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Peer-reviewed Astronomy Education Activities

Fizzy Balloons – CO2 in School

Investigate the properties of carbon dioxide with this fun demonstration.

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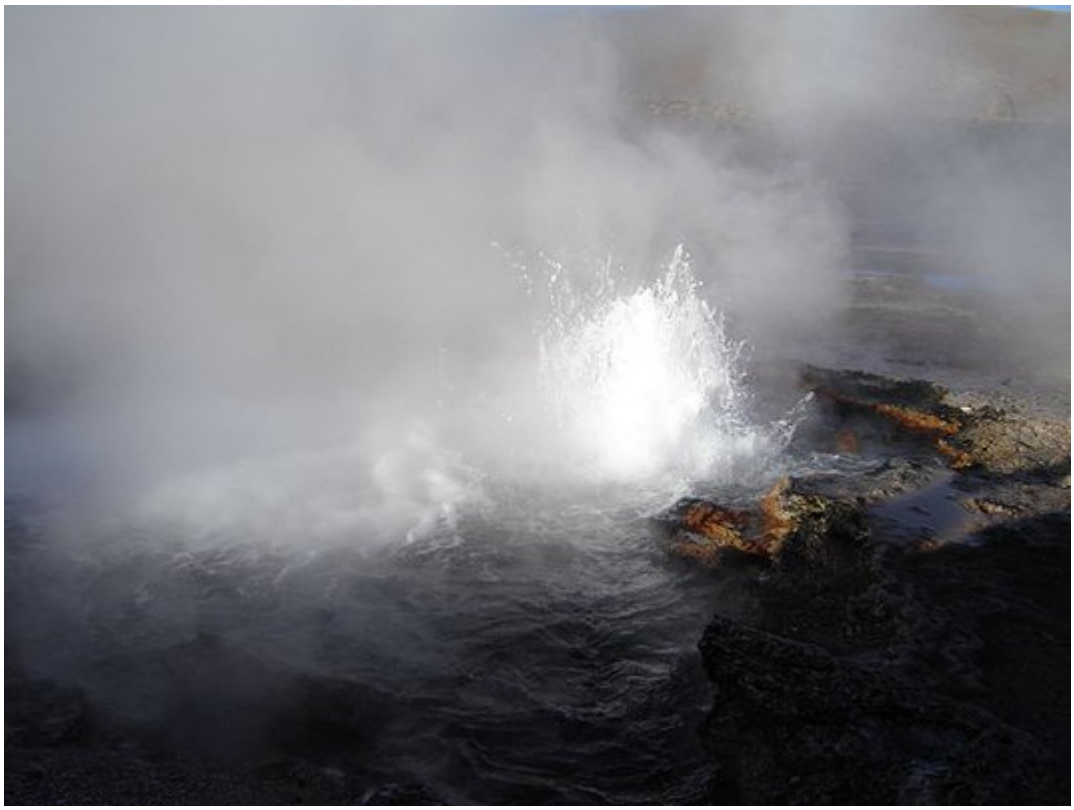


KEYWORDS

Carbon Dioxide, Chemistry, Earth Science

LOCATION

Small Indoor Setting (e.g. classroom)

AGE

8 - 12

LEVEL

Primary, Secondary

TIME

2h

GROUP

Group

SUPERVISED

Yes

COST

Medium Cost

SKILLS

Asking questions, Planning and carrying out investigations, Analysing and interpreting data, Constructing explanations, Engaging in argument from evidence

TYPE OF LEARNING

Interactive Lecture, Traditional Science Experiment

GOALS

This activity introduces carbon dioxide (CO_2) to students through a hands-on experiment. Students learn some properties about CO_2 behaviour.

LEARNING OBJECTIVES

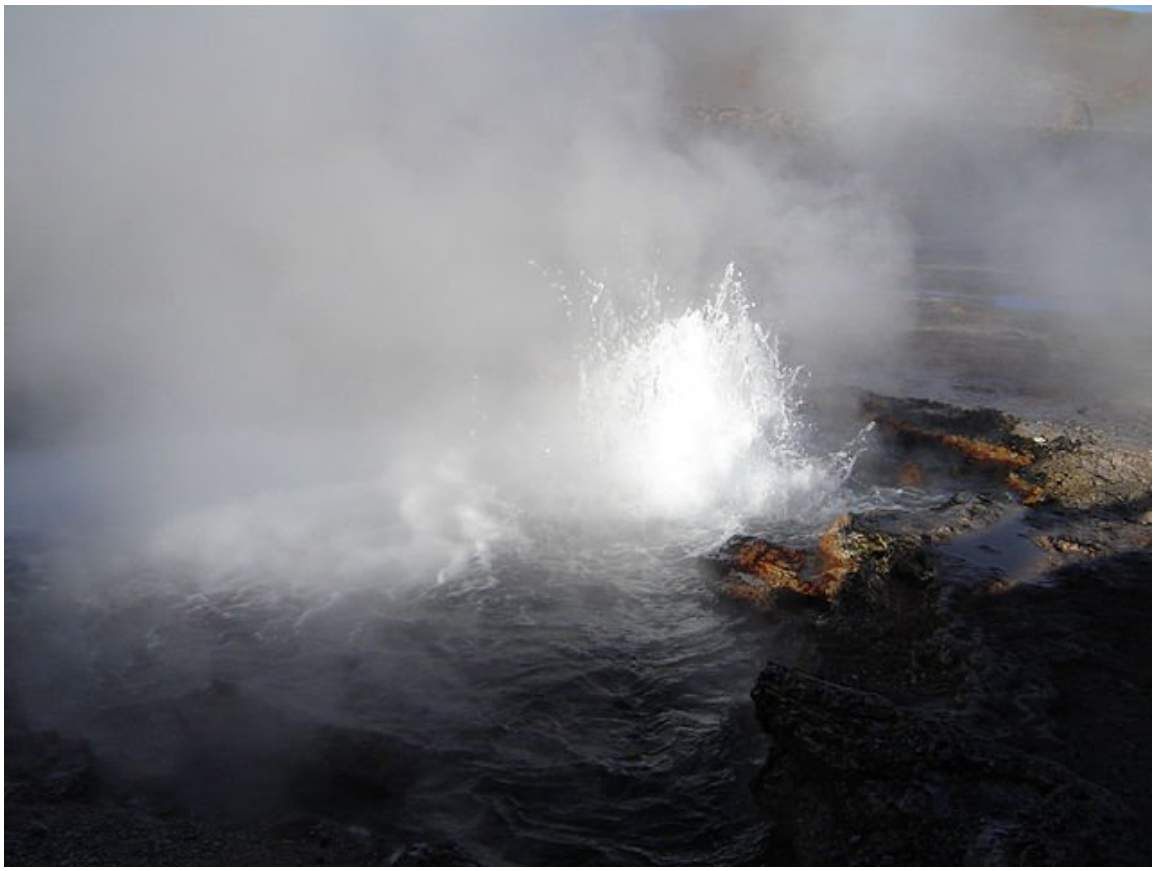
- Students demonstrate the presence of CO_2 with lime water.
- Students explain that carbon dioxide from any source reacts chemically with lime water to form carbonic acid.
- Students demonstrate that CO_2 is heavier than air and describe a daily situation using this property.
- Students conduct and interpret an experiment (individually or in small groups).

BACKGROUND

Carbon dioxide

Carbon dioxide (CO_2) is not only one of the most important greenhouse gases, it is found all around us: in the air (0.0388 vol%) we breathe; in the air we exhale (4 vol%). It is also found in fizzy drinks; in cakes, which rise thanks to the CO_2 produced by baking powder; and when organic compounds such as paraffin, paper, wood or petroleum are burned. Geysers can be driven by carbon dioxide, as well as steam. In liquid form, it is used in fire extinguishers and as a refrigerant in the food industry (for example to store and transport ice cream).

Image: Close-up to one of the geysers in "El Tatio" in San Pedro de Atacama, Chile. Credit: AndresGottlieb



In high concentrations, CO_2 can become dangerous for humans and other animals, but it is also a source of life: during photosynthesis, plants use CO_2 and light to produce sugar, starch, fats, and proteins, as well as the oxygen we need to survive. *A volume per cent or vol% is the number of cubic centimetres of a substance (usually oxygen or carbon dioxide) contained in 100 ml of another substance (for example blood).

Note: The amounts of carbon dioxide produced in these activities are not high enough to be dangerous.

CO_2 properties

Carbon dioxide is colourless. At low concentrations, the gas is odourless. At higher concentrations it has a sharp, acidic odour. At standard temperature and pressure, the density of carbon dioxide is around 1.98 kg/m ^{3} ; this is about 1.67 times more than air. CO_2 is present in very small quantities in the air, which makes it hard to keep as one layer. Gases don't stay still but move around in the air. CO_2 then doesn't remain on the lower parts of the atmosphere even though it is heavier than air.

Detection of CO_2 with lime water

The lime water test to detect CO_2 was developed by chemist Joseph Black (1728–1799). Lime water is a solution of calcium hydroxide (slaked lime). When carbon dioxide is bubbled through it, a solid precipitate of calcium carbonate is formed. Calcium carbonate is chalk or limestone, and it is this that makes the lime water cloudy.

calcium hydroxide + carbon dioxide -> calcium carbonate + water.
$Ca(OH)_2 (aq) + CO_2 (g) CaCO_3 (s) + H_2O(l)$

FULL DESCRIPTION

The first six steps are common to both activities A and B– then you have two options as to how to proceed.

Step 1:

Blow up a balloon and let the air out again to make the rubber more elastic.

Step 2:

Use the funnel to fill the balloon with a packet of baking powder (20 g) or five crushed effervescent tablets.

Step 3:

Pour 2-3 cm of water into the bottle.

Step 4:

Cover the bottleneck with the balloon and tip the baking soda / effervescent tablets into the bottle. You may need to hold the balloon onto the bottleneck to prevent it from slipping off.

Step 5:

Shake the bottle lightly. The balloon fills with a gas that is produced in the effervescence.

Step 6:

When the balloon has stopped inflating, twist it shut so that no gas can escape and pull it off the bottle.

Ask students to describe what is happening. Ask them to share their hypotheses about what caused the balloon to fill. Discuss the hypotheses before going to part A.

A) What type of gas is it?

Step 7:

Put some lime water into a beaker.

Step 8:

Place a drinking straw into the mouth of the balloon, and slowly and carefully release the gas from the balloon into the lime water. The lime water will become cloudy.

Step 9:

Repeat step 7 with clear water.

Ask students to draw the two different beakers and illustrate their observations. Why is the water clear and the lime water cloudy? What could cause the clouds in the lime water?

Discuss the answers with the students. What conclusion can we make? How does this relate to the hypothesis discussed in the first part of the activity?

Image credit: Chemol

Safety note: if you get lime water into your eyes, rinse them immediately with water. See also the general safety note.

The gas in the balloon is CO_2. Where did our CO_2 come from? Both baking powder and effervescent tablets contain sodium bicarbonate ($NaHCO_3$) and a solid acid (such as citric acid crystals or monocalcium phosphate). In contact with water, sodium bicarbonate and the acid react with one another, ultimately forming water and CO_2. This gas is what forms the bubbles when a fizzy tablet dissolves. In our daily lives, it is also what makes cakes rise.

B) The gas is heavy

Step 7:

Hold the mouth of the balloon into a beaker and let the gas flow out. You cannot see anything, but we will see whether anything has happened. Put the beaker to one side.

Step 8:

Light a tea light candle and use a pair of tongs to place it in a second, empty, beaker (alternatively, you could stick a wooden skewer into the wax and use that to lift the tea light candle into the beaker). It should continue to burn.

Step 9:

Now place the tea light in the first beaker, which contains the gas from the balloon. The candle should stop burning because the gas (CO_2) will choke the flame. Ask students to draw the experiment and note their observations. Discuss their notes. What caused the flame to extinguish in the first beaker?

Step 10:

Repeat steps 1-7 to collect more CO_2 in a beaker. Now pour the invisible contents of this beaker into yet another empty beaker. Place a burning tea light into this beaker. What happens? Again, the flame is extinguished, showing that we were able to pour the gas from one beaker to another, as though it were a liquid.

Ask students to draw the experiment and note their observations. Discuss the results with the students. What conclusions can we draw from this experiment?

This experiment demonstrates that CO_2 is heavier than air. Ask students what would have happened if CO_2 were lighter than air.

Ask students if they can think of daily applications of this property. An example is the use of CO_2 in some fire extinguishers. Such extinguishers expulse CO_2 on fire to contain the flames and extinguish the fire. They work exactly as demonstrated in part B.

EVALUATION

- Ask students to draw the steps of each experiment and note their observations.
- Write the students' hypotheses on the board after implementing each experiment. At the end of the activity, check with them which hypotheses can be validated.
- Ask students to explain what happens to the tea light candle when it is placed in the beaker with CO_2. Check by experimenting.
- Ask students to draw what would have happened with the tea candle if CO_2 were lighter than air.
- Ask students to describe one use of CO_2 being heavier than air in daily life.

CURRICULUM

Country	Level	Subject	Exam Board	Section
UK	KS2: Year 5	Science	-	Properties and changes of materials: explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning and the action of acid on bicarbonate of soda.
UK	KS3	Science: Chemistry	-	Chemical reactions: reactions of acids with alkalis to produce a salt plus water.

ADDITIONAL INFORMATION

The activity works best when it is done with small groups of 5 to 6 students. Teachers demonstrate each step throughout the activity and supervise the groups to follow the demonstration.

CONCLUSION

Through a practical demonstration, this activity introduces primary-school students to CO_2. They will notice that CO_2 is heavier than air, can be used to extinguish flames, and turns lime water cloudy.

CITATION

Space Awareness, , *Fizzy Balloons – CO2 in School*, astroEDU, 1601 doi:10.14586/astroedu/1601

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