction of solutions of lead nitrate ($Pb(NO_3)_2$) and potassium iodide (KI). Each of these substances in a solution is clear and colorless. But if you mix a solution of each substance, lead iodide (PbI_2) and potassium nitrate (KNO_3) form as products. Lead iodide is insoluble, so it separates from the solution as a yellow precipitate (shown in the image on the right). The potassium nitrate remains in the solution.



Change in Color
You may have seen rust form on a steel object, such as a chain or an automobile. In this chemical reaction, iron (Fe) in the steel reacts with oxygen (O_2) in the air as well as water (H_2O) to produce rust ($Fe(OH)_3$). The properties of steel are different than the properties of rust. Steel is a shiny, silver metal made from iron and other elements. Rust is a flaky, reddish-colored substance. The change in color from silver to red provides evidence that a chemical reaction has happened. Rusting is a complex reaction that happens in stages, and it is easy to observe these changes as they happen.

Try Now

What Do You Know?

Tell whether each property is a chemical property or a physical property.

1. Color
2. Density
3. Combustibility
4. Melting point
5. Reactivity

Label each picture as a chemical change or a physical change.

1. 

2. 

3. 

4. 

Connecting With Your Child

Investigating Chemical Reactions

To help your child learn more about chemical reactions, work together to determine how to identify the evidence that may be observed when a chemical reaction occurs. To do so, gather the following materials:

- 3 glasses of water
- 2 effervescent tablets
- 1 tablespoon of sugar
- 1 tablespoon of Epsom salts
- Thermometer

While performing the chemical reactions, encourage your child to record all observations.

Let the first glass contain the control sample in which no chemical reaction occurs. Add a tablespoon of sugar to the water in the glass and stir until the sugar dissolves completely. Record all observations until the sugar dissolves. Remember that this control sample does not involve a chemical reaction because sugar dissolving in water is only a physical change.

Then, have your child add both of the effervescent tablets to the second glass of water. Record any observations for at least two minutes while the tablets dissolve.

Finally, place the thermometer in the third glass and record the initial water temperature. If a thermometer is not available, feel the outside of the glass and record if it feels hot, warm, or cold. Then, add a tablespoon of Epsom salt and gently stir the liquid using the thermometer. Make sure to watch the temperature closely and determine how the temperature changes when the salt is added.

After performing the reactions, discuss the following questions with your child:

- In which of the glasses did a chemical reaction take place? How do you know?
- Why can you assume that a chemical reaction did not take place in all three glasses? How could you confirm that a chemical reaction took place in the glasses?
- Can you write a chemical equation to describe each chemical reaction that occurred?