

Activity 4: Steel Wool and Chemical Reactivity

Often when matter reacts to something, it changes at the atomic level. Chemical reactions change the molecular composition of a substance by redistributing atoms or groups of atoms but without altering the structure of the nuclei of the atoms. Signs of a chemical reaction include the following:

- a change in color
- a change in temperature
- a change in odor
- the formation of a gas (bubbles)
- the formation of a precipitate
- the production of light
- decomposition (breaking down of organic matter)
- an obvious change in the composition of the reactants (one or more of the reactants look very different)

In this brief activity, you will see evidence of chemical reactivity. Your challenge will be determining what types of evidence demonstrate that a chemical reaction has occurred. Follow the steps and answer the questions on the "Steel Wool and Chemical Reactivity" pages. When you are finished, read the following note to set up tomorrow's experiment.

NOTE: Tomorrow you will complete a second activity illustrating chemical reactivity. To prepare for this activity, place three cotton balls in a clean jar and pour hydrogen peroxide over the cotton balls until they are submerged. Stir this mixture and set it aside for tomorrow. Clean out one of the jars used in Activity 4 and repeat the process using the hydrogen peroxide and salt solution (1 cup hydrogen peroxide and 1/4 cup table salt).

Day 3

Activity 5: Cotton Balls and Chemical Reactivity

Check the mixture with the cotton balls and hydrogen peroxide you created yesterday. Does it look like a chemical reaction took place? It probably doesn't. This is because the reaction between the peroxide and cotton balls takes a very long time to happen. Did the addition of table salt make a difference in this reaction? Probably not because salt is not a good catalyst for this reaction.

The following video demonstrates what happens when you add an effective catalyst. The reaction in the video is called a *decomposition reaction* because the cotton is broken down into simpler compounds. How many signs of a chemical reaction can you identify?

Cotton Ball and Hydrogen Peroxide

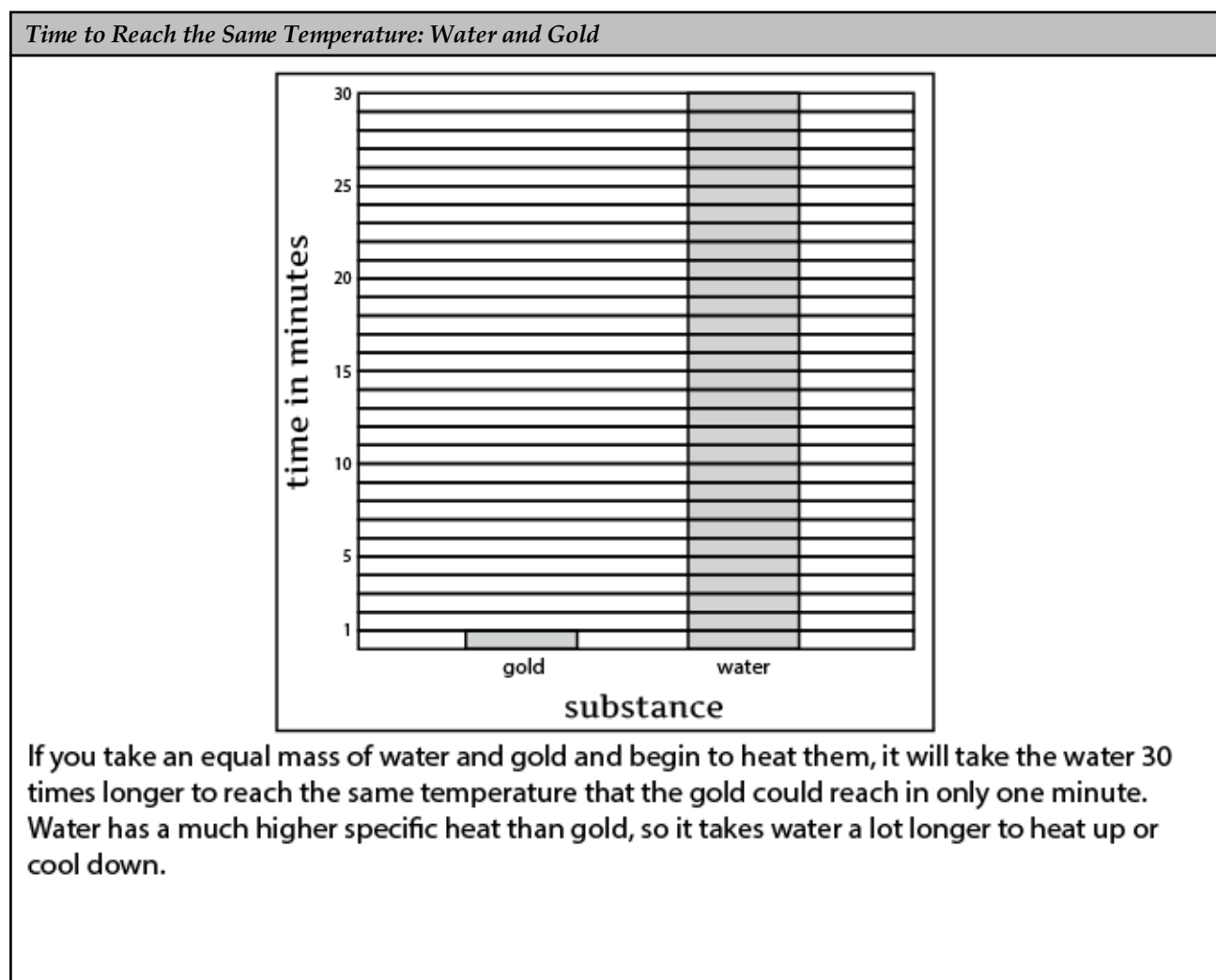
www.movingbeyondthepage.com/link/4273/

As you watch, do not worry about the captions or the cue cards. The main point of the video is for you to see what happens when a catalyst is added to a reaction.

Activity 6: Understanding Specific Heat and Density

Specific heat is the amount of heat energy needed to raise the temperature of one gram of a substance by one degree. The specific heat of a substance is a physical property that doesn't change. It is measured in joules (J), a unit of energy.

Look at the following graph comparing the specific heats of water and gold. Water has a specific heat of $4.19 \text{ J/g}^\circ\text{C}$. This means that it requires 4.19 joules of energy to raise the temperature of 1 gram of water by 1 degree Celsius. The specific heat of gold is $0.13 \text{ J/g}^\circ\text{C}$.



This activity has two parts. First, you will learn more about the specific heat of water and how it affects your everyday life. In part two, you will examine the relationship between density and specific heat.

Part 1: Water and Specific Heat

Water has a high specific heat. This is because as you add heat to water, heat energy is used to break hydrogen bonds between water molecules before it begins to raise the temperature of the water. This physical property of water is extremely important, as you will see. Read the following excerpt, then click on the links to find out more about the specific heat of water.

Water and Specific Heat

Specific heat is the amount of heat required to raise the temperature of one gram of a substance by one degree Celsius. Consider water — it takes a lot of energy to raise the temperature of water one degree Celsius. This is significant for a number of reasons. First, a large body of water can absorb and store a huge amount of heat from the Sun in the daytime and during summer while warming up only a few degrees. At night and during the winter, the gradually cooling water can warm the air, leading to milder weather and climates. The specific heat of water is one of the reasons that coastal areas generally have milder climates than inland regions. The high specific heat of water also tends to stabilize ocean temperatures, creating a favorable environment for marine life. Because of the unusually high specific heat of water, which covers most of the planet, Earth's temperatures are not subject to radical temperature ranges like those found on other planets. Basically, water keeps temperatures from changing at a rate that is harmful to life on land and within water.

The specific heat of water also enables the regulation of body temperature amongst organisms because organisms are primarily made of water. Organisms are better able to tolerate and survive changes in their own temperature because the specific heat of water keeps the changes from becoming too extreme for survival.

Specific heat also influences rates of evaporation. If water were to have a lower specific heat, it would evaporate more quickly, causing an increase in the amount of atmospheric water and a reduction of water on Earth's surface. If such a situation were to exist, atmospheric temperatures would increase greatly while potentially leading to a reduction of surface temperatures or more extreme weather. The tendency for sudden changes in temperature caused by a lower specific heat would lead to greater likelihoods of large air masses with different temperatures.

Heat Capacity and Water

www.movingbeyondthepage.com/link/9401/

This web page from the USGS introduces the concept of *heat capacity* and provides more information about the specific heat of water.

Specific Heat of Water

www.movingbeyondthepage.com/link/9402/

This short video animation illustrates why water's specific heat is high.

Part 2: Specific Heat and Density

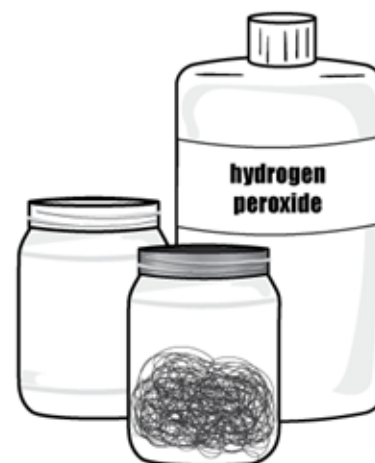
Specific heat is influenced by another physical property, density, a term you learned about in the unit on matter. To review, density is a measure of the amount of matter in a specific volume of space. Water has a density of 1. This means that 1 cubic centimeter of water has a mass of 1 gram.

In this part of the activity, you will explore the relationship between density and specific heat. Find the "Specific Heat and Density" activity pages and follow the instructions.

Steel Wool and Chemical Reactivity

Materials:

- one lid with a hole large enough for the thermometer (kit)
- table salt
- thermometer (kit)
- two glass jars (kit)
- bottle of hydrogen peroxide
- scissors
- steel wool (kit)
- measuring cup



Instructions:

1. Measure the temperature in the room and record it in the first and second rows of the "Room Temperature" column of the chart.
2. Place the thermometer in the steel wool and record its temperature in the first and second rows of the "Dry Steel Wool Temperature" column.
3. Cut the steel wool in half using sharp scissors.
4. Place one of the steel wool pieces into an empty glass jar and pour hydrogen peroxide over it until the steel wool is completely covered.
5. Close the jar with the lid that has a hole in it. Thread the thermometer through the hole. Adjust the height of the thermometer bulb so that it is roughly in the middle of the steel wool.
6. Record the temperature of the steel wool in the first row of the "Steel Wool Start Temperature" column.
7. Record the temperature of the steel wool every 5 minutes for 15 minutes.
8. Dissolve 1/4 cup of table salt into one cup of peroxide in another one of the jars. Some of the salt may not dissolve. That will not hurt the experiment.
9. Place the other steel wool piece into the jar with peroxide and salt. It is fine if some of the undissolved salt gets on the steel wool.
10. Repeat Steps 5-7. Record the temperatures on the second row of the chart.
11. Answer the questions at the bottom of the page.

	Room Temperature	Dry Steel Wool Temperature	Steel Wool Start Temperature	Temperature (5 minutes)	Temperature (10 minutes)	Temperature (15 minutes)
Peroxide Only						
Peroxide + Salt						

Questions:

What is some evidence that a chemical reaction has occurred?

Do you think the temperature will continue to increase?

The table salt was a catalyst in the reaction between the steel wool and peroxide. Did the catalyst make a difference in what the reaction looked like and how much heat was released? Do you think table salt is a good catalyst for this experiment?

Look at the chemical changes you identified in Activity 1. What signs of a chemical reaction would you expect to see for these reactions?

Specific Heat and Density

Directions: Cut out the strips on Page 2. Order the strips according to density, from smallest to largest, and record your results below. Next, order the strips according to specific heat values, also from smallest to largest. Record this order, too. Then answer the questions.

Density
(smallest to largest)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Specific Heat
(smallest to largest)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Questions:

1. What is the relationship between the density of a substance and its specific heat?
2. What do you think would happen if you changed the specific heat of water from 4.19 to 8.4?
3. What do you think would happen if you changed the density of water from 1.0 to 0.5?
4. Can specific heat help you predict which substance will cool down faster? (Consider a hot metal cooking utensil versus a cup of hot water. Which will cool faster?)
5. Are density, specific heat, melting point, and boiling point considered physical or chemical properties of a substance?

Tip!



When one value goes up as another value goes down, the two values are said to have an **inverse relationship**.

Aluminum Al	Density: 2.7 g/cm ³ Specific Heat: 0.91 J/g°C Freezing/Melting Point: 1220.666°F Boiling Point: 4472.6°F
Vinegar CH ₃ COOH	Density: 1.0056 g/cm ³ Specific Heat: 3.80 J/g°C Freezing/Melting Point: 28°F Boiling Point: 213.8°F
Lead Pb	Density: 11.3 g/cm ³ Specific Heat: 0.13 J/g°C Freezing/Melting Point: 621.5°F Boiling Point: 3182°F
Iron Fe	Density: 7.87 g/cm ³ Specific Heat: 0.45 J/g°C Freezing/Melting Point: 2800°F Boiling Point: 5184°F
Tap Water H ₂ O	Density: 1 g/cm ³ Specific Heat: 4.19 J/g°C Freezing/Melting Point: 32°F Boiling Point: 212°F
Steel Wool	Density: 7.82 g/cm ³ Specific Heat: 49 J/g°C Freezing/Melting Point: 2400°F Boiling Point: 5400°F

Activity 4: Steel Wool and Chemical Reactivity

For this activity your child's science kit should include a lid that has been punctured. If the hole isn't big enough to fit the thermometer, you can widen it slightly by inserting a screwdriver. If you need to puncture a lid yourself, you can use a hammer and nail and then widen the hole with a screwdriver.

The exact rise in temperature that your child notices will vary. In general, the jar with hydrogen peroxide should change very little. However, the jar containing the salt and hydrogen peroxide should show a significant increase in temperature because salt acts as a catalyst to the chemical reaction between the steel wool and the hydrogen peroxide. Your child might be interested in leaving this jar undisturbed for a few hours to continue watching the reaction.

Your child should also prepare for a second activity she will complete tomorrow. Be sure that she sets up the cotton ball experiment and stores it in a safe place.

Answers to Questions:

- *What is some evidence that a chemical reaction has occurred?*

Answer: This reaction has several signs: a change in temperature, the formation of a gas (bubbles), a change in color, and it appears that the composition of the reactants steel is changing (rust is forming).

- *The table salt was a catalyst in the reaction between the steel wool and peroxide. Did the catalyst make a difference in what the reaction looked like and how much heat was released? Do you think table salt is a good catalyst for this experiment?*

Answer: Yes, the addition of the salt made the reaction more vigorous. Bubbles were produced more quickly, the temperature climbed more quickly and rust appeared on the wool and in the solution. Table salt was a good catalyst.

- *Do you think the temperature will continue to increase?*

Answer: No. For a reaction to occur, reactants are needed. Eventually all of the reactants will be used up and the reaction will stop.

- *Look at the chemical changes you identified in Activity 1. What signs of a chemical reaction would you expect to see for these reactions?*

Answer: Metal rusting would show a color change and an obvious change to the composition of the metal. Food digesting would show evidence of decomposition (the organic matter breaking down). Oil burning would create heat and light.

Day 3

Activity 5: Cotton Balls and Chemical Reactivity

For the cotton ball activity, the goal is for your child to see evidence of a simple decomposition reaction. The video shows what the reaction looks like when an appropriate catalyst is added. With an effective catalyst, cotton balls will completely disintegrate in hydrogen peroxide. Ask your child what signs of a chemical reaction she recognized. She should be able to note decomposition, a color change, and an obvious change in the composition of the cotton balls.

Activity 6: Understanding Specific Heat and Density

In Part 1 of this activity, your child explored why water has a high specific heat and why that fact is so important to life on Earth. Invite her to share what she has learned with you

Part 2, your child explored the relationship between density and specific heat. She also learned about the importance of water's high specific heat.

Answer Key:

Density (smallest to largest):

1. Tap water
2. Vinegar
3. Aluminum
4. Steel wool
5. Iron
6. Lead

Specific heat (smallest to largest):

1. Lead
2. Iron
3. Steel wool
4. Aluminum
5. Vinegar
6. Tap water

Answers to Questions:

- *What is the relationship between the density of a substance and its specific heat?*
It is an inverse relationship because as one increases, the other decreases. Higher density means lower specific heat. Lower density means higher specific heat.
- *What do you think would happen if you changed the specific heat of water from 4.19 to 8.4?*
It would take longer for the water to heat up or cool down.
- *What do you think would happen if you changed the density of water from 1.0 to 0.5?*
If you decrease the density, the specific heat would increase.
- *Can specific heat help you predict which substance will cool down faster? (Consider a hot metal cooking utensil versus a cup of hot water. Which will cool faster?)*
Yes. Substances that heat up more slowly tend to cool down more slowly. Substances that heat up quickly also tend to cool quickly.
- *Are density, specific heat, melting point, and boiling point considered physical or chemical properties of a substance?*
They are all physical properties of a substance.

Wrapping Up

Questions to Discuss

- What is the difference between a physical change and a chemical change? (A physical change represents a change in state — solid, liquid, gas — or shape/size or density. A chemical change represents a change in the structure of matter at an atomic level, the rearrangement of particles to make new matter or to break down what is there.)
- How do you represent the different states of matter using chemical symbols? [Solid (s); Liquid (l); Gas (g).]