Lesson 3
Forming a precipitate

TEACHER GUIDE

Lesson summary

Students meet chemist Adriana Garcia, who is a chemist at a wastewater treatment plant in Lima, Peru. She explains that one of the challenges of cleaning water is removing particles that are so small they do not settle or get caught in the filters. The best way to solve this problem is to use a chemical reaction that forms a precipitate, which is large enough to settle or get caught in the filters. Students combine two clear colorless solutions and get a white precipitate, which they filter. The products of this chemical reaction are chalk, salt, and water, which are recognizable and noticeably different from the reactants.

This lesson will take two class periods. You will begin with a demonstration, and then students will conduct a chemical reaction that forms a precipitate. The precipitate will need to filter slowly and then dry overnight. On the first day, while students wait for the products to dry, introduce the chemical equation for this reaction. Students will be able to recognize all of the products. On the second day, students compare the precipitate to the reactants to find that it is truly a different substance with different properties.

Key concepts

- Formation of a precipitate is a clue that a chemical reaction may have occurred.
- A precipitate is a solid that forms in the chemical reaction between liquids. It does not dissolve in the resulting solution.
- The products of a chemical reaction are different from the reactants, but are made of the same type and number of atoms.

Safety

Be sure you and the students wear properly fitting goggles. Read and follow all safety warnings on the labels of the calcium chloride and sodium bicarbonate containers. Bromthymol blue is alcohol-based and flammable. Have students wash their hands after the activity.

Proper disposal

At the end of the lesson, have students pour their used solutions in a waste container. Dispose of this waste down the drain or according to local regulations. The leftover calcium chloride, sodium bicarbonate, and the product calcium carbonate can be disposed of with the classroom trash. Wipe up spills with paper towels and dispose of them with the classroom trash.

Introduction

1. Introduce students to a scientist and her work.
Distribute the student activity sheets for Lesson 3. In this lesson, students meet water chemist Adriana Garcia, who works to reduce the use of water from mountaintop glaciers by reusing wastewater. Students use a chemical reaction to form a precipitate from substances that were dissolved in water. Then students compare the solubility of the precipitate to the solubility of the reactants to prove that the precipitate is different from the reactants.

Teacher demonstration

2. Do a demonstration to introduce students to the term *precipitate*.
Hold up a cup of calcium chloride solution and sodium carbonate solution. Tell students that while both solutions are clear and colorless like ordinary water, both have different chemicals dissolved in them. A coffee filter cannot be used to remove these dissolved particles, because they are so small that they can slip right through little holes in the filter. Even the holes are too small for us to see. A chemical reaction between the two solutions can change these reactants into products that are large enough to get trapped in this filter.

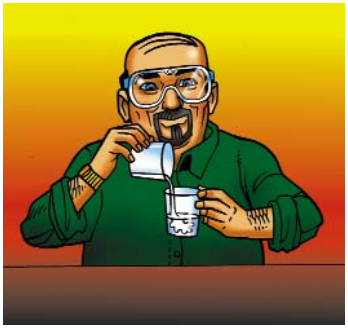
You will need

- Goggles
- Sodium carbonate
- Calcium chloride
- Water
- Small metric measuring cup
- 2 small spoons
- 2 clear plastic cups

Spoon

Preparation instructions

- Place about 30 mL of water in each of two plastic cups.
- Add 1 spoon of calcium chloride to one of the cups. Swirl until the calcium chloride dissolves.
- Add 1 spoon of sodium carbonate to the other cup. Swirl until the sodium carbonate dissolves.



Procedure

1. Very slowly pour the calcium chloride solution into the sodium carbonate solution.

Expected results

White particles will form and sink to the bottom.

Tell students that you combined two liquids, and a solid was formed. Although they are small particles, they are solid, and will not dissolve no matter how much you stir. Tell students that the solid that forms from two liquids is called a *precipitate*. This solid is calcium carbonate, which is the main substance in chalk and sea shells.

Student activity

3. Have students make a precipitate and collect it with a coffee filter.
Tell students that they will use calcium chloride and sodium bicarbonate, not sodium carbonate, which you used in the demonstration. In this reaction, the precipitate is the same, calcium carbonate, but there is another noticeable product. Tell students to watch out for other clues of chemical change, which they learned about in the first two lessons.

Activity summary

Information on how to conduct this activity is included on the student activity sheet. First, students will make sodium bicarbonate and calcium chloride solutions. They will combine the solutions and then use a filter to collect the precipitate. The liquid will need to drip through overnight to give the precipitate a chance to dry.

Note

While students are making their sodium bicarbonate and calcium chloride solutions, they may notice that the solutions change temperature. As sodium bicarbonate dissolves in water, the solution gets colder. As calcium chloride dissolves in water, the solution gets warmer. This phenomenon is not the focus of this activity, but may be something students notice. If they do observe this, you can explain that although a temperature change is one of the four clues of chemical change, it can also occur during the physical change of dissolving.

Preparation instructions

- Use the pre-made stickers to label a set of portion cups *calcium chloride*. If you conducted lesson 1, reuse the portion cups labeled *sodium bicarbonate.*
- Place ½ teaspoon of calcium chloride and sodium bicarbonate in their labeled cups.

Expected results

The combined solutions will slowly bubble and will look much whiter than the clear-looking solutions you started with. The white color is actually caused by particles of the precipitate calcium carbonate. After filtering and drying, the precipitate is white and powdery. It is calcium carbonate, which is chalk.

Collect the cups and filters and store them out of the way until the next time the class meets. Once the liquid has flowed through the filter, you may choose to remove the coffee filters with the precipitate from the top of each cup and lay them flat on a paper towel. This will speed up the drying process.

If you'd like to separate the sodium chloride from the water that flowed through the filter, pour the liquid into a wide shallow dish, like a petri dish, and allow the water to evaporate for a few days. As the water evaporates, students will see salt crystals forming in the solution. Eventually, they will see the characteristic cubic shape of salt crystals (sodium chloride).

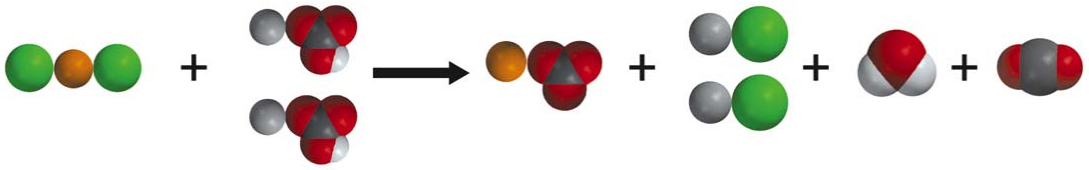
Class discussion

4. Discuss student observations and introduce the chemical equation for the reaction.

Ask students

- **Which two clues of chemical change did you observe?**
  Bubbling and a precipitate. Students may include a color change, because the liquid that was once clear and colorless turned white.
- **Could you get the precipitate to dissolve?**
  No. Even if you stir, the precipitate will not dissolve.

Have students look at the following chemical equation on their activity sheets.



$CaCl_2$	$2NaHCO_3$	$CaCO_3$	$2NaCl$	H_2O	CO_2
calcium chloride	sodium bicarbonate	calcium carbonate	sodium chloride	water	carbon dioxide

Ask students

- **Which are the reactants, and which are the products?**
  The reactants are calcium chloride and sodium bicarbonate. The products are calcium carbonate, sodium chloride, water, and carbon dioxide.

- **How many of each type of atoms is on the reactant side? The product side?**

Types of atoms	Number of each type of atom in the... reactants	products
calcium atom	1	1
chlorine atoms	2	2
sodium atoms	2	2
hydrogen atoms	2	2
carbon atoms	2	2
oxygen atoms	6	6

- **What do you think was in the bubbles?**
  Carbon dioxide gas was in the bubbles.

- **What is the precipitate? How do you know?**
  The precipitate is calcium carbonate, which is chalk and is also in eggshells, seashells, and coral. Looking at the chemical equation, the products are calcium carbonate, sodium chloride, water, and carbon dioxide. Carbon dioxide leaves the reaction as a gas and sodium chloride dissolves in the water, so the precipitate must be calcium carbonate.
- **What is the liquid left behind after you filtered the precipitate?**
  The liquid is saltwater. Students may not realize this, but there may also be some unreacted sodium carbonate or calcium chloride still in solution.

Class discussion

5. The next time the class meets, have students investigate whether the precipitate is really different from either of the reactants.
Distribute the paper towels or coffee filters with the dried precipitate to student groups.

Ask students

- **The precipitate looks similar to baking powder and calcium chloride. Could the precipitate be the same as one of the reactants?**
  The precipitate is calcium carbonate, which is different from the reactants.

Tell students that the precipitate is supposed to be different from the reactants, but that you would like them to do an activity to prove whether or not this is true. Remind students that the baking soda and calcium chloride both dissolved in water. Tell students that they will find out whether or not the precipitate dissolves in water. If it dissolves, we'd need to do another test to find out if it is the same as one of the reactants. But if it doesn't dissolve, we know that it must be different.

Activity summary

Have students follow the procedure on the student activity sheet. This activity provides evidence that the precipitate calcium carbonate really is a different substance from either of the reactants. Both sodium carbonate and calcium chloride dissolve in water. However, students will discover that the precipitate, calcium carbonate, does not dissolve in water. These white powders may appear similar, but they have different chemical properties and are therefore different.

Teacher demonstration

6. Do a demonstration to review the three clues of chemical change introduced in the first three lessons.

You will need

- Goggles
- Bromthymol blue indicator
- Sodium bicarbonate
- Calcium chloride
- Water
- Small metric measuring cup
- 2 small spoons
- 2 clear plastic cups

Spoon

Procedure

1. Place 10 mL of water in a clear plastic cup.
2. Add 1 spoon of sodium bicarbonate and swirl to dissolve.
3. Add 10 drops of bromthymol blue indicator to the sodium bicarbonate solution.
4. Place 10 mL of water in a separate clear plastic cup.
5. Add 1 spoon of calcium chloride and swirl to dissolve.
6. Pour the calcium chloride solution into the sodium bicarbonate solution.

Expected results

There will be bubbling, a color change, and a precipitate.

Ask students

- **Which three clues of chemical change did you observe?**
  A color change, bubbling, and the formation of a precipitate.
- **Did a chemical reaction occur? How do you know?**
  The chemicals you started with have changed, so the products are different.

Application

Have students read the real-world application on the student activity sheet. Explain that the United States and other countries use filtering, along with chemical reactions that produce a precipitate, to make drinking water safe. The reading will describe the general process.