

## Purpose

Students will explore the differences between physical changes and chemical changes by performing an experiment.

## Student Guide

The student guide is provided during both the Instruction and Assignment. Be sure either to provide copies to students or enable them to print the guides themselves when they do the **Instruction** portion of the lab lesson.

## Background Information

Changes in matter are of two types:

**Physical Changes** When matter undergoes a physical change, the original properties of the material do not change. Physical changes are results of physical processes, such as crushing, tearing, cutting, crumpling, mixing of two materials that can later be physically separated without loss of original properties, and phase changes such as boiling or freezing. For example, heating water does not change the properties of water as it goes through the phase change to boiling.

**Chemical Changes** Chemical changes, on the other hand, are always the result of a chemical reaction and always create a new substance or substances. This new substance has a different composition and different properties than the original material. Indicators of chemical change may be one or more of the following: the production of gas, which can be observed as bubbling; an unexpected color change; the formation of a precipitate; a temperature change; and the release of energy. The fireworks seen at a Fourth of July celebration are a result of a chemical change. The materials in the fireworks come together in the presence of heat and create new substances that create the explosions of different colored lights in the sky.

There are many applications of this knowledge in the real world. Here are two examples:

- When iron is exposed to oxygen in the air, a chemical change occurs where the iron and oxygen combine to form iron oxide ( $\text{Fe}_2\text{O}_3$ ) or rust. This reaction occurs slowly, but in the presence of water, such as for a bridge spanning a river, this chemical change occurs more quickly and can corrode or decay the structure. Steel, a metal alloy of iron and carbon, is often preferable because the reduced use of iron allows makes steel more resistant to corrosion, allowing bridges to last longer with reduced maintenance costs.

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- Oil from the ground is black and very thick. This dark, thick, sludge-like ooze is processed into usable components. The oil refining process involves separating the components using a physical change: the change from a liquid phase to a gas phase. These components are then used in the manufacture of shoes, CDs, toothpaste, gasoline, and even basketballs!

## Preparation / Alternatives

- Students should wear protective gear: lab coat, goggles, and chemical resistant gloves. Additionally, all loose clothing should be avoided and long hair tied back.
- Make sure that you understand the proper handling of the chemicals by reading all MSDS (Material Safety Data Sheets) provided by the manufacturers. You may want to consider asking students about specific allergies before performing this lab.
- You may wish to set up each step of the lab as a separate station.
- Do not return excess chemicals to stock bottles. Dispose excess chemicals properly.
- You may wish to make the following substitutions:
  - Egg shells, seashells, plaster of Paris, and marble chips may be used in place of calcium carbonate (white chalk).
  - You can prepare 100 mL of 1M HCl by adding 17 mL of muriatic acid (6M) to 83 mL distilled water. (Each student needs 20mL of HCl, so this is enough for 5 students.) When you prepare, be sure to pour the acid into the water, not vice versa. Pouring water into an acid is dangerous because it may cause an explosive reaction and/or spluttering.
- Provide the following receptacles for disposal or recycling:

For Step 3: large beaker for calcium carbonate and hydrochloric acid mixture

For Step 5: large beaker for anhydrous copper(II) sulfate

For Step 6: one beaker each for iron filings and sulfur

For Step 7: large beaker for lead nitrate and potassium iodide mixture

For Step 8: filter set-up to separate the magnesium from the hydrochloric acid

For Step 9: large beaker for candles and a small beaker for matches if these are used

## Monitoring the Lab Procedure

- Ensure that safety procedures are followed at all times.
- Make sure that students are aware that they should not smell or taste the chemicals.
- Make sure that hot plates, Bunsen burners, and gas outlets are turned off when not in use and when the experiment is done.

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- Follow waste disposal protocol for the chemicals used in this lab per local, state, and federal laws.

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### Data

While students perform the procedure, they should record their data in the format that best shows their findings. The data table format below, used in the lab lesson, is sufficient for this purpose. A sample data table is shown below. (The data matches the results of the virtual version of the experiment.)

Step	Material	Change(s) Observed	Type of Change (Physical/Chemical)	Reasoning
2	Calcium carbonate	calcium carbonate retained its properties after crushing	physical	Even though calcium carbonate was crushed into powder, the powder is still calcium carbonate.
3	Calcium carbonate and hydrochloric acid	presence of bubbles	chemical	A new substance is formed.
4	Water	physical	physical	Water is still water even if it is boiling.
5	Copper(II) sulfate pentahydrate	color of the substance turned from blue to white	chemical	Heating removed the water from the hydrate, creating a new substance.
6	Iron filings and sulfur	mixture turned into a gray material; iron filings can be separated from sulfur powder using a magnet	physical	Original substances retain their properties and can be separated through physical means.
7	Lead nitrate and potassium iodide	formation of yellow precipitate	chemical	A new substance was formed.

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8	Magnesium and hydrochloric acid	presence of bubbles and increase in temperature	chemical	A new substance was formed, and heat was produced.
9	Candle	light and heat was produced	physical AND chemical	Solid wax changes to melted wax and back (physical) and the wick burns and produces energy (chemical).

## Analysis

When students write their lab reports, they should provide a written explanation of their results. A sample analysis is shown below:

**Sample Analysis:** Physical changes are changes that occur in matter where the properties of the material are retained and/or the materials can be recovered after the change. Crushing calcium carbonate, boiling water, and mixing iron filings and sulfur are all physical changes. Specifically, crushed calcium carbonate is calcium carbonate in powdered form, the boiling of water changes liquid water to water vapor, and the iron filings and sulfur retained their properties after they were separated through physical means (magnet).

Chemical changes, on the other hand, involve the formation of a new substance and/or energy. Mixing calcium carbonate and hydrochloric acid, mixing lead nitrate and potassium iodide, mixing magnesium and hydrochloric acid, and heating copper(II) sulfate pentahydrate are all chemical changes. Mixing calcium carbonate and hydrochloric acid produces bubbles, indicating the formation of a gas. Mixing lead nitrate and potassium iodide produces a precipitate, indicating the formation of a new substance. Mixing hydrochloric acid and magnesium metal produces gas as indicated by bubble formation and heat as indicated by the increase in the temperature of the solution. The heating of copper(II) sulfate pentahydrate is a chemical change because the color change indicates loss of water from the hydrate.

Burning a candle involves both a physical change and a chemical change. Lighting a candle produces heat and light, which is an indicator of chemical change. However, the wax melts and then solidifies, which represents a physical change.

## Conclusion

Students should write the difference between chemical and physical changes in their own words and describe indicators of chemical change. A sample conclusion is shown below:

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**Sample Conclusion:** Physical changes can be distinguished from chemical changes through observation. When the change does not change the properties of the material, then it is a physical change. When a new substance or energy is produced, in the form of light or heat, then a chemical change has occurred. The indicators of chemical change include the production of bubbles, color change, the formation of a precipitate, and the production of light and heat.

An example of a physical change is the cutting of a log for firewood because the log and the firewood are made of the same material and have the same properties but just in a different shape and size. The burning of firewood is a chemical change because it produces energy in the form of heat and light.

## Extension Activities

Here are some variations that may lead to an increased understanding of the difference between chemical and physical changes and its applications.

- Have students identify the physical and chemical changes that take place when a cake is baked.
- Have students do research on the chemistry of fireworks and ask them to identify the physical and chemical changes involved.
- Have students do research on the refining of oil and oil products, and their uses.
- Have students watch a video of how sea salt is produced. Let them identify whether this production process involves a physical or chemical change.