scdi Scottish Council for Development and Industry

Young Engineers & Science Clubs Scotland

TEN GREEN BOTTLES

An introduction to Carbon Dioxide and its properties

Ten Green Bottles: An Introduction

Ten Green Bottles chemistry for you
Ten Green Bottles to study CO_2
If these Green Bottle tests you try to do
You'll carry out experiments on eco-issues too

Contents

Overview of Ten Green Bottles

Carbon Capture is seen by many as an important new area of scientific research and engineering and it is being pioneered in Scotland. The importance of carbon dioxide as a greenhouse gas and its significance in relation to climate change is generally recognised. A brief, simple summary/explanation can be found on line at **http://www.clean-air-kids.org.uk/globalwarming.html**. Other links are suggested within the activities.

The activities included within this resource pack have been designed for use within a Science Club situation with an aim of developing the children's practical skills while also encouraging problem solving, communication and teamwork. It is not the intention to be prescriptive in how you might use them.

The experiments in this project have been designed to use non-laboratory equipment such as recycled water bottles, plastic cups and jam jars to encourage primary school pupils to investigate carbon dioxide and its properties as a prelude to project work on the exciting new field of carbon capture and storage.

The resource pack contains activities on the following:

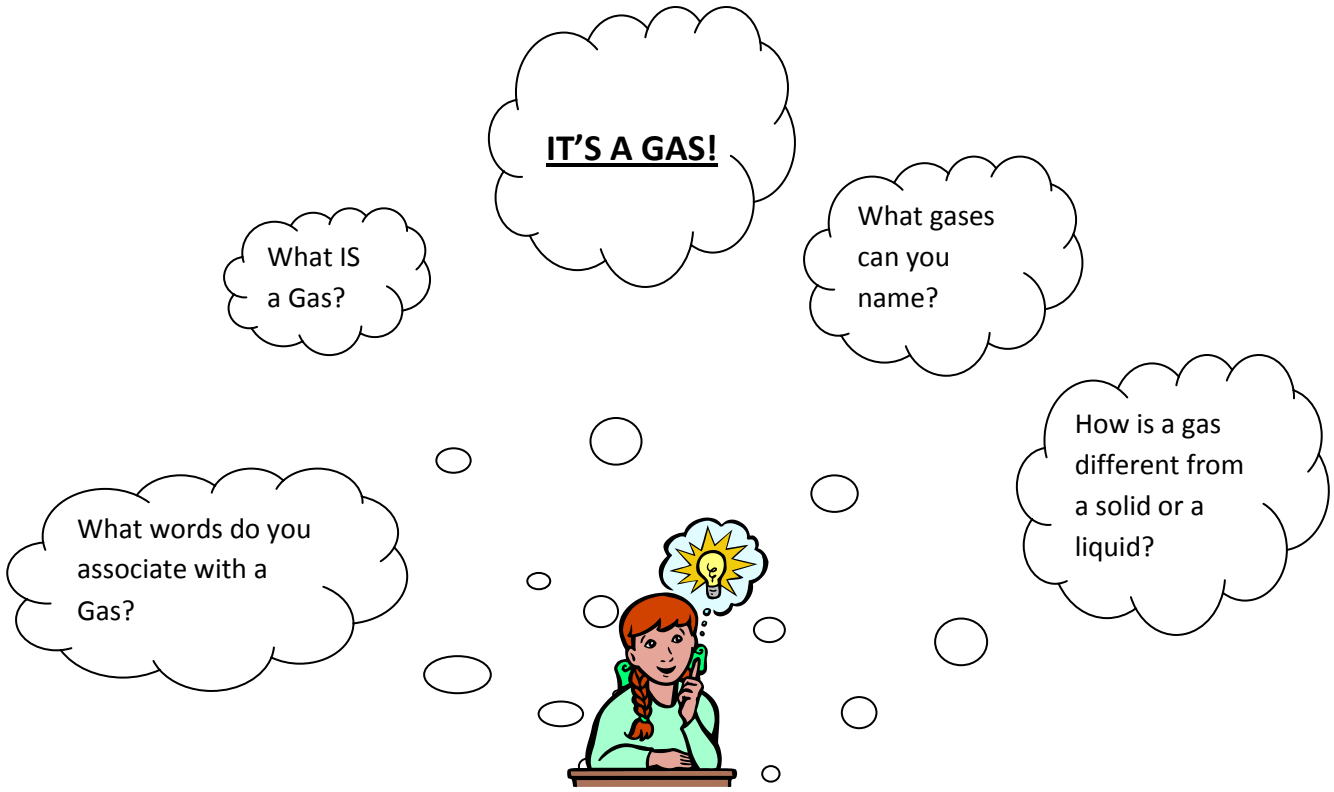
1. Fizzy, fizzy! Let's Get Busy! • Activity 1.1 – It's a Gas • Activity 1.2 –Greenhouse Gases • Activity 1.3 – Making Carbon Dioxide	Experimenting with lemon juice, vinegar + baking soda
2. Cabbage Water Indications • Activity 2 – Measuring Acidity	Making and using red cabbage indicator
3. Collecting a gas you can't see or smell • Activity 3 - Downward Displacement	Modelling the downward displacement of water
4. Burning, Breathing & Baking • Activity 4 – Identifying Carbon Dioxide	Using lime water to identify carbon dioxide as a product of combustion, respiration and in baking
5. Be a Biologist! • Activity 5 – Using Bicarbonate Indicator	Testing with Bicarbonate Indicator - experiment with pond weed, snails and cress seedlings
6. Density Matters • Activity 6 – Density Matters	Investigations using balloons
7. Fizzy versus Still • Activity 7 – Fizzy versus Still	Investigating differences
8. The Greenhouse Effect • Activity 8 – The Greenhouse Effect	Modelling the effect using experiments

Please Note:
Teachers are responsible for carrying out risk assessments.

Teachers' Notes about Carbon Dioxide

- Carbon Dioxide is a colourless and odourless gas. It makes up about 0.4% of the atmosphere. It is produced as a waste product when fuel is used to make energy, in fermentation, and in respiration of animals and employed by plants in the photosynthesis of carbohydrates. (mor later!)
- Do not confuse carbon dioxide (CO_2) with carbon monoxide (CO). Carbon monoxide is a toxic gas.
- Carbon Dioxide gas is produced if you react baking soda with either lemon juice or vinegar. It is also released when tablets such as Alka-Seltzer or Steradent are added to water.
- It is denser than air.
- It dissolves only slightly in water to form a weak acid.

Ten Green Bottles – Fizzy, Fizzy! Let's Get Busy!
Activity 1.1: It's a Gas!
Student Worksheet



Take a few minutes to brainstorm with your group, jotting ideas on a poster page. Compare your poster with other groups and decide what you agree on.

Which gases are in the air around us? How much of each one do we expect to be present normally?

Carry out some research to help you to you fill in the table :

Gas	Percentage in the Air
O _ _ _ _ _	
N _ _ _ _ _ _ _	
C _ _ _ _ _ D_ _ _ _ _ _	
Other Gases	

EXTRA: Can you show this information in a bar chart or pie chart?

Ten Green Bottles - Fizzy, Fizzy! Let's Get Busy!
Activity 1.2: Greenhouse Gases
Student Worksheet

'Carbon Dioxide is a Greenhouse Gas'

What does this mean?
Why is it important? – visit **http://www.clean-air-kids.org.uk/globalwarming.html** for some handy hints

Can you unscramble the names of 5 greenhouse gases:

WAVE OUR TRAP	
HEN MEET	
OOZEN	
I DID CON A BOXER	
IT IS UNDER OXO	

Name 3 things we can expect to change because of global warming:

FIN GRAM	
HE WATER	
ALE VESSEL	

Ten Green Bottles – Fizzy, Fizzy! Let's Get Busy!
Activity 1.3: Making Carbon Dioxide
Student Worksheet

What you will need

- Lemon Juice
- Vinegar
- Water
- Baking Soda
- 4 Small plastic bottles
- 1 pipette
- 1 teaspoon
- Straw / Stirrer
- 1 Green Bottle
- **For Experiment 1.4 you will also need:** Alka-Seltzer or Steradent tablet/film canister or Steradent tube

Remember:

- Wear Safety glasses when handling chemicals!
- Always wash your hands after carrying out chemical tests!
- Never taste chemicals!

Experiment 1

1. Measure out 20ml (or 4 teaspoons) of lemon juice into a plastic cup
2. Add 1/2 teaspoon of baking powder to the juice
3. Note any reaction that takes place
4. In another cup, repeat the experiment using vinegar instead of lemon juice.
5. Note any reaction that takes place
6. In the third cup, repeat the experiment using water instead of vinegar
7. Note any reaction that takes place

Substance	Reaction with Baking Soda
Lemon Juice	
Vinegar	
Water	

QUESTIONS

1. Which mixtures gave the strongest reactions?	
2. What type of substance was produced	
3. Which substance did not react with the baking soda?	

Experiment 2 – Comparing Baking Soda Powder and Solution

1. Put 3 teaspoons of baking soda into 30ml water to make a solution.

2. Repeat **experiment 1** but this time add 10ml baking powder solution to each liquid.

3. Note any reactions that occur.

Substance	**Reaction with Baking Soda Solution**
Lemon Juice	
Vinegar	
Water	

Were the results the same as in Experiment 1?

_____

_____

Experiment 3 – Measuring the volume of bubbles produced

1. Decide which liquid you think gave the strongest reaction in experiment 2.

2. Using it, repeat **experiment 1**,in a plastic bottle, using double the quantity of each substance but this time add a squirt of detergent and some food colouring to the mixture.

3. Measure the height of the column of 'fizz' produced.

4. Compare the result if you repeat the experiment with different strengths of baking soda solution.

Strength of baking soda solution	Height of bubble column (cm)
1 tsp per 20ml	
2 tsp per 20ml	
3 tsp per 20ml	

Conclusion: The stronger the baking powder solution the _____ the amount of gas produced.

Extras:

- Your bottle can be adapted to collect the gas which is being produced, if you carefully make a hole in the bottle top just big enough to fit a bendy straw through. This will be useful for Activity 3 (Downward Displacement).
- Your bottle can be adapted to be a fun toy if you replace the top with a cork which will be 'fired' when the gas pressure increases inside the bottle. **CARE is required to ensure no-one is hit by the cork and all spills are wiped up straight away!! Safety glasses should be worn.**
- The reaction between lemon juice and baking soda can be used to make natural cleaning products – Check out **http://webecoist.momtastic.com/2013/02/08/12-ways-to-clean-your-home-with-lemon-and-baking-soda/**

Experiment 4 - The Same FIZZ using different experiments

1. Put a ¼ Alka-Seltzer tablet into each of 3 plastic cups, labelled A, B and C
2. Crush the tablet in cup C
3. Add 20ml cold water to cup A
4. Add 20 ml warm water to each of cups B and C
5. Compare the reactions and note your findings below:

Which was stronger, A or B? ___

Why should this be? _____

Which was stronger, B or C? ___

Why should this be? _____

6.(i) Put the last ¼ tablet in the film canister and add 20ml warm water. **REMEMBER TO WEAR SAFETY GLASSES!**
(ii) Quickly replace the lid firmly.
(iii) Place the canister, lid side down, on the floor in an open space, **stand well back** and wait ……

The gas being produced by the reaction will build up inside the canister until the pressure is great enough to force open the lid.

Describe what happens next

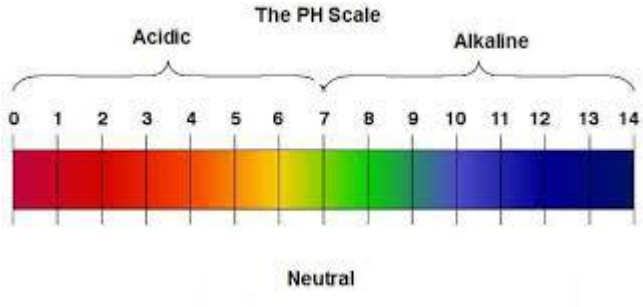
_____

_____

Safety Note: remember to wipe up the spills!!

Measuring Acidity – Teachers' Notes

Acidity is normally measured using pH paper or universal indicator. The pH scale ranges from 1 to 14, where pH1 is a strong acid, pH 14 is a strong alkali, and pH 7 is neutral



For background information, visit BBC Bitesize website:
http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_pre_2011/chemical_synthesis/acidsalkalisrev2.shtml

Acids can be identified using an INDICATOR which changes colour depending on the acidity of the substance being tested.

A simple indicator can be made using the leaves of red cabbage, as described on BBC Bang Goes the Theory website:
http://www.bbc.co.uk/bang/handson/acid_cabbage.shtml

Lemon Juice and Vinegar are both acidic so should give a pink colour with cabbage water indicator, The Baking Soda solution is alkaline so should give a blue/green colour. Mixing them in suitable proportions will result in a neutral solution and therefore a purple colour.

Ten Green Bottles – Cabbage Water Indications
Activity 2: Measuring Acidity
Student Worksheet

Making and Using Red Cabbage Indicator

You will need:

Red cabbage, knife and chopping board, bowl or large heat proof beaker, hot water, water bottle or jam jar to store the indicator, wooden spoon or potato masher

Example of samples to test:

Laundry detergent, fizzy drinks, indigestion tablets, vinegar, lemon juice, baking soda

A. How to make the Cabbage Water Indicator

1. Chop around six leaves of red cabbage to provide around 2 cups of shredded cabbage leaves.

2. Place the cabbage leaves into the heat proof beaker and cover with very hot water. Steep for at least 10 minutes to let the colour leach from the leaves and then strain the red/purple juice into a jam jar.

4. Leave the red cabbage juice to cool before using as an indicator

B. How to use the Cabbage Water Indicator

1. Pour a small amount of red cabbage juice into a series of disposable cups. Keep one as a control cup to compare the original colour with any colour change taking place as you add the test samples.

2. Add a test sample to each of the red cabbage juice indicator cups and record any colour change.

The BBC Bang Goes the Theory website - **http://www.bbc.co.uk/bang/handson/acid_cabbage.shtml** - has an excellent video explaining the science behind the colour change. Use this website to help you fill in the table:

Substance	Indicator Colour	Acidity

Repeat the strongest reaction you found in **Activity 1c** but this time add a few drops of cabbage water indicator to the chemicals before you start.

Note any changes in indicator colour before and after the reaction.

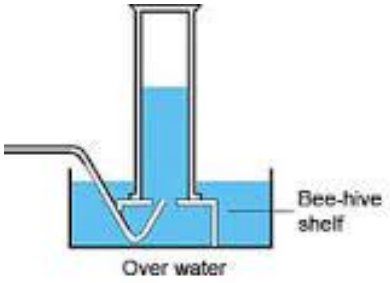
Suggest what is happening :

When the acid _____ is mixed with the alkali _____ a chemical reaction takes

place, leaving a _____ substance at the end of the reaction.

Downward Displacement – Teachers' Notes

By bubbling the gas you wish to collect through water which is then forced out of its container by the gas, you can monitor the volume of gas you have collected. The bottle to be used to collect the carbon dioxide must initially be full of water and inverted in a reservoir of water. The carbon dioxide can then be fed in through a tube inserted at the mouth of the bottle. As the bubbles flow to the top they will displace water from the bottle. The process is better if a Beehive shelf is used to improve the positioning of the supply tube.



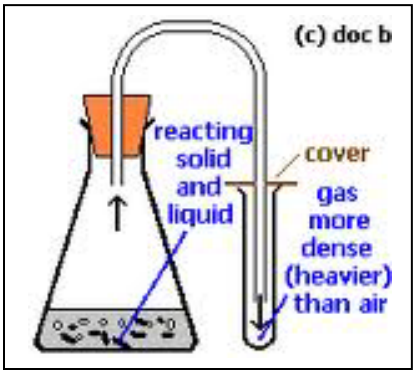
If the children are shown how this is normally done in a lab they can be challenged to design their own system using items such as plastic bottles, margarine tubs and bendy straws.

More information on collecting gases can be found on the BBC Bitesize Website:
http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/chemicalreactions/preparinggasesrev1.shtml

Ten Green Bottles – Collecting a Gas you can't see or smell
Activity 3: Downward Displacement
Student Worksheet

Modelling the Downward Displacement of Water

The carbon dioxide gas produced when you react lemon juice or vinegar with baking soda is colourless and has no smell. It is denser than air and so if it is piped into an 'empty' container it will naturally fall to the bottom and gradually fill it up.



BUT you can't tell when the container is full of carbon dioxide and all the air has been pushed out or **displaced….**

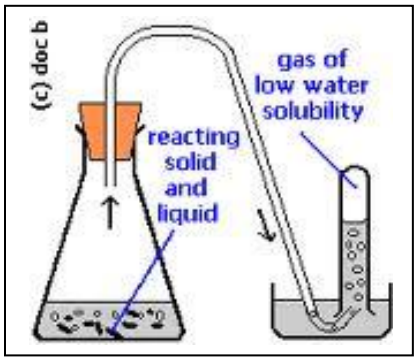
It would be better to start with a container full of water and make the gas displace it.

BUT the bubbles naturally rise through the liquid and escape from the top!

It would be better if the water container was upside down

BUT the water would fall out of the bottle!

It would be better if the bottle was sitting in a tub of water



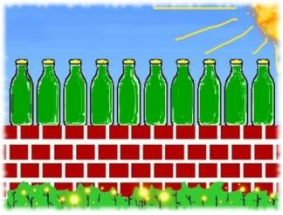
BUT the tube supplying the gas would get squashed by the mouth of the bottle…

It would be better to use a **BEEHIVE SHELF**

Visit **http://en.wikipedia.org/wiki/Beehive_shelf** for more information

This method of collecting a gas is called the **Downward Displacement of Water**

Your challenge is to design a simple kit to use to collect your carbon dioxide by this method using simple recycled materials such as margarine tubs, plastic bottles and drinking straws



Ten Green Bottles – Burning, Breathing & Baking
Activity 4: Identifying Carbon Dioxide
Teachers' Notes

Identifying Carbon Dioxide – Teachers' Notes

Carbon Dioxide can be identified using either of two chemical tests:

(i) Using Lime Water Solution
(ii) Using Bicarbonate Indicator Solution

Lime water is normally colourless but will turn 'cloudy' or 'milky' if carbon dioxide is bubbled through it or if it is added to carbon dioxide gas. We can therefore carry out simple tests to show carbon dioxide being produced by several different processes.

1. In the reaction between lemon juice or vinegar and baking soda or between water and Alka-Seltzer (or Steradent) tablets
2. As a product of respiration (exhaled air contains more carbon dioxide that inhaled air)
3. As a product of combustion (eg when a candle or taper burns, it produces carbon dioxide)
4. As a product in baking reactions (eg experiments with yeast, - check out Science Bob **http://www.sciencebob.com/experiments/yeast.php**)

Lime water can be purchased from suppliers such as SciChem or Timstar but as it has a short shelf life it may be better to request some from secondary school chemistry departments. Alternatively, it can be "home made" as follows.

Making Limewater

Limewater is used in many science experiments and is easy to make on your own.

Put 1 teaspoon of **calcium hydroxide** in a clean glass jar, up to 1 gallon in size. (Limewater is a saturated solution, which means there will be some extra chemical that doesn't dissolve. A teaspoon will result in a fully saturated solution whether you use a gallon jar or a smaller one.) Fill the jar with distilled or tap water. Shake the jar vigorously for 1-2 minutes, then let it stand for 24 hours. Being careful not to stir up the sediment, pour the clearer solution off the top of the jar through a clean coffee filter or **filter paper**. Repeat the filtering step if necessary to obtain a clear limewater solution. Store in a clean jar or bottle.

Ten Green Bottles – Burning, Breathing & Baking
Activity 4: Identifying Carbon Dioxide
Student Worksheet

Identifying Carbon Dioxide

If you have a colourless gas with no smell, how can you tell what it is?

There are two chemical tests you can use to identify carbon dioxide:

1. Carbon Dioxide will turn **Lime Water** milky
2. Carbon Dioxide causes **Bicarbonate Indicator** to change from a red liquid to a yellow one.

Testing using Lime Water – the chemical, NOT Lime Juice

TAKE CARE during experiments! Wear Safety Glasses!

Experiment 1

1. Bubble the gas produced when lemon juice or vinegar react with baking soda into a plastic cup containing LIME WATER.
2. Observe the change in colour. If the gas is carbon dioxide the lime water will become cloudy, or milky.

Complete the sentence:

When lemon juice or vinegar react with baking soda, _____ _____ gas is produced.

Experiment 2

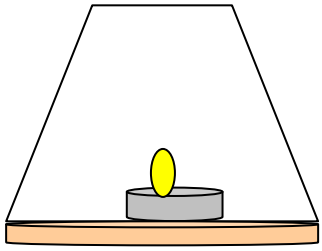
1. Take a fresh sample of lime water and gently breathe **out** through a straw so that the exhaled air passes through the lime water.
   Take CARE! Do NOT drink the lime water!
2. Count how many breaths it takes to turn the lime water milky.
3. Repeat steps 3 and 4 but this time do some exercise before you breathe out through the straw.

Complete the sentence:

The air we breathe out (exhale) contains _____ _____. The air we breathe out after exercise contains **more / less** carbon dioxide than when we are resting.

Experiment 3: Carbon Dioxide produced in burning

1. Carefully set a candle or nightlight on the lid of a jam jar.
2. Use an upturned jam jar to cover the lit candle or nightlight placed on the lid.
3. When the flame goes out, allow the jar to cool before turning it over. Any carbon dioxide formed during the burning should stay in the jar when you remove the lid sufficiently to add a few ml of lime water, (carefully avoiding the candle!)



Note your results:

The lime water **did/ did not** turn milky.

The burning candle **produced / did not produce** carbon dioxide

Experiment 4: Carbon Dioxide produced in bread making

Part 1: The reaction of yeast and sugar

What you need

A packet of yeast (available in the grocery store)
A small, clean, clear, plastic soda bottle (16 oz. or smaller)
1 teaspoon of sugar
Some warm water
A small balloon

What you have to do

1. Fill the bottle up with about one inch of warm water.
   (When yeast is cold or dry the micro-organisms are resting.)
2. Add the entire yeast packet and gently swirl the bottle a few seconds.
   (As the yeast dissolves, it becomes active - it comes to life! Don't bother looking for movement; yeast is a microscopic fungus organism.)
3. Add the sugar and swirl it around some more.
   (Like people, yeast needs energy (food) to be active, so we will give it sugar. Now the yeast is "eating!")
4. Blow up the balloon a few times to stretch it out then place the neck of the balloon over the neck of the bottle.
5. Let the bottle sit in a warm place for about 20 minutes - If all goes well the balloon will begin to inflate!
6. Carefully remove the balloon and release the gas into a cup of lime water.

Note your results:

The lime water **did/ did not** turn milky.

The yeast and sugar reaction **produced / did not produce** Carbon Dioxide

Part 2: To compare the amount of carbon dioxide produced using varying amounts of basic bread making ingredients

What you need

Disposable cups
dried yeast
sugar, plain or bread flour
warm water
spatula
timer
small soda bottle
balloons

What you have to do

1. Half fill five cups with warm (not hot) water and prepare as follows:

Cup 1: 1 teaspoon flour + 1 teaspoon sugar + 0 teaspoon yeast
Cup 2: half a teaspoon yeast only
Cup 3: half a teaspoon yeast + 1 teaspoon sugar
Cup 4: half a teaspoon yeast + 1 teaspoon flour
Cup 5: half a teaspoon yeast + 1 teaspoon flour + 1 teaspoon sugar

2. Label the paper cups with the names of solutions.
3. Mix ingredients well and over a period of 30 minutes note what is happening in each of the cups.

Results

Cup	Observations **0 mins**	Observations **15 mins**	Observations **30 mins**
1			
2			
3			
4			
5			

Which cup produced the most carbon dioxide?

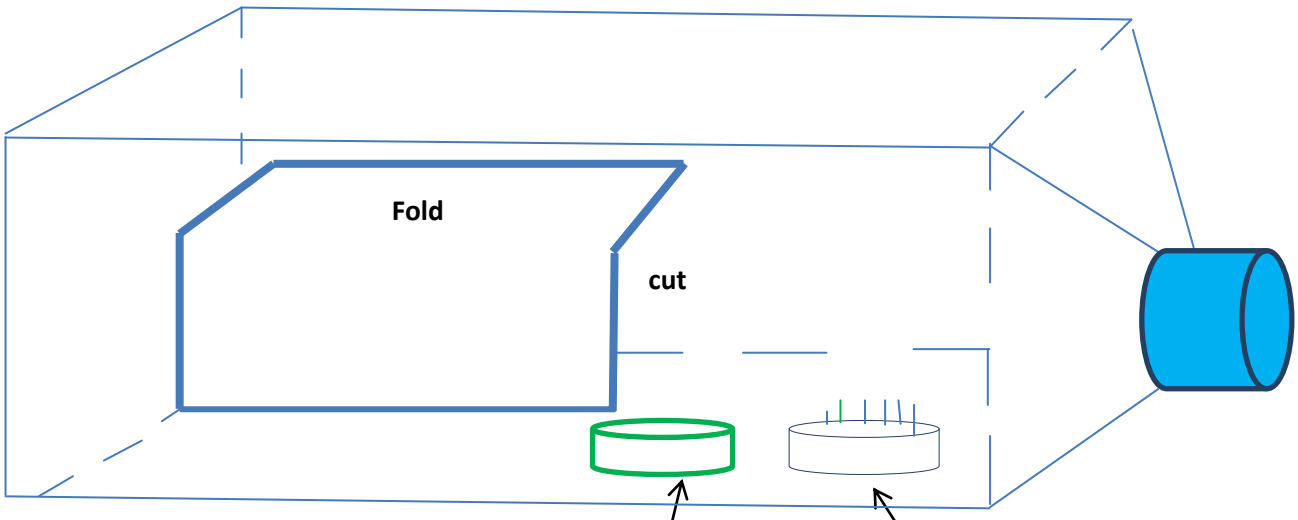
Using Bicarbonate Indicator – Teachers' Notes

Bicarbonate Indicator solution is normally a light red colour (cf Rose wine!) but it will change to yellow (cf white wine!) if Carbon Dioxide is present and will become a deeper red (cf red wine!) if oxygen is present. Pond weed will survive in Bicarbonate Indicator and so can be used to investigate the exchange of gases in plants. (eg in **Photosynthesis** Carbon Dioxide is used up in the presence of sunlight and oxygen is produced, whereas in **Respiration**, which living things (plants and animals) do all the time, oxygen is used up and carbon dioxide is produced.)

Bicarbonate Indicator is often used for biology experiments and so may be available from your local secondary school, but can be purchased from suppliers such as SciChem or Timstar.

http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway_pre_2011/environment/1_food_factory1.shtml contains further information on photosynthesis and respiration.

Model Greenhouse Diagram



Cut a flap as shown to put the contents in the bottle then seal with clear tape.

Bicarbonate Indicator

Seedlings on wet cotton wool or blotting paper

Ten Green Bottles – Be a Biologist!!
Activity 5: Testing with Bicarbonate Indicator
Student Worksheet

Testing with Bicarbonate Indicator

Bicarbonate indicator is often used by Biologists to test for the presence of Carbon Dioxide gas in their experiments.

What you need

Step 1
A container (test tube or small bottle)of Carbon Dioxide
Bicarbonate Indicator Solution
Pipette

Step 2
The lemon juice or vinegar reaction with baking soda
Bicarbonate Indicator Solution
Plastic cup

What you have to do

1. Carefully pipette some Bicarbonate Indicator solution to the bottle of gas and swirl it around gently. Note any colour change that takes place.
2. Pour some of the indicator solution into the plastic cup. Bubble the gas from the lemon juice or vinegar reaction through a straw into the Bicarbonate Indicator and note any colour change that takes place.

Results:

The Bicarbonate Indicator changes colour from _____ to _____

Bicarbonate indicator also changes colour if the carbon dioxide level is reduced – if oxygen levels are increased the red colour will darken to become more purple. This allows us to monitor the exchange of gases going on in plants and animals.

Investigations using Bicarbonate Indicator

1. **Using Cress or Mustard Seedlings**

What you need:

1 large plastic bottle (2l plus)
2 small containers or bottle tops
cress seedlings/ mustard seedlings
cotton wool

bicarbonate indicator solution
CO_2 supply

What you need to do

1. Use a large plastic bottle to make a mini greenhouse.
2. Plant cress or mustard seeds in moist cotton wool on a bottle top. Once the seeds have germinated place them in the greenhouse beside another bottle top containing Bicarbonate Indicator solution.
3. Leave the greenhouse in a sunny position such as on a windowsill for an hour and note the colour of the indicator
4. Repeat the experiment but this time place the greenhouse away from the light, eg in a cupboard.

Lighting Conditions	Colour at Start	Colour at finish

Conclusion

In the light: _____

In the dark: _____

EXTRA

Using a soda stream or reacting lemon juice or vinegar with baking soda, add extra carbon dioxide to the greenhouse and investigate whether or not it affects the growing seedlings.

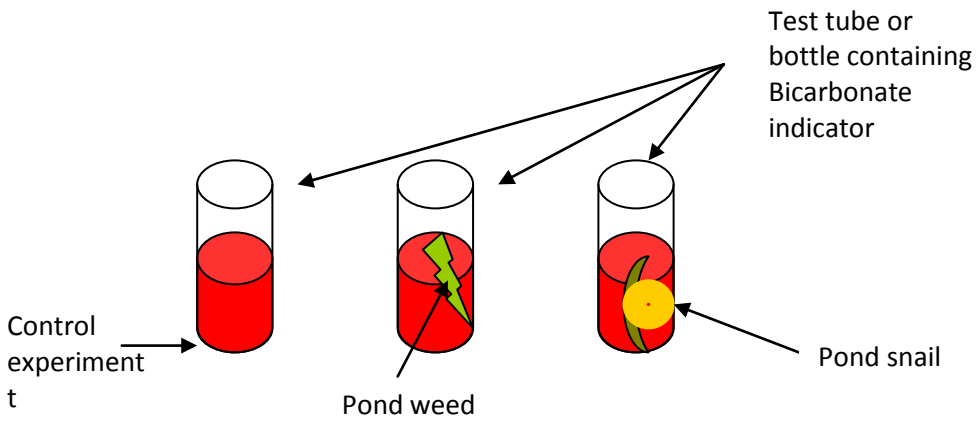
2. Carbon Dioxide production by plants and animals

What you need

3 test tubes, small plastic bottles or jam jars with stoppers or lids
Bicarbonate Indicator solution
Small pieces of pond weed
1 pond snail
Tin foil
Safety glasses

What you have to do

1. Fill the containers with Bicarbonate Indicator.
2. Place a strand of pond weed into one, a snail into one and nothing in the third.
3. Stopper the test tubes (or replace the lids) and place them in the light.
4. Note any colour change in the indicator after 30 minutes.
5. Repeat the experiment but this time cover each container with tin foil to cut out the light



Results

	Colour		
Conditions	Pond Weed	Snail	Control
In the Light			
In the Dark			

Conclusions

Which set up showed carbon dioxide was being produced?	
Which set up showed carbon dioxide was being used up?	
What was the point of the control experiment?	

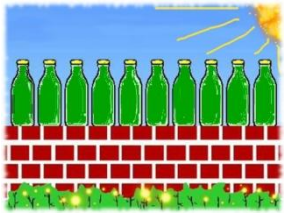
All living things – plants and animals – are carrying out **RESPIRARTION** all the time. In this process food and oxygen are reacting together to provide energy, but carbon dioxide and water are produced as waste products which have to be removed.

Green plants are able to use carbon dioxide and sunlight to make starch using a process called **PHOTSYNTHESIS**. In this case oxygen is released

Do you think your experiments demonstrated either Respiration or Photosynthesis? _____

Explain how you could tell: _____

_____



Density Matters – Teachers' Notes

Materials float upwards if they are less dense than their surroundings and sink if they are denser, so balloons of equal volume but different densities will behave differently. Helium is less dense than air and so will float upwards whereas carbon dioxide is denser than air and therefore sinks.

Carbon dioxide can act as a fire extinguisher as it 'falls' around the flame, starving it of the oxygen necessary for it to continue burning.

Exhaled air contains more carbon dioxide that inhaled air so there could be a slight difference between a balloon inflated using a pump and one 'blown' up by a person.

If balloons of equal volume containing different gases are compared over a few days (e.g. pinned to the wall) they will gradually deflate as the gas molecules diffuse through the balloon membrane. Helium has the smallest molecules and so that balloon will deflate fastest. Carbon dioxide molecules are the largest and so its balloon should deflate at the slowest rate (providing it does not react with the balloon itself!)

Carbon Dioxide can act as a fire extinguisher as it 'falls' around the flame, starving it of the oxygen necessary for it to continue burning.

BBC Bang Goes the Theory website (**http://www.bbc.co.uk/programmes/p007qw5b**) contains a short video on creating your own carbon dioxide fire extinguisher.

Density Matters

A forest with lots of trees closely packed together is said to be DENSE.

A country with many people living in a small area is said to have a DENSE population

If two objects are exactly the same volume but one is heavier than the other we say that the heavier one is more DENSE

In general, an object will float in another substance if it is LESS DENSE than that substance.

A. Comparing the Density of Different Gases

What you need

4 balloons
balloon pump
helium
carbon dioxide
tape measure
drawing pins

What you have to do

Inflate each balloon to the same size with a different gas

(i) Helium
(ii) Carbon Dioxide
(iii) Air from a pump
(iv) Exhaled air

Hold them all at the same height and release them at the same time. Observe their motion and answer the questions:

Which balloon floated upwards?

Which balloon fell fastest?

Which was faster, fresh air or exhaled air?

Can you explain why?

B. Comparing the particle size of each Gas

What you have to do

Measure the circumference (round the widest part) of each balloon then carefully pin them to the wall. Note the measurements in the table:

Measure them again after a few hours and calculate the change in circumference for each balloon

Gas in the balloon	Original circumference(cm)	Circumference after X hours (cm)	Change in size (cm)
Helium			
Carbon Dioxide			
Fresh Air			
Exhaled Air			

Which balloon deflated the most? _____

Which balloon deflated the least? _____

Why have balloons got smaller? _____

The bigger the size of the gas particles the harder it is for them to "escape" out of the balloon.

What does this experiment suggest about the size of the particles of each gas?

_____

Do your results show there is more or less carbon dioxide in exhaled air?

_____

Making a fire extinguisher

The BBC Bang Goes the Theory web site (**http://www.bbc.co.uk/programmes/p007qw5b**) has a demonstration to show how carbon dioxide can be used as a fire extinguisher.

Your Challenge:

Given the following equipment, can you demonstrate this effect?

Lemon juice or vinegar

Baking Soda

Shallow plastic cup or shot glass

Tea light candle

Wooden block

Use a diagram to help you describe your demonstration:

Fizzy versus Still – Teachers' Notes

Carbon Dioxide is slightly soluble in water and will form a weak acid solution. Pupils can investigate possible differences in the properties of still and carbonated water.

Some things they might consider are:

- Do they boil at the same temperature? If equal volumes are heated at the same rate, which comes to the boil first?
- Do they freeze at the same temperature? If equal volumes are cooled in the freezer, which solidifies first? **OR** Do ice cubes made with carbonated water melt faster than ice cubes made with still water?
- Do the ice cubes made from fizzy water retain bubbles?
- Does a nail rust more readily in carbonated water?
- Do substances like salt or sugar dissolve faster/more in still or carbonated water?
- Does the type of water used affect the development of seedlings such as cress?
- Do pink shells (from the fish tank) bleach more readily in still or carbonated water?
- Does the amount of carbon dioxide you add to a bottle of water affect the pH (change the acidity) of the water?

If you do not have access to a soda stream, rather than preparing water with different concentrations of carbon dioxide, the investigation could compare different brands of bottled water.

Small pressurised carbon dioxide cylinders are used by cyclists to repair their tyres. Such cylinders could provide an alternative supply of CO_2. Please see Supplier List for further details.

Ten Green Bottles – Fizzy versus Still
Activity 7: Fizzy versus Still
Student Worksheet

Fizzy versus Still

Carbon Dioxide is slightly soluble in water and will form a weak acid. (This can be checked out using an indicator- see activity 2)

The fizz in the fizzy water we buy in shops is due to the addition of carbon dioxide gas under pressure. We can do this using a soda stream or small CO_2 cylinder

Investigate! How does fizzy water compare with still water?
It's time to design your own experiments and produce a report of your findings.

What are the differences in properties of Still and Fizzy water?

Some things you might consider are:

- Do they boil at the same temperature? If equal volumes are heated at the same rate, which comes to the boil first?
- Do they freeze at the same temperature? If equal volumes are cooled in the freezer, which solidifies first? OR Do ice cubes made with carbonated water melt faster than ice cubes made with still water?
- Do the ice cubes made from fizzy water retain bubbles?
- Does a nail rust more readily in carbonated water?
- Do substances like salt or sugar dissolve faster/more in still or carbonated water?
- Does the type of water used affect the development of seedlings such as cress?
- Do pink shells (from the fish tank) bleach more readily in still or carbonated water?
- Does the amount of carbon dioxide you add to a bottle of water affect the pH (change the acidity) of the water?

If you don't have access to a soda stream or compressed CO_2, you might compare different brands of fizzy water instead.

EXTRA

Repeat the experiments using salty water with and without carbon dioxide added.

10 Green Bottles – Fizzy versus Still
Activity 7: Fizzy versus Still
Report Sheet

Investigation Report Sheet

Experiment Title:

_____

My Aim

To find out _____

My Hypothesis (Prediction)

_____

_____

How I set it up (use a labelled diagram)

My Method (what you did)

_____

_____

_____

_____

My Results (Measurements or Observations)

?	Fizzy water	Still Water

My Conclusions

_____

_____

My Hypothesis:

(a) Was correct
(b) Was incorrect and should have been: _____

_____

The Greenhouse Effect – Teachers' Notes

Global Warming has attributed to an increase in the amount of gases such as carbon dioxide in the atmosphere. Using a soda stream, mini cylinder or a reaction which produces CO2, pupils can attempt to demonstrate this effect for themselves.

Useful Links

BBC Bang Goes the Theory - http://www.bbc.co.uk/programmes/p00b16d0 – How does the Greenhouse Effect Work?

The Franklin Institute- http://sln.fi.edu/tfi/activity/earth/earth-5.html - The Greenhouse Effect in a Jar

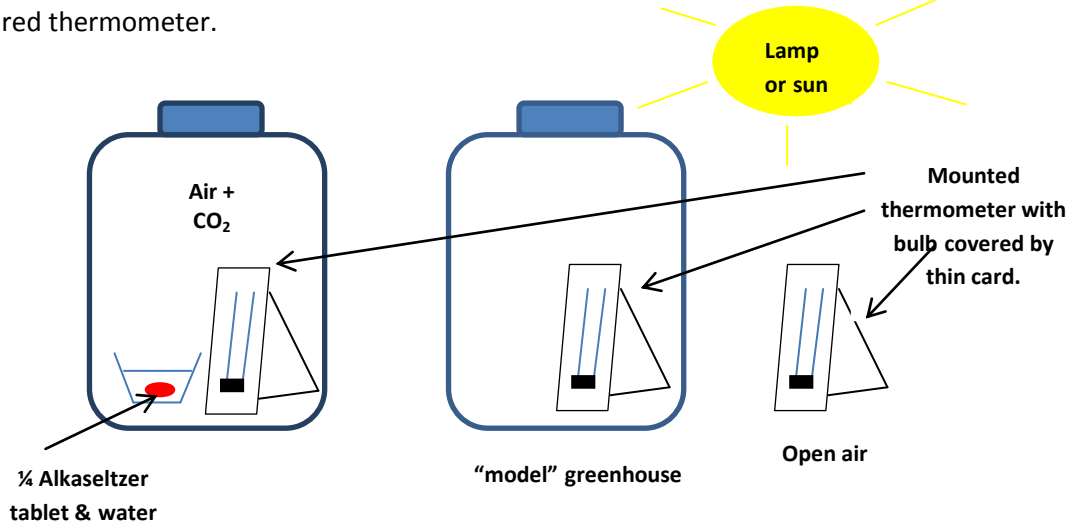
Scientist in Residence - http://www.scientistinresidence.ca/pdf/earth-science/Climate%20Change%20PDF/SRP_Climate%20Change_Lesson%201%20F.pdf - Greenhouse Effect: Pop Bottle Experiment

While it is widely used, there is a body of opinion claiming it to be 'wrong science' giving the right results but for the wrong reasons

http://www.weatherquestions.com/Why_the_greenhouse_effect_in_a_jar_experiment_does_not_work.htm – Why the Greenhouse Effect in a jar experiment does not work

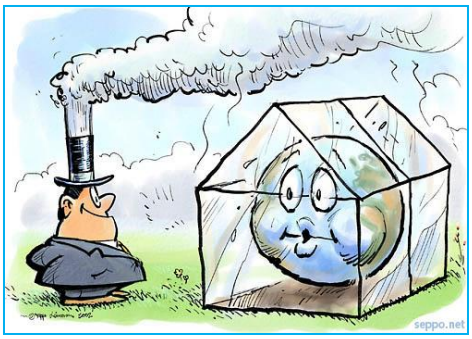
http://www.weatherquestions.com/A_backyard_greenhouse_effect_experiment.htm – A Backyard Greenhouse Effect Experiment

You may wish to debate the validity of such demonstrations. Secondary school physics departments may be able to lend an infrared thermometer.



Ten Green Bottles – The Greenhouse Effect
Activity 8: The Greenhouse Effect
Student Worksheet

Building a Model Experiment



Research Global Warming and Climate Change using websites such as:

Kids 4 Clean Air - **http://www.clean-air-kids.org.uk/globalwarming.html**

EnWin Kids Zone - **http://www.enwin.com/kids/conservation/greenhouse_effect.cfm**

Kids News Room - http://www.kidsnewsroom.org/climatechange/greenhouse.html

What do you understand by the term "Greenhouse Effect"?

_____

_____

Which gases are thought to be mainly responsible?

_____

_____

Increasing the level of carbon dioxide in the atmosphere is thought to cause the temperature to

_____

Your task is to design and build a model experiment using plastic bottles, a reading lamp (or sunshine if you can get it!) and thermometers to try to demonstrate

(i) the air in the bottle warms up faster than the air around it
(ii) adding carbon dioxide to the air in the bottle causes the temperature rise to more rapidly

What you have to do

1. Prepare a plan of your experiments using diagrams to show how you will set them up. Note any safety precautions you think you should take.
2. Have the plans checked by your teacher before you proceed to carry them out.
3. Prepare a poster to explain your model.
4. Demonstrate your experiment to the rest of the club/class.

BUT, you maybe read in the news somewhere…

There are scientists who argue that these demonstrations give the results we want but for the wrong reasons. (For example - the temperature differences happen because carbon dioxide has a greater density than air and so the gas circulation in the bottle will be different. It is suggested instead that by far the **best demonstration of the greenhouse effect** is with a handheld Infra Red thermometer.

The greenhouse effect operates by downward infrared emission from the sky warming the surface, which is exactly what happens inside the thermometer when it is pointed at the sky.

Take measurements using the thermometer pointing at the sky in different directions, in dry and humid conditions and at clouds.

So, what do YOU think?

Ten Green Bottles – Supplier List

List of Suppliers

- Pipettes
  http://www.amazon.co.uk/s/ref=nb_sb_noss?url=search-alias%3Daps&field-keywords=pipettes OR
  http://www.timstar.co.uk/

- CO_2 Inflator
  http://www.amazon.co.uk/s/ref=nb_sb_noss?url=search-alias%3Daps&field-keywords=CO2+Inflator&rh=i%3Aaps%2Ck%3ACO2+Inflator

- Rose Cup Shells
  http://www.hobbycraft.co.uk/hobbycraft-rose-cup-shells/572147-1000

- Thermometer Strips
  http://www.thermometersdirect.co.uk/lcd-liquid-crystal-display-thermometers/prodlist_ct498.htm

- Infrared Thermometers
  http://www.amazon.co.uk/tag/infrared%20thermometer/products

- Chemicals
  http://www.scichem.com/ OR
  http://www.timstar.co.uk/ OR
  ask your friendly secondary science department!

  All other equipment required is readily available from your local supermarket