PRESENTER'S GUIDE

WHAT'S NEW, CO_2?

GET TO KNOW A CHEMICAL REACTION

TABLE OF CONTENTS

PLAN FOR SUCCESS

Thank you for volunteering to share chemistry with students. They will definitely enjoy their time with you. Some will excitedly tell their parents all about you and the experiments as soon as they get home. Many will give their families and friends a quick science lesson whenever they see or hear about something you mentioned. Your short visit will definitely make an impact!

The teacher will appreciate your efforts, too. After all, your visit gives students the opportunity to learn chemistry concepts from a real scientist! In order to make your visit as beneficial as possible, give the teacher the Teacher's Guide included in this kit before your visit. Also be sure to discuss the information presented on these two pages with the teacher. Planning together will ensure that you, the teacher, and the students all have a wonderful experience.

Learning objectives

Teachers must make sure that their students have a variety of experiences covering concepts outlined by their district. So it is best if your lesson introduces, reinforces, or relates to one or more of these required concepts.

The teacher will be pleased to know that as a result of the *What's New, CO_2?* lesson, students will meet the following learning objectives:

- Discover that the way to increase the amount of product in a chemical reaction is to increase the amount of the reactants.
- Use a beaker to measure milliliters.
- Recognize that carbon dioxide gas has characteristic properties.
- Explain that in chemical reactions, molecules break apart, rearrange, and join together to form different substances.

Vocabulary words

After completing this lesson with you, students will be familiar with the following terms:

- Chemistry
- Chemical reaction
- Carbon dioxide gas
- Property

Ask the teacher to…

- Place students in groups of 3 or 4 around a shared workspace.
- Provide a space where you can set up the demo immediately before your presentation.
- Provide access to water before your presentation. Each group of 4 students will need about a half cup of water.
- Provide safety goggles for each student and adult. (You may need to help with this.)
- Arrange to have all students wash their hands and desks after your visit.

Safety plan

- Review the MSDSs (page 22) for baking soda, citric acid, and bromthymol blue indicator.
- Let the teacher know that the activities in this kit have been reviewed by the ACS Committee on Chemical Safety.
- Students must wear safety goggles during the activities when indicated. They may take "goggle breaks" between activities, but they should take care not to place their hands on their faces or in their mouths at this time.
- Take all waste with you so that students are not tempted to play with the materials in the trash can after you leave. Liquids can be collected and poured down a sink followed by water.
- The cups used in this kit may be reused, recycled, or placed in the trash. However, the cups should never be reused with food or drinks!
- Any used paper towels can be disposed of with regular trash.

Bring

- Kit with all materials
- Waste container for each group
- Bucket
- Roll of paper towels

Most importantly…have fun! When students experience your enthusiasm for science, they can't help but enjoy science, too. After your presentation, please send a quick e-mail to the staff in the Kids & Chemistry Office at *kids@acs.org* to let us know what you did and how it went. We'd love to hear from you!

POP THE TOP DEMO

1. Prepare for the activities and demonstration before you meet the students.

Allow some time before your scheduled presentation to prepare for the demonstration and activities.

Prepare for the activities

1. Fill 8 plastic cups (9-ounce size) about halfway with water. These will be for the student groups to use in the activities.
2. Use your dropper to add about 1 mL of detergent solution to each cup labeled "detergent solution". Students will use only about 3 drops of detergent solution in the activity Foam Dome.
3. Inflate 1 Mylar balloon by either hitting the liquid-filled bag with your fist or by stepping on it. We recommend students step on the balloon in The Grand Finale.

Prepare for the demonstration

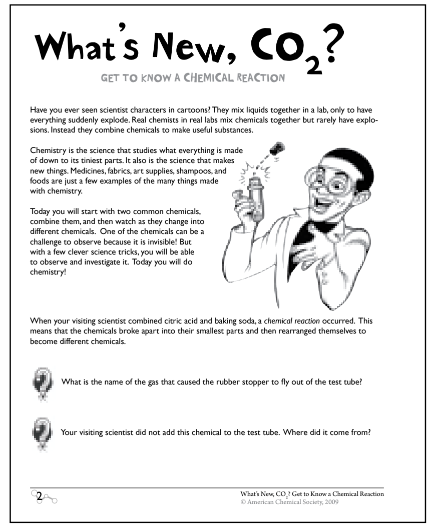
1. Place the following items near the area where you will conduct the demonstration:

    - Test tube
    - Rubber stopper
    - Graduated dropper
    - 2 small scoops
    - Citric acid
    - Baking soda
    - Small amount of water

2. Place one level scoop of citric acid into the plastic test tube. Then using the graduated dropper, add 1 mL of water. Place the rubber stopper on the test tube and shake until the citric acid dissolves. Leave the test tube sealed until you present this demonstration to the students.

2. Introduce yourself, chemistry, and the activity.

Introduce yourself and let students know that you like doing experiments, making discoveries, and solving problems. Tell students: *Chemistry* is the science that explores everything! Chemists figure out what everything is made of down to its tiniest bits. They study what makes different materials special, and then they make new useful materials that have certain characteristics. Today you will explore some amazing materials developed by chemists. One is so useful that it is used by movie-set designers, gardeners, firefighters, and babies! Today you will do chemistry!


What's New, CO_2?

GET TO KNOW A CHEMICAL REACTION

Have you ever seen scientist characters in cartoons? They mix liquids together in a lab, only to have everything suddenly explode. Real chemists in real labs mix chemicals together but rarely have explosions. Instead they combine chemicals to make useful substances.

Chemistry is the science that studies what everything is made of down to its tiniest parts. It also is the science that makes new things. Medicines, fabrics, art supplies, shampoos, and foods are just a few examples of the many things made with chemistry.

Today you will start with two common chemicals, combine them, and then watch as they change into different chemicals. One of the chemicals can be a challenge to observe because it is invisible! But with a few clever science tricks, you will be able to observe and investigate it. Today you will do chemistry!

When your visiting scientist combined citric acid and baking soda, a *chemical reaction* occurred. This means that the chemicals broke apart into their smallest parts and then rearranged themselves to become different chemicals.

What is the name of the gas that caused the rubber stopper to fly out of the test tube?

Your visiting scientist did not add this chemical to the test tube. Where did it come from?

2

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009

Student Lab Guide, Page 2

Distribute goggles and the Student Lab Guides. Have students read the first three paragraphs on page 2 as you and the teacher walk around helping students adjust their goggles. Students will answer the questions on page 2 after you discuss what happened in the demonstration.

Let students know that they do not need to wear their goggles while reading. However, they will need to wear their goggles during the demonstration and in the specified activities.

If some students finish reading before you are finished adjusting goggles, have them flip through the Student Lab Guide to get a quick overview of the lesson.

3. Introduce students to citric acid and sodium bicarbonate.

Tell students that you have combined citric acid powder and water in the test tube. Explain that citric acid is found naturally in lemons and limes. Since it makes things taste sour, it is also an ingredient in many different kinds of sour candies. Tell students that you will add baking soda to the citric acid. Explain that baking soda is often an ingredient in cookies or cakes. People sometimes place it in their refrigerator to keep it smelling fresh.

Show students the test tube and rubber stopper that you will use. Explain that chemists use test tubes when they want to combine small amounts of chemicals and see what happens. Test tubes are made of glass or plastic.

You may choose to tell students that this test tube is a little different from most used in science. If you look carefully, it seems to have a lot in common with a plastic pop bottle. It is called a "preform" and is the shape bottles are before they are heated and blown into the 2-liter bottle shape we are familiar with.

4. Conduct a demonstration to show that citric acid and baking soda react with each other.

Select a student volunteer or have the teacher help you with this demonstration.

Tell students to watch as citric acid and baking soda change into different chemicals. Ask students to tell you when they notice a clue that the chemicals have changed.

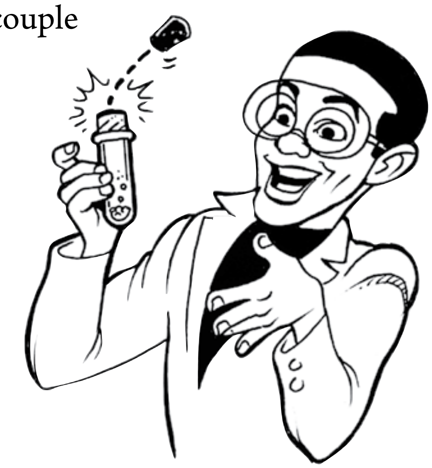
Note: The success of this demonstration depends on the effectiveness of your baking soda and how quickly you can conduct the following procedure. If you can, practice this demonstration a few times at home so that you know what to expect.

1. Remove the rubber stopper and select a volunteer. Make sure that both you and the student are wearing goggles! In fact, direct all students and adults in the classroom to wear their goggles during this demonstration.

2. Hold the test tube away from your body and take care to hold it vertically. Direct your volunteer to scoop out 1 level scoop of baking soda and add it to the liquid in the test tube.

3. Hold the test tube up so that students can see a little bit of bubbling. Then securely place the rubber stopper in the top of the test tube and hold the sealed test tube up for all to see.

4. Replace the rubber stopper a couple of times.



Expected Results: The rubber stopper pops off of the test tube almost immediately. When you replace the rubber stopper, it will pop again as the reaction continues. However, each time you replace the rubber stopper, there will be a longer and longer interval of time before the stopper pops off again. Eventually, the stopper will remain on the test tube.

5. Discuss student observations.

Ask students:

- What were some clues that let you know that something new was made?

Everyone should notice the rubber stopper pop off of the test tube. Some students, especially those who are sitting nearby, may have seen bubbling and white foam develop. Some may have even heard a fizzing sound.

6. Introduce the term *chemical reaction*.

Explain to students that the bubbling, fizzing, and flying rubber stopper are all clues that a chemical reaction occurred. A chemical reaction is when chemicals like citric acid and baking soda break apart into their smallest parts and rearrange themselves to become different chemicals. In this reaction, one of the new chemicals is carbon dioxide gas, and it is this gas that pushed the rubber stopper up and out of the test tube.

Tell students that they will have the chance to make and investigate carbon dioxide gas in the activities that they will do with you. Explain that carbon dioxide is invisible so investigating it can be a little tricky. But with students' outstanding observation skills and a few clever ideas, you are confident that all the students can do it!

7. Distribute materials as students answer questions about the demonstration.

Have students go back to page 2 of their Student Lab Guide and answer the questions about the demonstration. During this time, distribute a source cup of water, a small cup of detergent solution, and a bag of materials to each student group.

1. Introduce the role bubbles will play in this activity.

Remind students of the bubbling some may have seen in the demonstration. Admit that it was very difficult for everyone to see this. Tell students that this activity focuses on the bubbling. So to make it easier to see the bubbles, we'll add 1 drop of detergent solution. This will make the bubbles last longer, too.

Explain that the bubbles are important because they can give us an idea of how much carbon dioxide gas is made in the chemical reaction. If we trap the gas inside bubbles, we will be able to get an idea of how much gas is made when citric acid and baking soda react with each other.

2. Show students what the bubbling will look like in the activity.

Tell students that they will combine citric acid and baking soda the same way you will do in this demonstration.

1. Place 2 level scoops of citric acid in a small plastic cup labeled "citric acid solution".
2. Use a beaker to measure 10 mL of water. Add this water to the citric acid.
3. Use a dropper to add 1 drop of detergent solution. Swirl gently until the citric acid dissolves.
4. Add 2 level scoops of baking soda to a separate small clear plastic cup.
5. While holding the cup containing the baking soda, pour the citric acid and detergent solution into the cup. Be sure that students can see the foam as it rises in the cup.

Expected Results: Foam will develop which will rise about half-way up the cup.

3. Help students make the connection between the amount of foam and the amount of CO_2 produced.

Ask students:

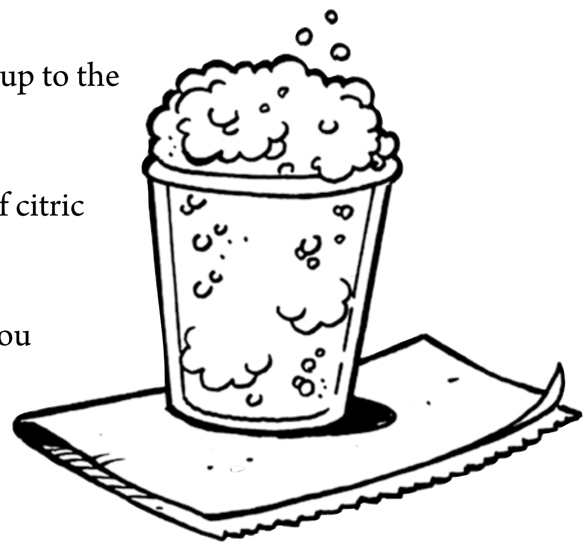
- We mixed two solids and a liquid. Do you think that the foam is a solid, liquid, or a gas?
- What is inside each of the tiny bubbles?
- If I did this demonstration again and the foam rose all the way to the top of the cup, would you say that I made more or less carbon dioxide gas?

Explain that foams contain gases trapped in either a liquid or a solid. Help students realize that carbon dioxide gas is inside the tiny bubbles. They should be able to reason that more foam means more carbon dioxide gas.

4. Discuss how students can make just enough foam to reach the top of the cup.

Ask the whole class:

- How do you think you could make the foam come right up to the top of the cup without overflowing?



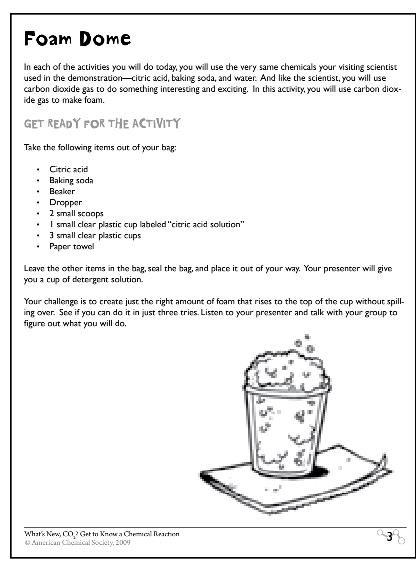
Students should agree that they will need to add more scoops of citric acid and/or baking soda.

Point out the number of scoops of citric acid and baking soda you used in the demonstration. Explain that these amounts should be used as a reference when deciding how much citric acid and baking soda to use.

5. Have students remove only the materials needed for this activity from the materials bag.

Tell students that they will need to remove the following items from their materials bag. This list is also included in the Student Lab Guide.

- Citric acid
- Baking soda
- Beaker
- Dropper
- 2 small scoops
- 3 small plastic cups
- 1 small clear plastic cup labeled “citric acid solution”
- Paper towel



Foam Dome

In each of the activities you will do today, you will use the very same chemicals your visiting scientist used in the demonstration—citric acid, baking soda, and water. And like the scientist, you will use carbon dioxide gas to do something interesting and exciting. In this activity, you will use carbon dioxide gas to make foam.

GET READY FOR THE ACTIVITY

Take the following items out of your bag:

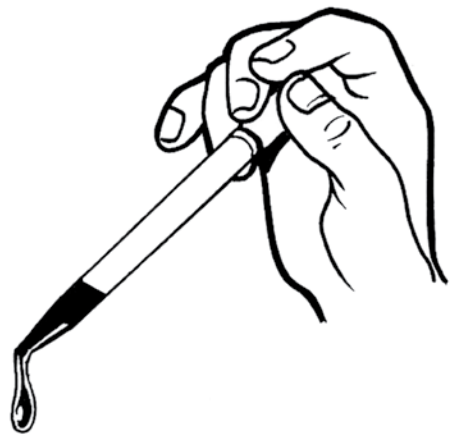
- Citric acid
- Baking soda
- Beaker
- Dropper
- 2 small scoops
- 1 small clear plastic cup labeled “citric acid solution”
- 3 small clear plastic cups
- Paper towel

Leave the other items in the bag, seal the bag, and place it out of your way. Your presenter will give you a cup of detergent solution.

Your challenge is to create just the right amount of foam that rises to the top of the cup without spilling over. See if you can do it in just three tries. Listen to your presenter and talk with your group to figure out what you will do.

Student Lab Guide, Page 3

6. Have students practice using the dropper.

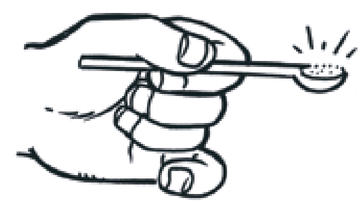


Show students how to squeeze the bulb of the dropper in order to pick up a liquid. (Practice with the source cup of water.) Then point out how to carefully squeeze the dropper in order to release single drops.

Give students a couple of minutes to practice using the dropper. Ideally, each student in the group should have a chance to practice using the dropper. As students practice, walk around the room to check on their progress. Ask the teacher to help you with this, so that the two of you can quickly check on all students. Be sure to praise students when you notice them using the dropper properly, and help those who have not yet mastered the skill.

7. Explain what students will do in the activity.

Tell students that they have 3 tries to get the foam to rise to the top of the cup without overflowing. Make a point that students should use level scoops, not rounded or heaping scoops.

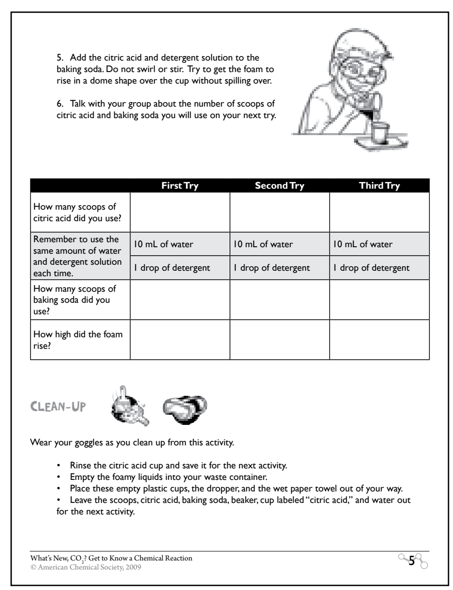


Point out the chart on page 5 of the Student Lab Guide. Ask students the following questions to help them understand how to use the chart:

- How many milliliters of water will you use on your first try?
- How much detergent solution will you use?
- How much water and detergent solution will you use on your second and third tries?
- Where will you write the number of scoops of citric acid and baking soda you use on your first try?
- How can you describe how high the foam rises in the cup?

Students should realize that they must keep the amount of water and detergent solution the same in each trial. The only thing they should change is the amount of citric acid and/or baking soda. Point out that students can report their results with phrases like "almost to the top" or "overflowed a tiny bit."

Direct students to talk with their group and agree on the amounts of citric acid and baking soda they will add on their First Try. Then have each group write their planned amounts in the first column. Let them know that they should wait until after they have seen their foam finish rising to decide on the amounts to use for the Second Try.



5. Add the citric acid and detergent solution to the baking soda. Do not swirl or stir. Try to get the foam to rise in a dome shape over the cup without spilling over.

6. Talk with your group about the number of scoops of citric acid and baking soda you will use on your next try.

	First Try	Second Try	Third Try
How many scoops of citric acid did you use?			
Remember to use the same amount of water and detergent solution each time.	10 mL of water	10 mL of water	10 mL of water
	1 drop of detergent	1 drop of detergent	1 drop of detergent
How many scoops of baking soda did you use?			
How high did the foam rise?			

CLEAN-UP

Wear your goggles as you clean up from this activity.

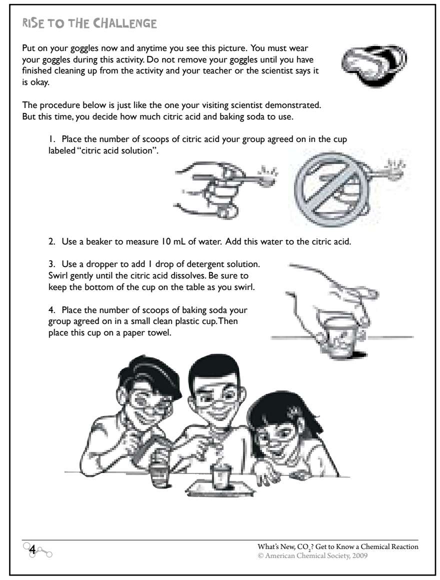
- Rinse the citric acid cup and save it for the next activity.
- Empty the foamy liquids into your waste container.
- Place these empty plastic cups, the dropper, and the wet paper towel out of your way.
- Leave the scoops, citric acid, baking soda, beaker, cup labeled "citric acid," and water out for the next activity.

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009
5

Student Lab Guide, Page 5

8. Have students try to get the foam to rise to the top of the cup without overflowing.

Walk around the room and talk to each group as students work.



RISE TO THE CHALLENGE

Put on your goggles now and anytime you see this picture. You must wear your goggles during this activity. Do not remove your goggles until you have finished cleaning up from the activity and your teacher or the scientist says it is okay.

The procedure below is just like the one your visiting scientist demonstrated. But this time, you decide how much citric acid and baking soda to use.

1. Place the number of scoops of citric acid your group agreed on in the cup labeled "citric acid solution".
2. Use a beaker to measure 10 mL of water. Add this water to the citric acid.
3. Use a dropper to add 1 drop of detergent solution. Swirl gently until the citric acid dissolves. Be sure to keep the bottom of the cup on the table as you swirl.
4. Place the number of scoops of baking soda your group agreed on in a small clean plastic cup. Then place this cup on a paper towel.

4

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009

Student Lab Guide, Page 4

1. Place the number of scoops of citric acid your group agreed on in the cup labeled "citric acid solution".

2. Use a beaker to measure 10 mL of water. Add this water to the citric acid.

3. Use a dropper to add 1 drop of detergent solution. Swirl gently until the citric acid dissolves. Be sure to keep the bottom of the cup on the table as you swirl.

4. Place the number of scoops of baking soda your group agreed on in a small clean plastic cup. Then place this cup on a paper towel.

5. Add the citric acid and detergent solution to the baking soda. Do not swirl or stir. Watch the level of foam rise in the cup. Try to get the foam to rise in a dome shape over the cup without spilling over.

6. Record your observations in the chart.

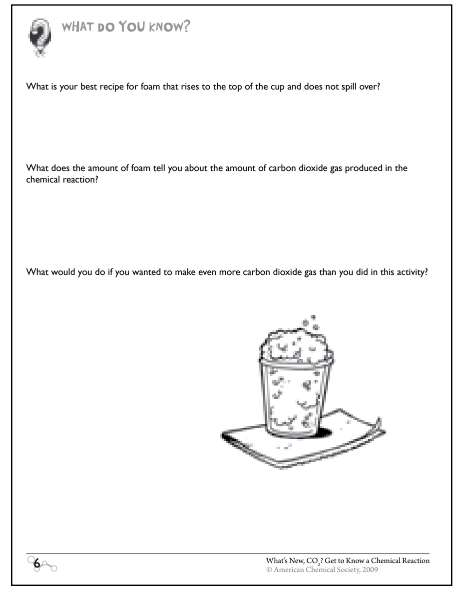
7. Talk with your group about the number of scoops of citric acid and baking soda you will use on your next try. Record this in the chart.

Expected Results: About 5 scoops of citric acid and 5 scoops of baking soda will create enough foam to form a dome over the top of the cup without spilling over.

Note: Students may notice that the cups of foam feel cold. This happens because the chemical reaction between citric acid and baking soda is endothermic.

9. Clean up from the activity, answer questions about the activity, and prepare for the next demo.

Make sure students wear their goggles as they pour the liquid and foam into a waste container or classroom sink. Have students pour a little bit of water into their citric acid cup, swirl, and empty into their waste container. Students will reuse this cup in the next activity. With the help of the teacher, collect the detergent solution and the 3 empty unlabeled cups. Also collect the used paper towel and dropper from each group. The cups and dropper may be rinsed and reused after your presentation. However, if you intend to discard these items, collect them in a bag and take them with you when you leave. They may be placed in ordinary household or workplace trash.



WHAT DO YOU KNOW?

What is your best recipe for foam that rises to the top of the cup and does not spill over?

What does the amount of foam tell you about the amount of carbon dioxide gas produced in the chemical reaction?

What would you do if you wanted to make even more carbon dioxide gas than you did in this activity?

6

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009

Student Lab Guide, Page 6

Students should leave the cup labeled "citric acid solution", 2 small scoops, bottles of citric acid and baking soda, beaker, and water out for the next activity.

When students finish cleaning up, have them answer the questions on page 6 of the Student Lab Guide. Use this time to prepare the demonstration for the next activity.

Prepare for the demonstration

1. Use a beaker to add 60 milliliters of water to a tall clear plastic cup.
2. Add 20 drops of bromthymol blue indicator solution. Swirl gently to mix.
3. Place a straw in the indicator solution.

10. Discuss student observations.

If you have time, go over the questions the students answered in their Student Lab Guide. Otherwise move on to the next demonstration and activity.

- What is your best recipe for foam that rises to the top of the cup and does not spill over?
- What does the amount of foam tell you about the amount of carbon dioxide gas produced in the chemical reaction?
- What would you do if you wanted to make more carbon dioxide gas than you did in this activity?

Make sure students understand that the amount of foam gives an idea of the amount of carbon dioxide gas produced in the chemical reaction. More foam means more carbon dioxide gas is produced. Students should realize that if they want to make more carbon dioxide gas, they should use more citric acid and baking soda.

1. Do a demonstration to show that carbon dioxide can change the color of bromthymol blue indicator.

- Tell students that you will blow into a special liquid called bromthymol blue indicator. Ask them to tell you if they notice a change.
- Hold the straw so that the end is at the bottom of the cup. Then blow into the indicator solution until it turns green.

Note: Be sure to blow out so that you do not accidentally drink the bromthymol blue indicator solution.

Expected Results: The blue solution will change to green and then light green.

Tell students that carbon dioxide gas comes out of people's mouths as they talk and breathe out. Explain that when you blew through the straw, the gases in your breath dissolved in the water. And one of these gases, carbon dioxide, changed the color of the bromthymol blue indicator.

2. Introduce the term *property* and the questions you and the students will investigate.

Ask students:

- Do you know of another way to get carbon dioxide gas?
- Will carbon dioxide gas from the citric acid and baking soda reaction make bromthymol blue indicator turn green, too?

Students should suggest that they can combine citric acid and baking soda to make carbon dioxide gas. Explain that you want students to help you find out whether carbon dioxide gas from any source will make bromthymol blue indicator solution turn green. If it does, being able to turn this special blue liquid green is a property of carbon dioxide gas. A property is a special characteristic. Being soft, smooth, or colorful are all properties of substances. Changing color or making bubbles whenever certain chemicals mix together are chemical properties of substances.

3. Prepare for the activity.

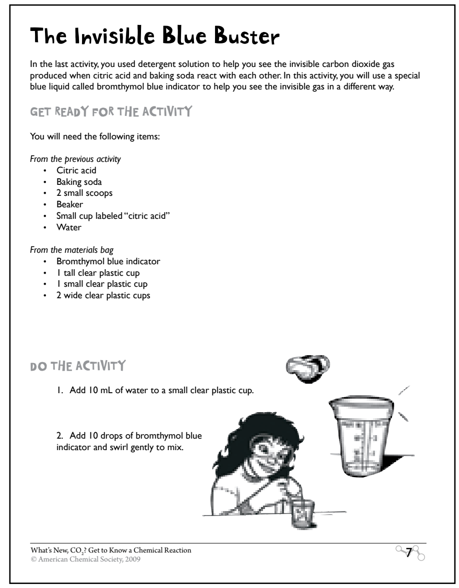
Have students gather the materials necessary for this activity.

From the previous activity

- Citric acid
- Baking soda
- 2 small scoops
- Beaker
- Small cup labeled “citric acid solution”
- Water

From the materials bag

- Bromthymol blue indicator
- 1 tall clear plastic cup
- 1 small clear plastic cup
- 2 wide clear plastic cups



The Invisible Blue Buster

In the last activity, you used detergent solution to help you see the invisible carbon dioxide gas produced when citric acid and baking soda react with each other. In this activity, you will use a special blue liquid called bromthymol blue indicator to help you see the invisible gas in a different way.

GET READY FOR THE ACTIVITY

You will need the following items:

From the previous activity

- Citric acid
- Baking soda
- 2 small scoops
- Beaker
- Small cup labeled “citric acid”
- Water

From the materials bag

- Bromthymol blue indicator
- 1 tall clear plastic cup
- 1 small clear plastic cup
- 2 wide clear plastic cups

DO THE ACTIVITY

1. Add 10 mL of water to a small clear plastic cup.
2. Add 10 drops of bromthymol blue indicator and swirl gently to mix.

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009 7

Student Lab Guide, Page 7

Show students one set of empty cups arranged like they will be in the activity. Explain that the small cup will be filled with indicator solution. A small amount of citric acid, water, and baking soda will be in the wide clear plastic cup. The top cup will act like a lid to trap the carbon dioxide gas.

Be sure to point out that the citric acid and baking soda will never touch the indicator solution. Using the set of empty cups, show students how to gently swirl the cups so that the invisible carbon dioxide gas that forms during the chemical reaction will enter the small cup containing the indicator solution.

Ask students:

- What do you think will happen to the bromthymol blue indicator when the carbon dioxide gas mixes in with it?

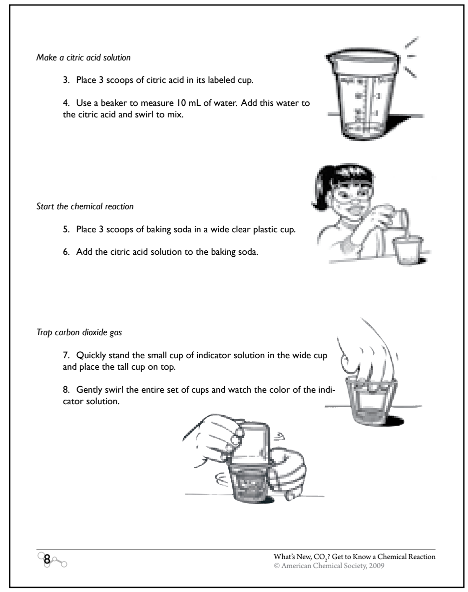
Based on the demonstration and your earlier discussion, students should be able to predict that the indicator solution will turn green.

4. Have students practice arranging the cups.

This procedure is a bit complicated and needs to be done quickly, so have students practice assembling and swirling empty cups on their desktops before doing the procedure. Have students stand the small cup inside of the wide cup. Then have them flip the tall cup upside down to make a tall lid. Finally, when all cups are assembled, have students carefully swirl the cups.

5. Have students do the activity to find out whether carbon dioxide gas from the citric acid and baking soda reaction will change the color of bromthymol blue indicator.

This procedure has four different parts. If there are four students in a group, each student can do a section of this procedure.



Make a citric acid solution

3. Place 3 scoops of citric acid in its labeled cup.
4. Use a beaker to measure 10 mL of water. Add this water to the citric acid and swirl to mix.

Start the chemical reaction

5. Place 3 scoops of baking soda in a wide clear plastic cup.
6. Add the citric acid solution to the baking soda.

Trap carbon dioxide gas

7. Quickly stand the small cup of indicator solution in the wide cup and place the tall cup on top.
8. Gently swirl the entire set of cups and watch the color of the indicator solution.

8

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009

Student Lab Guide, Page 8

Prepare the indicator solution

1. Add 10 mL of water to the unlabeled small clear plastic cup.
2. Add 10 drops of bromthymol blue indicator and swirl gently to mix.

Make a citric acid solution

3. Place 3 scoops of citric acid in its labeled cup.
4. Use a beaker to measure 10 mL of water. Add this water to the citric acid and swirl to mix.

Start the chemical reaction

5. Place 3 scoops of baking soda in a wide clear plastic cup.
6. Add the citric acid solution to the baking soda.

Trap carbon dioxide gas

7. Quickly stand the small cup of indicator solution in the wide cup and place the tall cup on top.

8. Gently swirl the entire set of cups and watch the color of the indicator solution.

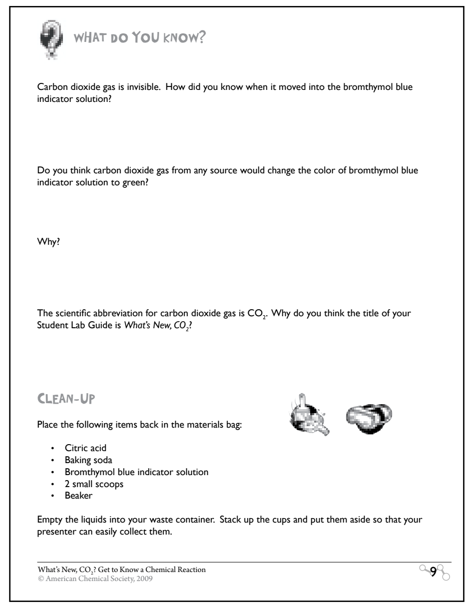
Expected Results: The blue indicator solution will turn green and possibly even yellow as students swirl the cups.

Note: The color of the indicator solution gives an idea of the amount of carbon dioxide dissolved in it. When some carbon dioxide gas dissolves in the indicator solution, it turns green. But if even more carbon dioxide gas dissolves, the indicator turns yellow. After some time left alone, students may notice that the indicator solution turns darker green. It may even return to blue. These color changes show that the dissolved carbon dioxide gas has come out of solution. If this happens, have students swirl the cups one more time, to force the carbon dioxide gas to dissolve again.

Optional: If students would like to see the green or yellow indicator return to blue, you may choose to have them sprinkle a small amount of baking soda in the cup of indicator solution. Then have them swirl only this small cup.

6. Have students answer the questions about the activity and then discuss observations with the whole class.

As soon as groups finish the activity, direct them to answer the questions on page 9 of the Student Lab Guide. When most of the students are finished, ask them the following questions:


WHAT DO YOU KNOW?

Carbon dioxide gas is invisible. How did you know when it moved into the bromthymol blue indicator solution?

Do you think carbon dioxide gas from any source would change the color of bromthymol blue indicator solution to green?

Why?

The scientific abbreviation for carbon dioxide gas is CO_2. Why do you think the title of your Student Lab Guide is *What's New, CO_2?*

CLEAN-UP

Place the following items back in the materials bag:

- Citric acid
- Baking soda
- Bromthymol blue indicator solution
- 2 small scoops
- Beaker

Empty the liquids into your waste container. Stack up the cups and put them aside so that your presenter can easily collect them.

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009
9

Student Lab Guide, Page 9

- Does any of the citric acid, baking soda, or water from the wide cup go up and over the edge into the little cup?
- What must be moving into the cup?
- Carbon dioxide gas is invisible. How did you know when it moved into the bromthymol blue indicator solution?
- Do you think carbon dioxide gas from any source would change the color of the bromthymol blue indicator solution to green? Why?
- The scientific abbreviation for carbon dioxide gas is CO_2. Why do you think the title of your Student Lab Guide is *What's New, CO_2?*

Students should agree that the color of the solution in the small clear plastic cup changed noticeably. Be sure students realize that none of the citric acid, baking soda, and water is going into the little cup. The only substance entering the small cup is the carbon dioxide gas formed in the reaction between citric acid and baking soda. Students should realize that the carbon dioxide gas from your breath turned the blue liquid green and so did the carbon dioxide gas from the chemical reaction. They should conclude that carbon dioxide gas from any source would change the color of bromthymol blue indicator.

Help students realize that carbon dioxide gas is "new" because it is something that was not there before. Students mixed citric acid, baking soda, and water together, not carbon dioxide gas. The gas was produced during the chemical reaction. Explain that CO_2 is a scientific abbreviation for carbon dioxide gas. Students at this age are likely familiar with the use of abbreviations, but in the event that they are not or need to be reminded, you can explain that an abbreviation is a short-cut way of writing something that is long.

7. Clean up from the activity while wearing goggles.

Have students empty the cups in their waste container. Then they should stack the emptied cups and push them aside. You may choose to have one student collect the cups. It is best if you take these cups and all trash out of the classroom and dispose of them with your regular household or workplace trash.

You may choose to clean and reuse the cups and droppers, but be sure to only use them for science and never with food or drinks.

Have students place the following items back in the materials bag.

- Bromthymol blue
- Beaker
- Citric acid
- Baking soda
- 2 small scoops

With the help of the teacher or a couple of students, collect the waste containers, cups, and trash. Also collect the goggles because students will not need them in the next activity.

1. Discuss how self-inflating Mylar balloons might work.

Show students one fully inflated (self-inflating) Mylar balloon. Point out that there is no opening where air can be blown in like on a regular balloon. Tell students that they can figure out how a self-inflating balloon works based on the activities they did with you today and what they observe when they carefully feel what is inside the balloon.

Distribute one Mylar balloon to each group and ask students to gently feel it and guess what is inside. Model what you want students to do with the balloons and instruct them to take turns so that everyone in the group has a chance to touch the balloon. Give students a couple of minutes to carefully observe the balloons.

Note: Students do not need to wear goggles during this activity.

2. Distribute a clear self-inflating balloon to each group.

Explain that it might be easier to figure out how the balloon works if students could see what is inside. Distribute one clear self-inflating balloon to each group.

Ask students:

- What do you think the white powder is?
- What do you think the liquid in the little bag is?
- How do self-inflating balloons work?

Tell students that the powder is baking soda and the liquid is citric acid dissolved in water. Students should realize that the balloons inflate when carbon dioxide gas is produced during the chemical reaction between citric acid and baking soda. Tell students not to activate the balloons until you tell them to do so.

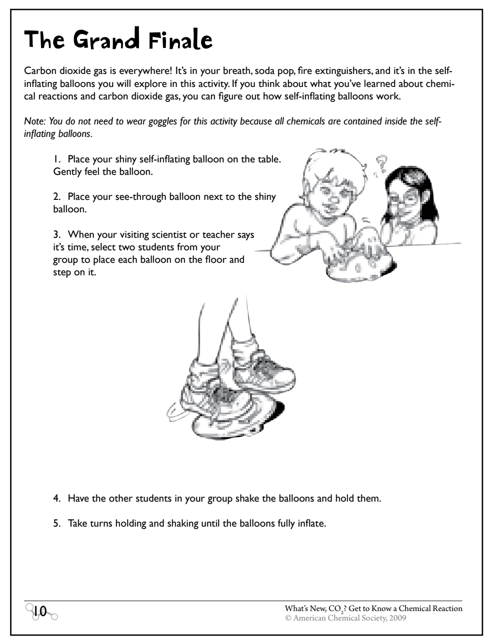
Note: The powder in the clear self-inflating balloon may be slightly yellow due to a binder added to the baking soda during the manufacturing process.

3. Have students start the reaction and observe their balloons.

Tell students that you will count to three and after that one person from each group will step on the little packet of liquid inside the balloon. Point out that there are two balloons so only two people in each group will be able to start the balloons. Once the balloons are started, the other two members in the group should pick them up and shake them.

1. Give each group a minute to decide who will step on the balloons and who will first shake the balloons.
2. Have the students who are stepping, place their foot directly over the packet of liquid. Tell them when to put their weight on it. Students will know that the balloon is activated because they will be able to hear a fizzing sound, especially if they hold the balloon up to their ear.
3. Encourage students to take turns shaking the balloons so that everyone in each group has the opportunity to feel both the decorated and the clear balloons.

Expected Results: As the balloons inflate, they will make a fizzing sound and will feel colder. Expect the see-through balloon to inflate first.



The Grand Finale

Carbon dioxide gas is everywhere! It's in your breath, soda pop, fire extinguishers, and it's in the self-inflating balloons you will explore in this activity. If you think about what you've learned about chemical reactions and carbon dioxide gas, you can figure out how self-inflating balloons work.

Note: You do not need to wear goggles for this activity because all chemicals are contained inside the self-inflating balloons.

1. Place your shiny self-inflating balloon on the table. Gently feel the balloon.
2. Place your see-through balloon next to the shiny balloon.
3. When your visiting scientist or teacher says it's time, select two students from your group to place each balloon on the floor and step on it.
4. Have the other students in your group shake the balloons and hold them.
5. Take turns holding and shaking until the balloons fully inflate.

10

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009

Student Lab Guide, Page 10

4. While students are waiting for the balloons to inflate, have them answer the questions in their Student Lab Guide.

Give students a few minutes to answer the questions on page 11 of their Student Lab Guide.


WHAT DO YOU KNOW?

What is the powder in a self-inflating balloon?

What is the liquid inside the little bag in a self-inflating balloon?

How do self-inflating balloons work?

What's New, CO_2? Get to Know a Chemical Reaction
© American Chemical Society, 2009
11

Student Lab Guide, Page 11

5. Reinforce the ideas presented in the lesson.

Tell students that you want to find out how much they learned during your visit.

- Carbon dioxide gas is invisible. Name three ways you observed it in the activities we did together.
- You can make carbon dioxide gas at home by combining baking soda and vinegar. What color would you expect bromthymol blue indicator to turn if you did the Invisible Blue Buster activity with vinegar and baking soda?
- What would you mix together if you wanted to fill a sandwich-sized zip-closing plastic bag with carbon dioxide gas?
- What is CO_2 an abbreviation for?
- What is a chemical reaction?

Explain that like chemists, students carefully observed a chemical reaction. They just did chemistry!

MATERIALS LIST

This kit is designed for up to 32 students working in groups of 4 and contains:

- 1 Presenter's Guide
- 1 Teacher's Guide
- 32 Student Lab Guides
- 1 bag of materials for the presenter
- 8 bags of materials for the students
- 1 bag of self-inflating balloons

Download and copy additional Presenter's Guides, Teacher's Guides, and Student Lab Guides from the Kids & Chemistry pages of *www.acs.org/education*.

Materials for the presenter

- Citric acid
- Baking soda
- Bromthymol blue indicator in dropper bottle
- Detergent solution
- 8 plastic cups (9-ounce size) for water
- Straw
- Test tube with rubber stopper
- 2 small scoops
- Dropper with 3-mL markings
- Beaker
- 1 small clear plastic cup
- 1 small clear plastic cup labeled "citric acid solution"
- 8 small clear plastic cups labeled "detergent solution"
- 1 tall clear plastic cup
- 9 self-inflating Mylar balloons
- 8 clear self-inflating balloons

Materials for each student group

- Citric acid
- Baking soda
- Bromthymol blue indicator in dropper bottle
- 2 small scoops
- Dropper
- Beaker
- 4 small clear plastic cups
- 1 small clear plastic cup labeled "citric acid solution"
- 1 tall clear plastic cup
- 1 wide clear plastic cup
- 1 paper towel

Goggles are not included in this kit but must be worn when indicated.

Bromthymol Blue Solution

Universe of Science
6079 Brushy Mountain Rd.
Moravian Falls, NC 28654
(336) 667-9397

Material Safety Data Sheet
MSDS # 6003-1
EMERGENCY ASSISTANCE CALL
CHEMTREC 800-424-9300

Chemical Name & Synonyms
Bromthymol Blue Solution,
BTB Indicator

Hazard Rating

Health	0
Fire	0
Reactivity	0

Least	Slight	Moderate	High	Extreme
0	1	2	3	4

Formula $C_{27}H_{28}Br_2O_5S$ in water

Unit Size 15 milliliters

CAS No. 34722-90-2 for bromthymol blue, none assigned for the solution.

Health Hazards
Not considered hazardous

Physical Data
Blue liquid, color changes with pH. pH = 7.6. Soluble in water.

Incompatibility (Materials and Conditions to avoid)
Oxidizing agents

Reactivity
Stable

D.O.T.
Not regulated

Fire Hazards
Not flammable.

Spills and Leaks and Disposal Method
Absorb with suitable material and dispose of in trash.
Wash residue with water.

Special Precautions
None needed. Prudent laboratory practices should be observed.

First Aid
Wash with large amounts of water.
Eye contact: Wash with water for 15 minutes. See a physician.
If swallowed: Give water or milk to drink.

Citric Acid

Universe of Science
6079 Brushy Mountain Rd.
Moravian Falls, NC 28654
(336) 667-9397

Material Safety Data Sheet
MSDS # 6003-2
EMERGENCY ASSISTANCE CALL
CHEMTREC 800-424-9300

Chemical Name & Synonyms
citric acid

Hazard Rating

Health	0
Fire	1
Reactivity	0

Least	Slight	Moderate	High	Extreme
0	1	2	3	4

Formula C_6H8O7

Unit Size 5 grams

CAS No. 5959-29-1

Health Hazards
Not considered hazardous.
May be skin or eye irritant to some people.

Physical Data
White crystals

Incompatibility (Materials and Conditions to avoid)
Strong oxidizing agents and reducing agents. Bases.

Reactivity
Stable

D.O.T.
Not regulated

Fire Hazards
Not flammable.

Spills and Leaks and Disposal Method
Wash with large amounts of water.

Special Precautions
None needed.
Prudent laboratory practices should be observed.

First Aid
Wash with large amounts of water.
Eye contact: Wash with water for 15 minutes. See a physician.
If swallowed: Give water or milk to drink. Call a physician.

Sodium Bicarbonate

Universe of Science
6079 Brushy Mountain Rd.
Moravian Falls, NC 28654
(336) 667-9397

Material Safety Data Sheet
MSDS # 6003-3
EMERGENCY ASSISTANCE CALL
CHEMTREC 800-424-9300

Chemical Name & Synonyms
sodium bicarbonate, baking soda,
sodium hydrogen carbonate

Hazard Rating

Health	0
Fire	0
Reactivity	0

Least	Slight	Moderate	High	Extreme
0	1	2	3	4

Formula $NaHCO_3$

Unit Size 1 ounce

CAS No. 144-55-8

Health Hazards
Considered non-hazardous

Physical Data
White powder, odorless, soluble in water.

Incompatibility (Materials and Conditions to avoid)
Acids cause decomposition releasing carbon dioxide.

Reactivity
Stable

D.O.T.
Not regulated

Fire Hazards
None

Spills and Leaks and Disposal Method
Sweep up and place in trash, wash residue with water.

Special Precautions
None needed. Prudent laboratory practices should be observed.

First Aid
Wash with large amounts of water.
Eye contact: Wash with water for 15 minutes. See a physician.