Secret Science of Self-Inflating Balloons

Facilitator Led Tabletop Activity

How do self-inflating balloons work? Plan to inflate a balloon on a test tube using the same chemicals that are inside of foil self-inflating balloons. But wait, which of two white powders will do the job? Atomic tokens and custom cards help participants figure out which will react with citric acid and inflate the balloon. Celebrate students' success learning chemistry with self-inflating foil balloons for all!

Question to investigate

Which white powder will react and inflate the balloon?

Chemistry concepts

- In a chemical reaction, the atoms in the substances you mix together rearrange to form different groups of atoms.
- You can only make carbon dioxide in a chemical reaction if you start with the atoms you need in the substances you mix together.
- A chemical equation is a summary of what happens in a chemical reaction.

Activity logistics

- **Ages**: As written, this activity is best suited for elementary and middle school students.
- **Group Size**: This activity serves up to 48 children or teens over a period of 2 hours, with each iteration of the activity lasting approximately 10 minutes.
- **Set-up**: Arrange the materials along one side of an 8-foot table into four stations to reach up to four children at once.
- **Facilitators**: One facilitator can comfortably manage four stations at the same time.

Prepare in advance

What you'll need

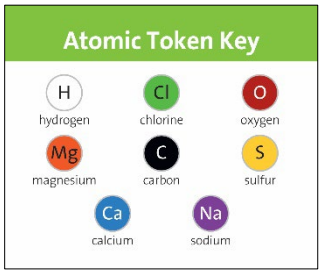
- 50 self-inflating balloons
- 3 Test tube racks
  - Two with 12 holes
  - One with at least 2 holes
- 24 glass test tubes, 18 x 150 mm
- Scissors
- Magnesium sulfate
- Sodium bicarbonate
- Citric acid
- Water
- Bottle, 250 mL
- 2 small clear plastic cups
- 1 scoop, 5 mL
- 1 medicine cup
- 1 powder funnel
- 1 bag of small latex balloons
- 24 small rubber bands
- 2 regular-sized rubber bands
- 2 pairs of disposable gloves
- 4 sets of atomic tokens and cards
- 4 trays

Notes about the materials

- Wear the disposable gloves when preparing the two demos.
  - Make citric acid solution.
  - Cut one self-inflating balloon to remove its contents.
  - Fill latex balloons with magnesium sulfate and sodium bicarbonate.
- There are four extra cards which are not needed for this version of the activity.
- Refer to the lesson Kids & Chemistry React with Self-inflating Balloons if you would like to use all the cards as part of a 30-minute classroom visit with fifth and sixth graders.

Make the compound cards and pack atomic tokens

1. Make four copies of pages 12-13 and cut along the lines.
   Four of the twelve cards will not be used in the tabletop version of this activity.
2. Group the following 8 cards into each of four sets.
   - 1 atomic token key
   - 1 yellow hydrochloric acid card
   - 1 blue magnesium sulfate card
   - 1 blue sodium bicarbonate card
   - 1 green carbon dioxide card
   - 1 green sodium chloride card
   - 1 green water card

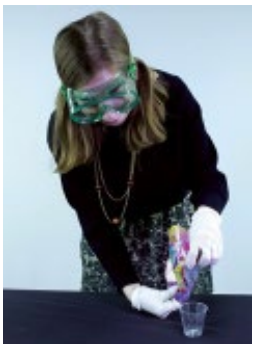


3. Prepare 4 sets of atomic tokens containing the following quantities and colors.
   - 4 red tokens
   - 3 white tokens
   - 2 green tokens
   - 1 each of the following color tokens
     - black, yellow, purple, orange, and blue

Prepare on-site

Prepare the balloons that will introduce the activity

1. Inflate one self-inflating balloon using the method described on page 9.
2. Use scissors to cut one balloon open.
3. Pour the entire contents of the balloon into one small clear plastic cup.
4. Remove the packet of citric acid and place it in another small clear plastic cup.



Prepare the citric acid solution and test tube racks

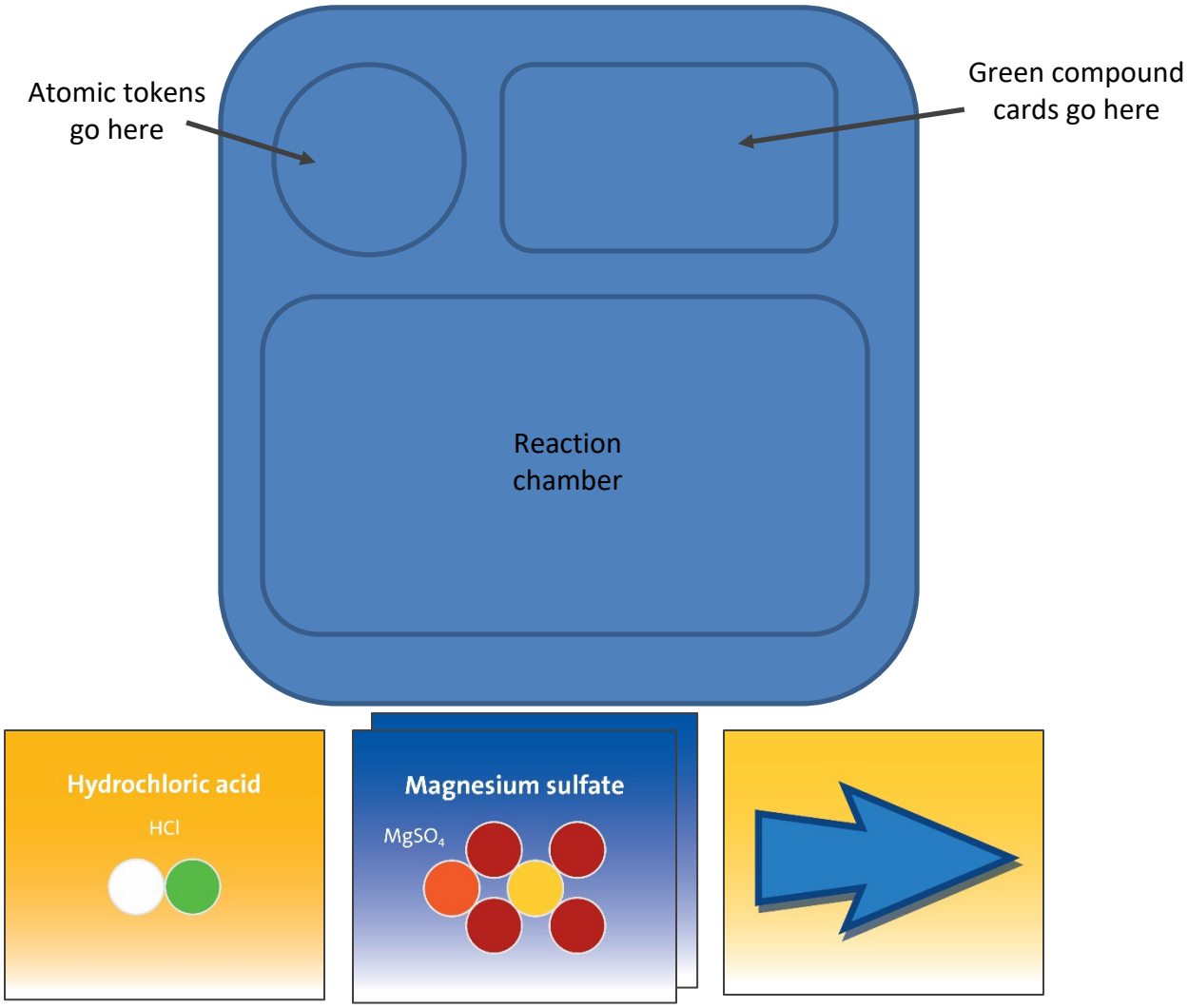
1. Stretch 2 or 3 rubber bands horizontally across each test tube rack.
2. Label one 250 mL bottle “citric acid solution.”
3. Use the powder funnel to place two level scoops of citric acid in the bottle.
4. Remove the powder funnel and fill the bottle with water.
5. Secure the lid on the bottle and shake it until the citric acid dissolves.
6. Place 24 test tubes into the two larger test tube racks.
7. Use the medicine cup to measure and pour 10 mL of citric acid into each test tube.

Prepare the demo

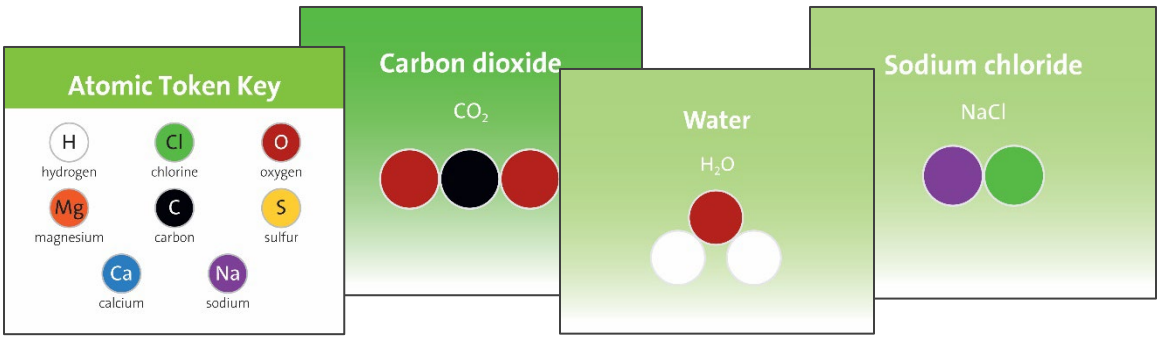
1. Place one small rubber band over the neck of a balloon. Then stretch the band and neck over the narrow end of the powder funnel.
2. Pour 1 level scoop of one powder into the funnel and balloon. Make sure all of the powder goes into the rounded portion of the balloon. Carefully remove the balloon from the funnel.
3. Stretch the opening of the balloon over its labeled test tube. Use caution so that the powder remains inside the rounded portion of the balloon. Position the small rubber band so that it rests just under the lip of the test tube.
4. Use another small rubber band to hold the rounded portion of the balloon down, as shown

Prepare four stations to accommodate up to four participant groups at one time

1. Arrange four divided trays along the front of the table. Arrange atomic tokens and compound cards as shown.
2. Tuck the sodium bicarbonate card underneath the magnesium sulfate card so that it cannot be seen.



3. Arrange the remaining cards in the following order and then place them face up in the area on the tray for the green compound cards.



Facilitate the activity

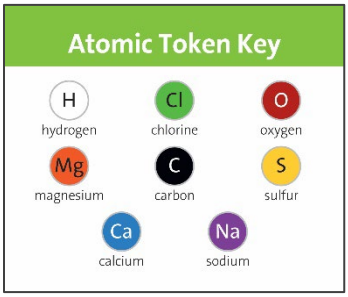
Invite participation

1. **Introduce the activity by showing both a flat and an inflated self-inflating balloon.**
   This is a self-inflating balloon before being inflated and after. What is interesting about this balloon is that there is no opening where you could blow air or pump helium into it. How is this balloon like other foil balloons you have seen? [*Shake the inflated balloon.*] How is it different? [*Shake the inflated balloon near participants' ears to give them the clue that something is inside this balloon.*]

2. **Show what is inside the balloon**
   Let's discover the secret-science of self-inflating balloons! I cut one open and put what I found in two cups.
   - [*Show the clear plastic cup with the intact packet of citric acid.*]
     I found a packet that contains citric acid. You can find citric acid in citrus fruits and sour candies. Name a citrus fruit or sour candy that you have tasted before. Even lollipops and hard candies that aren't super sour, have citric acid as one of their ingredients.
   - [*Show the clear plastic cup with the white powder. Do not reveal its identity yet because figuring out what it is becomes the focus of the activity.*]
     There is also a white powder. I'm not exactly sure what this powder is, but together we can figure it out. It's either magnesium sulfate or sodium bicarbonate.

3. **Introduce the question to investigate, atomic tokens, and compound cards.**
   Which one of these two white powders will be the best choice to inflate a regular balloon over a test tube? We are going to investigate this scientific question the way chemists do. I am a chemist and am going to introduce you to some models. Chemists use models to represent atoms and molecules, because they are too small to see, even with a very powerful microscope. Models also help chemists make predictions about what will happen before mixing chemicals together. It is expensive, takes a lot of time, and can even be dangerous to randomly mix things together and just see what happens. So, chemists have to work smarter and you can, too!

   In front of you, you have some atomic tokens. Each color represents a different kind of atom.
   - Take a look at the atomic token key to find out what the red token represents.
     [Oxygen.]

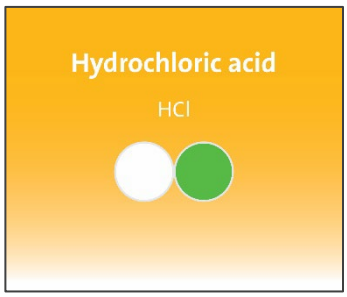
   

   Oxygen is very important to people and animals because we need it when we breathe.

Deepen Understanding

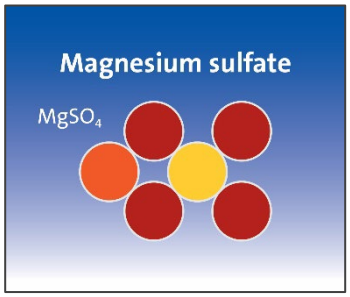
4. **Model what participants will do.**
   I am going to show you how you will use atomic tokens to build the compounds shown on the cards near your tray.

   - **The yellow card represents the acid.**
     [*Build this acid on your tray*.] This acid is made of only two atoms—hydrogen and chlorine.
     [Optional for older children.] Citric acid is safe and inexpensive so is a good choice to use inside balloons. The card has the name of a different kind of acid that uses only two atomic tokens. It is going to work in a similar way in the chemical reaction, so we are using it in our model.

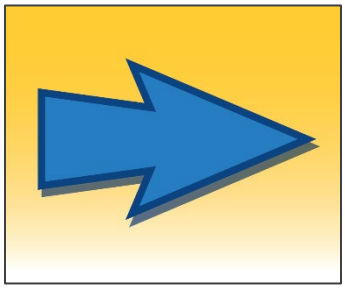


Note: The card shows hydrochloric acid which is not used in the balloon. However, it requires fewer atoms than citric acid. This simplification will help students get the point that the atoms in the reactants are used to make the products.

   - **The blue card represents magnesium sulfate.**
     [Show the white powder labeled $MgSO_4$ and use atomic tokens to build this compound in the reaction chamber area of your tray.]
     [Optional] You might have this chemical at your house. It is also called Epsom salt because it is found in the town of Epsom in England. The water there, which people said had healing properties contains high levels of magnesium sulfate. People still like to put Epsom salt in their bathwater to soothe achy muscles.

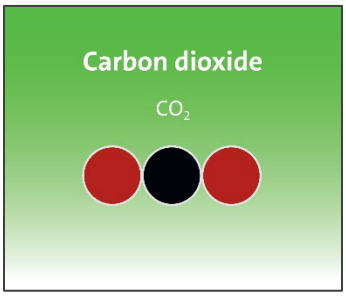


   - **The arrow card means "makes."**
     I want to know if mixing these compounds together will *make* carbon dioxide gas. This is what we need to inflate the balloon. [Pull out the carbon dioxide card from and place it next to the arrow.]



   In chemistry, you can only use the atoms from the substances that you mix together to make different compounds.

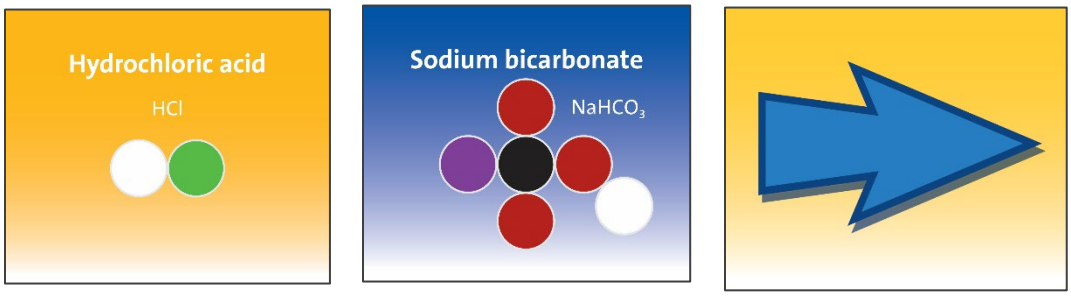
   - **Can we make carbon dioxide gas out of the atoms in the reaction chamber?**
     - Do we have red atomic tokens? [Yes.]
     - Do we have a black atomic token? [No.]



   This means that magnesium sulfate, will not inflate a balloon.

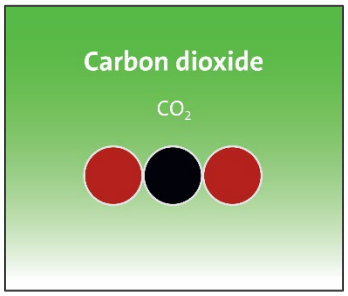
5. **Have participants explore what happens when sodium bicarbonate is the white powder in the reaction chamber.** Now I would like you to see if you can make carbon dioxide gas by adding a different white powder to your reaction chamber. Hand me your blue card that says magnesium sulfate on it.
[This will reveal the sodium bicarbonate card underneath.]

I'd like you to build the compounds shown on these cards in your reaction chamber.
[*As participants are building compounds, pull the carbon dioxide card out of their stack of green cards, and place it next to the arrow.*]



Remember, in chemistry, you can only use the atoms from the substances that you mix together to make different compounds.

- **Can we make carbon dioxide gas out of the atoms in the reaction chamber?**
    - Do we have red atomic tokens? [Yes.]
    - Do we have a black atomic token? [Yes.]



Build carbon dioxide out of the atomic tokens you have.

Now, we can't just throw away atoms that are needed to make the compound we want. These atoms need to make other compounds, otherwise the chemical reaction will not happen at all. Look at the cards underneath your atomic token key. Can you make any of these compounds? If you can, place the cards for the compounds you can build next in your line of cards.

Point out when kids make water and sodium chloride with their remaining atomic tokens.

Okay! This means that sodium bicarbonate, also known as baking soda, is the white powder inside the self-inflating balloon!

Support Exploration

6. **Conduct a demonstration to confirm what was discovered with the atomic tokens.**
   Which one of these two white powders will inflate a regular balloon over a test tube?

   - Will magnesium sulfate and citric acid make carbon dioxide gas and inflate this balloon?
     [*Show participants the test tube and balloon containing citric acid and magnesium sulfate. Point out that citric acid is in the bottom of the test tube and magnesium sulfate is in the balloon. Hold the neck of the balloon firmly on the test tube while you lift the balloon with the other hand so that the contents drops into the citric acid.*]
     [The balloon will not inflate, yet participants are proud of themselves because they expected this]

   - Will sodium bicarbonate and citric acid make carbon dioxide gas and inflate this balloon?
     [*Show participants the test tube and balloon containing citric acid and sodium bicarbonate. Point out that citric acid is in the bottom of the test tube and magnesium sulfate is in the balloon. Hold the neck of the balloon firmly on the test tube while you lift the balloon with the other hand so that the contents drops into the citric acid.*]
     [The balloon will inflate, and participants will be very excited to see that their prediction is correct.]

7. **Clean-up the modeling portion of the activity.**
   I am going to give you each a self-inflating balloon so that you can experience this chemical reaction for yourself. You will be able to take this balloon home. It stays inflated for about a month!

   Before I do this, we need to clean up. Please put all your atomic tokens and all compound cards in their areas on the tray. Then push the tray closer to me, so that there is a spot right in front of you for your new balloon.

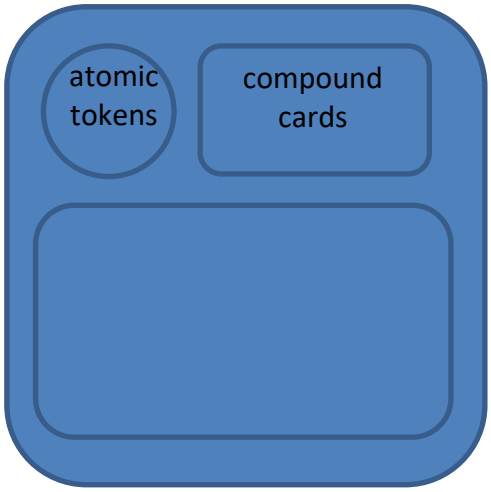


Photo Opportunity: Tell families that the moment people first hear the chemical reaction is always memorable. Encourage them to get their camera's ready to photograph the children or teens in their group at that moment.

8. **Distribute one balloon per person and give instructions on how to inflate it.**
Place your balloon flat on the table and feel it. Do you feel the packet of citric acid? We are going to have to break this packet open, without breaking the balloon, to get the chemicals to mix.

Let's break the inner pouch of citric acid and start the chemical reaction.

- Toddlers on up to 8-year-olds should place the balloon on the floor, position a foot directly over the pouch, and step on it.
- Children older than 8, should place the balloon on the table and press the pouch with the heel of one hand pushed down by the other.

As soon as the pouch is broken, return to the table with your balloon.

9. **Experience the chemical reaction as the balloon inflates.**
Shake the balloon to help the chemicals mix. Hold your balloon to your ear.
    - Can you hear the chemical reaction happening?
    - Do you hear the bubbles filled with the newly-made carbon dioxide gas?

Hold your balloon flat between your hands like a sandwich. Chemical reactions change temperature.

- Is this chemical reaction getting warmer or colder? [Colder]

Now you know the secret science inside self-inflating balloons!

Clean-up

Reset for the next group

1. Set up the trays, atomic tokens, and compound cards as shown on page 4.
2. Empty the contents of the test tubes into a yellow or blue bucket.
3. Dispose of the balloons and small rubber bands with the solid trash.
4. Place the empty test tubes in another yellow or blue bucket.

At the end of the event

- Neutralize the liquid using extra sodium bicarbonate or citric acid before pouring it down the sink. Get a little cochineal dye or pH paper from the *Color with Bugs* activity station to help.
- Rinse the test tubes with water. Wrap them, it's ok that they are still wet, in bubble wrap and a zip-closing plastic bag. Place these in the white cardboard box so that can be shipped safely.
- Pack everything back in the large bin to return to ACS.

Frequently asked questions

Where can I buy a self-inflating balloon?
Self-inflating balloons are sold at dollar stores, sometimes with seasonal themes. They can be purchased online from www.store.acs.org.

How much do the ACS balloons cost?
The balloons cost $24 for a pack of 25 balloons and 25 cards. At a dollar store, they are typically $1 per balloon.

Do these self-inflating balloons contain latex?
The balloons do not contain latex. They are made of aluminum deposited on a material similar to a plastic bag (polyethylene).

How long will my balloon remain inflated?
Balloons remain fully inflated for several weeks.

What is inside the balloon?
At first, the balloon contains 5 mL of a 10 % citric acid solution in a small plastic pouch and 3 grams of sodium bicarbonate (baking soda). Once the pouch is broken, a chemical reaction between citric acid and baking soda takes place. Carbon dioxide gas inflates the balloon. Water and sodium citrate ions are also formed. These new substances, along with some unreacted citric acid or baking soda, remain sealed inside the balloon.

- **What is the chemical equation for the reaction that inflates self-inflating balloons?**
  Baking soda (also known to chemists as sodium bicarbonate) and citric acid react to produce carbon dioxide gas. Other chemicals are formed, too.

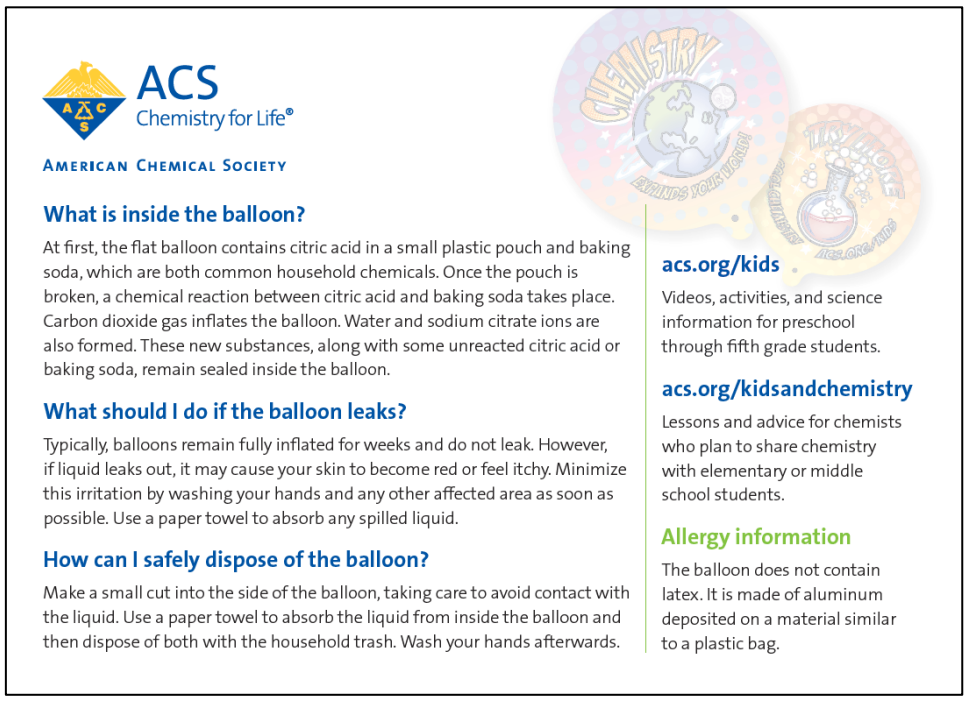
$$3NaHCO_3 + C_6H_8O_7 \longrightarrow 3Na^+ + C_6H_5O_7^{3-} + 3H_2O + 3CO_2$$

sodium bicarbonate citric acid sodium ion citrate ion water carbon dioxide

  Everything on the left side of the reaction arrow is referred to as a "reactant", while everything on the right side of the arrow is called a "product". In a chemical reaction, the products are always chemically different than the reactants. All the same atoms are present (and in the same amounts!) on both sides of the equation. The difference is in the way the atoms in the products are rearranged and recombined. These new arrangements make different molecules and ions, which are unlike those in the reactants.

- **What should I do if the balloon leaks?**
  Typically, balloons do not leak. However, if liquid leaks out, it may cause your skin to become red or feel itchy. Minimize this irritation by washing your hands. Use a paper towel to absorb any spilled liquid.

Note: Anytime a chemistry item is sent home with participants, it should be accompanied by safety information. The text below is included on a card placed in the take home bags each participant receives at the end of this event.



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What is inside the balloon?

At first, the flat balloon contains citric acid in a small plastic pouch and baking soda, which are both common household chemicals. Once the pouch is broken, a chemical reaction between citric acid and baking soda takes place. Carbon dioxide gas inflates the balloon. Water and sodium citrate ions are also formed. These new substances, along with some unreacted citric acid or baking soda, remain sealed inside the balloon.

What should I do if the balloon leaks?

Typically, balloons remain fully inflated for weeks and do not leak. However, if liquid leaks out, it may cause your skin to become red or feel itchy. Minimize this irritation by washing your hands and any other affected area as soon as possible. Use a paper towel to absorb any spilled liquid.

How can I safely dispose of the balloon?

Make a small cut into the side of the balloon, taking care to avoid contact with the liquid. Use a paper towel to absorb the liquid from inside the balloon and then dispose of both with the household trash. Wash your hands afterwards.

acs.org/kids

Videos, activities, and science information for preschool through fifth grade students.

acs.org/kidsandchemistry

Lessons and advice for chemists who plan to share chemistry with elementary or middle school students.

Allergy information

The balloon does not contain latex. It is made of aluminum deposited on a material similar to a plastic bag.