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 cm³ 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

IRRITANT dilute hydrochloric acid

Food must not be eaten in the laboratory

eye protection must be worn

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

SALTERS' The Chemistry Club

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

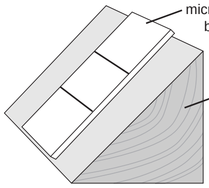
Baby shampoo pH 7.0; label - kind to eyes, does not sting.
Anti-dandruff shampoo pH 4.0; label - avoid contact with eyes, wash with lots of water if it splashes into eyes, seek medical help if necessary.
All the others were in the range pH 5.0 - 5.5; label - avoid contact with eyes.

B: Comparing the flow properties of different shampoos

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

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.