A Breath of Air

Make and test atmospheric gases in zipper baggies

Lesson Plan

Description: Visitors work in pairs to fill three baggies with samples of different gases: exhaled breath, oxygen, and carbon dioxide. They generate carbon dioxide using baking soda and vinegar and oxygen using yeast and hydrogen peroxide. Visitors then test their samples with phenol red indicator and a glowing splint to identify the gases.

Audience: Hands-on activity for families and children ages 8 and up

Length: 20 minutes

Learning Objectives

Visitors learn:

- Our atmosphere contains many gases, including oxygen, carbon dioxide, and nitrogen.
- Human beings and other animals breathe in gas from our atmosphere, use some of the oxygen to create energy, and exhale additional carbon dioxide as a by-product.
- Plants use carbon dioxide when they store energy as food, and they release oxygen as a by-product.
- Gases can be a product of a chemical reaction.
- Chemists can identify gases by testing their properties.
- Some chemical reactions are exothermic (give off heat) and some are endothermic (take in heat).

Visitors develop skills related to chemistry and science, including:

- Developing and testing predictions
- Measuring volumes of solids
- Pipetting liquids
- Observing chemical reactions
- Analyzing data
- Communicating and discussing experiment results

Learning Standards

National Science Education Standards

1. Science as Inquiry
   K-4: Abilities necessary to do scientific inquiry
   K-4: Understanding about scientific inquiry
   5-8: Abilities necessary to do scientific inquiry
   5-8: Understanding about scientific inquiry
   9-12: Abilities necessary to do scientific inquiry
   9-12: Understanding about scientific inquiry

2. Physical Science
   K-4: Properties of objects and materials
   5-8: Properties and changes of properties in matter
   5-8: Transfer of energy
   9-12: Structure and properties of matter
   9-12: Chemical reactions

3. Life Science
   K-4: Organisms and environments
   5-8: Structure and function in living systems
   9-12: Matter, energy, and organization in living systems

Background Information

The air in our atmosphere is primarily made of two different gases: nitrogen (78%) and oxygen (21%). Nitrogen is a very nonreactive gas. Oxygen is very reactive. Many organisms (including humans) have evolved to use oxygen to live.

When you take in a breath of air, it contains about 21% oxygen. But when you breathe out, your breath only contains about 16% oxygen. What happens to the missing 5% of the oxygen? It was used by you to release energy from food, through the process of *respiration*. In that process, the oxygen combined with carbon in the sugars in your body to make carbon dioxide (CO_2) and water.

Plants produce energy through the process of *photosynthesis*. In this process, plants convert light energy from the sun into chemical energy using carbon dioxide and water. The end-products are glucose (sugar for energy) and oxygen.

Both carbon dioxide and oxygen can be produced from simple household products. The presence of carbon dioxide and oxygen can be determined using readily-obtained materials.

Carbon dioxide

Carbon dioxide can be generated from baking powder and vinegar. Baking powder is the common name for sodium bicarbonate. It reacts with any acid to produce carbon dioxide. In this activity we use vinegar, which is a 5% solution of acetic acid in water.

Carbon dioxide dissolves in water and forms carbonic acid (H_2CO_3). The more CO_2 in solution, the lower the pH. This can be detected with a pH indicator such as phenol red, which is red when neutral or basic and yellow when acidic.

Oxygen

Oxygen can be made when living cells (in this case, yeast) break down hydrogen peroxide. Peroxides form as a by-product of reactions with oxygen. Peroxides are toxic, so most organisms have an enzyme

called “catalase” that breaks down peroxides into oxygen and a harmless compound like water.

High levels of oxygen or carbon dioxide can be detected with a glowing splint. If a glowing splint is placed into a volume of oxygen gas, it will reignite. If the splint is placed into a volume of carbon dioxide, it will be extinguished. In the air of the room, the splint will continue to glow for some time, and then go out.

EXPECTED RESULTS

	phenol red	**glowing splint**
carbon dioxide	yellow	extinguishes
oxygen	red	reignites
exhaled breath	yellow	continues to glow
air in the room	red	continues to glow

Materials

For each pair of visitors

- Three 1-pint zipper baggies labeled “breath”, “1”, and “2”
- Small container of sodium bicarbonate (baking soda)
- Small container of dry bakers yeast
- Small container of 6% hydrogen peroxide
- Small container of 5% acetic acid (white vinegar)
- Phenol red solution in dropping bottle
- 5 pipettes
- Well plate
- Teaspoon
- ¼ teaspoon
- Safety glasses for each visitor

For the presenter

- One set of the materials at the visitors’ workstations
- Matches
- Toothpicks (to use as splints)
- Glass or metal container with water for extinguishing matches and glowing splints
- Optional: Empty, transparent container (prop for program)

Notes to the Presenter

- The zipper baggies should be the kind you press together, not the kind with a slider. (The sliders are not always airtight.)
- 6% hydrogen peroxide is available in beauty supply stores as “20 volume” hydrogen peroxide or developer
- Check the expiration date on your yeast, to make sure it’s fresh

- It is convenient to place the indicator solution in a small dropper bottle. This makes it easy for program visitors to measure it out, and encourages them to use only the amount needed.

CAUTION: Always supervise visitors during this activity. Be sure visitors wear safety glasses and don't let them taste any chemicals (even foods).

Set Up

Set up takes approximately 15 minutes.
(Set up will take longer the very first time you do the activity.)

1. Label three baggies for each visitor: "breath", "1" and "2".
2. Place the indicator solution (phenol red) in a small dropper bottle.

Program Delivery

Welcome visitors. Explain that they will be working in pairs or groups of three, and divide them among the workstations. Explain to parents that this is a family activity, and they should work with their children.

Our program today is all about the thing that I have in this container. *Show empty, transparent container.*

Who can tell everyone what's in the container? *Various responses; wait/hint until someone says "air."*

That's right: my container is full of air. What do you think air is? Is it a solid, a liquid, or a . . . ? *Wait/hint until someone says "gas."*

Is air all one kind of gas, or are there many different gases in the air in our atmosphere? *Response: Many different gases.*

Can anyone name some of the gases in our atmosphere? *Wait/hint until oxygen, carbon dioxide, and nitrogen have been named.*

Which of these gases do human beings breathe in to get energy from their food? *Response: Oxygen*

Which do we breathe out as a waste product? *Response: Carbon dioxide*

Which of these gases do plants use to trap energy from the sun in food? *Response: Carbon dioxide*

Which do they release into the atmosphere as a waste product? *Response: Oxygen*

How do we know which gases are in our atmosphere? Chemists have developed tests for different gases.

Today we're going to make two important gases in our atmosphere: oxygen and carbon dioxide. Then we're going to learn how chemists test for these gases in the air.

We're going to work together, step-by-step, because there are several different procedures that you'll need to do just right in order for the activity to work. Please stay with the group instead of moving ahead.

Let's start by putting on our safety glasses. *Make sure everyone is wearing safety glasses*

PART 1: GENERATING GASES IN BAGGIES

Note: You (the presenter) should make all three baggies along with the visitors. Demonstrate each procedure for the visitors.

The first thing we're going to do is get a sample of our own exhaled breath. *Demonstrate the following procedure.*

Filling a baggie with exhaled breath

1. Find the baggie marked "breath".
2. Pull open the zipper seal just a little bit.
3. Blow into the baggie so that you fill it with your breath.
4. Seal the baggie by pressing the zipper closure.
5. Pat the baggie to be sure it isn't leaking.

Now, we're going to make samples of carbon dioxide and oxygen using chemical reactions. I'm not going to tell you which is which—although some of you may know if you've done these reactions before! Once we've made the gases, we'll test them.

To make the gases, we're going to be using transfer pipettes. I'm going to quickly show you how to use them.

A pipette works like an eyedropper. It has a bulb you squeeze and a stem you can put into whatever you want to suck up (liquid or gas). To fill a pipette, here's what you do. *Demonstrate the following procedure.*

Filling a pipette with gas or liquid

1. Squeeze the bulb and hold it flat.
2. Place the stem into the container.
3. Release your pressure on bulb (continuing to hold the pipette gently).

Let's make our first gas! To do this, we're going to combine baking soda and vinegar. *Show containers with baking soda and vinegar.*

Has anyone ever tried this before? Have you ever made a model volcano using these ingredients? Do you know what gas you made? *Various responses*.

Let's find out! We're going to get our baggies ready first. When everyone's done, we'll start our chemical reactions together. *Demonstrate the following procedure.*

Generating carbon dioxide in a baggie

1. Find the baggie marked "1".
2. Open the zipper seal all the way.
3. Put one teaspoon of baking soda into the baggie.
4. Shake the baggie so the baking soda settles into one corner.
5. Fill a pipette with vinegar. Don't squeeze out the vinegar!
6. Place the full pipette inside the baggie, with the stem facing the baking soda.
7. Gently pat the baggie to get out as much air as possible.
8. Seal the baggie.
9. Wait until everyone is ready.
10. Squeeze the bulb of the pipette to start the reaction.

What's happening in your baggie? What do you see? hear? feel?

Visitors should see bubbles and hear a fizzing sound right away. After a while, they should notice that the bag has inflated and that the contents feel cold.

Now we have a bag containing one of the important gases in our atmosphere. Don't open it! We're going to use it later. Set it aside for now, while we make a second gas.

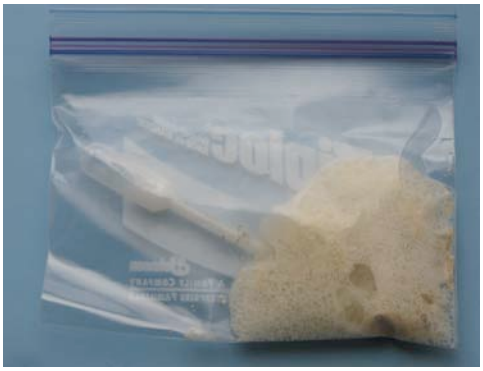
Again, we're going to get our baggies ready, then start the reaction all together.

To make this gas, we're going to use yeast and hydrogen peroxide. *Show containers with yeast and hydrogen peroxide.*

Does anyone want to predict what will happen when we combine them? Think about what happened when we combined the baking soda and vinegar. Do you think the same thing will happen with yeast and hydrogen peroxide? What will be the same? What will be different? *Various responses.*

Let's find out! *Demonstrate the following procedure.*

Generating oxygen in a baggie



1. Find the baggie marked "2".
2. Open the zipper seal all the way.
3. Put ¼ teaspoon yeast into the baggie.
4. Shake the baggie so the yeast all settles into one corner.
5. Fill a pipette with hydrogen peroxide. Don't squeeze it out!
6. Place the full pipette inside the baggie, with the stem facing the yeast.
7. Gently pat the baggie to get out as much air as possible.
8. Seal the baggie.
9. Wait until everyone is ready.
10. Squeeze the bulb of the pipette to start the reaction.

What's happening in your baggie? What do you see? hear? feel?

Visitors should see bubbles and hear a fizzing sound right away. After awhile, they should notice that the bag has inflated and that the contents feel hot.

What's different this time? *Response: The bag feels hot instead of cold.*

When we made a gas in the other baggie, did it feel hot or cold? *Response: Cold*

A chemical reaction that takes in heat—so it feels cold—is called an endothermic reaction. "Endo" means "in", so an endothermic reaction takes in heat.

The other reaction was exothermic. "Exo" means "out." A reaction that gives out heat—so it feels hot—is called an exothermic reaction.

Now we have a bag of our breath, a bag of carbon dioxide, a bag of oxygen. We know which baggie has our breath in it. But which one has carbon dioxide, and which has oxygen? Let's find out!

PART 2: TESTING GASES IN BAGGIES

We're going to do some tests on the gases in our bags to figure out which baggie contains carbon dioxide, and which contains oxygen. These tests take advantage of the fact that oxygen and carbon dioxide have different properties.

What do I mean when I talk about the "properties" of a gas? What's a property? *Response: Property is something that belongs to you, that you own.*

When we talk about something's *properties* in science, we mean how it behaves, which is sort of like something it owns. Has anyone ever told you that you have to own up to your behavior?

First we're going to do a test that tells us whether a gas (or mixture of gases) contains carbon dioxide. We're going to use an indicator called phenol red to test for carbon dioxide. The phenol red is dissolved in water. *Show dropper bottle of phenol red.*

Phenol red turns yellow in the presence of an acid. Carbon dioxide dissolves in water and forms carbonic acid. So if we put carbon dioxide gas into this indicator, it will create an acid and the indicator will turn yellow. The more carbon dioxide there is, the more yellow it will turn.

Let's start by testing the baggie with our breath. What do you think will happen? Does anyone want to make a prediction? *Various responses. Someone will probably say that the baggie has carbon dioxide in it so the phenol red will turn yellow.*

Let's find out. I'm going to show you how to test a sample, or a little bit, of gas from your baggies.

It's a little tricky to do it without letting all the gas out of your baggie or letting other air in, so you should watch carefully.

I'm going to do this by myself because I've practiced it, but you will probably want a helper to hold the bag for you.

We're going to test the bag with our breath first, because if you make a mistake, you can just refill the bag and try again. *Demonstrate the following procedure.*

<u>Getting a sample of each gas</u>

1. Have your helper hold a bag filled with gas.
2. Take a pipette, and squeeze the bulb and hold it flat. Keep holding it.
3. Open the bag a tiny bit, just enough to get the stem of the pipette in. Push it in as far as you can.
4. Release your pressure on bulb (continuing to hold the pipette gently). This will suck up some of the gas in the bag.
5. Remove the pipette quickly. Don't squeeze it again! Just hold it, with the stem pointing up.
6. Reseal the bag.

Go ahead and get your sample. When everyone's ready, I'll show you how to test it. *Wait until visitors are ready, then demonstrate the following procedure.*

Testing the gases: Phenol red indicator

1. Fill a well in your well plate about halfway with phenol red. It will take about 20 drops.
2. Take your pipette full of gas and put the stem all the way into the phenol red.
3. Squeeze the bulb so that you bubble the gas through the phenol red.
4. Release the bulb so that you suck the phenol red up into the bulb.
5. Turn the pipette upside down (stem pointing up).
6. Shake it gently.
7. Observe what happens.

What happened? *Response: It turned orange.*

What do you think that means? *Response: It has some carbon dioxide but not a lot.*

Now let's try the same thing with the bag marked "1". You'll need to be careful NOT to suck up the solid or liquid in the bag—just the gas.

Does anyone want to predict what will happen? *Various responses.*

Have visitors repeat the procedure above with the "1" bag.

Now what happened? *Response: The indicator turned yellow.*

Finally, let's test the gas in the bag marked "2". Does anyone want to predict what will happen? *Various responses.*

What do you observe? *Response: The indicator didn't change color. It stayed red.*

Hold up the three pipettes, stem side up, so visitors can see all three colors (red, orange, and yellow).

What did this test show us?

Baggie #1 contains carbon dioxide. Baggie #2 does not.

Who remembers what we used to make the gas in baggie #1? *Response: baking soda and vinegar*

What did the baking soda and vinegar do? *Response: The baking soda and vinegar made CO_2, which created carbonic acid when it mixed with the phenol red. The carbonic acid turned the phenol red yellow.*

How about your breath? *Response: It has some CO_2 in it, which created a little bit of carbonic acid when it mixed with the phenol red. The carbonic acid turned the phenol red orange.*

What about the third bag? *Response: The phenol red stayed red, so it doesn't contain carbon dioxide.*

Our test used phenol red to indicate carbon dioxide. We found out that two of the bags contained CO_2.

Now let's find out what's in the third bag! Let's do a test for oxygen.

Does anyone know of a way to test for oxygen? Or, to put it another way, does anyone know what you should NOT let come into contact with oxygen (unless you want a big explosion)? *Various responses. Someone will probably say "fire".*

That's right. Fires need oxygen to burn. That's why you can put them out by smothering them with a blanket—you keep the oxygen in the air from reaching the fire.

We're going to test for oxygen using a glowing splint. I'm just going to demonstrate this test—we're not all going to do it. I need a grown-up to help me. Who would like to be my assistant? *Choose a responsible adult.*

We're going to start out with the bag of breath. Find your bag with breath in it.

Note: Use your own (presenter's) baggies for the glowing splint test demonstration, so that you're sure the contents haven't been contaminated by sloppy sampling.

Demonstrate the following procedure.

Testing the gases: Glowing splint

1. Ask the helper to hold the presenter's bag.
2. Tell your helper to keep it closed until you ask them to open it.
3. Light the end of a toothpick.
4. Drop the match into your container of water to extinguish it.
5. When the end of the toothpick is glowing orange, blow it out.
6. Ask your helper to open the bag.
7. Hold the toothpick inside the bag. Don't drop it!

What did you notice? *Response: Not much happened.*

Now let's try the bag with oxygen. What do you think will happen? Any predictions? *Various responses.*

Let's find out. Can everyone see?

Repeat above procedure with your bag of O_2. The splint will reignite.

How come the splint reignited? *Response: There was oxygen in the bag.*

Now let's try the bag with carbon dioxide. What do you think will happen? Any predictions? *Various responses.*

Let's find out. Can everyone see?

Repeat above procedure with your bag of CO_2. The splint will be extinguished.]

Now what happened? *Response: The carbon dioxide put out the fire.*

So, let's recap! Today we learned how to test for two important gases in our atmosphere. What are they? *Response: carbon dioxide and oxygen*

How did we make carbon dioxide? *Response: By combining baking soda and vinegar.*

And how did we test for the carbon dioxide? *Response: Using phenol red, which turns yellow in the presence of an acid like carbonic acid.*

How did we make oxygen? *Response: By combining yeast and hydrogen peroxide*

And how did we test for the oxygen? *Response: Using a glowing splint, which reignites in the presence of oxygen and is extinguished in its absence.*

What was in the other baggie? *Response: Exhaled breath.*

Did it have carbon dioxide or oxygen in it? *Response: Both/neither*

How do you know? *Response: The splint didn't ignite, but it also wasn't extinguished.*

Clean Up

- All the chemicals used in this activity can be poured down the drain.

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