Science of Dragons Show

support notes
by

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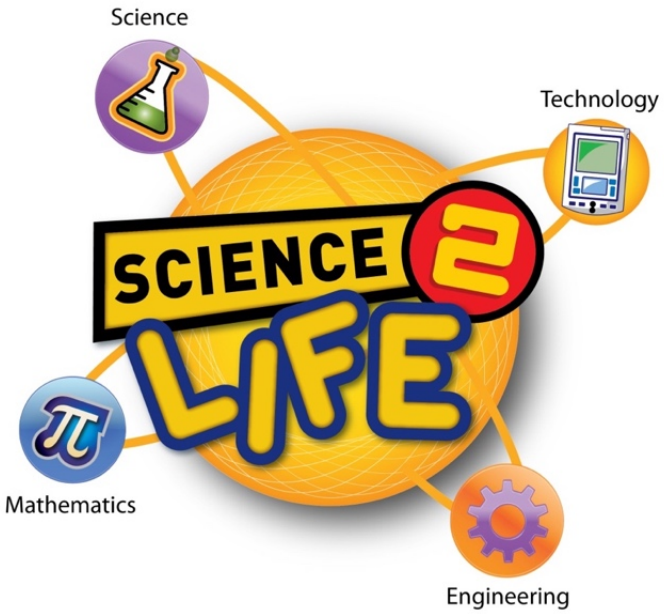

"Effect change, achieve results and make science fun!"

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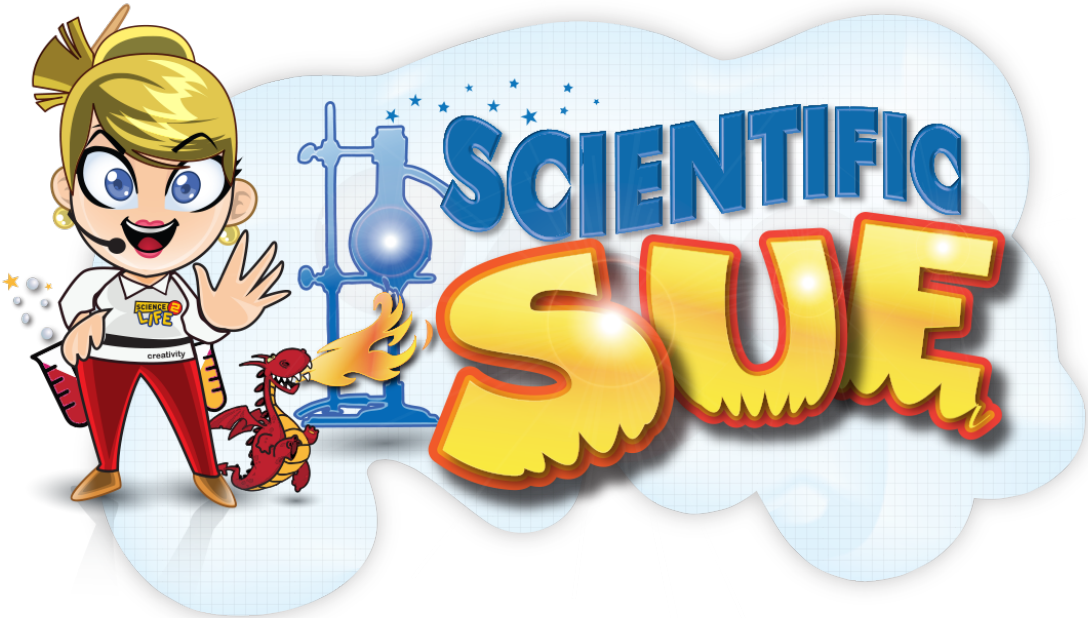

Sue is a Physics and Applied Mathematics graduate of Queen's University Belfast. She taught Physics, Chemistry and Drama for 10 years before becoming the Senior Manager for Educational Programmes in the start-up team for the now world-renowned Science Centre whowhatwherewhenwhy-w5 based at Odyssey, Northern Ireland.

Sue McGrath aka 'Scientific Sue' is the founding director of Science2Life, an educational provider and consultant organisation dedicated to the communication of STEAM (science, technology, engineering, art and mathematics) topics in a passionate and engaging fashion.

In her current role as a professional science communicator, Sue combines her in-depth subject knowledge, her creativity and drama background with her commercial and strategic expertise to develop and deliver a range of thought-provoking and engaging educational activities and training programmes. These programmes have taken her all over Ireland, Great Britain, Nigeria, Qatar, Kingdom of Saudi Arabia and the United Arab Emirates.

Sue has published a book and written for several science magazines such as Science Spin and Physics Education (of which she was an editorial board member), produced hands-on science kits, and has extensive television exposure in Ireland. She was made a Fellow of the Institute of Physics in 2004 and has been a Teacher Network Coordinator for IOPI for the last 6 years.

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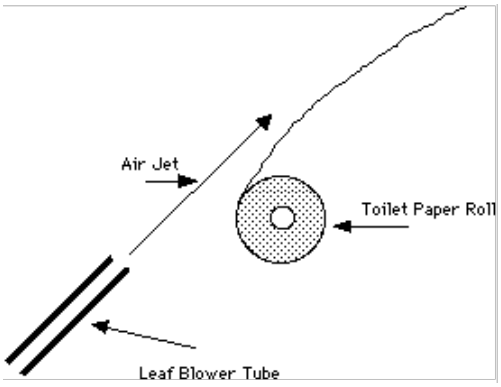
Flying Toilet Roll



Nuts & Bolts

- Leaf blower (or hair dryer)
- Paint roller
- Toilet roll
- Beach Ball

Secrets for Success

Push the toilet roll on to the paint roller (or stick); have one person hold the roller.
Allow another volunteer to hold the leaf blower, get them to hold it so that one hand (their strongest) holds the handle and the other places a hand underneath the airflow nozzle (see photo below). Switch on the leaf blower.
Place the toilet roll in to the stream of air, allowing the air to flow over the top of the toilet roll and watch the paper take off!
Experiment a bit with the right angle and distance from the paper to get the maximum elevation and speed of the toilet paper.
Now try placing a beach ball in the stream of air.

Science in a Nutshell

The floating beach ball, like airplanes that fly, are examples of Bernoulli's Principle. Airplanes fly because the shape of the wing makes the air flow faster over the top of the wing than the air below the wing. The gas molecules in the fast moving air are more spread out. The number of molecules per unit volume is less than the number of molecules per unit volume in the slower moving air. Bernoulli discovered that the faster moving air flowing over a surface causes less air to be able to push on the surface –
we say the surface experiences lower air pressure.

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Balloon Blow-Up

Nuts & Bolts

- Distilled Vinegar - diluted ethanoic acid
- Baking Soda - sodium hydrogen carbonate
- Small clear plastic bottle
- Small funnel
- Spoon
- Balloon
- Tall beaker
- Small candle
- Matches
- Splint
- Safety glasses
- Safety glove

Secrets for Success

- Fill a balloon with baking soda using the funnel.
- Half fill the bottle with clear vinegar.
- Carefully stretch the opening of the balloon over the neck of the bottle without allowing any powder to fall into the bottle.
- Hand bottle to your volunteer- who must be wearing safety glasses and a safety glove - a helmet can also be worn; this will add to the drama!
- Ask the volunteer to gently lift up the balloon so that the powder falls into the bottle.

At this stage lots of carbon dioxide gas will be formed. Is this gas explosive? Ignite it to find out!

To add to the drama, you can attach a splint to the end of a metre stick so that you are a very long way away from the balloon when it explodes. The volunteer holding the balloon maybe a bit concerned, however the rest of the class will love it!

Pour some vinegar into a tall glass, add a spoonful of baking soda. Let the class see the fizz. Light a candle. Lift up the glass and pour the invisible CO_2 gas over the flame. The flame will be extinguished.

Safety: glasses and a glove must be worn so that the volunteer is protected against any flying balloon pieces once the balloon is burst.

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Science in a Nutshell

When the ethanoic acid (vinegar) is mixed with the sodium hydrogen carbonate (baking soda) a chemical reaction takes place. Lots of carbon dioxide bubbles are formed in a very short period of time.

This experiment is an example of a reaction between an acid and a base. Such reactions typically form a 'salt' and water.

ACID + BASE SALT + WATER

Because the acid component in this experiment is ethanoic acid, it allows the production of one of the products to be sodium ethanoate. That is the stuff referred to as the "salt." In this experiment the base has a carbonate component; hence carbon dioxide is also formed. The fancy shorthand symbols used by scientists to represent our reaction are:

$$\mathbf{CH_3\,COOH + NaHCO_3 \rightarrow NaC_2\,H_3\,O_2 + H_2\,CO_3}$$

Ethanoic acid (vinegar) sodium hydrogen carbonate (baking soda) makes sodium ethanoate + carbonic acid.

The $NaC_2\,H_3\,O_2$ is the salt called sodium ethanoate. The $H_2\,CO_3$ (carbonic acid) then breaks down into water and carbon dioxide:

$$\mathbf{H_2\,CO_3 \rightarrow H_2\,O + CO_2}$$

This break down is rapid and the balloon expands quickly.

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Wasp sting venom is alkaline and so its effects can be neutralized with vinegar or another weak acid and this neutralisation then reduces the pain.

Bee sting venom is acidic and so its effects can be neutralized with bicarbonate of soda or another weak base or alkali solution and this reaction also reduces the pain.

Neutralisation

Wasps naturally prey on other animals. They feed insects and other arthropods to their young, which develop in the nest. They are beneficial because they prey on caterpillars, flies, crickets and other insects which are considered to be pests.

During late summer and autumn, as queen wasps stop laying eggs and their nests decline, wasps change their food gathering priorities and are more interested in collecting sweets and other carbohydrates. Some wasps may become aggressive scavengers around human food and are commonly found around outdoor activities where food or drinks are served.

Bees feed only on nectar (carbohydrates) and pollen (protein) from flowers. Honey bees sometimes visit rubbish bins and soft-drink containers to feed on sugary foods.

What can we do to stop wasps and bees from annoying us whilst we are in the park enjoying a fun day out?

- Leave the sugary food at home!
- Put out sliced cucumbers

One unusual wasp repellent is sliced cucumber!

This vegetable has a chemical property wasps just don't like. Use your purple cabbage to juice to find out what it is!

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Lots of household chemicals have been used over the years to neutralise wasp and bee stings: vinegar, bicarbonate of soda, honey, toothpaste, lemon and onion.
Using the cabbage chemistry below, carry out your own experiments to find out which of the above chemicals can be used to neutralise a wasp sting or a bee sting. Also test some cucumber to find out why wasps don't like it.

Cabbage Chemistry

Nuts & Bolts

A red cabbage
Saucepan
Water
Sieve
Two large clear plastic beakers
Paper towels!
Two assistants
Two pairs of safety glasses

Chemicals to test:

Vinegar
Bicarbonate of soda
Honey
Lemon
Onion
Cucumber

Secrets for Success

Chop up the red cabbage, place it in a saucepan and add just enough water to barely cover it. Bring the water to the boil, and simmer for about 15 minutes. Pour the water through a sieve. This purple water is your indicator dye – store in a clear plastic drinks bottle. Label: Red Cabbage Indicator – DO NOT DRINK!

Testing the indicator:

Half fill one of the beakers with vinegar and hand this to assistant 1. Half fill the second beaker with water and add two tablespoons of bicarbonate of soda (baking soda) to it; hand this beaker to assistant 2 ask them to stir in the powder with a spoon or magic wand – whichever is closest to hand! The amount of showmanship is up to you but make sure you highlight the fact that the vinegar is an acid and the baking soda is a base (which when dissolved in water makes an alkali solution).

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Get your audience to guess what will happen when a squirt of the purple coloured cabbage juice is added to each of the beakers. The bicarbonate of soda solution (alkali) will turn the cabbage water a green-blue colour. The vinegar (acid) will turn the cabbage water a reddish-pink colour. The cabbage dye behaves as an indicator, a chemical substance which changes colour, depending on the acidity or alkalinity of its environment.
Finally ask which assistant should pour the contents of their beaker into the other assistants' beaker to neutralise their opponent! – you could mention here that there is a strong possibility that a reaction will occur and the size of the reaction might depend on which beaker is poured first (? .. just adding to the excitement!) hence the need for safety glasses.

Safety: Eyewear should be worn by your assistants just in case there is splash back.

Science in a Nutshell

The purple colour in the red cabbage comes from a class of pigments called anthocyanins; this pigment is also found in the skin of red apples, grapes, plums and is the pigment in leaves which turn red in the autumn.

When the vinegar is mixed with the baking soda solution a chemical reaction takes place. You not only see a colour change; the end solution will be a purple colour – indicating neutralisation has taken place, but LOTS of bubbles of carbon dioxide are formed; these bubbles are as a result of the reaction. Provided that the beakers had enough liquid in them to begin with they will not have a large enough volume to hold the bubbles and they will cascade over the top of the beakers leaving a very wet mess on the floor – hence the paper towels!

Acids and Bases

The word acid comes from a Latin word meaning sharp or biting to the taste. You would have experienced this sensation if you have ever sucked a lemon! Many acids occur naturally and, in the kitchen, the two most common are citric acid (found in citrus fruits) and ethanoic acid (vinegar – a dilute solution of ethanoic acid). Most of the acids found in and around the home are weak but some are very strong, they are poisonous and extremely dangerous. One of the strongest acids is hydrochloric acid, HCl, a compound made up of two atoms; one hydrogen atom and one chlorine atom. This acid is used for soldering but we also find it in our stomachs which is why, if you have a stomach ulcer, you suffer so much pain. Sulphuric acid is another strong acid which is found in the battery of cars. They most definitely should not be tasted!!
The chemical opposites of acids are bases. Bases are usually found as a solid compound and for it to react with an acid it is usually dissolved in a solvent, such as water, to form a solution. Bases in solution are called alkalis. At home the most common place to find bases and alkalis is under the kitchen sink because they are very good cleaners; examples would be washing soda crystals and bleach. You will also find some bases in the food cupboard; baking soda (sodium bicarbonate) being the most common.

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When a base (or alkali) is added to an acid, it will neutralise the acid's properties and vice versa.

In this experiment you are initially investigating acid-base reactions using vinegar (ethanoic acid CH_3COOH) and baking soda (sodium bicarbonate $NaHCO_3$). When these two chemicals are mixed a salt ($NaC_2H_3O_2$), water (H_2O) and carbon dioxide (CO_2) are produced. Water is a liquid (l), carbon dioxide is a gas (g). If water is used to dissolve a solid (s) to form a solution the scientific symbol for aqueous (aq) is put after the chemical. Hence the reaction can be written as:

CH_3COOH (aq) + $NaHCO_3$ (s) → $NaC_2H_3O_2$ (aq) + H_2O (l) + CO_2 (g)

By using these symbols scientist cut down on a lot of writing time which ultimately gives them more time to experiment, think and solve problems. By mastering the scientific language, a whole new world is opened up for you to play in – just like learning Spanish will allow you to enjoy the company of the Spanish speaking communities as well as appreciate their culture and history. More books to read, more songs to sing!

Note that in the general case of simple acid-base reactions, the term, "salt" refers to the non-water, ionic product. If hydrochloric acid and sodium hydroxide were the reactants, then NaCl (sodium chloride - common salt) would be the non-water product. Just as a reminder our reaction looks like this:

CH_3COOH + $NaHCO_3$ → $NaC_2H_3O_2$ + H_2CO_3

Ethanoic acid plus sodium hydrogen carbonate makes sodium ethanoate plus carbonic acid. The $NaC_2H_3O_2$ is the salt called sodium ethanoate. The H_2CO_3 (carbonic acid) then breaks down into water and carbon dioxide:

H_2CO_3 → H_2O + CO_2

This break down is rapid hence the reason why the contents will bubble over the edge of the beaker – most impressive!!

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Although the cabbage we are using has purple leaves we call it RED CABBAGE! The reason for this is the plant changes colour according to acidity of the soil. On acid soils, the leaves grow more reddish while on alkaline soil will produce rather greenish yellow leaves.

We can see much more dramatic colour changes by just using cabbage juice. We always get the colours red, pink and magenta in acidic solutions whilst alkaline solutions will give us colours ranging from blue to aquamarine to green to yellow depending on the strength of the alkaline solution. If the solution is neutral, we see the colour purple.

We can use red cabbage juice as a pH indicator because it contains a pigment called anthocyanin which changes the colours we see depending on the acidity or alkalinity of the solution we put it into.

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Pupil Activity Sheet Name: _____

Neutralisation Date: _____

In the 'Science of Dragon Show' Scientific Sue used the juice from purple cabbages to produce the colours: Yellow, Green, Aquamarine, Blue, Purple, Pink and Red

Can you remember why these cabbages are labelled as RED cabbages in the shops?

When insects sting you they inject liquids which can be acidic or alkaline.

Cure for Bee or Wasp Sting	**Colour change with purple cabbage juice**	**Acid**	**Alkaline**
Vinegar	**Red**	**Yes**	**No**
Bicarbonate of Soda	**Blue/Green**	**No**	**Yes**
Honey			
Toothpaste			
Lemon			
Onion			
Cucumber			

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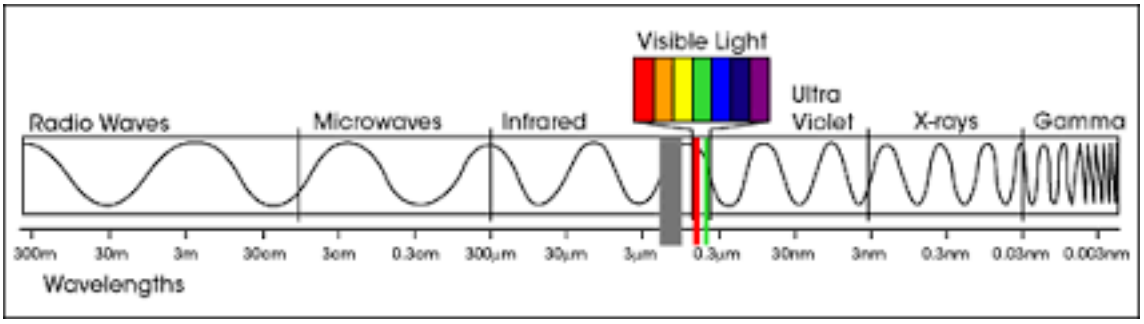
Going Further

How we see the colour changes.

Light travels in waves - electromagnetic waves. These waves are vibrations of electric and magnetic fields that pass through space. In physics, the visible spectrum has three primary colours: red, green and blue. Chemically, colour is derived from pigments and compounds and the three primary colours here are: red, yellow and blue. Any of these two colours will give a third colour – a secondary colour.

The diagram below shows what a small part of the whole electromagnetic spectrum light actually forms. We generally refer to the wavelengths of visible light as colour, which we split into seven bands: red (longest wavelength), orange, yellow, green, blue, indigo and violet (shortest wavelength).

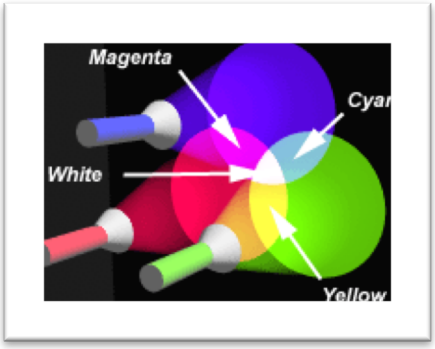


There are two basic ways by which we see these colours. Either an object can directly emit light in the wavelengths of the observed colour, or an object can absorb all other wavelengths, or combinations of light waves, and reflect only those that appear as the observed colour. White light is a combination of all colours whilst black is the absence of colour.

As you can see from the red cabbage colour chart a range of colours can be made; for example, when we add vinegar to the purple coloured cabbage juice we see the colour red.

We see colour with the sensors in the retina of the eye called rods and cones. The rods are sensitive to low light and the cones, which require a greater intensity of light, are sensitive to colour. This message is passed on to the optic nerve and then onto the brain.

The rods and cones of our eyes pick up this particular wavelength of red because at this concentration the cabbage pigments reflect rays from the red end of the spectrum and absorb rays from the blue end.



Colour can be investigated using this colour chart, three torches and three colour filters: red, green and blue – This is called colour addition. Cover the front of one torch in a blue light filter, one with a green light filter and the other with a red light filter. Use a white

wall or surface to shine the torches on. The effect is best achieved in a very dark room with a white wall. Use three volunteers to arrange the torches so that the beams of light just overlap each other. The result is that in the middle of the three light beams, the area is white.

Whole Class Activities:

1 Make your own pH paper

Soak filter paper (or coffee filters) in a concentrated solution of red cabbage juice. After a few hours remove the paper and allow it to dry. Cut the filter into strips and use them to test the pH of a selection of solutions made from, for example, fruit and vegetable juices, toothpaste, alka-seltza tablets, vitamin C tablets, surface cleaners and soap.

2 Invisible writing

Mix equal parts of water and baking soda and, using a cotton bud or paint brush, write a message or draw a diagram onto a sheet of white paper using the baking soda solution as ink. Allow the message to dry.

Pour some of your concentrated red cabbage solution into a small spray bottle (obtainable from a garden centre). Spray this solution over the message. The message will appear in a different colour.

Visit these websites:

http://www.halton.gov.uk/schintranet/science/Gases.pdf
This site gives you four investigations including teachers notes and worksheets.
http://www.echalk.co.uk/Science/chemistry/universalIndicator/universalIndicator.html
This resource helps pupils learn the pH of different household products. Pupils use a universal indictor and colour chart in order to estimate the pH of different solutions. (Macromedia flash).
http://www.4to40.com/activities/artcraft/index.asp?article=activities_artcraft_vinegarvolcano
Everything is made of chemicals. And all chemicals are made of tiny particles called atoms. During a chemical reaction, one group of atoms are shuffled and taken a part, they get mixed with the other atoms to form a different group and make a new chemical. Similarly when Vinegar is mixed with Bicarbonate of soda (baking soda) one of the new chemicals formed is a gas. The bubbles of this gas can be made to make a volcano fizz.

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Pupil Activity Sheet

Name: _____

A Catalyst and the Rate of Reaction

Date: _____

Making Oxygen

Nuts & Bolts

- 500 ml plastic bottle
- 1 Tablespoon of dried active yeast
- Small beaker
- 10 ml warm water
- Stirrer
- 50 ml 6% Hydrogen Peroxide
- Candle
- lighter
- Wooden splint
- Food colouring
- Washing up liquid
- Safety glasses
- Small tray

Safety: Hydrogen peroxide can irritate skin and eyes. Safety glasses must be worn. If liquid is accidently spilt on the skin wash with water immediately.

Key Concepts

- A catalyst is a substance that can help the reactants in a chemical reaction react with each other faster.
- A catalyst does not actually become part of the products of the reaction.

Secret for Success

Put on Safety glasses.
Add 50 ml of 6% hydrogen peroxide H_2O_2 to the 500 ml bottle (or beaker).
Mix the yeast and warm water in the small beaker and stir for 20 seconds, then add to the hydrogen peroxide.
Bubbles of oxygen will immediately start to be formed. Wait until the bubbles have reached the half way mark then gently shake the bottle to burst a few of the bubbles.
Light the splint and let it burn for a few seconds. Lift up the bottle and hold it at a 45 degree angle. Slowly insert the glowing splint into the bottle.
Remove the splint when it relights.

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When ready repeat the above but this time place the bottle on a small tray; add food colouring and a squirt of washing up liquid to the hydrogen peroxide before you add the yeast. You will not be able to relight a splint this time but the vision of a colourful bubbling foam is awesome!

Science in a Nutshell
Hydrogen Peroxide (H_2O_2) is a reactive molecule that readily decomposes into water (H_2O) and oxygen gas (O_2): In this demonstration, an enzyme in the yeast called catalase, catalyses the decomposition so that it proceeds much more rapidly than normal, producing firstly bubbles of oxygen and in the second demo foam filled with oxygen. In addition to being a nice example of a decomposition reaction and a catalysed reaction, the reaction is exothermic, so heat is produced and can be felt by the students when holding the bottle.

EXPLAIN IT WITH ATOMS & MOLECULES The decomposition of hydrogen peroxide and be written as:

$$2H_2O_2\ (l) \rightarrow 2H_2O\ (l) + O_2\ (g)$$

hydrogen peroxide water oxygen

Which new substances are created when hydrogen peroxide decomposes?

What was used as a catalyst in this experiment?

What does a catalyst do in a chemical reaction?

If the catalyst is involved in the chemical reaction, why isn't it included as a product in the chemical equation?

What clues did you have that a chemical reaction occurred in this activity?

What evidence do you have that hydrogen peroxide decomposed faster when you added the yeast?

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