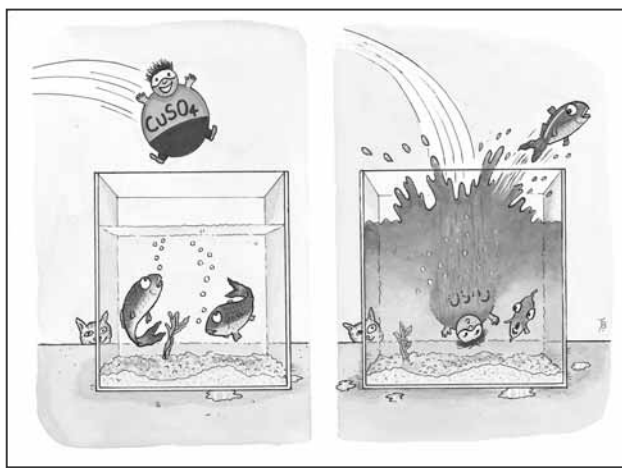


Activity 2 More Chemical Changes



GOALS

In this activity you will:

- Observe several typical examples of evidence that a chemical change is occurring.
- Make generalizations about the combinations of materials that result in the same evidence.
- Make generalizations about materials that tend to react with everything and materials that tend not to react with anything.
- Practice careful laboratory techniques, such as avoiding contamination of reactants, to ensure that results observed are repeatable and unambiguous.

What Do You Think?

Mix 1 cup flour, 1/3 cup sugar, 1 teaspoon of baking powder with a cup of milk and 1 egg, well-beaten. Place the mixture in an oven for 30 minutes.

Add two drops of sodium carbonate (0.1 M Na_2CO_3) to two drops of sodium hydrogen sulfate (0.1 M NaHSO_4).

- Which of the instructions above will result in a chemical reaction? Why?
- Describe one similarity and one difference in the above instructions.

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

Investigate

1. Eight solid materials listed on the next page have been dissolved in distilled water to make solutions. You will combine the solutions (one to one) with each other in an organized manner in order to observe their interactions.

What Do You Think?

Students may be tempted to predict (incorrectly) that the second set of instructions will result in a chemical change. In the first case you would get some kind of a dry cake. The properties of the chemicals would change, forming a new material. This is an example of a chemical reaction. In the second case you would see that nothing happens. The students will have difficulty in drawing this conclusion since they do not know their chemical reactions. Some students may note that both solutions contain a common cation. If they do note this then they should be able to predict that no observable change will occur when the two solutions are mixed together. The second case is an example of a physical reaction.

Student Conceptions

Students explaining chemical changes often do not understand the differences between parts and wholes. They may not realize, for example, that compounds made of combined elements have different properties than the individual elements. In other words, students think that “wholes are like their parts.” The ways students conceptualize chemical changes influence whether they conclude that matter is being conserved. If they focus on evidence such as the disappearance of a reactant or the production of a gas, they may not see that mass is conserved. This is especially problematic if they believe that gases are weightless.



Active Chemistry Cool Chemistry Show



Safety goggles and a lab apron must be worn during this activity.

- barium nitrate $\text{Ba}(\text{NO}_3)_2$
- sodium hydroxide (NaOH)
- sodium hydrogen carbonate (NaHCO_3)
- copper (II) sulfate (CuSO_4)
- potassium iodide (KI)
- silver nitrate (AgNO_3)
- iron (III) nitrate $\text{Fe}(\text{NO}_3)_3$
- hydrochloric acid (HCl)

After mixing two solutions, make notes on your chart of any changes you observe. Don't overlook any color changes, the formation of a precipitate (sometimes observed as a cloudy solution), the formation of a gas (fizzing or bubbles), or a change in temperature.

Using another dropper, continue by adding three drops of the sodium hydrogen carbonate to the second well.

	$\text{Ba}(\text{NO}_3)_2$	NaOH	NaHCO_3	4	5	6	7	8
$\text{Ba}(\text{NO}_3)_2$								
NaOH								
NaHCO_3								
4								
5								
6								
7								
8								



Silver nitrate will stain skin and clothing. Handle with care.

- a) Begin by making a chart to record your data. Your chart will require an entire page of your notebook. Allow plenty of room to record your observations. A sample chart has been provided. Notice that some of the blocks in this chart are shaded, indicating there is no need to mix those particular chemicals. Why do you suppose those particular blocks are shaded?

2. Now it is time to mix the solutions.

Begin with barium nitrate. Add three drops of the barium nitrate solution to each of seven wells of a well plate. Add three drops of sodium hydroxide solution to the first well.

It is important that you do not allow the tip of the dropper of one solution to come in contact with another solution. Your attention to this detail will prevent contamination of solutions.

Continue by adding copper (II) sulfate to the third well, and so on.

- a) After mixing the pairs of solutions, make note on your chart of any changes you observe.

Continue by putting three drops of sodium hydroxide into each of seven wells and adding the other solutions.

Investigate

Teaching Suggestions and Sample Answers

1. - 2.

	Barium Nitrate	Sodium Hydroxide	Sodium Hydrogen Carbonate	Copper (II) Sulfate	Potassium Iodide	Silver Nitrate	Iron (III) Nitrate	HCl
Barium Nitrate	XX	Cloudy ppt	Cloudy ppt	Blue/ White ppt	NRx	NRx	NRx	NRx
Sodium Hydroxide		XX	NRx	Blue ppt	NRx	Brown ppt	Brown ppt	Slight heat
Sodium Hydrogen Carbonate			XX	Lt blue ppt	NRx	Yellow ppt	NRx	Gas
Copper (II) Sulfate				XX	Brown ppt	Light ppt	Green Soln	NRx
Potassium Iodide					XX	Yellow ppt	NRx	NRx
Silver Nitrate						XX	NRx	White ppt
Iron (III) Nitrate							XX	Light Yellow
HCl								XX

Chem Tip:

These dilute solutions still must be handled with extreme care. Silver nitrate will stain skin and clothing. Any students with skin allergies should wear gloves. Spray n' Wash® will remove silver nitrate from skin. It may not remove all of the stain. Keep a spray bottle on hand.

This lab lends itself to microchemistry throughout. Students may have trouble detecting some thermal reactions within the very dilute solutions.

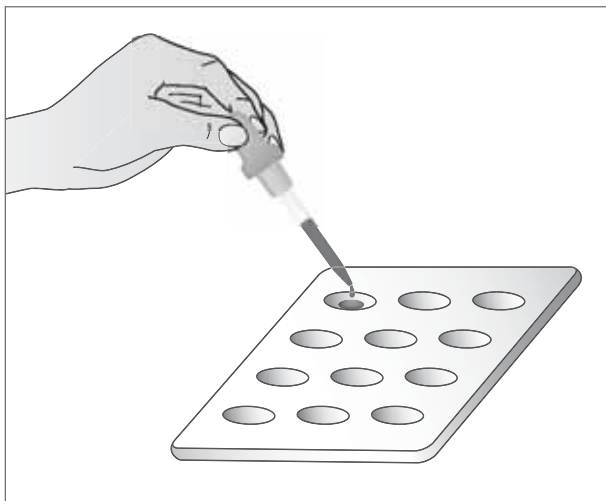
After completing your *entire* chart in this fashion and mixing all possible one-to-one combinations of solutions, clean up your workstation. Your teacher will provide disposal information. Wash your hands.

3. Use your chart to answer the following questions:

- Which combination of reactants seems to produce no reaction when mixed together?
- Which combination of reactants forms a gas? Can you guess which gas is formed? Try to deduce this from the reactants' names and chemical formulas.
- Which combination of reactants produces a color change when mixed together?
- Which combination of reactants forms precipitates quickly? Slowly?
- Which combination of reactants forms a yellow precipitate? A muddy brown precipitate? A white precipitate? A blue precipitate?
- Which combination of reactants produces heat? How could you tell?
- What evidence indicates that a chemical change is occurring?

4. Place the following chemicals in a quart-size resealable plastic bag with a zipper seal:

One teaspoon (scoop)(~28 g) of calcium chloride (CaCl_2)



One teaspoon (scoop)(~28 g) baking soda (NaHCO_3)

Seal the bag and mix the powders.

a) Record your observations in your *Active Chemistry* log. Did a chemical reaction occur?

Pour 10 mL of phenol red indicator solution into the bag and seal quickly. Make sure the solids come in contact with the indicator solution.

b) Observe the reaction and, in your *Active Chemistry* log, describe what you see.

c) Did a chemical reaction occur in the plastic bag? If so, identify all of the evidence of the chemical change.

d) For this particular reaction, calcium chloride and sodium hydrogen carbonate combined to produce an aqueous solution of sodium chloride and calcium oxide in addition to the carbon dioxide and water.

3. a) Barium nitrate/potassium iodide;
 Barium nitrate/silver nitrate;
 Barium nitrate/iron (III) nitrate;
 Barium nitrate/hydrochloric acid;
 Sodium hydroxide/sodium hydrogen carbonate;
 Sodium hydroxide/potassium iodide;
 Sodium hydrogen carbonate/potassium iodide;
 Sodium hydrogen carbonate/iron (III) nitrate;
 Copper sulfate/hydrochloric acid;
 Potassium iodide/iron (III) nitrate;
 Potassium iodide/hydrochloric acid;
 Silver nitrate/iron (III) nitrate
- b) Sodium hydrogen carbonate/hydrochloric acid. Carbon dioxide gas.
 For the teacher only. Overall reaction:

$$\text{NaHCO}_3(\text{aq}) + \text{HCl}(\text{aq}) \longrightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{CO}_3(\text{aq}) \longrightarrow$$

$$\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}$$
- c) Brown precipitate: Sodium hydroxide/silver nitrate;
 Sodium hydroxide/iron (III) nitrate;
 Copper (II) sulfate/potassium iodide;
 White precipitate: Barium nitrate/sodium hydroxide;
 Silver nitrate/hydrochloric acid;
 Barium nitrate/copper sulfate is bluish white;
 Blue precipitate: sodium hydroxide/copper sulfate
- d) Barium nitrate/sodium hydrogen carbonate;
 Barium nitrate/copper (II) sulfate;
 Sodium hydroxide/copper sulfate;
 Sodium hydroxide/silver nitrate;
 Sodium hydroxide/iron (III) nitrate;
 Sodium hydrogen carbonate/copper (II) sulfate;
 Sodium hydrogen carbonate/silver nitrate;
 Potassium iodide/silver nitrate;
 Copper sulfate/potassium iodide;
 Silver nitrate/hydrochloric acid;
 Slow precipitate: Barium nitrate/sodium hydroxide;
 Copper sulfate/silver nitrate
- e) Potassium iodide/silver nitrate(yellow precipitate);
 Sodium hydroxide/silver nitrate and sodium hydroxide/iron nitrate
 (brown precipitate);
 Silver nitrate/hydrochloric acid; barium nitrate/sodium hydroxide;
 and copper sulfate/ silver nitrate (white precipitate);
 Barium nitrate/copper sulfate; sodium hydroxide/copper sulfate;
 and sodium hydrogen carbonate/copper sulfate (blue precipitate)

- f) Sodium hydroxide/hydrochloric acid released heat and was detected by touching the side of the cell.
- g) Formation of a precipitate, heat released, gas given off and production of a new color when the reaction is complete.
4. a) The powders when mixed together cause no apparent reaction.
- b) When the phenol red solution was added a reaction took place and carbon dioxide was released as well as heat given off.
- c) Chemical reaction took place as described in **Part b**.
- d) Calcium chloride and sodium hydrogen carbonate combine to produce an aqueous solution of sodium chloride and calcium oxide in addition to the carbon dioxide.
- e)
$$\frac{\text{CaCl}_2(\text{aq}) + 2 \text{NaHCO}_3(\text{aq})}{\text{reactants}} \longrightarrow \frac{2 \text{NaCl}(\text{aq}) + \text{CaO}(\text{aq}) + 2\text{CO}_2(\text{g}) + \text{H}_2\text{O}}{\text{products}}$$



Active Chemistry Cool Chemistry Show



What are the names of the reactants? What are the names of the products?

5. Your teacher will provide you with a small amount (~25 mL) of limewater, a solution of calcium hydroxide ($\text{Ca}(\text{OH})_2$), in a beaker or flask.

Gently blow through a straw into the solution for a minute or so. One end of the straw should be submerged in the solution. You are actually bubbling carbon dioxide through the solution.

- a) Did a chemical reaction occur? What is the evidence?

ChemTalk

TESTS FOR CHEMICALS

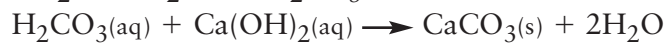
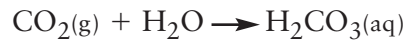
Chemical Tests for Gases

In this activity you focused on chemical reactions, those processes that result in the formation of new products. You also tested for the presence of some of the new materials. You used **chemical tests** to identify the unknown substances. A chemical test is a form of a diagnostic test. To test for the presence of oxygen, you introduce a glowing splint into a test tube with a small amount of gas. If the splint bursts into a flame, you then know that the gas is oxygen. When you introduce a burning splint into a test tube and heard a loud pop, you assume the gas present to be hydrogen. In this activity you tested for the presence of carbon dioxide. Since carbon dioxide does not burn or support burning, by using a glowing or burning splint, you could not tell if a gas was carbon dioxide.

Chem Words

chemical test: a physical procedure or chemical reaction used to identify a substance

5. a) The carbon dioxide caused the solution to become cloudy due to the increase in the production of calcium carbonate. Carbon dioxide combines with water to produce carbonic acid, which then reacts with the basic solution:



Activity 2 More Chemical Changes

(If the splint is extinguished you can say that the gas is neither oxygen nor hydrogen and therefore could be carbon dioxide.) The test for carbon dioxide uses limewater, a clear, colorless solution of calcium hydroxide in water. When you blew bubbles into the test tube you were actually blowing carbon dioxide from your lungs into the limewater. The carbon dioxide reacted with the calcium hydroxide forming a precipitate. The precipitate caused the limewater to turn cloudy in appearance.

Indicators for Acids and Bases

When acids and bases are involved in a chemical reaction the appearance of the products is often very similar to the appearance of the reactants. (You will learn more about acids and bases in a later activity.) Therefore, indicators are used to determine the presence of an acid or base. Substances that change color when they react with an acid or a base are called **acid-base indicators**. In this activity you used phenol red, an acid-base indicator that turns yellow in the presence of an acid. Chemists use a great variety of acid-base indicators. You may also have used litmus in previous science classes. It is a very common indicator used in school laboratories.



Checking Up

1. What is a chemical test?
2. Describe how you can use a burning or glowing splint to test for hydrogen or oxygen.
3. Why does a glowing splint test not work with carbon dioxide?
4. What test is used to identify the presence of carbon dioxide?
5. What is a precipitate?
6. What are acid-base indicators and how are they useful?

Chem Words

acid-base indicator: a dye that has a certain color in an acid solution and a different color in a base solution

Reflecting on the Activity and the Challenge

In this activity you saw evidence of chemical changes taking place when you observed a color change, a change in temperature, a gas being emitted, a precipitate being formed, or light being produced. Which of these chemical reactions would be an exciting or informative addition to your class's

Cool Chemistry Show? Does your class want to be sure to include a variety of reactions that provide different types of evidence of a chemical reaction, or does your class just want to highlight a few of them? These are decisions your class will need to make as you build your **Cool Chemistry Show**.

ChemTalk

Checking Up

1. A special reaction that is used to help identify a particular material.
2. Oxygen supports combustion and if you place a glowing splint in a tube that contains oxygen it will burst into flame. If you are testing for hydrogen gas and you bring a burning splint to the mouth of the test tube, it will produce a loud pop.
3. Carbon dioxide does not support combustion and it is not explosive and so a negative test would be produced when either a glowing or burning splint is brought close to the mouth of a test tube.
4. Carbon dioxide gas will dissolve in water to produce carbonic acid. If the water solution contains calcium hydroxide then the carbonic acid will react with the calcium hydroxide solution (limewater solution) to produce calcium carbonate precipitate.
5. When a compound forms it will produce a precipitate if it exceeds its solubility product at that temperature. For example, barium hydroxide is slightly soluble in water, but as more barium hydroxide is formed it will start causing the solution to become cloudy or form a precipitate.
6. Acid-base indicators are weak acids and when exposed to either an acid or base solution, it will give a unique color. Phenol red is an indicator that will be yellow in an acid solution and will turn red in a basic solution.



Active Chemistry Cool Chemistry Show

Chemistry to Go

1. In both **Activity 1** and **Activity 2** you gathered evidence for chemical changes. However, this evidence does not always indicate a chemical change. For instance, a change in color can be evidence of a chemical change. However, when you add water to a powdered drink mix, the color often changes, but a chemical change has not taken place.
In each of the following situations indicate whether the evidence suggests a chemical change or not:
 - a) An acid is dissolved in water and heat is released.
 - b) A burning match produces light.
 - c) A “seed” crystal is placed in a supersaturated solution and the extra solute particles “join” the crystal and come out of the solution.
 - d) A bottle of a carbonated beverage is opened and carbon dioxide is released.
 - e) The glowing filament of a light bulb produces light.
 - f) A small piece of metal is placed into an acid and hydrogen is released.
 - g) Solutions of sodium hydroxide and copper (II) sulfate are mixed and a blue precipitate appears.
2. Anhydrous copper (II) sulfate (CuSO_4) is a white solid. When it is dissolved in water, the solution becomes blue. Is this a chemical change? Explain how you would defend your answer.
3. If a glass of carbonated soda drink is allowed to sit out for a period of time, you find that the drink seems to be flat. Discuss this observation in terms of whether this is a physical or chemical change.

Preparing for the Chapter Challenge

Select one of the reactions you observed in this activity that you thought was pretty cool. Describe how you might incorporate it into a possible event in the **Cool Chemistry Show** you are designing. Would it meet the needs of

the fourth-grade teacher, the fifth-grade teacher, or both? What additional information would you need to be able to explain the chemistry to the audience?

Chemistry to Go

- Heat is released when an acid is dissolved in water; this is an example of a physical reaction. When salts are dissolved in water they release heat or in some cases absorb heat.
 - The burning match produces a chemical reaction. Heat is released and light is produced. The final product is different material than what the reactants were.
 - Seeding a supersaturated solution or evaporation of a saturated solution is a physical reaction and the salt can be recovered if the water is evaporated from the solution.
 - Opening a bottle of carbonated drink will release carbon dioxide gas and is classified as a physical reaction. Remember that the carbon dioxide was placed in the drink by using pressure or maybe we could say that we have supersaturated the drink.
 - Glowing filament in a light bulb appears to be a physical reaction because it looks like that when you turn off the light bulb the filament returns to its original form. However, over a period of time the filament will deteriorate and finally break. This does show that it is a chemical reaction after all.
 - A metal such as zinc will react with hydrochloric acid and hydrogen gas will be released. This is an example of a chemical reaction in particular, a single-displacement reaction.
 - The reaction indicates that a chemical reaction has taken place with the production of a precipitate. The reaction is:
$$2 \text{NaOH}(\text{aq}) + \text{CuSO}_4(\text{aq}) \longrightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{Cu}(\text{OH})_2(\text{s})$$
- Anhydrous copper sulfate will absorb water and become hydrated. If you apply heat you will dehydrate the hydrated copper sulfate back to the anhydrous form. It is a physical change even though the color changed from white to blue.
- Although the carbon dioxide was placed in the soda drink with pressure, it does not appear that it chemically reacted and when the carbonated solution is allowed to stand over a period of time, the carbon dioxide will escape from the soda drink. Overall, we classify this as a physical process.

Preparing for the Chapter Challenge

This will be an open discussion by the students.