All quantities are per pupil or per group of pupils working together

1: Crystal Garden

● **Basic level** ● **30 minutes**

Requirements

3-5 mm diameter crystals of the following:
iron(II) sulphate (**harmful**)
copper(II) sulphate (**harmful**)
calcium nitrate
manganese(II) sulphate
iron alum
potash alum
cobalt chloride (**toxic**)
iron(III) chloride (**irritant**)
zinc sulphate
nickel sulphate (**irritant/sensitiser**)

200 cm^3 thick water glass
(a solution of sodium silicate)

glass jar with lid
glass rod
forceps to pick up crystals

Advance preparation

Dilute the thick water glass (density ca 1.5) in the ratio water glass:water 1:3.

Method

See pupils' sheet.

Safety advice

Nickel sulphate and cobalt chloride solids may cause sensitisation by skin contact. If the pupils cannot reasonably be trusted to use forceps the teacher should demonstrate these two.

The pupils must wash their hands after this activity.

Chemical background

When a crystal of, say, copper sulphate is placed in a solution of sodium silicate it dissolves to form a concentrated solution around the crystal. This solution reacts with the sodium silicate to form a hard shell of copper silicate, which surrounds the crystal. The shell acts as a semi-permeable membrane separating the concentrated solution within from the more dilute solution outside. Water passes into the shell until osmotic pressure causes it to burst. Once it escapes the copper sulphate solution reacts with the silicate to form a new shell a little farther from the original crystal. The process continues with repeated breaking and forming until the crystalline shoot reaches the surface.

Extension

After a day the sodium silicate solution can be siphoned off using a syringe and replaced with water. The metal silicates do not dissolve so the garden should last until the structures break (when the jar is moved or knocked).

eye protection must be worn

TOXIC
cobalt chloride

HARMFUL
iron(II) sulphate
copper(II) sulphate

IRRITANT
iron(III) chloride
nickel sulphate

forceps to pick up crystals

HIGHLY FLAMMABLE
ethanol in food colouring

eye protection must be worn

VERY HOT
sugar

do not eat anything in the laboratory

2: Fake Stained Glass

● **Basic level** ● **30 minutes**

Requirements

100 g granulated sugar
25 g powdered glucose
40 cm^3 tap water
solid food colouring (purchased at shops specialising in the decoration and icing of cakes)
small quantity (a few drops) ethanol (**highly flammable**)
100 cm^3 measuring cylinder
balance
test tube
baking sheet or shallow metal tray, or tray covered with kitchen foil
petroleum jelly (Vaseline) or vegetable oil (to grease baking sheet/foil covered tray)
small saucepan
metal spoon
glass stirring rod
Bunsen burner
tripod and gauze
thermometer (reading up to 200°C)
2 x heat proof mats
250 cm^3 beaker containing tap water

eye protection

Advance preparation

Use a spatula to place a small quantity (< 0.1 g) of solid food colouring in a test tube. Dissolve in a few drops (< 1 cm^3) ethanol.

Method

See pupils' sheet.

The sheets should be as transparent as glass, so do not overdo the colouring.

Sugar solids are very hygroscopic. The glass will keep well in a dessicator.

Thin strips of Plasticine can be used to make shapes to pour the hot mixture into. The Plasticine can then be removed when the 'glass' has set.

Safety advice

The saucepan and the sugar syrup are HOT. The saucepan should have a suitable handle and care should be taken to avoid burns.

Eye protection should be worn.

Do NOT allow the children to eat the sugar glass if it is prepared in the laboratory. The ethanol used in schools is industrial methylated spirits and should NEVER be eaten.

The activity could be done in a food technology room in which case vodka or gin could be used to dissolve the food colourings. The product would then be edible, but beware of allergies to food colourings.

Chemical background

Glucose, $C_6H_{12}O_6$, is the simplest of the sugars. Sucrose, of which granulated and caster sugar are crystalline forms, has molecules made up of two glucose-like units linked together. When it is sufficiently concentrated (as indicated by the boiling point) the syrup will solidify on cooling to form a transparent glass. The solid is a glass because the sucrose and glucose molecules are not stacked in the regular repeating pattern of a crystal. In effect rapid cooling has 'frozen' the random arrangement of the liquid.

Reference

This activity is based on instructions for making 'poured sugar' in *The Brothers Roux on Patisserie*, Michel and Albert Roux, Little Brown, 1986.

3: Bouncing Custard Balls

eye protection must be worn

● **Basic level** ● **30 minutes**

Requirements

15 cm^3 PVA glue
measuring cylinder
2 spatulas of borax (sodium tetraborate, $Na_2B_4O_7.10H_20$)
2 spatulas custard powder
test tube
test tube rack
100 cm^3 beaker
glass stirring rod
eye protection

Method

See pupils' sheet.

Pupils may need to adjust the quantities of custard powder and borax, as PVA glues vary in consistency.

Wash hands after handling the custard ball; wash the beakers as soon as possible after use.

Safety advice

Eye protection must be worn.

Chemical background

The glue is a polymer called polyvinyl acetate. The custard powder contains mostly starch which is a polymer made up from glucose. The borax acts as a cross-linking agent and binds the two polymer chains together. Too much borax gives too many cross links and hence a brittle substance.

Extension

To make different coloured balls, use cornflour and a tiny amount of food colouring instead of custard powder.

Reference

A variation on this activity using talcum powder instead of custard powder to make 'GakiStuf' can be found in *Chemistry Review*, September 1999.

4: A Gas Cannon

eye protection must be worn

● **Basic level** ● **30 minutes**

N.B. This activity demonstrates in a different way the same reaction as 5: King Kong's Hand.

Requirements

6 g sodium hydrogencarbonate (bicarbonate of soda)
10 cm^3 vinegar or 5% ethanoic acid (0.7 mol dm^{-3})
plastic bottle (e.g. a small Coke bottle)
cork*
petroleum jelly (Vaseline)
spatula
25 cm^3 measuring cylinder
eye protection

*The quality of the cork is crucial because so many have fissures down the sides which let all the gas escape. It is well worth a trip to the local homemade wine shop to pick some. It's not as much fun as emptying bottles of wine while trying not to drill a hole right through the cork, but much cheaper!

Method

See pupils' sheet.

Safety advice

Make sure pupils have a large empty space in front of them **before** they add the vinegar to their bottle. Emphasise they must aim the cork away from the windows, themselves and other people.

Chemical background

The cork 'cannon ball' is propelled by the expansion of carbon dioxide gas, produced by the reaction between sodium hydrogencarbonate and ethanoic acid.

eye protection must be worn

5: King Kong's Hand

● Basic level ● 30 minutes

N.B. This activity demonstrates in a different way the same reaction as 4: A Gas Cannon

Requirements

50 cm^3 colourless vinegar
10 g sodium hydrogencarbonate, $NaHCO_3$
50 cm^3 measuring cylinder
150 cm^3 beaker
disposable latex glove
permanent felt tip pen in black or brown

funnel

eye protection

Method

See pupils' sheet.

Pupils must hold the glove closed to prevent the now fizzing and foaming mixture from spilling out. If the pupils keep the glove tightly sealed, the gas will be trapped and the glove will inflate. Eventually the reaction slows down, the gas begins to escape and the glove returns to its normal size.

Safety advice

Eye protection should be worn.

Pupils must be carefully supervised to prevent inappropriate behaviour, e.g. squirting at each other. Although the chemicals are relatively low hazard, vinegar in the eyes might necessitate a trip to hospital.

Chemical background

This is an exothermic reaction - pupils should notice a change in the temperature of the 'hand'.

sodium hydrogencarbonate + ethanoic acid → sodium ethanoate + carbonic acid
↓
decomposes → carbon dioxide + water

IRRITANT citric acid **eye protection must be worn**

6: Bath Bombs

● Basic level ● 30 minutes or less

Requirements

20 g bicarbonate of soda (sodium hydrogencarbonate)
10 g citric acid (**irritant**)
sunflower oil (a few drops per pupil)
2 x 250 cm^3 beakers
glass stirrer

dropper
cling film
large bowl of water

eye protection

Method

See pupils' sheet.

Safety advice

Eye protection must be worn.

Chemical background

Citric acid is a solid carboxylic acid. Although its structure is a little more complicated than that of the more familiar hydrochloric acid, in aqueous solution its reaction with hydrogencarbonates is similar in that it forms salts and, at the same time, produces carbon dioxide gas. Bath bombs are made by mixing citric acid crystals and sodium hydrogencarbonate without any water being present (the oil helps the mixture to stick together). When the mixture is dropped into water the chemicals dissolve in the water and their solutions react with each other. The products are water, a soluble salt and carbon dioxide gas. The 'fizz' is the carbon dioxide gas escaping. The reaction is endothermic - takes in heat.

Extension

Recipes are readily available on the Internet to make 'bath bombs'. The recipes usually use almond oil (or similar) instead of sunflower oil, and also add borax, colourings and fragrances and sometimes petals or lavender.

Instead of a ball shape, try using cling-film lined containers (e.g. small coffee jar lids) as moulds, or making bath cubes in an old ice cube tray.

7: Custard Behaving Strangely

● **Basic level** ● **20 minutes**

food (custard) must not be eaten in the laboratory

Requirements

300 g custard powder
400 cm^3 glass beaker (squat form)
250 cm^3 measuring cylinder
glass rod (or spoon)

Method

See pupils' sheet.

As an alternative to custard powder, use cornflour and a few drops of food colouring.

Safety advice

Pupils must not eat the custard suspension.

Chemical background

Custard powder and water are mixed to form a colloidal suspension. When pushed, it feels hard like a solid; when poured it flows like a liquid. It is a non-Newtonian fluid.

Reference

'Outrageous Ooze' from *Enlivening Chemistry*, produced by Department of Chemistry and Chemical Engineering, Paisley University.

eye protection must be worn

IRRITANT sodium carbonate

HIGHLY FLAMMABLE phenolphthalein indicator

8: The Blushing Buttonhole

● Basic level ● 30 minutes or less

Requirements

2.6 g sodium carbonate, Na_2CO_3 (**irritant** solid)
2 cm^3 phenolphthalein indicator (**highly flammable**)
a few white flowers
250 cm^3 glass beaker or jam jar
10 cm^3 cylinder or graded dropper
small glass beaker (just large enough to hold one flower head)
plant sprayer
test tube
eye protection

Advance preparation

Dissolve 2.6 g of sodium carbonate in water and dilute to 250 cm^3 to give a concentration of 0.1 mol dm^{-3}.

Method

See pupils' sheet.

Safety advice

Take care with the spray. Everyone should wear eye protection. Empty the spray afterwards.

Chemical background

The sodium carbonate solution will have a pH >11. This should have an instant effect on the phenolphthalein.

Extension

It may be possible to make the magenta pink flower white again by spraying with dilute acid.

eye protection must be worn

9: Fizzy Dancing

● Basic level ● 30 minutes

Requirements

400 cm^3 tall beaker or glass jam jar
70 g sodium hydrogencarbonate
80 cm^3 colourless vinegar or 5% ethanoic acid (0.7 mol dm^{-3})
glass stirring rod
raisins
gooseberries
small bits of dry pasta
eye protection

Method

See pupils' sheet.

Safety advice

Eye protection must be worn.

Chemical background

Bubbles of carbon dioxide attach themselves to the surface of the submerged object. For this to happen the surface needs to be hydrophobic (drops of water placed on the surface do not spread). Gas bubbles also attach themselves more readily if the surface is slightly rough. Once the object carries a number of bubbles its mean density becomes less than that of the water. It then rises to the surface and floats. The bubbles now burst and the carbon dioxide escapes to the atmosphere. The object sinks again.

This activity is more than an entertaining trick. It demonstrates the principle behind *froth flotation*, a method used to concentrate copper ores (see reference). The ore is crushed to a powder in which the grains of copper mineral are separate from other rock fragments. The crushed material is mixed with water. Substances, which bind to the surface of the mineral grains and make them hydrophobic, are added. Air is then blown into the mixture. The valuable copper mineral floats to the surface where it becomes concentrated in a froth. The mineral is scooped off with the froth.

Reference

Chemical Storylines, Salters Advanced Chemistry, Heinemann, 2000.

Alternative approach

It is possible to use soda water or lemonade in place of sodium bicarbonate and vinegar.

10: Disappearing Worms

● Basic level ● 30 minutes + advance preparation

eye protection must be worn

IRRITANT calcium chloride

Requirements

2 g sodium alginate
200 cm³ deionised water
1 g calcium chloride, $CaCl_2$ (**irritant**)
5 cm³ Gaviscon liquid antacid (optional)
sodium chloride, NaCl
3 x 250 cm³ beakers
clean test tube with tight-fitting rubber bung
forceps
food colouring (optional)
eye protection

Advance preparation

Add 2 g of sodium alginate powder to 100 cm³ of deionised water. Stir the suspension vigorously for several minutes or if possible leave to stand overnight.

Method

See pupils' sheet.

Food colouring can be added to give coloured 'worms'.

Safety advice

Eye protection should be worn.

Chemical background

Alginate is a polysaccharide (M_r - 240,000) extracted from seaweed in which it is a structural component of cell walls. Alginate is composed of D-mannuronic acid and L-guluronic acid subunits, linked 1,4. Alginic acid polymers form interchain associations in the presence of di- and trivalent cations, particularly calcium, producing hydrated gels. This ability to gel in the presence of cations is the basis for the widespread use of alginates in industry.

Extension

Organise a competition: who can produce the longest worm?

11: Magic Sand

● Basic level ● 20-30 minutes + advance preparation

Requirements

100 cm^3 oven dried inland sand (with rounded edges)
Scotchguard water-repellent spray
4 x 250 cm^3 beakers
100 cm^3 beaker
glass rod
food colouring
plastic disposable pipette

Advance preparation

Spray half of the oven dry sand with Scotchguard and allow it to dry overnight in a well-ventilated room or fume cupboard.

Method

See pupils' sheet.

Safety advice

Take care not to inhale the Scotchguard spray.

Chemical background

Sand is largely silica (silicon dioxide) that has broken into small grains. At the atomic level, silica consists of a three dimensional network of covalently bonded silicon and oxygen atoms. Typically, silica surfaces contain mostly oxygen atoms, many of which are covalently bonded to hydrogen atoms. The surface contains many polar bonds and can hydrogen bond to water molecules. Therefore water is attracted to silica surfaces, which are said to be hydrophilic (water loving).

Magic sand also consists of silica grains, but the grains have been treated with water repellent organohalsilanes. This greatly reduces the attraction of water molecules to their surfaces.

Extension

Why would magic sand be effective for cleaning up oil spills? What advantage would it have over the use of detergents?

References

Chemistry in the Marketplace, Ben Selinger (4th edition), Harcourt Brace Jovanovich, 1989

CORROSIVE
concentrated hydrochloric acid

IRRITANT
calcium chloride

TOXIC
barium chloride
copper(II) chloride

eye protection must be worn

12: Mystery Metal

● Basic level ● 30 minutes

Requirements

fume cupboard with gentle fan
barium chloride, $BaCl_2$ (**toxic**)
calcium chloride, $CaCl_2$ (**irritant**)
copper chloride, $CuCl_2$ (**toxic**)
potassium chloride, KCl*
sodium chloride, NaCl
cobalt glass, for viewing potassium flame
concentrated hydrochloric acid (11.6 mol dm^{-3}) (**corrosive**)
crucible to contain concentrated hydrochloric acid
5 labelled crucibles, each containing one salt
5 crucibles, labelled A-E, each containing the same salts as 'unknown'
flame test wire (platinum or nichrome wire with cork holder)
eye protection

*In the case of potassium chloride the violet of the flame may be masked by yellow from sodium impurities. Potassium chloride of analytical reagent grade should therefore be used.

To detect potassium it may be helpful to view the flame through cobalt glass.

Advance preparation

Using a small pestle and mortar crush a little of each salt and place in crucibles.

Method

See pupils' sheet.

This activity could be set up as a 'circus', with pupils moving from one station to another. This avoids the need to keep cleaning the flame test wire between each test. Set up ten 'stations', five for each of the known elements and five for unknown elements A to E.

Metal	Flame colour
barium	yellow green
calcium	orange red
copper	greenish blue
potassium	lilac blue
sodium	bright yellow

Safety advice

Concentrated hydrochloric acid has a vapour which irritates and can damage the eyes. Pupils should be closely supervised. This experiment should be carried out in a fume cupboard. Eye protection must be worn, preferably goggles rather than safety spectacles.

Chemical background

Electrons in the metal ions are excited by the heat of the burner flame. They are raised to higher energy levels. On falling back the energy is emitted as visible light. Note that the emission spectrum of magnesium cannot be observed in the visible region.

The colours of fireworks have a similar origin. They are produced by heating either metal atoms or metal compounds. The best emitters are CuCl for blue, SrCl for red, BaCl for green and Na atoms for yellow. BaCl and SrCl only exist at high temperatures.

Extension

The flame colours can be demonstrated by spraying solutions of metal salts in ethanol into a Bunsen flame but this demonstration must be done with **great care**. It is possible to produce spectacular jets of coloured flame. Full details of the procedure are given in *Classic Chemistry Demonstrations*, published by the Royal Society of Chemistry, 1995.

13: Hard Evidence

A: Making plaster of Paris
B: Whose teeth marks are in the apple?

● Basic level ● A 30 minutes; B 15 minutes
Both A and B need to be left for 24 hours to set.

eye protection must be worn | **food must not be eaten in the laboratory**

Requirements

A

10 g gypsum, calcium sulphate ($CaSO_4.2H_2O$)
spatula
boiling tube
Bunsen burner
clamp stand
clamp
key or coin
evaporating basin
piece of cardboard
eye protection

B

plaster of Paris
apple
disposable cup
glass stirring rod
water

eye protection

Method

See pupils' sheet.

A

Water collects inside the test tube when gypsum is heated. Gypsum is a mineral made up of hard lumps, while the plaster of Paris formed is a soft powder.

Safety advice

The pupils must wear eye protection when they are heating the gypsum.

Food must not be eaten in the laboratory because of the risk of contamination. Pupils must not even bite an apple in the laboratory.

Before pupils go to the laboratory someone should bite the apple. Find a place where eating is allowed. The aim is to leave a clear set of teeth marks. This can take a little practice.

Chemical background

When gypsum is heated it loses some water of crystallisation:

$2CaSO_4.2H_2O \rightarrow (CaSO_4)_2.H_2O + 3H_2O$

The reaction is reversed when the product, plaster of Paris, reacts with water to form gypsum again:

$(CaSO_4)_2.H_2O + 3H_2O \rightarrow 2CaSO_4.2H_2O$

Plaster is, of course, very widely used on the walls of buildings. It is also used for setting broken bones.

Extension

It is also possible to make plaster casts of shoe prints and tyre marks. The prints can be made in a tray of soil.

It is important to ensure that the soil is not contaminated.

A mould, made with a strip of cardboard and a paper clip, is placed round the print. Enough plaster of Paris to make the cast is made up. This is poured quickly into the mould and left to set.

When it has set, the cast is carefully lifted off and rinsed under the tap. It can be brushed clean if necessary.

Teethmarks, shoe prints and tyre marks could all form part of a forensic science investigation.

14: Investigating Smarties and M&Ms

● **Basic level** ● **30 minutes**

Requirements

Smarties and M&Ms: two each of the same colour
2 x watch glass
narrow capillary tube
chromatography paper
250 cm^3 beaker or coffee jar

Method

See pupils' sheet.

The main difficulty is getting a solution which gives a strong enough colour. It should be emphasised that 2 or 3 drops of water are enough.

Many of the colourings used in these sweets are the same and the pupils may notice that the sweets are both made by the same manufacturer, which could lead to a comparison of E numbers.

Chemical background

Separation by chromatography depends on the degree to which the various dyes are attracted to the paper and also their differing solubilities in water.

Extension

Investigate coloured sweets made by a different manufacturer, e.g. Skittles.

15: The Secret of the Disposable Nappy

● Basic level ● 30 minutes

eye protection must be worn

IRRITANT
The powder found in the nappy is an irritant. Avoid breathing it or getting it in your eyes. Be sure to wash hands after use.

Requirements

a disposable nappy
large zip-closing plastic bag
paper towel
food colouring
100 cm³ plastic beaker
100 cm³ glass beaker
250 cm³ glass beaker
plastic dropper
25 cm³ measuring cylinder

access to balance

eye protection

Method

See pupils' sheet.

Safety advice

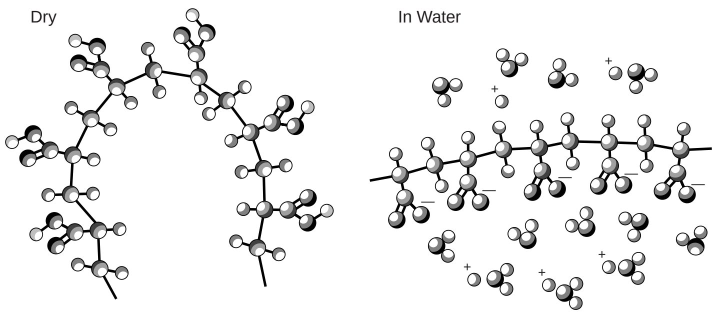
The powder found in the nappy (sodium polyacrylate) will irritate the nasal membranes if inhaled. Avoid eye contact; if it gets into eyes, they will become dry and irritated. Be sure to wash hands after use.

Wear eye protection.

Chemical background

Sodium polyacrylate is a polymer molecule of molecular weight greater than one million. Sodium carboxylate side groups are attached along the backbone of the molecule (see diagram). In water the sodium carboxylate dissociates so that the side groups are left as negatively charged carboxylate ions. The negative charges repel each other and the separated sodium ions attract water molecules. The result is that the polymer unwinds and absorbs water.

Superabsorbers have other uses:
- protecting industrial power cables from leaks
- filtering water out of aviation fuel
- conditioning garden soil to hold water.



Extension

Try adding sodium chloride to the jelly-like substance formed in step 7. It will turn into a watery liquid. The pupils could investigate whether there are other substances which can cause this effect.

The pupils can compare different makes of disposable nappy to see how much water they can hold. The nappy market is highly competitive and the details of the construction of the various brands of nappy are trade secrets.

Reference

'Working Knowledge: Diapers', *Scientific American*, **283**, p76 December 2000.

eye protection must be worn

HOT borax solution

IRRITANT powdered borax

16: Make a Snowflake

● Basic/Intermediate level ● 30 minutes + leave overnight

Requirements

about 40 g disodium tetraborate, $Na_2B_4O_7.10H_2O$ (borax) (**dust is irritant**)
400 cm³ tall glass beaker or jam jar
food colouring (optional)
3 white pipe cleaners (cotton ones work better than synthetic ones)
white string
pencils
scissors
heat proof mat
eye protection

Advance preparation

Dissolve about 40 g disodium tetraborate (borax) in 400 cm³ boiling water to prepare a hot saturated solution.

Method

See pupils' sheet.

Safety advice

Pupils should be warned to take care with the hot solution of borax.

Chemical background

As the saturated borax solution cools, crystals form on the pipe cleaner and string framework.

eye protection must be worn

IRRITANT washing soda

17: Washing Soda Stalactites

● Basic/Intermediate level ● 30 minutes + several days to grow

Requirements

250 g sodium carbonate (washing soda) (**irritant**)
two tall glass jars (about 15 cm tall, holding approx 400 cm³, e.g. large coffee jars)
400 cm³ measuring cylinder or beaker
a dish (cereal bowl, ice-cream tub or similar, to catch drips)
glass stirrer
string and scissors
a kitchen cloth (J cloth or similar)
spatula
warm water (water from a hot tap, or water heated in a kettle - make sure it is not too hot to avoid cracking the jars)
eye protection

Method

See pupils' sheet.

If smaller jars have to be used, they need to be raised so that their tops are 15 cm above the bench, to allow space for the cloth to hang down and the stalactites to grow.

Safety advice

Washing soda is an irritant, wash hands after use. Eye protection must be worn.

Chemical background

The washing soda solution soaks along the kitchen cloth by capillary action, then drips down the string in the centre of the cloth, forming a hard column of soda as the water evaporates.

18: Which Glue is Stronger?

- **Basic/Intermediate level**
- **60 minutes + later testing when dry**

eye protection must be worn

Requirements

125 cm^3 skimmed milk
15 cm^3 colourless vinegar

50 cm^3 measuring cylinder
250 cm^3 glass beaker
Bunsen burner
tripod and gauze
heat proof mat
glass stirring rod
filter funnel
filter paper
2 paper strips, approximately 3 cm x 20 cm
2 weight carriers + masses (several 1 kg and smaller)
retort stand or metal bar
2 pencils
cardboard box or waste-paper basket containing crumpled newspaper to catch falling weights

For 'Roman' glue
1 g sodium hydrogencarbonate

For 'Egyptian' glue
1 cm^3 milk of magnesia

eye protection

Method

See pupils' sheet.

Some of the pupils could make 'Roman' glue and the others 'Egyptian' glue. The testing stage could then be a competition.

Safety advice

Beware of falling weights. Keep feet and toes (and fingers) out of the way.

The milk-based glue is liable to microbial attack. Wash the glue away, with plenty of water, after the experiment.

Chemical background

The acid combined with the heat causes a milk protein called casein to coagulate. The particles of casein clump together. The sodium hydrogencarbonate, or magnesium hydroxide neutralises excess acid. To be effective as an adhesive the casein must bond more strongly to the material to be stuck than to itself. The glue sets because water evaporates from the casein.

Eye protection must be worn.

eye protection must be worn

IRRITANT hydrochloric acid

19: Eggsperiment

- Basic/Intermediate level
- 30 minutes + 30 minutes + 30 minutes + leave for a few hours

Requirements

A
2 egg shells
pestle and mortar
2 cm^3 2 mol dm^{-3} hydrochloric acid
2 cm^3 limewater
spatula
2 boiling tubes
10 cm^3 measuring cylinder
dropper pipette

eye protection

C
dry crushed egg shell
requirements for flame tests
(see 12: Mystery Metal p68)

eye protection

D
whole egg
250 cm^3 glass beaker
150 cm^3 2 mol dm^{-3} hydrochloric acid

eye protection

B
2 clean, dry egg shells
pestle and mortar
50 cm^3 measuring cylinder
50 cm^3 2 mol dm^{-3} hydrochloric acid
side-arm flask
thistle funnel
rubber tubing
gas jar
beehive shelf
trough
beakers
measuring cylinders
gas syringe
clampstand
top pan balance

eye protection

Advance preparation

Wash and dry 2 egg shells, removing the membrane.

Method

See pupils' sheet.

A What are egg shells made of?

When the pupils wash the egg shells they will notice the membrane attached to the inside. They should remove this as far as possible.

They may test the membrane with acid when they will find that it does not react. It is composed of a highly insoluble protein, ovokeratin.

B How much gas?

After trying to collect the gas in the boiling tube experiment (**A**) the pupils could be introduced to further possibilities. These include:

A side-arm flask with a thistle funnel may be used to add the acid with no loss of gas. The gas can be collected over water.

Since CO_2 is soluble some gas will be lost if it is collected over water (unless the water is pre-saturated). The pupils may try using a gas syringe.

It is also possible to measure the mass loss using a balance. 1.00 g of calcium carbonate produces 0.44 g of carbon dioxide.

Safety advice

Take care with the acid.

Chemical background

When the naked egg is produced there is a lot of froth, which is probably due to the protein that binds the calcium carbonate together in the shell.

The hard shell of the egg is permeable. The membrane is semi-permeable, it keeps moisture inside the egg.

Extension

The project could be extended to dyeing eggs, as described in *Salters' Chemistry Club Handbook* volume 1.

20: Paper-making

● **Intermediate level** ● **60 minutes**

Requirements

wooden mold and deckle (see below - one for each group of pupils to share)
3 double sheets newspaper
a magazine picture or a leaf (optional)
powdered laundry starch
a tea towel
a balloon whisk
an electric iron
a large bowl
absorbent paper

Advance preparation

Each group of pupils will need a mold and deckle, as in the diagram on page 39. (You might be able to get your Technology department to help with this.)

To make the mold

1 Cut two pieces of pine (2 cm x 2 cm) to 20 cm lengths.
2 Cut two similar pieces of pine to 12 cm lengths.
3 Fix the frame together with glue and screws and fix with a clamp until the glue is dry.
4 Sand any rough edges.
5 Seal the wood with varnish and leave to dry.

To make the deckle

1 Repeat steps 1-5 above.
2 Cut a screen which is slightly smaller than the outer edges of the frame, place over the frame and staple into place.

Method

See pupils' sheet.

Avoid using too much starch, because this makes the iron messy.

Safety advice

If possible, borrow an electric iron from the Technology department. Any electrical appliances brought in from home must undergo a portable appliance test before being used in school.

Chemical background

Paper is made of cellulose fibres. Laundry starch acts as a filler or sizer. It enables the paper to take ink and be erased. Paper deteriorates with age because it slowly oxidises in the air. Making paper harms the environment by destroying forests and polluting water.

Extension

Try making paper with other fibrous materials (e.g. broccoli spears, cotton rags or grass). You can also make 'papyrus' using the separated layers of a leek, cooked gently in a light starch solution.

eye protection must be worn

IRRITANT sodium hydroxide

hot glass

EXPLOSIVE Tollen's reagent is safe in solution, but must not be stored

CORROSIVE silver nitrate

21: Silvered Glass Balls

● Intermediate level ● 30 minutes

Requirements

Glass blowing

25 cm length of clean soda glass tubing
(5 or 6 mm internal diameter)
One end of each length should be heat-smoothed (see Advance preparation).
Bunsen burner

eye protection

Formation of 'silver mirror'

5 cm^3 of 0.1 mol dm^{-3} silver nitrate
5 drops of 0.4 mol dm^{-3} sodium hydroxide (**irritant**)
a few drops of 1 mol dm^{-3} ammonia
test tube
test tube rack
glucose
small spatula
teat pipette
100 cm^3 deionised water
hot water from a kettle
250 cm^3 glass beaker

Advance preparation

Heat smooth one end of each length of glass tube.

Dissolve 1.7 g of silver nitrate $AgNO_3$ (**corrosive**) in 100 cm^3 of deionised water. This makes a solution of concentration 0.1 mol dm^{-3}.

TOLLEN'S REAGENT SHOULD BE PREPARED IN **SMALL QUANTITIES ONLY.**

TOLLEN'S REAGENT SHOULD **NEVER BE MADE UP IN ADVANCE.**
IT SHOULD **NEVER** BE STORED.

It is suggested that pupils may prepare their own Tollen's reagent, just before forming the silver mirror.

Method for preparing Tollen's reagent

Place 5 cm^3 of 0.1 mol dm^{-3} silver nitrate solution in a test tube. Add 5 drops of 0.4 mol dm^{-3} sodium hydroxide. Shake. Add 1 mol dm^{-3} ammonia drop by drop until the precipitate just redissolves.

DO **NOT** SAVE THE USED SILVER SOLUTION IN A SILVER RESIDUE CONTAINER.
(See safety advice below.)

Method

See pupils' sheet.

The pupils will find the 6 mm tubing easier to blow than the 5 mm tubing.

There is no sensible alternative to using teat pipettes, but the solutions are hazardous so the pupils should be extremely careful.

Safety advice

Wear eye protection for glass blowing and for making the silver mirror.

Tie hair back for glass-blowing.

Siver nitrate will stain hands and clothing. Avoid skin contact.

There are rare reports of incidents where alkaline silver nitrate solution has exploded after standing for some time. To avoid this risk the ammoniacal silver nitrate solution should not be made up in advance of the practical.

Any Tollen's reagent left over should be washed down the sink with plenty of water. The silvered glass balls should be rinsed thoroughly with water and the washings washed down the sink as soon as the silvering is finished.

If pupils want to take their silvered glass balls home, make sure they are transported safely.

Chemical background

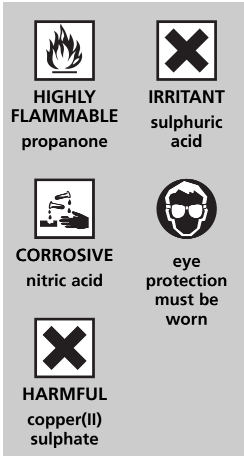
Tollen's reagent contains silver ions complexed with ammonia ($Ag(NH_3)^{2+}(aq)$). These ions are reduced to silver in the presence of aldehydes such as glucose. The silver is produced as a thin layer on the inside surface of the glass ball. This is the traditional method by which mirrors are silvered.

Extension

Small glass objects may be plated by hanging them on threads and then suspending them in the silver-plating solution. They must be very clean.

22: Electroplating a Design

● Intermediate level ● 30 minutes



Requirements

Per pupil

Brass key ring fob/dog tag (cost approx 20p each)
6 cm (approx) brass wire
tissue

eye protection

Teacher

dilute nitric acid (**corrosive**)
Brasso (check the label for hazard warning)
soft cloth

Per group of pupils

low voltage dc supply, 6V
2 connecting wires: 4 mm plug at one end and a crocodile clip at the other
0.9 mm thick scrap copper, minimum size 10 cm x 5 cm (you might be able to get this from the Technology department)
250 cm^3 beaker (for plating bath)
electrolyte of sulphuric acid and copper sulphate (125 g of copper(II) sulphate (**harmful**) dissolved in 500 cm^3 of 1 mol/litre sulphuric acid (**irritant**) - about 250 cm^3 per group)
propanone residue bottle, labelled 'propanone residue' and 'highly flammable'
pieces of cloth or cotton wool for drying and buffing
permanent ink felt-tip pens
propanone (**highly flammable**) (about 100 cm^3 per group)
paint brush

Advance preparation

Clean the brass discs beforehand: dip in dilute nitric acid (**corrosive**), wash under a tap and dry with a cloth, clean with Brasso and buff with a soft cloth.

Electroplating bath

Set up the current for electroplating using a piece of scrap copper (it need not be clean) as the anode (positive electrode). **Do not switch on the power pack**. Make sure it is set for 4 volts. The plastic coated wire plugged into the black (negative) terminal of the power pack should have a crocodile clip on the other end of the wire. This will hold the brass discs on the wire.

Method

See pupils' sheet.

Safety advice

Propanone is highly flammable and an irritant to the eyes. Ensure that the stock and residue bottles are kept closed and that students do not expose themselves to the vapours when rinsing the electroplated brass.

Chemical background

The propanone is used to help make sure the surface being coated or plated with copper is scrupulously clean, as it will not plate properly if the surface is dirty. The copper is used as an anode and is purified during the electrolysis process and plated onto the object at the cathode as pure copper metal.

Reference

This practical is based on a Nuffield experiment sheet.

HIGHLY FLAMMABLE propanone

eye protection must be worn

23: What Colour are Leaves *Really*?

● **Intermediate/High level** ● **40-50 minutes**

Requirements

Extraction of pigments

1g freshly collected copper beech or other coloured leaves (in winter you can use red leaves from plants such as *Heuchera* 'Raspberry Regal', or indoor red-leaved begonias)
2 g washed sand
5 cm³ propanone (**highly flammable**)
scissors
pestle and mortar

Paper chromatography

chromatography tank or coffee jar with lid
10 cm³ propanone for chromatography
capillary melting point tubes
chromatography paper (Whatman No.1, 40 x 150 mm)
pencil

eye protection

Method

See pupils' sheet.

Safety advice

The solvents used in this experiment are highly flammable. All Bunsen burners and other flames must be extinguished.

Chemical background

The red colour of the copper beech leaves comes from an anthocyanin pigment. The anthocyanins are members of a class of compounds called flavonoids. They are not responsible for all reds in plants; the red of beetroot and bouganvillea is due to other compounds (betacyanins).

Like the anthocyanin extracted from red cabbage water (cyanidin) these pigments are often pH sensitive.

Extensions

The purple/red pigment in copper beech leaves is similar to that in red cabbage. Does it act as an indicator? Test the spots with acidic and alkaline solutions.

You could do a comparison with green leaves on the same chromatography paper.

Autumn leaves could be analysed at various stages to see how their colours change. Here the yellow pigments are carotenoids while the reds are anthocyanins.

References

P. Borrows, *Education in Chemistry*, **33** (5), 119, 1996.
Molecules, P. W. Atkins, Scientific American Library, W.H. Freeman and Company, 1987.

24: Making and Colouring Glass Beads

● **Intermediate/High level** ● **30 minutes**

eye protection must be worn

HARMFUL
copper(II) sulphate
manganese(II) sulphate
iron(II) sulphate
nickel(II) sulphate
(may cause sensitisation)

TOXIC
cobalt(II) chloride or cobalt(II) nitrate

Requirements

lengths of nichrome (heat resistant) wire (15 cm), 2 lengths for each compound to be tested
corks
pliers
Bunsen burner
watch glasses
250 cm^3 glass beaker
powdered hydrated disodium tetraborate $Na_2B_4O_7.10H_2O$ (borax)
metal salts: the samples should be finely powdered

copper(II) sulphate (**harmful**)
manganese(II) sulphate (**harmful**)
chromium(III) potassium sulphate dodecahydrate ('chrome alum', $CrK(SO_4)_2.12H_2O$)
iron(II) sulphate (**harmful**)
cobalt(II) chloride or cobalt(II) nitrate (**toxic**)
nickel(II) sulphate (**harmful**)

eye protection

Although cobalt and nickel salts give interesting colours they are sensitisers and are best avoided by junior pupils.

Advance preparation

Push one end of each nichrome wire into a cork.

Some sources recommend coiling the free end in a small loop of 2mm diameter (so that a match can just pass through it). Others find this unnecessary.

The metal salts should be in the form of fine powders. Powder them if necessary.

Put powdered borax onto watch glasses.

Method

See pupils' sheet.

As the cobalt compounds should give good results they could be chosen for an initial demonstration.

It is important to allow only a *small* amount of material to adhere to the bead.

Chemical background

This activity is based on the 'borax bead test', which was once used as a method for identifying several transition elements.

For some metals the colours obtained vary depending on whether heating is done in the oxidising or reducing part of the Bunsen flame (see table). Pupils can use their knowledge of the structure of the flame.

Metal salt	**Oxidising flame**		**Reducing flame**	
	hot	**cold**	**hot**	**cold**
cobalt	blue	blue	blue	blue
copper	green	blue	-	opaque red-brown
iron	yellow-brown	yellow	green	green
manganese	violet	amethyst	-	-
chromium	yellow	green	green	green

The Chemistry of Art, a resource pack from the Royal Society of Chemistry and the National Gallery, London gives the activity a fresh context. It describes how glass beads, coloured by cobalt, were once ground up to make *smalt*, a blue pigment known to painters for many centuries. The pack contains detailed instructions. The method is slightly more elaborate as the borax beads are hardened using 'water glass' (a concentrated aqueous solution of sodium or potassium silicate) before they are coloured.

For an account of the history of glass, including glass made using borax, see *Molecules at an Exhibition*, John Emsley. Pyrex is, of course, borosilicate glass.

References

The Chemistry of Art, a resource pack from the Royal Society of Chemistry and the National Gallery Company Ltd., 1999

Molecules at an Exhibition, John Emsley, Oxford University Press, 1998

Safety advice

Eye protection is essential.

The table is from *Chemistry in the Marketplace*, Ben Selinger, 4th Edition, Harcourt Brace Jovanovich, 1989

25: Making a Blueprint

- **Intermediate/High level**
- **30 minutes plus time for paper to dry**

Requirements

solution A (see advance preparation)
solution B (see advance preparation)

aluminium foil for wrapping flask with solution A when in normal light
a room which can be semi-darkened
cartridge paper (heavy uncoated paper used for drawing)
paint brush or equivalent: this should be disposed of after use
photocopy of a negative photocopied on A4 acetate (see advance preparation)
metal key or small coin
scissors
absorbent paper on roll
25 cm^3 measuring cylinder
100 cm^3 glass beaker
glass stirring rod
old newspaper on which to lay a flat piece of A4 paper. This is for painting the solutions onto the paper
disposable glove for handling wet paper
washing up bowl for fixing i.e. washing prints in water

natural light

Advance preparation

A photocopy of a negative, photocopied on acetate (A4).
2 x 100 cm^3 volumetric flask

Solution A

18 g ammonium iron(III) citrate dissolved in distilled water to make 100 cm^3.

Solution B

10 g potassium hexacyanoferrate(III) dissolved in distilled water to make 100 cm^3.

Method

See pupils' sheet.

It is important to use the right type of paper. It has to take up the solution so that a good image is produced on exposure. The pores of the paper must lightly trap the blue pigment so that it does not get washed away in the final fixing (washing) step substances.

Safety advice

Solution A and solution B are low hazard.

Solution A will stain clothing.

Chemical background

Blueprints are also known as cyanotypes. Ready-made blueprint paper used to be available.

When the paper is exposed to UV light the Fe^{3+} ions from the ammonium iron(III) citrate are reduced to Fe^{2+}. The Fe^{2+} ions then react with hexacyanoferrate(III) ions to produce Prussian blue, $Fe_4^{III}[Fe^{II}(CN)_6]_3.15H_2O$.

The final wash removes any unreacted hexacyanoferrate(III) and prevents further coloration.

Prussian blue is an example of a mixed valence compound as it contains the same metal in two oxidation states. It can be obtained on mixing either Fe^{3+} with $[Fe^{II}(CN)_6]^{4-}$ or by mixing Fe^{2+} with $[Fe^{III}(CN)_6]^{3-}$. Blueprinting uses the second route.

Reference

Information on alternative photographic processes is available on the Internet:
http://duke.usask.ca/%7Eholtsg/photo

26: Find the Combination of the Safe

● Intermediate/High level ● 30 minutes

eye protection must be worn

HIGHLY FLAMMABLE
phenolphthalein indicator solution

IRRITANT
solution E
solution L

Requirements

25 cm^3 solution A' NaOH (0.04 mol dm^{-3})	25 cm^3 measuring cylinder
25 cm^3 solution D' NaOH (0.02 mol dm^{-3})	250 cm^3 conical flask
25 cm^3 solution E' NaOH (0.08 mol dm^{-3}) (**irritant**)	100 cm^3 glass beaker
25 cm^3 solution L' NaOH (0.06 mol dm^{-3}) (**irritant**)	burette
100 cm^3 HCl (0.10 mol dm^{-3})	plastic funnel for filling burette
phenolphthalein	clamp and stand
prize(s)	eye protection

Advance preparation (quantities sufficient for ALL groups)

Solution A'	25 cm^3 solution A diluted with water to make 250 cm^3
Solution D'	25 cm^3 solution D diluted with water to make 250 cm^3
Solution E'	25 cm^3 solution E diluted with water to make 250 cm^3
Solution L'	25 cm^3 solution L diluted with water to make 250 cm^3

NB These solutions MUST be made up accurately for a successful result.

Method

See pupils' sheet.

This practical is a test of accuracy - you could award prize(s) to the pupil(s) with the most accurate result. The results should be:

Solution	**Volume of acid needed to neutralise solution / cm^3**
A	10
D	5
E	20
L	15
Total volume of acid used	50*

The combination is DALE50.

The prize goes to those whose result for the total volume is nearest to 50 cm^3.
*The solutions have to be made up very accurately for the students to get this value.

Safety advice

Pupils must wear eye protection.

27: IT'S ELEMENTARY: PowerPoint Assignment

● High level

The assignment is to design and prepare a PowerPoint presentation on a chosen element for a school open evening or for use in local libraries. The presentation should aim to appeal to local citizens and must be presented in such a way that the average reader would understand it.

What you will need

Access to the Internet and PowerPoint software.
For a PowerPoint tutorial see www.umist.ac.uk/apt/index.htm

Method

See pupils' sheet.

28: Fizzing in the Kitchen

● All levels ● 30 minutes + investigation

Requirements

A: Powders and crystals

small amounts (about one small spatula full) of some of the following:

- salt
- sodium bicarbonate (sodium hydrogencarbonate)
- coffee
- washing soda (sodium carbonate)
- garden lime
- flour
- detergent powder
- sherbet
- sugar
- baking powder
- bath salts
- Rennies
- Andrews liver salts

dilute hydrochloric acid, HCl 2 mol dm^{-3} (**irritant**)
limewater
test tubes
test tube rack
test tube fitted with rubber bung and delivery tube
watch glasses
small spatulas (one spatula for each substance)
10cm^3 measuring cylinder
eye protection

B: Which drink has the most fizz?

cans of soft carbonated drinks (chilled)
table salt or sodium chloride
caster sugar
sand
spatula
test tubes
bungs
conical flask and bung to fit with a glass through tube (or side-arm flask or side arm boiling tube)
rubber tubing
washing up bowl
beakers (500 cm^3, 250 cm^3, tall 100 cm^3)
beehive shelf
measuring cylinders or burettes
Bunsen burner
tripod
gauze
heat proof mat
clamp stand
top pan balance

eye protection

Method

See pupils' sheet.

A: Powders and crystals

1 Care must be taken over labelling the substances to be tested.
2 Stress that there is one spatula for each substance under test. Explain that this will avoid one substance becoming contaminated with another.
3 Only a **small** amount of each substance needs to be put on the watch glass for the first test. It should be possible to test several substances on the same watch glass.

B: Which drink has the most fizz?

The pupils need to know that gases are less soluble in hot than in cold liquids. They seem to know this already (hence the question about 'flat' drinks).
Heating or adding a solid will release the gas.

Several methods can be used to measure the amount of gas released. They include:
(i) A side-arm flask with a thistle funnel may be used. The gas can be collected over water using an inverted measuring cylinder or burette full of water.
(ii) Since CO_2 is soluble, some gas will be lost if it is collected over water. The students may try using a gas syringe (or they could pre-saturate the water).
(iii) The loss of mass as the gas escapes may be determined by weighing.

Safety advice

Eye protection must be worn.

Warn the pupils there must be no eating or drinking in the lab.

Chemical background

All the powders and crystals that fizz contain either a carbonate or hydrogencarbonate and give off carbon dioxide.

Extension

Investigate the effect of temperature on the amount of carbon dioxide dissolved in a fizzy drink.

Reference

'There's bags more fizz in Fanta', *In Search of Solutions*, RSC, 1990
P. Borrows, *Education in Chemistry*, **38**(1), p 23, January 2001

29: Investigating Shampoos

● High level ● open ended investigation

eye protection must be worn

This investigation suggests activities for four sessions, but can be condensed by allocating different tasks to different groups of pupils in one session and pooling the results, or extended by adding further activities.

The pupils should try to work out their own method for each section but suggested methods, which have been tested, are given below.

What you will need

You will need at least six different shampoos to test.

Your test shampoos should include:
baby shampoo
shampoo for greasy hair
shampoo for dry hair
anti-dandruff shampoo
shampoo with built-in conditioner
herbal shampoo

Make sure your test shampoos include at least one with a warning on the label to keep the shampoo out of the eyes. Also include a really cheap shampoo, to see how it compares with more expensive ones.

eye protection must be worn

A: Comparing the pH of different shampoos

Requirements

6 different shampoos
6 droppers (keep one for each shampoo)
18 test tubes
test tube rack
10 cm^3 measuring cylinder
distilled water
Universal indicator (with dropper) (**highly flammable**)
chart to show colours for Universal indicator

Suggested method

1 Pour 5 cm^3 water into a test tube. Add a drop of shampoo and shake to mix with the water.
2 Add 4 drops of Universal indicator. Observe the colour. Look at the colour chart for Universal indicator and decide what value the colour indicates.
3 Repeat the measurement twice.
4 Measure the pH of the other shampoos using the same method.
5 Make a table for your results.

Shampoo	pH (test 1)	pH (test 2)	pH (test 3)	Average

Safety advice

Eye protection must be worn.

Trial results

Baby shampoo pH 7.0; label - kind to eyes, does not sting.
Anti-dandruff shampoo pH 4.0; label - avoid contact with eyes, wash with lots of water if it splashes into eyes, seek medical help if necessary.
All the others were in the range pH 5.0 - 5.5; label - avoid contact with eyes.

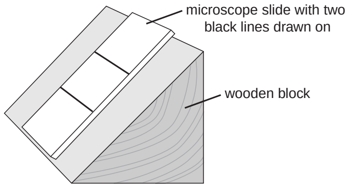
B: Comparing the flow properties of different shampoos

eye protection must be worn

Requirements

6 different shampoo samples
6 droppers (keep one for each shampoo)
stop watch
Blu tack
18 glass microscope slides
18 small wooden blocks with triangular cross section, angles 45°, 45°, 90° (as used in Physics for moments experiments – see diagram. The blocks are used to hold the slides at a 45° angle.)
black marker pen

eye protection



Suggested method

1 Use the black marker pen to draw two lines on each microscope slide, 2 cm apart.
2 Stick all the slides with Blu tack onto the longest sides of the wooden blocks, so that they are at the same angle of 45°.
3 Hold one block so that the slide is horizontal and use the dropper to put 0.2 cm3 shampoo on one of the black lines.
4 As you put the block down, with the slide at 45°, start the stopwatch. Time how long it takes for the shampoo to run down to the second black line.
5 Repeat twice and then carry out three tests with each of the other shampoos.
6 Make a table of your results.

Safety advice

Eye protection must be worn.

Trial results

There was a large variation in the flow properties of the different shampoos. The baby shampoo was much runnier than all the others.

C: Comparing the amount of lather produced by different shampoos

eye protection must be worn

Requirements

6 different shampoo samples
6 droppers (keep one for each shampoo)
8 test tubes
rubber bungs for test tubes
10 cm^3 measuring cylinder
stop watch
ruler

eye protection

Suggested method

1 Put 10 cm^3 of water into one test tube. Add 4 drops of one shampoo and put a bung on the test tube.
2 Shake the test tube for sixty seconds using a stop watch to measure the time.
3 Measure the height of the foam in cm, using a ruler. Record your result.
4 Repeat twice with the same shampoo.
5 Do the test three times on each of the other shampoo samples. Set out your results in a table.

Safety advice

Eye protection must be worn.

Trial results

The height of the foam varied from 4.0 cm to 8.0 cm. The results for each shampoo varied, but the shampoo with built-in conditioner usually produced the least foam.

HIGHLY FLAMMABLE Universal indicator

eye protection must be worn

D: Comparing the grease-removing properties of different shampoos

Requirements

6 different shampoo samples
7 x 100 cm^3 beakers
1 x 250 cm^3 beaker (optional)
6 droppers (keep one for each shampoo)
7 glass microscope slides
brush
glass stirring rod
olive oil coloured with Sudan III
sheet of white paper

eye protection

Suggested method

1 Drop 0.2 cm^3 of shampoo into 25 cm^3 of water in a beaker and stir vigorously with a glass rod until the water and shampoo are well mixed. Repeat for the other five shampoos.
2 Add 25 cm^3 water to a beaker with no shampoo.
3 Label the beakers A to G.
4 Label the glass microscope slides A to G (write near to one end).
5 Use the brush to paint three-quarters of each slide with olive oil coloured with Sudan III, leaving the labelled end clear to hold.
6 Hold slide A over a 250 cm^3 beaker (or over a sink) and pour the contents of beaker A so that the shampoo mixture flows over the olive oil. Place slide A on a sheet of white paper.
7 Repeat step 6 for B to G.
8 Rank the slides by how much oil has been removed.

Safety advice

Eye protection must be worn.

Trial results

Water alone removed almost no grease, baby shampoo removed very little. The other shampoos removed more, but there was little difference between them.

Further activity

Investigate different hair types, using a microscope.