FACILITATOR GUIDE

Breath of Fresh Air

EXPLORE SCIENCE
Voyage through the Solar System

Learning objectives

- The future of space travel will require a lot of recycling.
- Astronauts use a variety of systems to reuse and recycle as much as they can—even the air must be treated and filtered so they can breathe.
- The technology and systems being used on the International Space Station now help prepare us for future missions to the Moon and Mars.

Materials

- Neon yellow highlighters
- Two 10 mL graduated cylinders
- Two pipettes
- Water (may need distilled or filtered if the tap water is too hard)
- Small stirring straws
- Zeolite (size 4A) and safety data sheet
- ¼ teaspoon measuring spoon
- Measuring cup
- Two pitchers (one for premixing highlighter liquid, one for cleanup)
- Microfiber cloth (for cleanup)
- Trash bin (close by for used straws)
- Optional: micro flashlight (if you're working in a low-light environment)
- Optional: UV flashlight
- Optional: seltzer water

Safety

While highlighter ink is nontoxic, none of the liquids in this experiment should be consumed. Make sure participants only *blow* through the straws. You can encourage children to practice blowing through the straw onto their hand. Children under age 4 may need to be carefully monitored or try to encourage a caregiver to help with this step.

To reduce spreading germs, hand a straw to each participant instead of letting them select their own and have a trash bin close by for participants to carefully dispose of their straws.

The highlighter water might bubble out of the cup when the participants blow through the straw. Suggest that participants use a hand to cover the top of the container while they're blowing to prevent splashing.

Avoid pointing the flashlight directly into people's faces or eyes.

Advance preparation

Make the highlighter water in advance. Use the highlighter to color the inside of the pitcher on the bottom and about halfway up the sides. Try to get the ink to bead up on the sides as well. Make sure there is plenty of pigment in the pitcher! Then add about two cups of water and stir. This should be enough highlighter liquid for about 100 participants. If you need to make more highlighter solution during the activity, be sure to completely dry the pitcher before you color it with the highlighter again.

Notes to the presenter

If you have **hard water**, it may slow down the reaction and prevent the liquid from changing color. Try using filtered or distilled water instead.

The highlighter water won't always turn perfectly clear from blowing into it, but the experiment still works as long as the highlighter water is a noticeably lighter shade than the control.

The straws should only be used to blow air into one of the highlighter liquid cylinders (the experiment cylinder). After the color change occurs, the straws should be disposed of or used only to stir the water, if needed. **Optional**: ¼ teaspoon of seltzer water can be added to the highlighter water in place of blowing into the cylinder. Proceed with the other steps of the experiment as normal.

Use the empty pitcher to dispose of the highlighter liquid and zeolite. You can strain this mixture and dump the solids into the trash or flush it all down a toilet. The control cylinder can be used repeatedly if you want to avoid cleaning it out between groups—just explain that it is filled with the same materials (highlighter and water) as the experiment cylinder.

Swirling the cylinder gently after adding the zeolite helps the reaction happen faster. The reaction will still occur without swirling the cylinder, but it will take a few minutes longer.

When done, **store the unused zeolite in an airtight container**. Exposure to moisture may reduce its efficacy. If you run out of the zeolite and choose not to replace it, you can use laundry detergent as a consumable alternative. The result will be similar and the reaction may even happen more quickly, but the chemistry is different.

If you're doing the activity in low light, it can be hard to see the reaction. Use the optional microlight to help learners observe the color change.

Discussion prompts

While watching the color change and completing this chemistry experiment, you can engage participants in a conversation about some of the technology and systems being designed to support life as we explore beyond our home world. For example, try using these prompts to get participants thinking and talking about what we'll need to survive.

- How would you feel if you had to rely on a machine or other technology to breathe? Would you trust it?
- On spacecraft, there is no wind to move air around. This can lead to a buildup of waste gasses, like CO_2, around your face. If you were in a sealed spacecraft, how would you create wind and move the air around you?
- Earth is our home habitat and it has everything we need to live and play. How do you think we can protect our home planet and help prevent the buildup of CO_2 in Earth's atmosphere? (Before asking this question, inform participants that human breath does not contribute to climate change!)
- What else about living on a spacecraft might be different than living on Earth?

Some participants may have additional questions about the highlighter liquid used in this activity as a chemical indicator. You can use the UV flashlight included in the kit to show that even when the color of the indicator changes after adding CO_2, the highlighter is still present. Highlighters fluoresce under the UV, or blacklight, because the ink absorbs ultraviolet light, which isn't visible to the human eye, and remits it as visible light.

Common questions

Why does the zeolite bubble and warm up?
Carbon dioxide in your exhaled breath reacts with water and forms carbonic acid. That substance in turn bonds to the sides of the porous zeolite in a process that releases energy in the form of heat.

Why is there no air in space? Most regions of space contain very little air—often referred to as a "vacuum." Gasses around Earth are held in place by gravity. These gasses (nitrogen, oxygen, and small amounts of carbon dioxide, neon, and hydrogen) make up our atmosphere.

If there's no air in space, where does the oxygen on the International Space Station come from? Zeolite minerals remove CO_2 on the International Space Station (ISS), but oxygen still needs to be added back into the air. Right now, oxygen on the ISS is primarily made by water electrolysis, or splitting water (H_2O) into hydrogen and oxygen. A secondary source is a pressurized storage tank of oxygen transported from Earth.

Background information

On spacecraft, air must be treated so it remains safe and breathable for astronauts. On the International Space Station, CO_2 is pulled out of the air using manufactured zeolite, a porous material that adsorbs, or binds to, CO_2. Other treatment systems on the ISS pull out harmful gasses and water. The gasses are then vented into space, where they dissipate in zero gravity. In this experiment, we learn that by using materials and chemicals, we can change the chemistry of a liquid—much like how zeolite removes waste products from exhaled air.

Additional resources

Learn more about the Artemis Moon mission and Artemis Base Camp here:
www.nasa.gov/specials/artemis/

Closing the Loop: Recycling Water and Air in Space
https://www.nasa.gov/pdf/146558main_RecyclingEDA(final)%204_10_06.pdf

Staff training resources

Breath of Fresh Air Activity Training Video: https://vimeo.com/836955222

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Instructional photos, Emily Maletz for the NISE Network

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Developed and distributed by the National Informal STEM Education Network.

This material is based upon work supported by NASA under award numbers 80NSSC21M0082 and 80NSSC18M0061. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of NASA.