Activity 1

What Do You Think?

Chemistry is the study of matter and how matter changes. Changes in matter are described as physical changes and chemical changes. Consider two wooden matches. One is broken in half and the other is lit on fire by striking it along the side of the matchbox. In both of these instances matter has changed.

- Which match has undergone a chemical change? Which has undergone a physical change? Give specific reasons to support your answer. How did you make your decision?

The What Do You Think? questions are meant to get you thinking about what you already know or think you know. Don’t worry about being right or wrong. Discussing what you think you know is an important step in learning.

Record your ideas about these questions in your Active Chemistry log. Be prepared to discuss your responses with your group and the class.

Investigate

1. Here are 15 opportunities for you to observe changes in matter. Your teacher may choose to do some or all of these as a demonstration or set up stations for you to visit. Notice that the directions call for small amounts of substances.
Before you begin the activity, make a data table to organize your observations. You will want to record what was done and detailed observations for changes that take place.

a) Heat an ice cube in a beaker until it melts. Continue heating the ice cube after it melts.
b) Boil a small amount of water.
c) Melt a small amount of candle wax. Allow the wax to cool.
d) Break a wooden splint into several pieces.
e) Hold a wooden splint in a flame.
f) Add a few drops of lemon juice to a small amount of milk.
g) Add a few drops of vinegar to a small amount of baking soda (NaHCO₃).
h) Add a small amount of table salt to water. Stir. Consider what would happen if you allowed the water to evaporate from this mixture.
i) Add several drops of iodine solution to a small amount of starch.
j) Add a small piece of polished zinc to a small amount of hydrochloric acid (0.1 M HCl).
k) Add a drop of phenolphthalein indicator solution to a solution of sodium hydroxide (0.1 M NaOH).
l) Add two drops of sodium carbonate (0.1 M Na₂CO₃) to two drops of sodium hydrogen sulfate (0.1 M NaHSO₄).
m) Add a few drops of household ammonia to a small amount of a copper (II) sulfate (0.1 M CuSO₄) solution.
n) Add a few drops of vinegar to a small piece of chalk or marble chips.
o) Sharpen a pencil and collect the shavings.

Dispose of the materials as directed by your teacher. Clean up your workstation.

2. Look at your observation notes in your data table.

a) Prepare and complete a chart table that organizes your observations into separate columns. Create a separate column for each type of observation made, such as color changes observed, the formation of precipitates (sometimes visible as a cloudy solution), gas formation (fizz), and any other changes. Use one column to note where no visible change occurred.

3. A physical change involves changes in the appearance of the material, but does not involve creation of new substances. A chemical change involves the formation of new substances. Chemical reactions are characterized by a number of changes, including color changes and the formation of precipitates or gases.

a) Which of the interactions you observed were chemical changes? Write the words “chemical change” next to each of these interactions. Explain your answer.
b) Which of the interactions you observed were physical changes? Write the words “physical change” next to each of these interactions. Explain your answer.
c) When you placed the wooden splint into a flame, what other evidence (besides the color change) indicated that a chemical change took place?
d) Imagine a situation where two colorless solutions are mixed together. There is no color change, no precipitate is formed, and no gas is released. However, heat is released as the solutions are mixed. Even though dissolving is a physical process, it very often results in a change in temperature, which can be either positive or negative, depending on the solute and solvent. Is this an example of a chemical or physical change? Explain your choice.

4. Each group will be given some material used in disposable diapers. Place the piece in a beaker.

a) Predict how much liquid the diaper material will be able to hold. Record your prediction in your log.

b) Design an investigation to measure the amount of liquid that the diaper material can absorb. Record your procedure in your log.

c) With the approval of your teacher, carry out your investigation. Record your results.

d) Explain how your prediction compared with your observations.

e) The diapers contain a material called sodium polyacrylate. When it absorbs water, is this a physical or chemical change? Explain your answer.

5. Your teacher will show you a solution of sodium acetate in a 250-mL flask. Observe the solution carefully.

a) Record your observations in your Active Chemistry log.

Your teacher will then add one crystal of sodium acetate to the flask.

b) What happens? Record your observations in your log.

c) Was this a chemical or physical change?

6. In a large throwaway glass jar, mix 150 mL of sodium silicate (sometimes called water-glass solution) and 400 mL of water. Carefully drop solid-colored crystal compounds of cobalt, copper, nickel, iron, and/or manganese in different locations inside the jar.

a) Is there evidence of a change immediately? In several minutes? In several hours? In several days? In your Active Chemistry log, describe the results.

b) Is the phenomenon you see the result of a physical or a chemical change? Explain your answer.
In this activity, you observed a number of situations that involved changes in matter, both physical and chemical. A physical change involves changes in the appearance of the material but does not involve creation of new materials. A change of a solid to a liquid is a physical change. When the candle wax melted it may have appeared different, but it was still wax. After it solidified, it had a similar appearance to the initial product. When the ice cube melted it may have appeared different, but it was still water. Dissolving is also a physical change. When you added the salt to the water, the salt crystals seemed to disappear as they dissolved in the water. However, they had only spread out into a solution. A solution is a homogeneous mixture of at least two different materials. The materials forming a solution are called the solute and solvent. The material usually present in the largest amount is called the solvent. When the solvent (water) evaporated away, the solute (salt crystals) remained the same as it was originally.

A chemical change involves the formation of new materials. The new materials are called products and the starting materials are called reactants. The process that brings about a chemical change is called a chemical reaction. Chemical reactions are characterized by a number of changes, including color changes, the formation of a precipitate or gas, and in many cases a release of heat or light. Chemical changes are usually not easy to reverse. When you burned the wooden splint you could not put the charcoal and gases back together to form the original splint as you could when you simply broke the splint into pieces.
Saturated and Supersaturated Solutions

The solution your teacher used in the demonstration was a supersaturated solution of sodium acetate. Solutions are commonly described in terms of concentration. The concentration of a solution is the ratio of the quantity of solute to the quantity of solution. The concentration is often expressed as molarity, which is the number of moles of solute dissolved in one liter of solution. It is represented by the symbol $M$. A dilute solution has fewer solute molecules per volume than a concentrated solution. If you add more solute to a solution and it does not dissolve, the solution is saturated. If the solute does dissolve, the solution is unsaturated.

You probably recognize the term “saturated.” When something is saturated, it is full. A saturated sponge is full of water; it can’t hold any more. A saturated solution is one in which no more solute will dissolve under the given conditions. To say that the sodium acetate solution is supersaturated means that it is “over full.” A supersaturated solution contains more solute particles than it normally would under the given conditions. A supersaturated solution can be made using some solutes. If a saturated solution at a high temperature is allowed to cool undisturbed, all the solute may remain dissolved at the lower temperature. The solution is then supersaturated. As you observed in the activity, such solutions are unstable. By introducing a “seed” crystal the extra solute particles “joined” the crystal and came out of the solution.

Polymers

The chemical material that you were working with when you investigated the absorbency of the diaper was sodium polyacrylate. It is a chemical compound called a polymer. It is made up of many (poly) repeating units of a smaller group of elements (the monomer called acrylate). This particular polymer has a unique property. It will absorb more than 800 times its own mass in distilled water. The fascinating ability of this polymer (sodium polyacrylate) to absorb large amounts of water has led to its use in a number of commercial endeavors.

Checking Up

1. What is a physical change? Provide two examples.
2. Explain the meaning of a solution, a solute, and a solvent.
3. What is a chemical change? Provide two examples.
4. What “clues” can you look for to determine if a chemical change has occurred?
5. How do you describe the concentration of a solution?
6. Explain the difference between a saturated and a supersaturated solution.
What Do You Think Now?
At the beginning of this activity you were asked to consider a match broken in half and one lit on fire.

- Which match has undergone a chemical change? Which has undergone a physical change? Give specific reasons to support your answer. How did you make your decision?

Did you have difficulty at the beginning of this activity in telling the difference between physical and chemical changes?

A match is lit. Is this an example of a chemical or physical change? An egg is fried. Is this an example of a chemical or physical change?

Chem Essential Questions
What does it mean?
Chemistry explains a macroscopic phenomenon (what you observe) with a description of what happens at the nanoscopic level (atoms and molecules) using symbolic structures as a way to communicate. Complete the chart below in your Active Chemistry log.

<table>
<thead>
<tr>
<th>MACRO</th>
<th>NANO</th>
<th>SYMBOLIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does it mean when substances undergo physical change?</td>
<td>What happens at the atomic level during a chemical change?</td>
<td>Determine which equation is representing a chemical change and which is representing a physical change: $H_2O(l) \rightarrow H_2O(g)$ $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$</td>
</tr>
</tbody>
</table>

How do you know?
Refer to the data collected from this activity and pick a “best example” for a physical change and a “best example” for a chemical change.

Why do you believe?
Water is a substance that you use in many different ways. When you use water in your daily life, are you changing it chemically? Explain.

Why should you care?
Giving a demonstration of chemistry in your Cool Chemistry Show will probably include both physical and chemical changes. How will you explain the difference between a physical change and a chemical change to your audience?
Reflecting on the Activity and the Challenge

In this activity, you investigated the two types of changes in matter. A physical change is a change in the appearance of the material without creating a new substance. The result is the creation of a solution or homogenous mixture. You also learned that solutions are commonly described in terms of concentration, which is the ratio of the quantity of solute to the quantity of solution expressed in molarity (M). The difference between a saturated and supersaturated solution is discussed. A chemical change, on the other hand, does involve the creation of new products from reactants. Chemical reactions are characterized by a color change or the formation of a precipitate or gas. You further investigated a type of physical reaction by testing the absorbency of a diaper made of sodium polyacrylate, a type of polymer. You can now use this knowledge of chemical and physical changes to amaze the fourth- and fifth-grade students.

1. Which of the following are chemical changes and why?
   a) Toast turns black after being in the toaster too long.
   b) Water condenses on the outside of a glass of iced tea.
   c) Green leaves turn orange, yellow, and red in the fall.
   d) Green bananas become yellow.
   e) Milk becomes sour if left at room temperature.
   f) Butter melts on a hot summer day.

2. Think back to a recent lunch or dinner. Describe two physical and two chemical changes that were involved in preparing and consuming the meal and explain why you think each was a physical or chemical change.

3. Write a paragraph describing the process of making a cake or driving a car. Indicate the physical changes and chemical changes taking place within the activity.

4. The following information is obtained for the element aluminum. Identify which are physical and which are chemical properties.
   Aluminum is a shiny silver metal and melts at 660°C. When a strip of aluminum is placed in hydrochloric acid, hydrogen gas is released. The density of aluminum is 2.70 g/cm³. When polished aluminum is exposed to oxygen over a period of time it forms aluminum oxide (Al₂O₃) on the surface of the metal.

5. How would you determine whether a clear liquid in a beaker is saturated sugar water or just water? Remember, you do not taste samples in the laboratory.

6. The decomposition of water is shown in the following equation:
   \[2H₂O(l) + \text{energy} \rightarrow 2H₂(g) + O₂(g)\]
   What type of process is this, physical or chemical? Explain!

7. Preparing for the Chapter Challenge
   Describe how you would demonstrate the difference between a physical and a chemical change in a “cool” way.
Inquiring Further

Factors affecting solubility and the rate of dissolving

Understanding the factors that affect how quickly a solute dissolves in a solvent is important in many practical applications in manufacturing. Design an investigation to determine the factors that affect solubility. Consider the following:

- nature of the solute and solvent
- temperature
- agitation (stirring or shaking)
- surface area (for example, try using a sugar cube, granulated sugar, and icing sugar)
- pressure of gases.

Remember that your investigation must be controlled, if your results are to be reliable. What will be your independent (manipulated) variables and what will be your dependent (responding) variables?