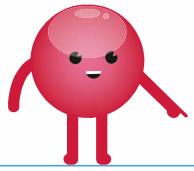
9. Capturing carbon dioxide

Make and collect your own balloon of carbon dioxide



Overview

The classic coke-and-mentos experiment is modified to collect the carbon dioxide gas made from the effervescent reaction by capturing it in a balloon.

What's happening?

Carbon dioxide is normally dissolved in the drink when it is bottled. It is responsible for the tingling sensation felt in the mouth when drunk as well as the bubbles observed in a glass. The carbon dioxide is initially forced into the drink at high pressure and low temperature at the bottling plant. When the bottle is sealed the contents become pressurised, forcing the carbon dioxide to stay in solution. When the bottle is opened, the carbon dioxide will be released from the drink until it has reached equilibrium with the air around it.

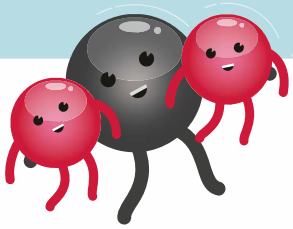
This process can be sped up by giving the dissolved carbon dioxide growth sites to form bubbles on.

When Mentos are added to a freshly opened diet coke the rough, bumpy surface of the mint allows bubbles of carbon dioxide to rapidly form and this sends a fountain of diet coke foam several metres into the air.

Why is this important?

Carbonated water is the main (over 90 %) ingredient of most fizzy drinks. Carbon dioxide is ideal to use as it is a colourless gas, inert, cheap and non-toxic. It provides a tingling sensation on the tongue, a mild acidic bite and can act as a preservative.

Beyond this it has a number of very important applications. As an inert gas it can be found in fire extinguishers and in canisters in life jackets for rapid inflation. As a supercritical fluid (a material with the properties of both liquid and gas) it is used to decaffeinate coffee as



a safe alternative to other solvents. Supercritical carbon dioxide can also be used to produce aerogels and is an incredibly good thermal insulator. It is also used by NASA on their Mars Rovers and in space suits (see Further Ideas and Information).

Carbon dioxide is often regarded as a pollutant. However, it is one of the primary components of photosynthesis, needed for most plants to live and grow.

More stories to tell

How do the Mentos work?

Imagine the carbon dioxide is stored within a network of water molecules, almost like a cage. The water molecules are connected via polar attractions (known as hydrogen bonds) and these attractions can be disrupted by rough surfaces, breaking open the cage. You can see this happening on a small scale when there is a scratch in the side of a glass and bubbles nucleate and grow from the scratch, sending a stream of bubbles up to the surface of the glass.

Mentos actually have a very rough surface and with a high surface area in a small volume they provide a huge number of growth sites for bubbles to form. They also sink, which means they create bubbles as they fall which in turn help provide more growth sites for even more bubbles!

Mentos also contain gum Arabic (the hardened sap from the acacia tree). It is a surfactant (reduces the surface tension of the liquid it is dissolved in) which also disrupts the hydrogen bonded network of water molecules, further increasing the amount of carbon dioxide that can be released.

Is breathing in carbon dioxide bad for us?

Carbon dioxide is not dangerous on its own in the way that carbon monoxide is. That is why we add it to our drinks to make them fizzy. Humans breathe out carbon dioxide as the end product of respiration. In fact, the concentration of carbon dioxide in our breath is one of the triggers for how regular and deep our breathing is.

However, humans do require oxygen to survive. In some situations, such as in an unventilated small space where the dense carbon dioxide can build up, oxygen in the air can be replaced by carbon dioxide and this can cause humans to pass out within minutes. Continued deprivation of oxygen would then result in permanent damage to the systems of the body or death.

The Activity

Before the show:

1. Put five Mentos into the neck of the 18 inch balloon.

2. Clip the bottom of the balloon to avoid premature release.

During the demonstration:

1. Open the bottle of fizzy drink and attach the balloon to the neck of the bottle, ensuring the clip (or your fingers) stop the accidental addition of Mentos to the bottle.

2. With a firm grip on the neck of the bottle and balloon, force the Mentos into the bottle.

3. The fizzy drink will immediately fountain into the balloon, the balloon and bottle will have to be supported and held to guide the fizzy drink back into the bottle.

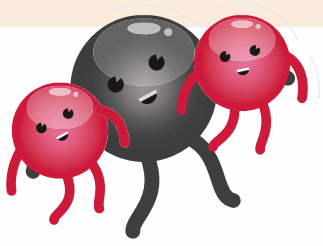
4. After around 30 seconds the balloon will be partially inflated and the fizzy drink will have stopped gushing into the balloon. Remove the balloon taking care to ensure you do not lose any trapped carbon dioxide.

The carbon dioxide can now be used in further experiments. For example, pour the carbon dioxide from the balloon into a jug with a cling-film lid with a gap at the front and the back. Light a series of tea-lights on the stage and pour the invisible gas over the candles to put them out one by one. This shows how carbon dioxide can be used to put out flames (see 'Carbon dioxide and its uses' in Further Ideas and Information).

Troubleshooting

1. Use a large (18 inch) thick balloon and keep one hand around the neck of the bottle at all times. Initially the balloon will begin to fill with liquid as well as gas so it is important to support the balloon and keep control – this is a great chance for mild peril and some humour.

2. Fruit or mint Mentos and diet coke are the most effective combination.



3. Diet coke produces the best fountains as aspartame also reduces the surface tension of the water, speeding up the release of carbon dioxide.

4. The larger the bottle, the more carbon dioxide dissolved. In pilot testing a 2 L bottle of diet coke easily produces several litres of carbon dioxide.

5. The jug used for putting out candles can be pre-charged with carbon dioxide by putting some solid carbon dioxide in and sealing the top with cling-film prior to the show.

6. An HD webcam will make the smothering of the candles with carbon dioxide more impactful.

Health and Safety

Every delivery centre must undertake their own risk assessments for the specific audiences, locations and conditions they are presenting in. Sample assessments are available on The Secret World of Gases website. Below is a guide to the key risks and hazards:

1. Please see risks associated with handling solid carbon dioxide in 'Additional Resources'.

2. If the balloon is not fixed securely, some of the diet coke will escape causing spillage and a possible slip hazard for the presenter or any volunteers on stage.

3. Mentos are appealing for children and pose a choke hazard.