Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

Over the course of two 50-minute class periods, students will combine unknown reactants (two white solids, a clear liquid, and a bright red liquid) and experience them reacting in a closed plastic bag. Several different changes will take place. Students are challenged to write a description of the reaction and its products, then try to determine what reactants are responsible for the products and changes observed.

Correlations to NC Science Standards

PS.8.1.4 Construct an explanation to classify changes in matter as physical changes (including changes in size, shape, and state) or chemical changes that are the result of a chemical reaction (including changes in energy, color, formation of a gas or precipitate).

Learning Target

Students will demonstrate knowledge and understanding of the following ideas and content:

- Chemical reactions produce observable changes in matter.

Brief Science Background

In a chemical reaction, ingredients (reactants) both break *and* form chemical bonds. Changes in chemical bonds often cause the result (product) to have characteristics that are different from the reactants. Some reactions occur spontaneously, others require some input of energy to begin. When reactants produce a chemical reaction, the reaction often causes observable changes such as color change, a temperature change, production of gas, an odor, light, or a precipitate.

In the chemical change demonstrated in this investigation, a careful observer may see many of the changes listed above.

Details of the reaction are complicated, *not important* at this time, and should not be discussed with the students. However, for reference, the reaction is:

$$CaCl_2 + 2NaHCO_3 \rightarrow 2NaCl + CaCO_3 + H_2CO_3$$
$$H_2CO_3 \rightarrow CO_2 + H_2O$$

Calcium chloride (*Powder A*, $CaCl_2$, a salt) and sodium bicarbonate (*Powder B*, $NaHCO_3$, baking soda, a salt) combine, in the presence of water (*Liquid C*), to produce sodium chloride (NaCl, table salt), calcium carbonate ($CaCO_3$, lime, a salt), and carbonic acid (H_2CO_3). Carbonic acid is unstable and breaks down to carbon dioxide (CO_2) and water (H_2O). Phenol red (*Liquid D*) is a pH indicator and does not take part in the reaction.

Common Student Preconceptions

Children have difficulty distinguishing between elements, compounds, atoms, and molecules for reasons having to do with basic language. For example, elements are described as “pure” substances, meaning “made of only one thing.” For many children, the term “pure” means “without harmful contents”. In addition, children have difficulty with the idea of “substance.” For example, some middle school children see ice and water as different substances. In general, most children understand matter in a macroscopic way, not at a microscopic level. As a result, they tend to view chemical combination as a kind of mixing, with only a hazy idea of microscopic internal chemical bonds.

Part 1 — Chemical Change

Materials

Materials for the whole class

- Powder A, calcium chloride, $CaCl_2$
- Powder B, sodium bicarbonate, $NaHCO_3$
- Liquid C, water
- Liquid D, phenol red (500 ml)
- pre-printed labels for A, B, C, and D
- large zip lock bags for storing powders
- copies of SD 1 (2 per team)

Materials for groups of 4 students

- 1 Powder A in a labeled and capped 3.5 oz cup
- 1 Powder B in a labeled and capped 3.5 oz cup
- 1 Liquid C (water) in a labeled 125mL dropper bottle
- 1 Liquid D (phenol red) in a 125 mL dropper bottle
- 2 medicine cups
- 2 zip lock sandwich bags
- 2 sets of measuring spoons
- 2 student instruction sheets (SD 1)
- safety glasses (supplied by teacher)
- science notebook (supplied by teacher)

Preparation

Allow for 20 min.

1. Prepare the phenol red solution by filling the 500 ml bottle, which already contains the phenol red powder, with water. Use this stock solution to fill the dropper bottles labeled Liquid D.
2. Fill the Liquid C bottles with water.
3. Label, fill, and cap Powder A and Powder B cups.
4. Gather materials for a model setup.

Procedure

1. Demonstrate the following setup for the students:
   - Put 5 mL (1 teaspoon) of Powder A and 2.5 mL (1/2 teaspoon) of Powder B in the sandwich bag.
   - Put 5 mL of Liquid C and 10 drops of Liquid D together in a medicine cup.
   - Set the medicine cup containing the liquid in the bag, but DO NOT turn it over.
   - Flatten out the bag between your hands and seal the bag.
   - Tell students that when they get this far they will turn over the cup of liquid so it pours onto the dry ingredients and observe what happens.

Procedure Cont.

2. Before handing out the materials, tell students to put on eye protection and that they should avoid either ingesting or inhaling any of the "ingredients" for the experiment.
3. Hand out the materials and the student directions and let the students go to work.
4. As students finish watching the reactions ask them to write a list of the changes they observed. Discuss the students' lists of observed changes. Here are changes that students might notice:

   - The reaction fizzes, producing bubbles of gas that partially inflate the bag if it was well zipped.
   - When one of the white powders dissolves in the liquid and gas is released, the chemicals cool a little and part of the bag feels cool. When the other white powder dissolves in the liquid, the bag gets warm. Depending on how reactants mix in the bag, students may feel both hot and cool at different places in the same bag at the same time.
   - The liquid changes from bright red to orange or yellow.
   - A white substance forms and makes the liquid cloudy. This might be hard to see because some of the reactants may still be undissolved.

5. If some students disagree on what they observed, ask the whole class to run the procedure again to see if everyone can observe the same changes. If there are no disagreements about observations, there is no need to run the standard bag setup a second time. If the class does a second run of the procedure, discuss any new observations.

There is no need at this time to discuss why students observed what they did. For the teacher's information only, the following points explain some of the students' observations:

- The reaction produces enough bubbles of carbon dioxide (CO_2) to partially inflate the bag.
- The act of dissolving the baking soda in water causes cooling. The reaction between calcium chloride and water produces heat.
- The product of the reaction between calcium chloride and sodium bicarbonate in water is carbonic acid, which changes the pH from basic to acidic and causes the phenol red to change from bright red to orange or yellow.
- The carbonic acid in solution rapidly breaks down to produce carbon dioxide gas which bubbles and fills the bag.
- One reaction product is calcium carbonate, a white precipitate that clouds the water. Leftover calcium chloride and sodium bicarbonate make this hard to see. Sodium chloride is also a product, but it tends to remain dissolved and does not cloud the water.

Content Connection

Say that early chemists first observed reactions, and then tried to figure out what caused each part of them. They investigated the reactants in one way, the reaction another way, and analyzed the products in another way. This approach led them to understand what different substances were made of. For example, an early chemist produced an unknown gas in a chemical reaction. To find out what the gas might be, he placed a candle in a jar of the gas. He saw that the candle burned more brightly than usual. From this,

he thought that the gas might be something in air that allows things to burn. Eventually, this led to the discovery of oxygen.

Formative Assessment/ Guided Practice

1. Ask students to write some procedures that they might use to investigate the reaction they observed.
2. Ask student to identify what was the most imporaant change to them and explain why.

Part 2 — Chemical Change 2

Materials

Materials for groups of 4 students

- 1 Powder A in a labeled and capped 3.5 oz cup
- 1 Powder B in a labeled and capped 3.5 oz cup
- 1 Liquid C (water) in a labeled 125 mL dropper bottle
- 1 Liquid D (phenol red) in a 125 mL dropper bottle
- 6 medicine cups
- 6 zip lock sandwich bags
- 2 sets of measuring spoons
- 2 student instruction sheets (SD 1 from previous lesson)
- 4 student activity sheets (SD 2)
- safety glasses (supplied by teacher)
- science notebook (supplied by teacher)

Preparation

1. Refill Liquid C and Liquid D bottles if necessary.
2. Fill 3.5 oz labeled cups with Powder A and Powder B if necessary.

Procedure

1. Ask students to share their ideas of what they might do to investigate the reaction in the bag to try and figure out what reactants caused the changes they observed. Hopefully, students will come up with the idea of changing the recipe to observe what happens differently. For example, they might leave out a reactant. If they do not come up with recipe changes on their own, explain that early chemists tried simplifying reactions by using fewer reactants and observing the reaction and products.
2. Give each student a student activity sheet (SD 2) and ask them to review the rules at the top.
3. Challenge pairs of students to work together to develop three new recipes that might help them study the reaction. Tell them that they can leave out whatever they want but that they are not allowed to more than double any reactant. The limit on amount of reactants helps to avoid exploding bags due to gas buildup caused by large amounts of reactants.
4. Ask the students to record their recipes and why they chose this recipe on SD 2 with detailed entries of their observations.

Content Connection

1. Tell students, "We are going to use an equation to explain our results." For example:

   1 t. Powder A + 5mL Liquid C results in a white liquid, no gas, and a temperature change

2. Ask students to write their other conclusions in the same form on strips of paper and have them post the strips where students can see them all together and compare them. Discuss what students observe. In the discussion try to bring out two things:

   a. a class consensus about what each reactant brings to the reaction and its products.

   b. ideas about what to do when results using the same reactants differ.

3. Have students classify their observations as a physical or chemical change.

Formative Assesment/ Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions before an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following “test items” to the class. Ask them to write responses in notebooks.

1. Early alchemists and chemists often observed reactions and then worked backwards to figure out what was happening. They did this especially where many reactants were involved, as in our bag reaction. Comment on how each procedure might give insights into what reactions are happening in our bag:

   a. Double the dry ingredients. Mix them together in the bag and let them sit for a week.

   b. Double the amount of one reactant and see what happens.

   c. Open the bag when you turn over the liquids.

   d. Double one reagent and see if the bag inflates more

SD 1

Chemical Change: Student Instructions

1. Put on your safety glasses.
2. Place 5 mL (1 teaspoon) of Powder A in the sandwich bag.
3. Place 2.5 mL (1/2 teaspoon) of Powder B in the same sandwich bag.
4. Put 5 mL of Liquid C and 10 drops of Liquid D together in a medicine cup. Place the cup in the same bag, but **keep it upright**!
5. Press the air out of the bag and zip the bag closed.
6. Tip the cup over and mix all the chemicals.
7. Write detailed descriptions of *everything you observed* below.

Name: _____

Your challenge is to plan a strategy to figure out which reactants caused which changes in the bag. Develop three new recipes that might help study the reaction. You can leave out whatever you want, but you are not allowed to more than double any reactant.

	Recipe 1	Recipe 2	Recipe 3
1. Which change in the bag do you want to find the cause of? Why?			
2. Create a new recipe to help you study this. Write the recipe, including the exact amounts.			
3. Why did you choose this recipe?			
4. Gather your materials and conduct your experiment. Record your results.			
5. Explain what was different or stayed the same.			
6. Explain what you learned from the observations of your new recipe.			