Science MAD!

Chemistry Lab

WARNING! Materials which may come into contact with the skin could cause allergic reactions to susceptible individuals. In the case of irritation discontinue use. If the lens becomes scratched or damaged, the goggles should be replaced. Eye protectors/goggles worn over standard ophthalmic spectacles may transmit impacts, thus creating a hazard to the wearer.

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Printed in China.

P38-CM002-81049003

CE

Item No. SM20

AGES 10 AND UP

Science MAD!

Chemistry Lab

Instructions

100 experiments all safety tested

WARNING! Not suitable for children under 10 years. For use under adult supervision. Contains some chemicals which present a hazard to health. Read the instructions before use, follow them and keep them for reference. Do not allow chemicals to come into contact with any part of the body, particularly the mouth and eyes. Keep small children and animals away from experiments. Keep the experimental set out of reach of children under 10 years old. Eye protection for supervising adults is not included. Functional sharp points and edges: cut and puncture wound hazard. Dispose of unwanted chemicals by greatly diluting with water and running into the waste water system. For chemicals labelled as hazardous to the environment, please contact your local council for safe disposal information.

Contents of this instruction booklet

Contents of the Chemistry Lab

CAUTION! Contains some chemicals that are classified as a safety hazard

CHEMICAL	RISK
Ammonium Chloride	**Harmful if swallowed Causes serious eye irritation.**
Calcium Carbonate	
Calcium Hydroxide	
Copper(II) Oxide	
Copper(II) Sulphate	**Harmful if swallowed. Causes skin irritation. Causes serious eye irritation. Very toxic to aquatic life with long lasting effects.**
Copper Foil	**Not hazardous.**
Iron(II) Sulphate	
Iron Filings	

CHEMICAL	RISK
Litmus Blue	**Not hazardous.**
Magnesium Strip	
Magnesium Sulphate	**Not hazardous**
Aluminium Potassium Sulphate	**Not hazardous**
Potassium Iodide	**Not hazardous**
Sodium Carbonate	**Causes serious eye irritation.**
Sodium Hydrogen Sulphate	**Causes serious eye irritation.**
Sodium Sulphate	**Not hazardous**
Sodium Thiosulphate	**Not hazardous**
Tartaric Acid	
Zinc Pellets	**Very toxic to aquatic life with long lasting effects.**

Equipment

1 x 100ml beaker
Universal Indicator papers
1 x 100ml conical flask
2 x Stoppers - cork
3 x Stoppers - cork with hole
Filter papers
1 x Plastic funnel
1 x 120mm glass stirring rod
3 x 100mm glass tubing
1 x Measuring spoon
1 x Plastic dropping pipette
1 x 100mm rubber tubing
1 x Safety goggles
1 x Small scoop
1 x Spirit burner
4 x Test tube caps
1 x Test tube cleaning brush
1 x Test tube holder
1 x Test tube rack
4 x Test tubes
1 x Instruction booklet

First Aid Instructions

- In case of eye contact: Wash out eye with plenty of water, holding eye open if necessary. Seek immediate medical advice.
- In case of skin contact and burns: Wash affected area with plenty of cold water for at least 10 minutes.
- If swallowed: Wash out mouth with water, drink some fresh water. Do not induce vomiting. Seek immediate medical advice.
- In case of inhalation: Remove person to fresh air.
- In case of doubt, seek medical advice without delay. Take the chemical together with the container with you.
- In case of injury always seek medical advice.

Record the telephone number of your local hospital (or local poison centre) in the box below.
(Write the number in NOW so you do not have to search for it in an emergency)

Telephone Local Hospital: ____________________

Safety Goggles User Information

Instructions for use, storage and maintenance.

- Hold goggles with one hand, if possible without touching the lens. Pull the elastic head band over the back of your head, just above the ears so that the goggles sit on your forehead. Carefully pull the goggles down over the eyes and adjust the strap for a snug and comfortable fit. Ensure the goggles are kept clean and dry, and cannot come into contact with loose chemicals or sharp objects.
- Wash with warm soapy water, rinse and dry with a soft cloth.
- These goggles are only to be used with the contents and instructions supplied. If goggles become damaged, do not attempt to repair; discard immediately.
- Materials which may come into contact with the wearer's skin could cause allergic reactions to susceptible individuals.
- Goggle markings - Edu-Science (HK) Ltd 1 S - EN166 3 S H CE
  - CE - complies with EN 166
  - H - designed to fit small heads
  - S - intended for protection against droplets or splashes
  - 3 - for use with liquids
  - European standard for Personal Eye Protection
  - S - increased robustness
  - Optical glass
  - Manufacturer

Safety Matters

THE SAFETY RULES

DO read these instructions before use, follow them and keep them for reference.
DO keep young children, animals and those not wearing eye protection away from the experimental area.
DO always wear eye protection.
DO store experimental sets out of reach of children under 10 years of age.
DO clean all equipment after use.
DO make sure that all containers are fully closed and properly stored after use.
DO wash hands after carrying out experiments.
DO dispose of chemicals in accordance with local and national regulations.
DO NOT use equipment which has not been supplied with the set or recommended in the instructions for use.
DO NOT eat, drink or smoke in the experimental area.
DO NOT allow chemicals to come into contact with the eyes or mouth.
DO NOT replace foodstuffs in original container. Dispose of immediately.

Advice for Supervising Adults

a) Read and follow these instructions, the safety rules and the first aid information, and keep for reference.

b) The incorrect use of chemicals can cause injury and damage to health. Only carry out those activities which are listed in the instructions

c) This chemical set is for use only of children over 10 years of age.

d) Because children's abilities vary so much, even within age groups, supervising adults should exercise discretion as to which experiments are suitable and safe for them. The instructions should enable supervisors to assess any experiment to establish its suitability for a particular child.

e) The supervising adult should discuss the warnings and safety information with the child or children before commencing the experiments. Particular attention should be paid to the safe handling of acids, alkalies and flammable liquids.

f) The area surrounding the experiment should be kept clear of any obstruction and away from the storage of food. It should be well lit and ventilated and close to a water supply. A solid table with a heat resistant top should be provided.

g) The Spirit Burner should be placed on a metal tray. Fill the burner three quarters full with Methylated Spirits. You need about 3mm of wick protruding from the cap. Keep the bottle of Methylated Spirits well away from the Spirit Burner. Light the burner with a match. CAUTION! The flame is nearly colourless and in bright sunlight it may be invisible. It is very easy to burn yourself.

This Chemistry Lab Instruction Booklet has been written by David Webster. Dr. Webster is a Fellow of the Royal Society of Chemistry and a Chartered Chemist. He has been teaching practical chemistry for over 40 years, and is the author of a chemistry textbook for younger secondary school children. He has designed and tested the 100 experiments in this instruction booklet. The experiments, which get more difficult and involve more complex ideas as you move through the booklet, are a collection of safe chemical experiments for you to carry out using both the chemicals and equipment in the Chemistry Lab and common chemicals and other readily available materials, many of which you will already have at home. The experiments are intended to show you some of the magic and mystery of chemistry, and the relevance of chemistry to your understanding of what is to be found in your home and in the world around you.

Introduction

You are now the owner of a Chemistry Laboratory. We hope that you enjoy the many interesting chemistry experiments which are given in this Instruction Booklet.

ADULT SUPERVISION IS NECESSARY AT ALL TIMES.

A Chemistry Laboratory, such as this, is not for 'playing' with. When carrying out chemistry experiments you need to take **GREAT CARE** in both following the instructions and in keeping a Laboratory Notebook of your experiments and results.

If you do this you will be working safely and learning some chemistry at the same time. Working safely must always be your main concern. The experiments given here are safe and enjoyable and at the same time you will learn about chemistry.

Always be careful to avoid getting chemicals on you, particularly not in your eyes or mouth. **Also be careful not to burn yourself.** To avoid injury read and follow all the safety rules which follow.

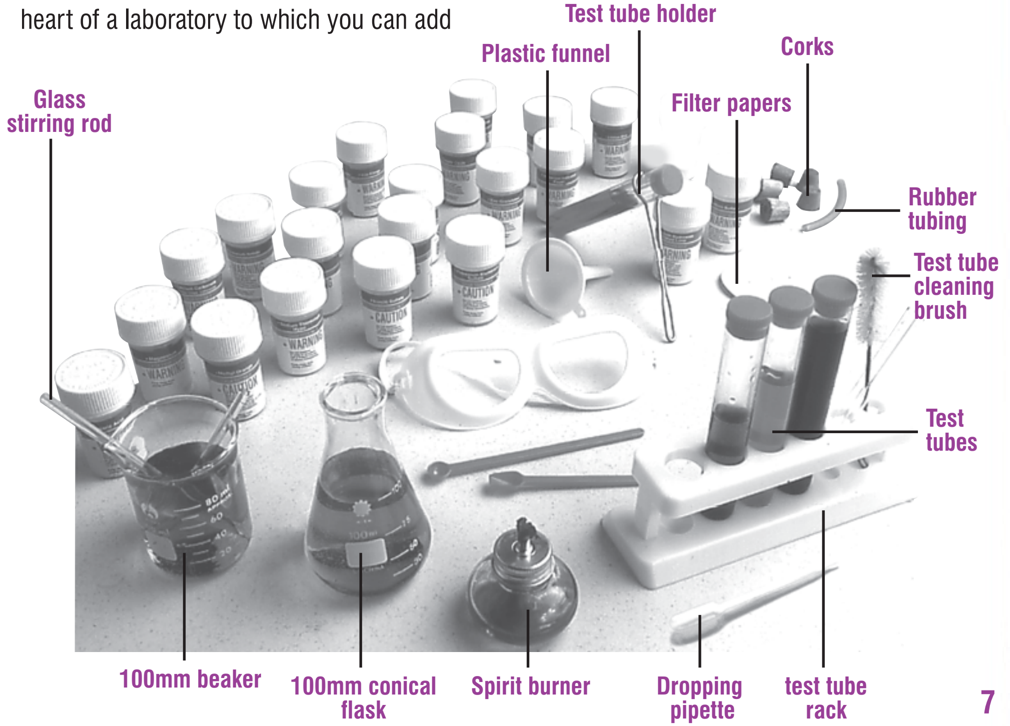
Chemistry is a very important science, because everything in the Universe is made of chemical substances. You, the water you drink, the air your breathe, the food you eat, the hills you climb, are all chemical substances.

All chemical substances are made from about 100 elements. You, for example, are a very complicated mixture of chemicals, but 98% of you is just 6 of these 100 elements (hydrogen, carbon, nitrogen, oxygen, phosphorus and sulphur). Many other elements make up the remaining 2% of you, such as iron, in your blood, and sodium, in the cells of your body.

When you carry out chemical experiments you are studying how the many different chemical substances behave. This Chemistry Lab contains the equipment and chemicals to carry out many interesting experiments, but no chemistry set can be "complete" as there are millions of possible chemistry experiments. You must regard your Chemistry Lab as the heart of a laboratory to which you can add other equipment and chemicals (only those suggested on pages 14/15 in this manual or listed in each experiment in this manual). Then you can carry out other experiments.

Some of the experiments here require other equipment and chemicals and these are described in the section Additional Equipment and Chemicals. DO NOT use anything not listed as a requirement in this manual.

It is a good idea to get together as much of this equipment and as many of these chemicals before your start. Certainly get them before you start the experiment which needs them. These additional chemicals and equipment need not be expensive. Part of the fun of using a chemistry set at home is to improvise, that is to make the equipment from common household items, and use common household chemicals, as much as possible.



Setting up your Chemistry Laboratory

You need to set up your laboratory work space in a well lit and ventilated room with, if possible, a heat resistant surface to work on. You will soon discover that an experimental chemist spends a lot of time washing dirty equipment so a close supply of running water, or a large container to hold waste water is essential.

For most people the kitchen is the best place to set up your laboratory.

You also need a clean area nearby where you can write in your laboratory notebook and keep other items safe and dry. It is unlikely that you will have a laboratory area that is not to be used by other people at other times. This is certainly so if you work in your kitchen. You need, therefore, to be able to easily pack away your Chemistry Laboratory. You can, of course, use the box which we have supplied, but you will quickly acquire other equipment and chemicals, and we strongly recommend that you get a large strong cardboard or plastic box in which you can conveniently pack and unpack everything and store it away when not in use.

IT IS VERY IMPORTANT that you store this set somewhere where young children do not have access to it. Read and act upon all the safety advice within this manual!

Have readily available at all times the following 6 items.

1

A sink or container for liquid waste.

2

A waste bin for solid waste.

3

A piece of hardboard or thick cardboard or similar (newspaper in an emergency) to put on the work bench. Then if you have any spills you can easily clean up the mess.

4

A kitchen roll, or some cloths, for keeping your laboratory area clean and tidy.

5

Two tea-towels (not those usually used in the kitchen). One dry tea-towel should be used for drying your apparatus after you have washed it. The other tea-towel should be wet and you should keep it handy so that you can quickly smother a small fire if you are unlucky enough to have one.

6

A biscuit tin lid, or something similar, in which to stand your Spirit Burner.

Working in your Chemistry Laboratory

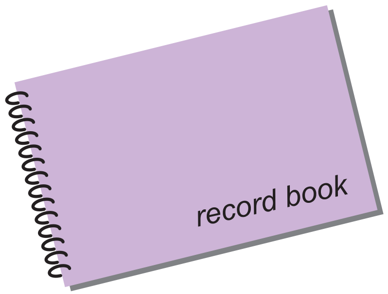
Keep accurate records of your work. There is little point in doing chemical experiments if you don't know what you have done, why you did it and what happened. Follow the instructions carefully and watch very closely what happens, and then try to work out why it happened. At the back of these instructions are answers to what you should see and conclude from your observations.

The Record Book

The best type of book to use is a hard covered book or one with a spiral binder.

Write up each experiment with:

- when you did the experiment (the date)
- what the experiment was about (its title)
- what you did (the method)
- what happened (the results)
- why it happened (the conclusions).



Laboratory Techniques

Practical chemistry requires you to carry out various tasks which will at first be unfamiliar to you. This section contains some hints and tips that will help you with these tasks.

Using The Spirit Burner

You must use the Spirit Burner with great care. It should always be placed on a metal tray that can catch any spillages - a biscuit tin lid is ideal.

Fill the burner three quarters full with Methylated Spirits, screw on the cap and wait a few minutes for the Methylated Spirits to soak up the wick. You need about 3mm of wick protruding from the cap. Ensure that the outside of the burner is dry. Keep the bottle of Methylated Spirits well away from the Spirit Burner. Light the burner with a match (or preferably a disposable cigarette lighter). You will see that the flame is nearly colourless and in bright sunlight it may be invisible. It is very easy to burn yourself and to minimise this risk we recommend the following tip.

Continued...

SAFETY TIP: Using the Spirit Burner. You can extinguish the burner flame by blowing it out, but a good tip to follow is to have a heat proof drinking glass that fits over the burner. To extinguish the flame just put the glass upside down over the burner and after a few seconds the flame will go out. (Do you know why? Experiments 9.8 and 9.17 have the answer).

Leave the glass in place until you next want to use the burner.

YOU THEN ALWAYS KNOW THAT IF THE BURNER IS NOT UNDER THE GLASS, IT IS ALIGHT.

NEVER LEAVE CHILDREN UNATTENDED WITH THE SPIRIT BURNER.

Using The Test Tubes

For these experiments you will usually be using less than 3cm depth of water in the test tubes. Do not overfill as the more liquid you have in a test tube the more difficult it is to control any boiling that occurs. Solids can be added to a test tube with the measuring spoon. You might find it easier to add liquids by using the funnel, or by pouring the liquid into a beaker and then into the test tube.

Heating A Test Tube:

Always point the test tube away from you and other people. Hold the test tube in the test tube holder whenever you are likely to boil the contents or heat them strongly.

TIP: A wooden clothes peg also makes a good test tube holder.

The easiest way to dissolve solids in water is to put a cork in the test tube and shake it. If the solid does not dissolve after about 15 seconds of shaking then gently warm the solution.

Most solids dissolve more readily in water if you gently warm the solution. You can hold the tube without the holder if you are only going to heat it for a few seconds to get the water warm to help a solid dissolve. To heat a tube hold it in a slanting position away from you and continually move it about in the flame. Even when told to heat a tube strongly, start with gentle heating and watch carefully in case the contents spit or spurt out of the tube.

SAFETY TIP: The use of clay pot. You can considerably reduce the risk of an accident due to the contents of a test tube spurting out, by putting one or two small pieces of clay pot into the tube. As the water boils the steam is formed as tiny bubbles on the sharp points of the clay pot and these then bubble smoothly out of the solution.

See Note 2 at the beginning of "The Chemistry Experiments" where how to make the pieces of clay pot is described. **Never heat a test tube with a cork in it.**

If you have hot water in the test tube you can safely put it into the test tube rack. If you have a hot solid in the tube then the tube may be VERY HOT and could melt the test tube rack – put the hot tube into an empty beaker and leave it there until it is cool.

Cleaning The Test Tubes

Wash them with running water and clean with the test tube brush. If necessary use a little washing-up detergent. The outsides of the test tubes will get black with deposits from the burner. Clean this off with a cream kitchen cleaner such as Cif. To dry inside test tubes use rolled up kitchen paper towel.

Your Water Supply

For washing dirty equipment a tap and sink are best. When carrying out the experiments you will need a "water bottle" for adding small quantities of water, in a controlled way, to the chemicals in the test tubes. Two suggestions are a "Washing-up Detergent Bottle" or a "Hand Sprayer".

TIP: A Washing-up Detergent Bottle. Remove the cap from an empty bottle (or better get an adult to do so for you by prizing the cap off with the edge of a knife) and thoroughly wash the bottle and, particularly, the cap to remove all traces of detergent.

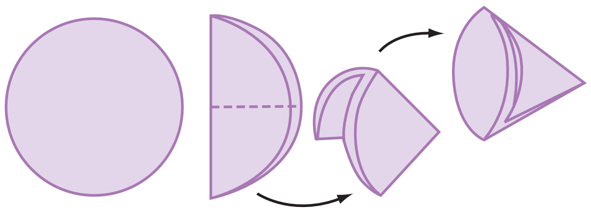
You can fill the bottle with water, replace the cap and use it by gently squeezing the bottle. However, the jet of water you get is rather too much. The bottle can be considerably improved for your purpose if you get an adult to heat a needle held in a pair of pliers in your Spirit Burner flame and melt a small hole through the centre of the top of the cap. Then click shut the top of the cap and squirt the water out of this fine hole.

continued...

TIP: A Hand Sprayer.
A small (1 pint) garden or indoor plant sprayer that is readily available at Garden Centres and DIY stores is ideal. It has a trigger action and is designed to give a spray. By rotating the spray head a fine jet of water can be produced instead. This is very controllable by lightly squeezing the trigger. Additionally the sprayer has the advantage of being easy to refill by just unscrewing the water container.

Using Filter Papers

You will use the filter papers supplied to separate solids from liquids and for the Paper Chromatography experiments. Always use a new paper for each experiment. You may need more papers than supplied here. Very cheap filter papers can be cut from Coffee Filter Papers; get the white ones rather than the brown ones if you can. You are advised to use the small filter papers and Coffee Filter Papers for filtering and retain the large filter papers supplied here for the Chromatography experiments. Filter papers are folded as shown in the diagram below.



Using Chemicals

NEVER TASTE A CHEMICAL.

REMEMBER to be careful when carrying out all the experiments. Wear your Safety Goggles, but should you get any chemical in your eyes, get someone else to wash them immediately with your water bottle or under a running tap.

You only have a limited supply of chemicals. Although these can be added to by buying more from elsewhere, you only want to work with small quantities.

In the experiments “one measure” is a level scoopful of the chemical in the round measuring spoon.

You will add other chemicals to those supplied and make up “Stock Solutions” of some of the chemicals that you will need for many experiments. Keep these in stoppered containers and bottles. It is most important that you always label any chemicals or solutions when you put them in your own bottles or containers.

TIP: You will need some empty bottles and containers. Small bottles that have had fizzy drinks, or something similar, are satisfactory, although smaller bottles would be better - you will need 4. Small plastic containers that have been used for 35mm films are perfect for solids. You can get as many as you want of these for nothing from your local photo-processor. They will be pleased to give them to you as they usually throw them away. **NEVER store chemicals and solutions near or with foodstuffs.**

Using Glassware

If you do have an accident and break some glassware clean it up immediately. Wipe up tiny fragments with several pieces of kitchen roll and throw it away. Wash your hands under running water when you have cleared up.

One of the trickiest tasks you will have to do is to push the glass tubing into a cork. It is very, very easy to break the tubing and cut your hand when doing this so take great care.

TIP: Thoroughly wet the cork and the end of the tubing with a strong solution of washing-up detergent. Hold the glass tubing and the cork in a tea-towel, or other cloth and push the tubing gently with slight twisting into the cork.

Wash the excess detergent off the cork and tubing and allow them to dry. Once it is in the cork it is usually impossible to remove the tubing without breaking it unless you cut the cork. Don’t try.

Additional equipment and chemicals

In order to carry out the full set of experiments described in this instruction booklet it is necessary to add other equipment and chemicals. The more important of these are listed below. You should have no difficulty in finding these but some sources are given. You should get these together before you start on the experiments. Readily available household items that are needed for specific experiments are given in the list at the side of the experimental instructions. (N.B. some experiments may require more of a chemical than we have supplied with your set (see example 3-8). Use your small scoop for refilling chemical bottles.

Equipment

A small ruler
To measure the amount of liquid in a test tube.

Crystallising dishes
Make them from yogurt pots or small plastic beakers by carefully cutting round the pot about 1cm from the base. The small dishes that you make are ideal. Make 5 or 6.

Metal evaporating spoons
Two different sizes are needed, large and small. Use two unwanted stainless steel spoons (one dessert and one tea) If you don't have any at home, a local charity shop will have them for a few pence.
N.B. Some experiments call for two identical teaspoons.

A water dispenser
See the section on "A Water Supply".

A small clay plant pot
(preferably a new one) - from a gardening shop.

Coffee filter papers
(preferably white) - from supermarket.

A box of matches/cigarette lighter
For lighting the Spirit Burner and other experiments.

A heat proof drinking glass
For covering the Spirit Burner.

Small bottles and containers
See the section "Using Chemicals".

Small self-adhesive labels

Wooden ice-cream or lolly sticks

A small artist's paint brush or cotton-buds

A pencil

A small mirror or piece of glass

Writing paper (preferably unglazed)

2 tea-towels

A kitchen roll

A roll of sellotape

A pair of scissors

A pair of tweezers or small pliers

5 small nails

A wooden clothes peg
(very useful as a test tube holder)

A small saucepan

An old cup or mug

An egg cup

A small plate

DO NOT RE-USE cutlery, plates, glasses or mugs etc. used in experiments for drinking and eating.

Additional equipment and chemicals

Chemicals that you will need

Methylated spirits
From a DIY store.

Colourless (distilled malt) vinegar
284ml bottle from supermarket.

Citric acid
50g packet from a pharmacist.

Sodium chloride (common salt)
From a supermarket.

Sodium bicarbonate
(Sodium hydrogen carbonate)
From a pharmacist or a supermarket.

Magnesium sulphate (Epsom salts)
500g packet from pharmacist.

Hydrogen peroxide
150ml bottle from a pharmacist.

Turmeric
From a supermarket.

Other items that you will need for specific experiments, check before you start.

Sparkling water

White sugar

Golden Syrup

Course ground pepper

Vitamin C tablets

Aluminium foil

Spray starch

Black ink

Black food dye

Green food dye

Black & coloured felt-tipped pens

A lemon(s)

Distilled water

Sewing thread

A potato

Red cabbage

Beetroot

Blackberry juice

Red rose or red carnation

Indigestion tablet

An apple

Soluble aspirin

A drop of gin, whisky or brandy
(Ask an adult for this.)

Chemicals that you may need

Washing soda (Sodium carbonate decahydrate)*
From a supermarket.

Sodium sulphate (Glauber's salt)*
200g packet from pharmacist.

Garden lime (Calcium hydroxide)*
From a garden centre (but note that very little will be needed).

(Do not get the items marked with a * until you need them. Epsom salts, Glauber's salt, washing soda and garden lime are included in the chemicals supplied, but you may need more.)

ALWAYS read and follow the manufacturers instructions for safe use as seen on the packaging.

NEVER substitute chemicals listed in each experiment for anything else.

The Chemistry Experiments

1

Before doing any of the experiments read and understand the two earlier sections in this Booklet on "Safety Matters" and "Your Chemistry Laboratory".

2

Collect together the "Additional Equipment and Chemicals" listed earlier. For many experiments you will need some small pieces of clay pot. Make these now by breaking up a small clay plant pot and collecting the little pieces that are smaller than a pea. Put these pieces of clay pot in a container and label it.

3

Some of the experiments will need equipment that you should be able to easily find at home. The chemicals and equipment needed for each experiment are given at the side of the instructions. Get everything ready before you start an experiment.

4

In this booklet the experiments are arranged with the easiest ones first. It is therefore best to carry them out in the order given here. You can, however, start at the beginning of any chapter which interests you. Please note that many experiments from Chapter 5 onwards use the solutions of acids and alkalis made in Chapter 5a.

5

Remember; one measure is a level scoopful of the chemical in the round measuring spoon.

6

The amount of liquid needed in an experiment is given as a length in the test tube. You do not need to have exactly this amount. If, for example, it says 2cm then anything from 1½ cm to 2½ cm is satisfactory. Use your ruler to check the amount of liquid in a test tube. You will find that after a few experiments you will be able to guess the amount accurately enough.

When scientists carry out an experiment they carefully observe what happens and then try to work out why it happens. This is what you will have to do here. For most of the experiments the instructions do not explain what happens. Do the experiment, record your results, and try to explain them. You can check to see if you have the correct result in the section Results of the Experiments at the end of this booklet. If the results of your experiment are different from those given there check to see if you followed the instructions and try the experiment again.

Chapter 1 - Soluble & Insoluble Substances

Some substances dissolve in water to form a solution, they are said to be soluble; others do not, they are insoluble. The water is called a solvent and the substance which dissolves is called a solute.

Experiment 1.1 — What substances dissolve in water?

- **copper sulphate**
- **sodium chloride**
- **calcium carbonate**
- **sugar**
- **course ground pepper**
- **test tubes**

Put ¼ measure of copper sulphate into a clean dry test tube and add about 2cm of water. Gently shake the tube. Does the copper sulphate disappear and the solution become coloured?

Repeat the experiment four more times using sodium chloride, then sugar, then calcium carbonate and then coarse ground pepper instead of copper sulphate.

Record your results for each substance as soluble or insoluble.

Experiment 1.2 — Solubility of substances in cold and in hot water

- **sodium sulphate**
- **test tube**

Put 1 measure (look at note 5 opposite) of sodium sulphate into a clean dry test tube and add about 2cm of water. Gently shake the tube. Roughly time how long it takes for the sodium sulphate to dissolve. Repeat the experiment but this time gently shake the tube in the burner flame to warm (not boil) the water.

Does the sodium sulphate dissolve slower or quicker in the warm water?

Keep the solution for Experiment 1.6.

Experiment 1.3 — To recover a dissolved substance by boiling off the water

- **sodium chloride**
- **test tube**
- **large evaporating spoon**

Put 1 measure of sodium chloride into a clean dry test tube and add about 2cm of water. Gently shake and warm in the burner flame.

Where do you think the sodium chloride has gone to when it dissolves? Has it disappeared? To see if it is still there pour the solution into the large evaporating spoon and CAREFULLY boil the solution over the burner flame until all the water has boiled away (evaporated). The white sodium chloride is left behind in the spoon. Be careful not to let the sodium chloride spit too much towards the end of the experiment - heat it very gently.

DANGER – The spoon will be VERY HOT – put it on the tin tray holding the burner and wait for it to cool down.

Experiment 1.4 — To see if there are any dissolved substance in tap water

- **distilled water**
- **large evaporating spoon**

This is a very simple experiment. Half fill the evaporating spoon with tap water. Boil the water over the burner flame until it has all boiled away. Is there anything left in the spoon? **Don't forget the spoon will be HOT**.

Try the same experiment with distilled water. Distilled water is also called deionised water and is used for adding to car batteries. Is there anything left in the spoon?

If you do not have any distilled water collect and use rain water. This has been distilled by nature for you.

With tap water there should be a visible thin film of solid on the spoon. This is because all tap waters contain dissolved solids. If you live where the water is "hard" there is more deposit than where the water is "soft", but even here there will be some solids dissolved in the water. Distilled water has had the solids removed, so in this part of the experiment the spoon should have no deposits remaining on it.

This is an important, but very easy, test to distinguish between tap water and distilled water.

Experiment 1.5 — To recover a dissolved substance by crystallisation

- **copper sulphate**
- **test tube**
- **crystallising dish**

In Experiment 1.3 you boiled away all the water to recover the chemical. As you do this it is likely that the chemical will get hot and be destroyed. If you allow the water to evaporate away more slowly then the chemical is left behind - often as beautifully shaped crystals as you will see in Chapter 3. This process is called **crystallisation**.

Put ½ measure of copper sulphate into a clean dry test tube and add 2cm of water. Dissolve by gentle shaking and warming. Pour the solution into a crystallising dish and leave it somewhere warm, such as a safe place in your kitchen or in an airing cupboard, until the water has evaporated away. What is left in the crystallising dish?

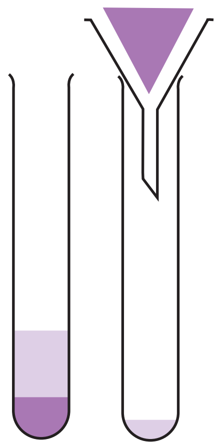
You cannot see the sodium chloride or copper sulphate in Experiments 1.3 and 1.5 because when they are in solution in water the particles of the chemical are very, very small.

This property can be used to separate insoluble solids from solids which have dissolved.

You can filter off the solid, and then recover both the solid and the chemical from the water.

Experiment 1.6 — To separate a mixture of a soluble substance and an insoluble substance

- **sodium sulphate solution from Experiment 1.2**
- **course ground pepper**
- **2 test tubes**
- **funnel**
- **filter paper (not one made from a coffee filter paper)**



You should have a solution of a soluble substance, sodium sulphate, from Experiment 1.2. Add 1 measure of course ground pepper to the solution and shake the test tube. The pepper will not dissolve.

Place the funnel and filter paper into the mouth of a test tube and pour the solution and pepper into it. The liquid **filtrate** passes through the fine holes in the filter paper into the test tube leaving the pepper stuck onto the filter paper.

To recover clean and dry pepper move the funnel into another test tube and gently wash the pepper with water. Then carefully lift the filter paper out of the funnel and put it somewhere warm for a few hours until it is dry. Carefully scrape the pepper off the paper. Try to recover the sodium sulphate from the clear filtrate as in Experiments 1.3 or 1.5.

You can repeat this experiment with other mixture of soluble and insoluble substances.

Chapter 2 - Invisible Inks

Some substances are a different colour when they are cold and when they are hot. We can use this property to make invisible inks. You can write on paper with the ink and it only becomes visible when you "develop" it, by heating the paper with an iron or holding it in front of a fire.

Experiment 2.1 — Invisible ink from a lemon

- **a lemon**
- **crystallising dish**
- **artist's paint brush or a cotton-bud**
- **writing paper**

Squeeze a lemon and pour some juice into a crystallising dish. Use the paint brush or a cotton-bud to write on a piece of white paper. Unglazed writing paper is best. Let the writing dry.

Get an adult to help you carefully heat the paper by pressing it with an iron or holding it in front of a fire. Take great care not to let the paper catch fire.

What colour is the writing?

Experiment 2.2 — Other invisible inks

- **iron sulphate**
- **test tube**
- **crystallising dish**
- **artist's paint brush or a cotton-bud**
- **writing paper**

Dissolve ¼ of a measure of iron sulphate in about 1cm of water in a test tube. Pour the solution into a crystallising dish and write on unglazed paper as in Experiment 2.1.

Develop the invisible ink by heating as in Experiment 2.1.

What colour is the writing?

Experiment 2.3 — An invisible ink made from two chemicals

- **iron sulphate**
- **test tube**
- **crystallising dish**
- **artist's paint brush or a cotton-bud**
- **writing paper**

Put ¼ measure of copper sulphate and ¼ measure of ammonium chloride in a clean dry test tube and add 1cm of water. Shake the tube gently until the chemicals have dissolved (do not heat the solution). Pour the solution into the crystallising dish and write on unglazed paper as in Experiment 2.1.

Develop the invisible ink by heating as in Experiment 2.1.
What colour is the writing?

Later in this instruction booklet you will see how sometimes when chemicals react together a colourless chemical changes into a coloured one. This property is used here to develop an invisible ink.

Chapter 2 - Invisible Inks

Experiment 2.4 — Using a chemical developer for invisible ink

- **iodine solution from experiment 2.5**
- **conical flask**
- **crystallising dish**
- **filter paper**
- **dropping pipette**
- **artists paint brush**
- **small plate**
- **spray starch**

Collect some starch from a Spray Starch spray in a small container (for example a mug or a bowl). It is likely that it will be a foam. Let the foam settle and then pour the solution into the crystallising dish and write on a filter paper with the paint brush. Let the writing dry. While the writing is drying carry out Experiment 2.5 to make the iodine solution which you will need as the developer.

When the writing is dry put 30ml of water into the conical flask. Add 10 drops of iodine solution using the dropping pipette. Pour a little of this iodine solution onto a small plate. Drop the filter paper into the iodine and the writing will magically appear.

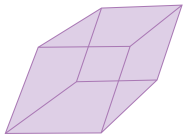
What colour is it?

Experiment 2.5 — Using a chemical developer for invisible ink

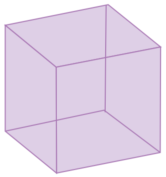
- **potassium iodide**
- **sodium hydrogen sulphate**
- **hydrogen peroxide solution**
- **test tube**
- **small clean dry bottle**

Put ½ measure of potassium iodide and ¼ measure of sodium hydrogen sulphate into a clean dry test tube and add about 2cm of water. Add 10 drops of hydrogen peroxide solution; yellow-brown iodine will be formed. Add water until the test tube is half full. Carefully pour this solution into a bottle. **Label it "Iodine Solution". THIS IS VERY IMPORTANT.**

Chapter 3 - Crystal Chemistry



Rhombohedral



Cubic

Long needle

In Experiment 1.5 you made some crystals of copper sulphate. Crystals are solid substances in which all the particles are arranged in a regular pattern. Crystals can be many different shapes, some are simple shapes like cubes, rhombohedra or long needles.

Crystals form in **solutions** when the solution contains as much of the substance (the **solute**) as it can dissolve. The solution is said to be **saturated** with the solute. Any excess amount of solute that is present in the solution forms **crystals**. As most substances increase in solubility as the temperature is increased, one way to form crystals is to start with a hot saturated solution and let it cool. As it cools the amount of solute needed to keep the solution saturated decreases and the excess is deposited out of solution as crystals. Crystals formed in this way are usually small ones.

The other way to form crystals, and the way that must be used if big crystals are wanted, is to start with a saturated solution and to let the solvent slowly evaporate away. As it does so the excess solute is deposited as crystals. A general rule for crystal growing is that **the slower the crystals grow the bigger they will be**.

Using the chemicals supplied with this Chemistry Lab you can grow big crystals if you are patient and let them grow over several days. To grow really big crystals you will need to buy more chemicals.

Chapter 3 - Crystal Chemistry 3a - Growing Crystals

Experiment 3.1 Copper sulphate crystals

- **copper sulphate**
- **test tube**
- **conical flask**
- **crystallising dish**
- **pencil**

Put 8 measures of copper sulphate into a clean conical flask and add 3cm of water from a test tube. Gently warm the conical flask until all the copper sulphate has dissolved. Pour the solution into a crystallising dish and leave it somewhere warm for several days until all the water has evaporated away. If possible prop up one side of the crystallising dish, say with a pencil, so the solution is not spread too thinly over the bottom of the dish.

You will have formed some large blue copper sulphate crystals. Grown in this way crystals do not have a regular shape, but look carefully at them (use a magnifying glass if you have one) and decide which of the 3 shapes shown opposite do copper sulphate crystals most resemble?

You can redissolve the crystals in water and grow them again if you wish. If you grow a lot of small crystals and want to grow bigger ones, try growing them where it is not so warm, the water takes longer to evaporate away and they grow bigger.

Do not throw the crystals away when you have finished crystal growing. Put the crystals somewhere warm until they are thoroughly dry and return them to your copper sulphate container.

Experiment 3.2 Aluminium potassium sulphate crystals

- **aluminium potassium sulphate**
- **test tube**
- **conical flask**
- **crystallising dish**
- **pencil**

Repeat Experiment 3.1 using 8 measures of aluminium potassium sulphate in place of copper sulphate, and 6cm of water instead of 3. Which of the 3 shapes shown opposite do aluminium potassium sulphate crystals most resemble?

Experiment 3.3 Sodium sulphate crystals

- **sodium sulphate**
- **test tube**
- **crystallising dish**
- **pencil**

Put 4 measures of sodium sulphate in a clean dry test tube and add 3cm of water. Heat the solution until it just boils and pour it into a crystallising dish, leaving any residue in the test tube. Put the crystallising dish somewhere warm for several days until all the water has evaporated away. If possible prop up one side of the crystallising dish, say with a pencil, so the solution is not spread too thinly over the bottom of the dish. Sodium sulphate crystals will be left in the crystallising dish when all the water has evaporated away. Initially the crystals are colourless but they quickly become white as they lose some of their **water of crystallisation**. This process is called **efflorescence**.

Which of the 3 shapes shown opposite do sodium sulphate crystals most resemble?

Experiment 3.4 — Sodium chloride crystals

- **sodium chloride**
- **test tube**
- **conical flask**
- **beaker**
- **funnel**
- **drinking glass**

Fill 6cm of a test tube with solid sodium chloride. Use the funnel to transfer it from the test tube into the conical flask. Add 20ml of hot water (measured in your beaker). Gently shake the flask to help the sodium chloride dissolve. It may not all do so. Allow the solution to cool.

Pour the solution into a glass container with a clear bottom (a drinking glass is ideal) and leave it somewhere warm.

Look at the container each day. You will see crystals of sodium chloride forming in the bottom of the container (some may also form on the surface)

Which of the 3 shapes shown on page 22 do sodium chloride crystals most resemble? You can see the crystals more clearly if you look up at the bottom of the container.

Experiment 3.5 — Magnesium sulphate crystals

- **magnesium sulphate**
- **beaker**
- **test tube**
- **small saucepan**
- **glass container**

There is a sample of magnesium sulphate in the Chemistry Lab, but to carry out this experiment you will need to buy more. It is sold as Epsom Salts. Magnesium sulphate has this name because it is an important chemical in drinking water, that was first found in spring water at Epsom in Surrey over 300 years ago in 1695.

Put half a beaker-full (60g) of magnesium sulphate into a small saucepan and add 3 test tube-fulls (60ml) of water. Heat, whilst stirring, until the magnesium sulphate has dissolved. Allow it to cool and then pour it into a glass container. Put this to stand undisturbed in a warm place. As the water evaporates away a mass of clear ice-like crystals of magnesium sulphate are formed. Which of the 3 shapes shown on page 22 do magnesium sulphate crystals most resemble?

Sometimes magnesium sulphate crystallises as big crystals over a period of time, sometimes as small crystals quickly. Exactly what will happen will depend on the conditions, such as how slowly the solution cools, how warm it is where you are keeping it, and how much it gets disturbed. If small crystals grow, try again. You can safely experiment using a slightly larger or slightly smaller quantity of magnesium sulphate.

Experiment 3.6 — Ammonium chloride crystals

- **ammonium chloride**
- **test tube**
- **crystallising dish**
- **dropping pipette**
- **small mirror or piece of glass**

Put ½ measure of ammonium chloride into a clean dry test tube, add 2cm of water, and shake the test tube until the ammonium chloride has dissolved. Pour the solution into a crystallising dish. Use the dropping pipette to put some of the solution onto a small mirror or a piece of clean glass. Put the mirror somewhere warm for the water to evaporate.

You can clearly see ammonium chloride crystals on the mirror. Which of the 3 shapes shown on page 22 do ammonium chloride crystals most resemble? Their beauty is best seen if you look at them through a magnifying glass.

Experiment 3.7 — Sodium thiosulphate crystals

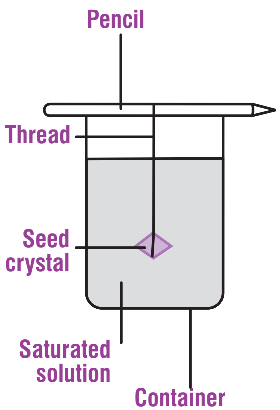
- **sodium thiosulphate**
- **test tube**

Put 9 measures of sodium thiosulphate into a clean dry test tube. Gently heat the crystals moving the test tube continually in the burner flame. Continue heating until all the solid has melted. **Put the HOT test tube into an empty beaker and allow it to cool**. The cold liquid has more solid dissolved in it than it can hold, it is **supersaturated**.

Get 1 small crystal of sodium thiosulphate and hold the test tube level with your eye. Drop the crystal into the liquid. Watch carefully and describe what you see.

Experiment 3.8 Growing large crystals

- aluminium potassium sulphate
- saucepan
- glass container
- sewing thread
- pencil



Note: The are insufficient chemicals supplied in your lab to carry out this experiment. Before you can carry out this experiment you need to buy more aluminium potassium sulphate or copper sulphate from a chemical supplier.

To grow really large crystals you need to suspend a small one (known as the **seed crystal**) in a **saturated** solution of the chemical and let the water slowly evaporate away. As it does so the chemical will grow as one large crystal on the seed crystal. The best chemicals for growing large crystals are aluminium potassium sulphate and copper sulphate. The method is described here for aluminium potassium sulphate; you can substitute copper sulphate if this is the crystal that you are growing.

First you need a seed crystal of aluminium potassium sulphate which you have grown as in Experiment 3.2 (If you are working with copper sulphate then the seed-crystal will be grown by Experiment 3.1).

Get a suitable container (e.g. an egg cup, a drinking glass or a jam jar) the size of which will depend on the amount of the aluminium potassium sulphate that you have available. Measure the volume of the container that you are using.

You now need a saturated solution of aluminium potassium sulphate that will fill your container. Prepare this by measuring into a small saucepan 32g of aluminium potassium sulphate and 1 measure of sodium hydrogen sulphate (to keep the solution acidic and prevent decomposition of the aluminium potassium sulphate) for every 100g (100ml) of water. (It is best to weigh the aluminium potassium sulphate but, if this is not possible, 32g is 1 test tube-full plus another 6cm in the test tube.) Gently heat and stir the solution until all the aluminium potassium sulphate has dissolved. When cool enough pour the solution into the container and leave it for 24 hours. Some aluminium potassium sulphate crystals should be formed, leaving a saturated solution. Filter, or carefully pour, off this solution into another temporary container and wash and dry the container in which you are going to grow the crystal. One of the crystals deposited during this initial cooling may be a suitable seed crystal.

If you are growing a copper sulphate crystal then you need to add 60g of copper sulphate and 1 measure of sodium hydrogen sulphate for every 100g (100ml) of water. (60g of copper sulphate is 2 test tubes-full.) Tie a piece of sewing thread around your seed crystal. Tie the other end of the thread around a pencil, or lolly stick so that the seed crystal hangs in the middle of the container. Carefully fill the container with the cold saturated solution and hang the seed crystal in place. Put the container where it will not be disturbed. Somewhere where the temperature does not change much from day to night is best, otherwise the crystal may grow during the cold night and dissolve again during the warm day! A good tip is to grow the crystal only at night when the temperature is falling. Each morning take the crystal out of the solution and lay it on a piece of paper towel. Each night put it back into the solution. A large crystal will grow over a period of several weeks. Take it out of the solution from time to time to look at it and to remove any small crystals that are growing on it and on the thread. If small crystals grow on the sides and bottom of the container pour out the solution, wash and dry the container and refill it, then continue the experiment.

In this way over a period of weeks and months very large crystals can be grown. It is easy to grow crystals but difficult to grow perfect big crystals. Sometimes you may see competitions for crystal growing. If you are interested in crystal growing you can buy a book on crystals and crystal growing and get the chemicals from a chemical supplier. Or you could start by buying a Crystal Growing Kit.

Chapter 3 - Crystal Chemistry 3b - Water of crystallisation

Experiment 3.9 — Does a substance contain water of crystallisation?

- magnesium sulphate
- aluminium potassium sulphate
- sodium chloride
- sodium sulphate
- test tubes

Put ½ measure of magnesium sulphate into a clean dry test tube. Heat the solid in the burner flame and look carefully at what happens. Do you see any water vapour coming off from the magnesium sulphate and condensing on the cool upper parts of the test tube? This water is part of the magnesium sulphate crystal. It is called water of crystallisation. Record in your notebook that magnesium sulphate contains **water of crystallisation**.

Repeat this experiment with aluminium potassium sulphate, sodium chloride and sodium sulphate. Do these substances contain water of crystallisation?

Experiment 3.10 — Heating blue copper sulphate crystals

- copper sulphate
- test tube
- dropping pipette

Put ½ measure of blue copper sulphate into a clean dry test tube. This contains water of crystallisation. Heat the test tube gently and record what you see happening. Do you see any water condensing on the upper parts of the test tube? The solid left behind is **anhydrous** copper sulphate. What colour is it? Put the HOT test tube into an empty beaker to cool.

When the tube is cool add one or two drops of water with the dropping pipette to the white copper sulphate solid in the test tube. Does it change colour? What to?

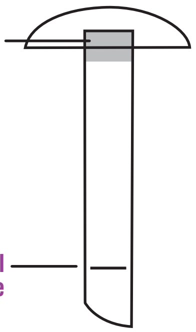
This colour change is a test for water. No other liquid makes anhydrous copper sulphate change colour.

Chapter 4 - Paper Chromatography

Paper chromatography is a method of separating two or more substances. It is particularly useful if the substances are coloured.

Experiment 4.1 — The analysis of black and green food colourings

- black & green food colouring
- test tube
- conical flask
- large filter paper
- sellotape
- pair of scissors
- pencil
- small paint brush or dropping pipette



Here we use filter paper to make a chromatogram. One filter paper can be used for 4 chromatograms. 1 filter paper can be used for 4 chromatograms.

Cut four 1½ cm wide strips from the widest part of a large (11cm) filter paper. Stick a second piece cut from the waste filter paper across the top as in the diagram. Draw a pencil line 2cm from the bottom end of each strip.

Put 3 strips aside for other experiments. Use the paint brush to paint a line of black food colouring on the pencil line, or add 2 drops of the colouring in the middle of the line using the dropping pipette. Put a test tube full of water in the conical flask and hang the strip in the flask. The colouring will be just above the water, which will rise up the paper taking the colouring with it, and separating the different dyes that make up the black food colouring.

Stop the experiment when the water reaches the top of the filter paper strip. Dry the chromatogram and label it. Describe what it shows.

Repeat the experiment using green food colouring.

The two food colourings have listed on their labels the single dyes which they contain. Do your paper chromatograms agree with what is given on the labels?

Experiment 4.2 — The analysis of inks

- black felt-tipped pen
- other inks or felt-tipped pens
- test tube
- conical flask
- large filter paper
- sellotape
- pair of scissors
- pencil
- small paint brush or dropping pipette

Use the method given in Experiment 4.1 to analyse black fountain pen ink. What colour dyes does the ink contain?

Repeat the experiment using a black felt-tipped pen.

Does this contain the same coloured dyes as the black ink?
Try the experiment with other inks or felt-tipped pens. Some colours will be just a single dye, others will be mixtures. Try several colours, for example red, green, blue, purple and brown felt-tipped pens. Do many of those that you try contain a single dye?

Chapter 5 - Acids and alkalis
5a - Making acid and alkali solutions

Solutions of acids and of alkalis must be handled with care. Always wash your hands if you spill any of the solutions on you. Always wear your goggles – ESPECIALLY WHEN HEATING ACID OR ALKALI SOLUTIONS.

The word "acid" is commonly used in everyday life where it is usually regarded as a dangerous liquid that eats away metal and burns your skin, it is said to be "corrosive". An acid is not necessarily corrosive, but they should all be treated with care. You will read in chemistry books that acids all have a sour taste and turn blue litmus red. An alkali is the opposite to an acid. We shall see that an alkali reacts with an acid to give water and a salt. The alkali neutralises the acid: acid + alkali ⟶ water + salt.

Experiment 5.1 — Making sodium hydrogen sulphate solution

- **sodium hydrogen sulphate**
- **conical flask**
- **test tube**
- **funnel**
- **small clean bottle**
- **label**

Sodium hydrogen sulphate is an acidic salt. You will need a solution of it for many of the experiments.

Put 8 measures of sodium hydrogen sulphate into a clean dry conical flask and add a test tube full of water. Gently shake and warm to dissolve. Now add a second test tube full of water.

Carefully pour the solution into a clean dry bottle, using the funnel if necessary. Add 2 more test tubes-full of water into the bottle. **Label the bottle - THIS IS VERY IMPORTANT.**

Experiment 5.2 — Making lime water

- **calcium hydroxide**
- **small clean bottle**
- **label**

Lime water is a solution of calcium hydroxide.

Put 2 measures of calcium hydroxide into a bottle and add 80ml of water, measured in the beaker. Put the cap on the bottle and shake for a minute or so. Leave it to stand and the solid particles of the calcium hydroxide which remain will settle leaving a clear solution. This clear solution is lime water. To use carefully pour off the clear solution. **Label the bottle - THIS IS VERY IMPORTANT.**

Experiment 5.3 — Making sodium carbonate solution

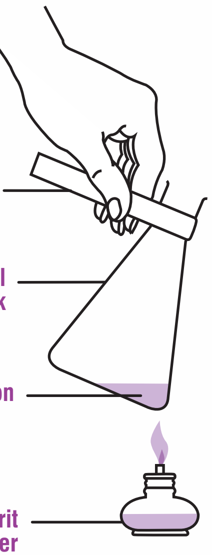
- **sodium carbonate**
- **beaker**
- **conical flask**
- **funnel**
- **filter paper**
- **wooden lolly stick**
- **small clean bottle**
- **label**

Add 3 measures of sodium carbonate to 50ml of warm water in the beaker. Stir the solution with a wooden stick until all the solid has dissolved. Filter the milky solution into the conical flask through a filter paper. Pour the solution into an empty bottle. **Label the bottle - THIS IS VERY IMPORTANT.**

Chapter 5 - Acids and alkalis
5a - Making acid and alkali solutions

Experiment 5.4 — Making sodium hydroxide solution

- **sodium carbonate**
- **calcium hydroxide**
- **test tube**
- **beaker**
- **conical flask**
- **funnel**
- **filter paper**
- **half a sheet of A4 paper**
- **small clean bottle**
- **label**



You make sodium hydroxide solution by reacting together sodium carbonate and calcium hydroxide. Calcium carbonate is formed as an insoluble solid, leaving sodium hydroxide in the solution.

Put 3 measures of sodium carbonate and 3 measures of calcium hydroxide in a clean conical flask. Add a test tube full of water, and gently shake and heat the flask over the burner for about 5 minutes. (As the flask will get hot you need to make a holder for it. Do this by cutting an A4 sheet of paper in half to give a piece 15cm x 21cm, and then folding this over 3 times to form a strip about 2cm x 21cm.

Put this strip round the neck of the flask and hold the paper strip near to the flask). Get the solution quite hot but do not boil it. **If you get any of the solution onto your hand then wash it off immediately.**

Carefully pour the solution into the beaker. Add a second test tube-full of water to the conical flask, swirl it round and pour this also into the beaker.

Wash the conical flask and filter the solution back into it. Carefully pour the clear solution from the conical flask into a clean empty bottle. Put a third test tubeful of water into the bottle. **Label the bottle - THIS IS VERY IMPORTANT.**

Experiment 5.5 — To show that acids have a sour taste and are neutralised by alkalis

- a lemon
- citric acid
- sodium hydrogen carbonate (sodium bicarbonate)
- a plate
- an egg cup

Normally you should NEVER TASTE a chemical. However some chemicals that are in our food are obviously safe to taste. One such chemical is citric acid. This is the acid in most citrus fruits such as oranges and lemons. It is also put into many sour tasting sweets and fizzy drinks.

An alkali which we can eat is sodium hydrogen carbonate (sodium bicarbonate). This is used in cooking to make cakes rise and in stomach powders that are taken if you have indigestion.

Squeeze a lemon and taste the juice. Does it taste sharp and sour? This is due to the citric acid in the lemon.

Put a little citric acid and a little sodium hydrogen carbonate (sodium bicarbonate) onto a plate. Wet a clean finger, dip it into the citric acid and taste it. Does it have the same sharp taste as the lemon juice?

Now do it again and immediately after putting the citric acid on your tongue dip your finger in the sodium hydrogen carbonate and taste it. Has the sharp citric acid taste disappeared?

You can do a similar experiment by putting a little lemon juice into an egg cup. Taste the lemon juice and then add a little sodium hydrogen carbonate (sodium bicarbonate) and taste again. Keep doing this until the sharp taste of the lemon juice has disappeared.

Why do you think citric acid has this name?

Experiment 5.6 — Using litmus to test for acids and alkalis

- litmus blue
- citric acid
- sodium hydrogen carbonate (sodium bicarbonate)
- test tube

Dissolve a "pinch" (less than ¼ measure) of litmus blue in 2cm of water in a test tube. Warm the tube to dissolve the litmus blue. Add ¼ measure of citric acid. The blue colour changes to red.

Now add ½ measure of sodium hydrogen carbonate (sodium bicarbonate) and shake the tube. Does the colour go back to blue? If not add more sodium hydrogen carbonate until it does.

The litmus is red in acidic solution and blue in alkaline solution. It is acting as an **acid-alkali indicator**.

Experiment 5.7 — Home made indicators - red cabbage & turmeric

- citric acid
- sodium hydroxide solution
- red cabbage
- turmeric
- saucepan
- beaker
- conical flask

Many common vegetables and flowers contain acid-alkali indicators. The substance that gives red cabbage its colour is an indicator.

Chop up a little red cabbage and gently boil it in water for 10 minutes or so. Let the deep purple water cool and pour some into your beaker.

Dissolve ½ measure of citric acid in 2cm of water in a test tube and pour it into the conical flask. Add 1cm of red cabbage water. What colour is the solution? Add 2cm of your sodium hydroxide solution. What colour is the indicator now? As in the previous experiment you can continually change the colour backwards and forwards as the solution changes from acidic to alkaline.

Repeat the experiment using a solution of the spice turmeric as the indicator. What are the colours of turmeric in acid and alkalis?

Experiment 5.8 — Other home made indicators

- citric acid
- sodium hydroxide solution
- beetroot
- blackberry juice
- red rose or red carnation
- saucepan
- beaker
- conical flask

Other coloured vegetables and flowers can be used as indicators. Beetroot indicator is made in an identical way to that used for red cabbage in Experiment 5.7, and can be tested as in Experiment 5.7.

Blackberry juice can also be used as an indicator. A red rose or a red carnation can be boiled in a little water in a saucepan. Let the water cool and use it as an indicator.

For most of these vegetable and flower indicators the colour in acid is usually red. In alkali the colour may be yellow, blue, green or purple.

Experiment 5.9 Using universal indicator paper

- **universal indicator paper**
- **sodium hydrogen sulphate**
- **solution lime water**
- **sodium carbonate solution**
- **sodium hydroxide solution**
- **tartaric acid**
- **citric acid**
- **sodium hydrogen carbonate (sodium bicarbonate)**
- **aluminium potassium sulphate**
- **iron sulphate**
- **test tubes**
- **dropping pipette**
- **white plate**

Chemists often need to test for acids or alkalis, and indicators that have been soaked onto filter paper and dried are usually used. The most useful is called **universal indicator paper**. This indicator not only shows the presence of an acid or alkali but also shows its strength. The colour of the universal indicator changes from red to violet (in the order that the colours are in a rainbow) from strong acid solution to strong alkali solution. These colours are shown on the covers of the book of universal indicator papers. They are: red (strong acid), orange (weak acid), yellow (weaker acid), green (neutral), blue (weaker alkali), indigo (weak alkali), violet (strong alkali).

To test with universal indicator paper cut one of the strips into about 8 pieces and spread them out on a white plate. To test a liquid put 1 drop with the dropping pipette onto a piece of the universal indicator paper.

Test the following liquids and record your results as acid, alkali or neutral (neither acid or alkali) from the colour of the universal indicator paper.

1. Your solution of sodium hydrogen sulphate.
2. Your solution of lime water.
3. Your solution of sodium carbonate.
4. Your solution of sodium hydroxide.
5. Tap water.
6. ¼ measure of tartaric acid in 1cm water.
7. ¼ measure citric acid in 1cm water.
8. ½ measure sodium hydrogen carbonate (sodium bicarbonate) in 2cm water.
9. ¼ measure aluminium potassium sulphate in 1cm water.
10. ¼ measure iron sulphate in 1cm water.

Check your results with the answers at the back of this booklet and if you do not agree do the test again.

Experiment 5.10 Testing household chemicals with universal indicator

- **universal indicator paper**
- **test tubes**
- **dropping pipette**

Repeat Experiment 5.9 with various household chemicals. Test the ones given here if you have them and any others that you can find around your house.

1. Lemon juice
2. Vinegar
3. Sparkling water
4. Laundry detergent dissolved in water
5. A vitamin C tablet dissolved in water
6. A soluble aspirin tablet dissolved in water
7. Sugar dissolved in water
8. Gin, whisky or brandy (just a drop) – ask an adult to supply this.

Record your results as acid, alkali or neutral depending on the colour of the universal indicator paper.

Experiment 5.11 Testing the soil from a garden

- **universal indicator paper**
- **dropping pipette**
- **cup**

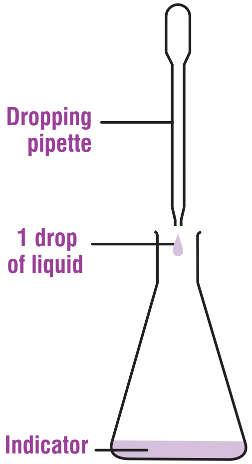
It is important for a gardener to know whether the soil is acid or alkaline, as some plants will only grow in acid soil and some in alkaline soil.

Dig a little soil from a garden. Do not take the surface soil, but go down a few centimetres. Add about a dessertspoonful of soil to twice as much water in a cup or mug. Stir the mud and leave it to settle overnight. Take a sample of the clear liquid with your dropping pipette and test it on a piece of universal indicator paper.

Chapter 5 - Acids and alkalis
5b - Testing for acids and alkalis

Experiment 5.12 — Neutralisation of an acid with an alkali using universal indicator

- universal indicator paper
- citric acid
- sodium hydrogen carbonate (sodium bicarbonate)
- sodium hydrogen sulphate solution
- sodium carbonate solution
- 2 test tubes
- conical flask
- 2 crystallising dishes
- dropping pipette



The indicator chemicals in a piece of indicator paper can be dissolved in water and used in solution. Tear a piece of universal indicator paper into several pieces and put them into a clean conical flask. Add 2cm of water from a test tube. Gently shake to dissolve the indicator from the paper, a green solution will be formed. Stand the conical flask on a piece of white paper so the colour of the indicator shows clearly.

Dissolve ½ measure of citric acid in 5cm of water in a test tube and pour the solution into a crystallising dish. Dissolve ½ measure of sodium hydrogen carbonate (sodium bicarbonate) in 5cm of water in a second test tube and pour this solution into a second crystallising dish.

Using the dropping pipette add 10 drops of the sodium hydrogen carbonate to the indicator. What colour is the indicator?

Wash the dropping pipette and use it to add the citric acid solution DROP BY DROP into the conical flask. Gently shake the flask after each drop and note the colour of the indicator. Suddenly the colour will change over one or two drops and remain the same as more citric acid is added. What colour is the solution now?

Repeat the experiment using sodium hydrogen sulphate solution instead of citric acid and sodium carbonate solution instead of sodium hydrogen carbonate. What are the colours of the indicator in sodium carbonate solution and in sodium hydrogen sulphate solution?

Try to explain what has happened as the indicator has changed colour from its original colour, to that with sodium hydrogen carbonate, that with citric acid, that with sodium carbonate and that with sodium hydrogen sulphate.

Chapter 6 - Chemical reactions of acids and alkalis
6a - Reactions of acids with metals

Acids contain hydrogen. When metals react with acids the hydrogen is released as hydrogen gas. The word equation for the reaction that takes place is: Acid + metal ⟶ hydrogen + salt.

Experiment 6.1 — The reaction of magnesium with an acid

- magnesium strip
- vinegar
- test tube
- matches

In Experiment 5.11 you found that vinegar is acidic. It contains an acid called ethanoic acid.

Add a 2cm piece of magnesium strip to 2cm of vinegar in a test tube. Tiny bubbles of hydrogen gas can be seen coming from the surface of the magnesium. This is hydrogen gas. Warm the test tube so that there is a vigorous reaction. **Loosely** put one of the red caps (not a cork) into the test tube and stand the test tube in the test tube rack. Wait for 30 seconds (count to 30). Light a match, remove the cap and immediately hold the match flame in the top of the test tube. There is a very tiny explosion as the hydrogen gas quickly burns with a POP. This is the test for hydrogen gas. If this doesn't happen repeat the experiment.

NOTE: It is perfectly safe to burn a test tube full of hydrogen gas, but you must NEVER try this experiment in a bigger container. You could break the container and do damage.

The word equation for the reaction that has taken place is: magnesium + ethanoic acid ⟶ hydrogen + magnesium ethanoate.

Experiment 6.2 — The reaction of zinc with an acid

- granulated zinc
- sodium hydrogen sulphate solution
- 2 test tubes
- funnel
- filter paper
- crystallising dish

Add 2 pieces of granulated zinc to 2cm of your sodium hydrogen sulphate solution (made in Experiment 5.1) in a test tube. Warm the test tube. Bubbles of hydrogen gas will be seen coming from the surface of the zinc. Warm the solution to increase the rate of the reaction. You can try capping the tube and collecting and burning the hydrogen as in Experiment 6.1, but the reaction here is not so vigorous and you will probably be unsuccessful.

Keep periodically warming the tube and keep it in the test tube rack for half an hour or so when no more hydrogen should be being formed. This means that all the acid has been used up.

The word equation for the reaction that has taken place is: zinc + sodium hydrogen sulphate ⟶ hydrogen + sodium sulphate + zinc sulphate.

Filter off the remaining zinc, wash it and return it to its container. The sodium sulphate and zinc sulphate are in the filtrate. Pour this into a crystallising dish and let the water evaporate off in a warm place leaving a mixture of sodium sulphate and zinc sulphate crystals.

6a - Reactions of acids with metals

Experiment 6.3 — The reaction of iron with an acid

- **iron filings**
- **sodium hydrogen sulphate solution**
- **2 test tubes**
- **funnel**
- **filter paper**
- **crystallising dish**

Repeat Experiment 6.2 using 1 measure of iron filings instead of the zinc. The crystals that you obtain are a mixture of sodium sulphate and iron sulphate.

Write a word equation for this reaction.

Experiment 6.4 — The reactions of aluminium & copper with an acid

- **aluminium foil**
- **copper foil**
- **sodium hydrogen sulphate solution**
- **test tube**
- **test tube holder or wooden clothes peg**
- **clay pot**

Cut a 2cm square piece of aluminium foil into small pieces and put them into a clean dry test tube. Add 2cm of your sodium hydrogen sulphate solution. Add a piece of clay pot. Carefully boil the solution and look at it very carefully. What do you see? If you do not see any reaction heat the test tube again and be patient.

Repeat the experiment with a 1cm square of copper foil instead of aluminium foil. Again look carefully. What do you see?

You have now studied the reactions of acids with 5 metals: aluminium, copper, iron, magnesium and zinc. Put these metals in the order of their reactivity with acid.

6b - Reactions of alkalies & water with metals

Only the most reactive metals react with alkalis and with water.

Experiment 6.5 — The reactions of aluminium with sodium hydroxide & sodium carbonate

- **aluminium foil**
- **sodium hydroxide solution**
- **sodium carbonate solution**
- **2 test tubes**

Cut up a 2cm square of aluminium foil into small pieces and put them into a clean dry test tube. Add 2cm of sodium hydroxide solution. Gently warm the solution and look carefully at the aluminium foil. What do you think the gas is that is being formed?

You can test to show that it is hydrogen gas by burning it as you did in Experiment 6.1.

Sodium carbonate is also an alkali. Repeat the experiment using your sodium carbonate solution instead of sodium hydroxide.

Experiment 6.6 — The reaction of magnesium with water

- **magnesium strip**
- **test tube**
- **test tube holder or wooden clothes peg**
- **clay pot**

Only very reactive metals react rapidly with water. Magnesium is the most reactive metal that you have.

Put 2cm of shiny magnesium strip into a clean dry test tube and add 2cm of water. Magnesium is a shiny metal. The strip you have may have reacted with impurities in air and have a black surface. Clean this off with some fine emery or sand paper to show the clean shiny surface.

Add a piece of clay pot, briefly boil the water and look carefully at the magnesium. What do you see? If you see nothing happening, boil the solution again and be patient.

Chapter 6 - Chemical reactions of acids and alkalis
6c - Reactions of acids with oxides & carbonates

When a metal oxide reacts with an acid the products are a salt and water. The word equation for the reaction is: metal oxide + acid ⟶ salt + water.

Experiment 6.7 — The reaction of copper oxide with acid

- **copper oxide**
- **sodium hydrogen sulphate solution**
- **2 test tubes**
- **test tube holder or wooden clothes peg**
- **clay pot**
- **funnel**
- **filter paper**
- **large evaporating spoon**
- **crystallising dish**

Put ½ measure of copper oxide in a clean dry test tube and add 2cm of your sodium hydrogen sulphate solution. Add 2 small pieces of clay pot. Boil the solution carefully, holding the tube in a test tube holder or a wooden clothes peg. The clay pot will help the solution to boil smoothly, but it can still spit and spurt out. WEAR YOUR GOGGLES and ensure that the test tube is not pointing at anyone. Boil the solution for about 5 minutes, adding more water if the amount gets too low. Put the test tube in the test tube rack and let the black copper oxide settle. What is the colour of the solution?

Filter off the excess copper oxide, wash it in the filter paper with water and let the washings go in with the filtrate. What is the substance in the filtrate that makes it pale blue? Concentrate this solution by boiling off most of the water in your large evaporating spoon. Only fill the spoon about half full and keep adding more solution from the test tube as the water boils away. When you have a tiny volume of water left, pour it into a crystallising dish and leave it somewhere warm for the mixture of copper sulphate and sodium sulphate to form crystals as the water slowly evaporates away.

When a metal carbonate reacts with an acid it forms a salt, water and carbon dioxide. The word equation for the reaction is: metal carbonate + acid ⟶ salt + water + carbon dioxide.

Experiment 6.8 — The reactions of carbonates with acids

- **sodium carbonate**
- **sodium hydrogen sulphate solution**
- **test tube**
- **indigestion tablet**

Put ½ measure of sodium carbonate into a test tube and add 2cm of your sodium hydrogen sulphate solution. A violent fizzing occurs as carbon dioxide gas is formed.

Repeat the experiment with 1 measure calcium carbonate instead of sodium carbonate.

Repeat the experiment again, this time with a crushed up indigestion tablet, or a little indigestion powder (not one that fizzes when you add water).

What makes some indigestion tablets fizz when you add water?

Chapter 7 - Other chemical reactions
7a - Reactions which give insoluble substances

Often when solutions of two chemicals are mixed a solid substance if formed. The solid is called a precipitate.

Experiment 7.1 — The formation of copper carbonate

- **copper sulphate**
- **sodium carbonate solution**
- **2 test tubes**
- **funnel**
- **filter paper**
- **small container**
- **label**

Dissolve ½ measure of copper sulphate in 1cm of water in a test tube. Add 2cm of your sodium carbonate solution. A blue-green precipitate of copper carbonate is obtained. Filter it off and dry it as described in Experiment 1.6. Put the copper carbonate in a container, label it and keep it for using in Experiment 8.6.

Experiment 7.2 — The formation of magnesium carbonate

- **magnesium sulphate**
- **sodium carbonate solution**
- **sodium hydrogen sulphate solution**
- **test tube**

Dissolve ½ measure of magnesium sulphate in 1cm of water in a test tube. Add 2cm of your sodium carbonate solution. A white precipitate of magnesium carbonate is formed. Magnesium carbonate readily dissolves in acids. Add a little of your sodium hydrogen sulphate solution and the precipitate will disappear.

Experiment 7.3 — The formation of aluminium hydroxide

- **aluminium potassium sulphate**
- **sodium hydroxide solution**
- **sodium hydrogen sulphate solution**
- **2 test tubes**

Dissolve ½ measure of aluminium potassium sulphate in 1cm of water in a test tube. Add sodium hydroxide solution drop by drop with the dropping pipette. A white precipitate of aluminium hydroxide is formed. This shows an unusual property; it will dissolve in both acids and alkalis. It is said to be **amphoteric**.

Pour half of the solution and precipitate into a second test tube. Add a little acid (use your sodium hydrogen sulphate solution) to one test tube of aluminium hydroxide, and a little alkali (use your sodium hydroxide solution) to the other test tube. The precipitate dissolves in both tubes. In the acid the aluminium hydroxide forms aluminium sulphate and in the alkali the aluminium hydroxide forms sodium aluminate.

Chapter 7 - Other chemical reactions
7a - Reactions which give insoluble substances

Experiment 7.4 — The formation of iron hydroxides

- iron sulphate
- sodium hydroxide solution
- 2 test tubes
- funnel
- filter paper

Dissolve ½ measure of iron sulphate in 1cm of water in a test tube. Add 2cm of sodium hydroxide solution. A precipitate of iron (II) hydroxide is formed. What colour is it?

Filter off this precipitate. Open up the filter paper and leave it for an hour or so. What colour is the precipitate now that it has been exposed to air?

Experiment 7.5 — The formation of sulphur

- sodium thiosulphate
- sodium hydrogen sulphate solution
- test tube

Dissolve ½ measure of sodium thiosulphate in 2cm of water in a test tube. Add 2cm of sodium hydrogen sulphate solution. The white milky precipitate formed is fine particles of sulphur.

Experiment 7.6 — The formation of copper sulphide

- sodium thiosulphate
- copper sulphate
- 2 test tubes
- test tube holder or wooden clothes peg
- clay pot

Warm ½ measure of sodium thiosulphate in 1cm of water in a test tube to give a clear solution. Wait until the solution is cool, or cool it under a running tap.

Dissolve ½ measure copper sulphate in 1cm of water in a second test tube and add the solution to the sodium thiosulphate solution. The blue colour will disappear.

Add a piece of clay pot and boil the solution. The solution will turn yellow, brown and then black as copper sulphide is formed.

Chapter 7 - Other chemical reactions
7b - Reactions which give metals

In Chapter 6 we saw that some metals react more readily than others. If a reactive metal (let us call it A) is added to a salt of a less reactive metal (let us call it B) then a metal salt of A is formed and the metal B, that was originally in the salt, is seen as a precipitate or as a coating on metal A. The word equation for the reaction is: metal A + salt of metal B ⟶ metal B + salt of metal A. Metal A replaces metal B.

Experiment 7.7 — The formation of magnesium carbonate

- copper sulphate
- small iron nail
- test tube
- cotton thread

Dissolve ½ measure of copper sulphate in 2cm of water in a test tube. Tie a piece of cotton thread on a small clean iron nail (clean the nail with sandpaper or emery paper if it is rusty) and put the nail in the copper sulphate solution. After 10 minutes pull it out. What has happened to the nail?

The word equation for the reaction is: iron + copper sulphate ⟶ copper + iron sulphate.

Experiment 7.8 — The replacement of copper by iron

- copper sulphate
- iron filings
- 2 test tubes
- funnel
- filter paper
- crystallising dish

Repeat Experiment 7.7 using 1 measure of iron filings instead of the nail. Leave the test tube and contents for several hours when the solution should have lost its blue colour. Filter off the solids and pour the filtrate into a crystallising dish and leave it in a warm place. Iron sulphate crystals will form. What colour are they?

Write a word equation for the chemical reaction that has happened here.

Experiment 7.9 — The replacement of copper by magnesium

- copper sulphate
- magnesium strip
- 2 test tubes
- funnel
- filter paper
- crystallising dish

Repeat Experiment 7.7 using a 2cm strip of magnesium strip (clean it with sandpaper or emery paper if it is not bright and shiny) instead of the nail. Describe what happens. Does the blue colour of the copper sulphate solution disappear as the copper is replaced by magnesium?

Leave the solution for a few hours, and then filter off the solids and crystallise the magnesium sulphate that is in the filtrate as in Experiment 7.8.

The word equation for the reaction is: magnesium + copper sulphate ⟶ copper + magnesium sulphate.

Chapter 7 - Other chemical reactions
7b - Reactions which give metals

Experiment 7.10 The replacement of copper by aluminium

- copper sulphate
- aluminium foil
- test tube
- test tube holder or wooden clothes peg
- clay pot

Repeat Experiment 7.7 using a 2cm square of aluminium foil cut in small pieces instead of the nail. Add a piece of clay pot, gently boil the solution and then remove the test tube from the flame. Look very carefully at the contents of the test tube and describe what you see. Leave the tube for an hour or so. Has the blue colour
of the copper sulphate disappeared? What has been formed?

Write a word equation for the reaction that has happened here.

See if you can recover any aluminium sulphate crystals from this reaction.

Experiment 7.11 The replacement of copper by zinc

- copper sulphate
- granulated zinc
- sodium carbonate solution
- 2 test tubes
- test tube holder or wooden clothes peg
- clay pot
- funnel
- filter paper

Dissolve 1 measure of copper sulphate in 2cm of water in a test tube. Add 2 pieces of granulated zinc. Add a piece of clay pot and gently boil the solution and then leave it for several hours until the blue colour of the solution has disappeared.

Write a word equation for the reaction that has happened here.

Filter the solution, wash the residue and add the washings to the filtrate. Add 2cm of your sodium carbonate solution to this filtrate. White zinc carbonate is precipitated. Filter this off and let it dry. Carry out a test on the zinc carbonate to show that it is a carbonate.

Experiment 7.12 The replacement of iron by magnesium

- iron sulphate,
- magnesium strip
- 2 test tubes
- funnel
- filter paper
- crystallising dish

Repeat Experiment 7.9 using iron sulphate in place of copper sulphate. Does a reaction occur?

Write a word equation for any reaction that occurs.

Experiment 7.13 The replacement of iron by aluminium

- iron sulphate
- aluminium foil
- test tube
- test tube holder or wooden clothes peg
- clay pot

Repeat Experiment 7.10 using iron sulphate in place of copper sulphate. Does a reaction occur?

Write a word equation for any reaction that occurs.

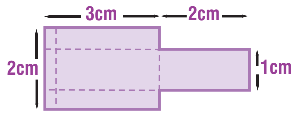
Using the results of the last 7 experiments can you say which of the metals aluminium, copper, iron, magnesium and zinc is the most reactive and which is the least reactive?

Chapter 8 - Heating substances

Substances behave in a variety of ways when they are heated. Most change to other substances. The most usual substances formed are oxides when the heated substance reacts with oxygen in the air

Experiment 8.1 Heating copper

- copper foil
- tweezers or small pliers



Cut a shape as in the diagram from a strip of copper foil about 5cm by 2cm. Fold in the 1cm flap, then fold the sides and end over it to make an envelope. Seal the edges by hammering them so that no air can get inside the envelope.

Hold the envelope in a pair of tweezers or pliers and heat it in the flame until it goes black. What is the black substance formed on the copper? Let the envelope cool and open it out. Is it black inside? Explain what you find.

Experiment 8.2 Heating an iron nail

- small iron nail
- tweezers or small pliers

Hold a shiny iron nail in a pair of tweezers or pliers and heat it in the flame for a minute or so. What happens? Explain what you find.

Experiment 8.3 Heating iron filings

- iron filings
- small evaporating spoon

Put ½ measure of iron filings into the small evaporating spoon and hold it above the flame of the burner. Gently tip the spoon so that the iron filings fall a few at a time into the flame. What happens?

Experiment 8.4 Heating aluminium foil

- aluminium foil
- tweezers or small pliers

Hold a piece of aluminium foil in a pair of tweezers or pliers and hold it in the flame. What happens? Does the aluminium foil melt?

Experiment 8.5 Heating magnesium strip

- magnesium strip
- tweezers or small pliers

Hold the end of a piece of magnesium strip about 3cm long in a pair of tweezers or pliers and put it in the burner flame. Hold it as steady as possible and be patient. The magnesium will ignite and burn with a bright white flame. Hold it over the tin tray near the burner to catch the hot ash. Do not look closely at the burning magnesium as the bright light can damage your eyes. Describe what happens. What colour is the ash?

Chapter 8 - Heating substances

Experiment 8.6 — Heating copper carbonate

- copper carbonate
- small evaporating spoon

In Experiment 7.1 you made a sample of copper carbonate.

Put the copper carbonate on the small metal evaporating spoon and heat it over the burner flame. Describe what happens. What colour is the residue in the spoon?

Look back at Experiment 6.7 to see if this contains any clues how you might check what the residue is.

Experiment 8.7 — Heating tartaric acid

- tartaric acid
- small evaporating spoon

Heat ½ measure of tartaric acid on the small evaporating spoon. What happens? Are any gases evolved. Is there a residue after heating for some time. (Tartaric acid contains carbon, hydrogen and oxygen. The carbon forms carbon dioxide gas and the hydrogen forms water vapour).

Experiment 8.8 — Heating citric acid

- citric acid
- small evaporating spoon

Repeat experiment 8.7 using citric acid. Does it behave like tartaric acid?

Experiment 8.9 — Heating ammonium chloride

- ammonium chloride
- test tube
- beaker

Put 1 measure of ammonium chloride in a test tube and heat only the bottom of the tube, gently at first and then more strongly. Describe what happens. REMEMBER THE TUBE WILL BE HOT - put it in an empty beaker until it is cool, not in the test tube rack.

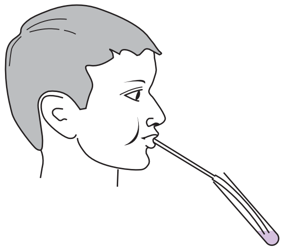
Ammonium chloride is an unusual substance in that it **sublimes**. This means that it changes from a solid straight into a gas or gases without first becoming a liquid.

Chapter 9 - The chemistry of some gases
9a - Carbon dioxide

Carbon dioxide is an important gas. It is present in air and all animals produce it when breathing, a process called respiration. It is used by plants during a process called photosynthesis when the plants use the carbon dioxide as their source of carbon.

Experiment 9.1 — To show that animals produce carbon dioxide

- lime water
- test tube
- glass & rubber tubing



Carbon dioxide can be detected by bubbling it through lime water (calcium hydroxide solution). The clear lime water turns milky due to the formation of the solid calcium carbonate.

The word equation for the reaction is: calcium hydroxide + carbon dioxide ⟶ calcium carbonate.

Put 3cm of lime water in a test tube and gently blow through it for a half a minute using the glass and rubber tubing. What happens?

Experiment 9.2 — To show that air contains carbon dioxide

- lime water
- small glass

Put a little lime water into a small glass and leave it standing for a day or so. Does the lime water turn slightly milky? What does this show you?

Experiment 9.3 — To show that carbon dioxide is an acid

- universal indicator paper
- test tube
- glass & rubber tubing

Carbon dioxide dissolves in water to give carbonic acid, as we saw in Experiment 5.11 where universal indicator paper was used.

A more accurate test is to use universal indicator in solution. Fold up 1 sheet of universal indicator paper and put it into a test tube. Add 3cm of water. Gently shake to dissolve the indicator from the paper, a green solution will be formed. Pour about half of this into another test tube.

Blow gently through the indicator in the second test tube for about 1 minute using the glass and rubber tubing. Compare the colour of the indicator with that left behind with the indicator paper. Is the one you have blown into more yellow coloured? As you saw in Chapter 5 acids turn universal indicator yellow then red. Carbon dioxide has been shown to be an acid.

Experiment 9.4 — To identify the gas in sparkling water (first experiment)

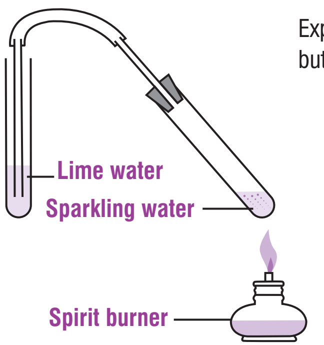
- sparkling water
- universal indicator paper
- test tube
- dropping pipette

Because carbon dioxide is an acid, with the characteristic sharp sour taste, it is used to put the fizz into sparkling water and fizzy drinks. It is also the gas in beer. In Experiment 5.11 you used universal indicator paper to test the acidity of sparkling water. You can carry out a more accurate test by using universal indicator in solution.

Pour some of the universal indicator solution left over from Experiment 9.3 into a test tube and with your dropping pipette add an equal volume of sparkling water. What is the colour of the indicator? Is it yellow showing that sparkling water is an acid? If you do not have any sparkling water you can try a fizzy soft drink, but many flavoured drinks have other acids, such as citric acid, added to them. This will interfere with this experiment.

Experiment 9.5 — To identify the gas in sparkling water (second experiment)

- sparkling water
- lime water
- 2 test tubes
- glass & rubber tubing
- test tube
- cork with hole
- test tube holder or wooden clothes peg
- clay pot



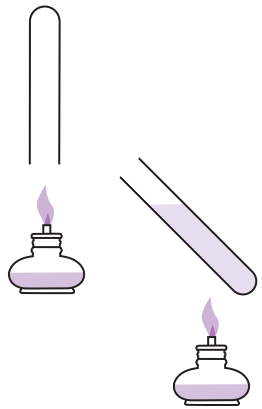
For this and later experiments you are going to need the two test tubes connected with the rubber tubing with one piece of glass tubing fitted into a test tube with a cork. Assemble this equipment. Read the section "Using Glassware" at the beginning of this booklet on how to do this. This is the "gas-tube".

Put 3 or 4cm of lime water into a test tube. Put 3 or 4cm of sparkling water (or fizzy soft drink) into a second test tube. Add a piece of clay pot. Assemble the gas-tube as shown in the diagram and heat the bottom of the test tube. The gas given off will bubble through the lime water. Describe what you see. Does the lime water go milky?

Experiment 9.4 might not work properly if you use a fizzy soft drink, but this experiment will. Why do you think this is?

Experiment 9.6 — The gases produced in a flame

- lime water
- 2 test tubes
- cork for test tube
- test tube holder or wooden clothes peg



You produce carbon dioxide by "burning" food inside you. When any carbon containing material burns it produces carbon dioxide. The methylated spirits in your spirit burner contains carbon.

Have ready a cork (NOT a plastic stopper) for a test tube. Using a test tube holder or a wooden clothes peg hold a clean dry test tube upside down about 1cm above the burner flame for about 1 minute. THE TOP OF THE TEST TUBE JUST ABOVE THE FLAME WILL GET VERY HOT SO TAKE GREAT CARE NOT TO BURN YOURSELF. Quickly put the cork in the test tube and leave the test tube for some time until it is cool.

When the test tube is cold, remove the cork, add a little lime water, replace the cork and shake the tube. Does the lime water go milky?

Also when the methylated spirits burns it produces water, as steam. You can show this by filling a test tube ½ full of cold water, wiping the outside of the tube completely dry and holding the tube above the burner flame for about 5 seconds. A thin film of water vapour appears on the outside of the test tube where the hot gases from the burner have condensed on the cold tube.

You will also have noticed that when using the burner your test tubes get a black deposit on them. What is this?

Experiment 9.7 — The reaction of carbonates with acid

- sodium hydrogen sulphate solution
- sodium hydrogen carbonate (sodium bicarbonate)
- vinegar
- aluminium foil
- lime water
- 2 test tubes
- glass & rubber tubing
- cork for test tube with hole
- lolly stick
- sellotape
- pair of scissors

In Experiment 6.8 you carried out the reaction between carbonates and an acid and saw a violent fizzing. You did not test to show that the gas was carbon dioxide by passing it through lime water. This is difficult to do as the reaction is so quick you do not have time to assemble the bubbling apparatus (as in Experiment 9.5) in time.

In this experiment a trick is used to slow down the reaction long enough for you to put the apparatus together.

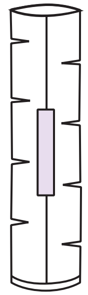
Have ready 3 or 4cm of lime water in a test tube, and have your gas-tube all assembled.

Cut a 4cm square of aluminium foil and fold it round a lolly stick to make a packet. Let the end of the foil extend over the end of the stick and fold it over to make a sealed bottom. Put a piece of sellotape on the foil edge to hold the packet together and slide it off the lolly stick. It should be about 3½ cm long.

Continued...

Chapter 9 - The chemistry of some gases
9a - Carbon dioxide

Experiment 9.7 — The reaction of carbonates with acid (continued...)



Carefully fill the packet with sodium hydrogen carbonate (sodium bicarbonate) and when full, very carefully cut 4 "nicks" up each side with a pair of scissors extending about ¼ way across the packet as in the diagram on the left.

Put 3cm of vinegar in a test tube, drop in the packet of sodium hydrogen carbonate and assemble the gas-tube as in the diagram with Experiment 9.5. The ethanoic acid in the vinegar will slowly mix with the sodium hydrogen carbonate and produce plenty of carbon dioxide gas. Bubble this into the lime water. Does the lime water go milky?

Experiment 9.8 — To show that carbon dioxide will extinguish a flame

- **sodium hydrogen carbonate (sodium bicarbonate)**
- **vinegar**
- **drinking glass**
- **matches**

Carefully hold a lighted match inside an empty drinking glass. The match continues to burn until you have to take. Be careful you do not burn your fingers.

Put about 1cm of vinegar into the glass and add half a teaspoonful of sodium hydrogen carbonate (sodium bicarbonate). Gently swirl the glass as the chemicals react together until the fizzing stops. The glass is now full of carbon dioxide gas.

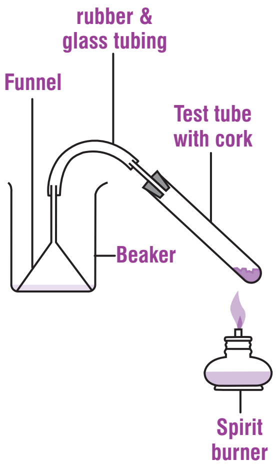
Now hold a lighted match into the glass (not in the solution in the bottom). The flame will immediately go out, because the carbon dioxide cannot support burning. For burning to occur oxygen gas is needed (see Experiment 9.17).

This property of carbon dioxide to extinguish flames is put to good use in some fire extinguishers.

Chapter 9 - The Chemistry of some gases
9b - Ammonia

Experiment 9.9 — The preparation of ammonia solution

- **ammonium chloride**
- **calcium hydroxide**
- **2 test tubes**
- **glass & rubber tubing**
- **cork for test tube with hole**
- **beaker**
- **funnel**
- **test tube holder or wooden clothes peg**
- **plastic test tube cap**
- **label**



Note: This is the most difficult experiment in this booklet. Do not try to do this experiment on your own, it is much easier if two people do it together.

Ammonia gas is formed when ammonium chloride reacts with calcium hydroxide. **The word equation for the reaction is:**
ammonium chloride + calcium hydroxide ⟶ ammonia + calcium chloride + water.

Ammonia is VERY SOLUBLE in water. Because of this special precautions must be taken when making it to ensure that no water gets onto the hot solids. The funnel is used so that if any water is sucked back it cannot get into the tube connecting the funnel to the test tube containing the hot solids.

Assemble the apparatus as shown in the diagram. You need to cut the "tag" off of the top of the funnel so that it will fit in the beaker. Put ½ a test tube-full of water into the beaker.

Mix 3 measures of ammonium chloride with 2 measures of calcium hydroxide on a piece of paper and carefully pour the mixture into a clean dry test tube. Connect the test tube to the funnel as shown in the diagram and arrange the apparatus so the solid reaction mixture can be heated in the burner flame, the funnel is in the water in the beaker, and the rubber tubing has no kinks in it. One person holding the test tube with the test tube holder or a wooden clothes peg and a second person gently holding the funnel in the beaker is best.

Heat the solid mixture in the flame. Fumes of ammonium chloride, some of which will condense on the cold parts of the test tube, and ammonia gas will be formed. The ammonia gas will dissolve in the water under the funnel.

Continue heating for about 10 minutes, when there should be no further change in the test tube. Remove the test tube from the flame (put the HOT test tube on the tin tray) and the funnel from the water. Pour the ammonia solution from the beaker into a test tube and put a plastic cap on it. Label the tube and store it safely.

Chapter 9 - The Chemistry of some gases
9b - Ammonia

Experiment 9.10 — Tests on ammonia solution

- ammonia solution
- universal indicator paper

Put a drop of the ammonia solution onto a piece of universal indicator paper. What colour is the paper? Does this show that ammonia is an acid or an alkali?

Smell the ammonia cautiously. DO NOT TAKE A DEEP BREATH - it has a distinctive strong smell.

Ammonia is used in bottles of "smelling salts" which some people use when they feel faint or giddy. Do you think that smelling ammonia would make you feel more awake?

Experiment 9.11 — The reaction of copper sulphate with ammonia

- copper sulphate
- ammonia solution
- test tube
- dropping pipette

Put ¼ measure of copper sulphate into a clean dry test tube and add a very small amount of water (about ½ cm). Warm the tube to dissolve the copper sulphate and let it cool. Add ammonia solution drop by drop using the dropping pipette. A blue-white precipitate of copper hydroxide is formed. Continue adding ammonia with the dropping pipette. The copper hydroxide precipitate dissolves to give a deep blue solution.

Experiment 9.12 — The reaction of iron sulphate with ammonia

- iron sulphate
- ammonia solution
- test tube
- dropping pipette

Dissolve ¼ measure of iron sulphate in 2cm of water in a test tube. Cool the solution under a running tap if you have heated it to dissolve the iron sulphate. Add ammonia solution with the dropping pipette. A dark green precipitate of iron(II) hydroxide is formed.

Filter off the precipitate and leave it for an hour or so. What happens to it?

Experiment 9.13 — The reaction of aluminium potassium sulphate with ammonia

- aluminium potassium sulphate
- ammonia solution
- test tube
- dropping pipette

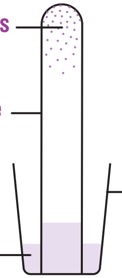
Dissolve ½ measure of aluminium potassium sulphate in 1cm of water in a test tube. Cool the solution if you have heated it. Add ammonia solution with the dropping pipette. A barely visible precipitate of aluminium hydroxide is formed. What colour is it?

Chapter 9 - The chemistry of some gases 9c - Oxygen

Oxygen is a very important gas. About one fifth of the Earth's atmosphere is oxygen. All animals need it to live, it is used by our bodies to "burn" food in our cells. In Chapter 8 metals heated in air reacted with oxygen to form metal oxides.

Experiment 9.14 — The proportion of oxygen in air

- iron filings
- test tube
- small glass



Wet the inside of a test tube and then sprinkle in some iron filings so they stick to the glass. Turn the tube upside down in 1cm of water in a small glass. Leave it for 2 or 3 days. When the level of water inside the test tube no longer changes estimate the proportion of the test tube containing water. What has happened to the oxygen in the air inside the test tube? What proportion of air is oxygen? What is the main gas left in the test tube? What has happened to the iron filings?

Experiment 9.15 — The rusting of iron

- 4 nails
- sodium chloride
- 2 test tubes
- 2 crystallising dishes

Get 4 bright shiny nails. Put one nail in an absolutely dry test tube and put the cap on the test tube. Put the second nail in a test tube with some water that has been boiled. Put the third nail in a crystallising dish with some water. Put the fourth nail in another crystallising dish with some water in which has been dissolved 1 measure of sodium chloride.

Leave them all for a few days. Describe what has happened to each of the nails. From the results of this experiment what do you think is necessary for iron to rust?

Experiment 9.16 — Making a glowing splint

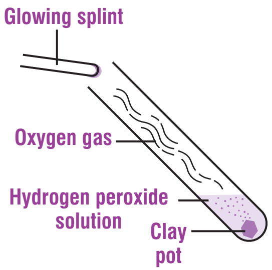
- lolly stick

Oxygen gas is needed for a substance to burn. In pure oxygen most things burn very vigorously in oxygen. This is the basis of the common test for oxygen gas; it relights a glowing splint.

Get a wooden splint ready for this test by lighting the end of a lolly stick in the burner flame and then blowing it out. The wood will still glow red. If you leave it in air the red glow soon goes out. If put into oxygen, however, the red glow increases and the wood relights. You will use this glowing splint in the next experiment.

Experiment 9.17 — The production of oxygen gas

- hydrogen peroxide solution
- iron sulphate
- test tube
- clay pot
- glowing splint



Hydrogen peroxide can react to produce oxygen and water. **The word equation for the reaction is: hydrogen peroxide ⟶ oxygen + water.** To make this happen another chemical, called a **catalyst**, must be added to the hydrogen peroxide.

Put 3cm of hydrogen peroxide solution in a test tube. Add ¼ measure of iron sulphate and a piece of clay pot. Warm the test tube. Oxygen gas will be produced, gently at first and then vigorously. Put the tube in the test tube rack.

Relight the glowing splint by putting it in the burner flame and then blowing it out. Immediately dip it into the top of the test tube. What happens? You can repeat this test several times. What is the purpose of the iron sulphate? What is the purpose of the clay pot?

Experiment 9.18 — The oxidation of iron(II) to iron(III) by oxygen

- hydrogen peroxide solution
- iron sulphate
- test tube
- dropping pipette

Iron in an iron(II) compound gets **oxidised** to iron(III) when it is treated with hydrogen peroxide.

Mix ½ measure of iron sulphate with 2cm of water in a test tube. Add a few drops of hydrogen peroxide solution with the dropping pipette and gently warm the solution. What happens? Are the colour changes the same as in Experiment 9.12?

Experiment 9.19 — Bleaching with oxygen

- hydrogen peroxide solution
- litmus blue
- test tube

Oxygen in hydrogen peroxide is used for bleaching. Hairdressers use it to bleach hair.

Mix a pinch (less than ¼ measure) of litmus blue with 2cm of water in a test tube. Warm to dissolve it (not all of it will dissolve). Add an equal volume of hydrogen peroxide solution. Is the blue colour bleached away?

Experiment 9.20 — Oxidation of fruit

- an apple
- vitamin C tablet
- knife
- 2 identical teaspoons

Many fruits, when they have had their skin removed, readily react with oxygen and spoil.

Cut an apple in half. Put one half aside.

Crush a Vitamin C tablet by breaking it into a few pieces and crush these to a powder by putting them into the bowl of a teaspoon and pressing the back of the bowl of an identical spoon on them. Rub the crushed Vitamin C onto the second half of the apple.

Leave the two apple pieces and look at them after a few hours. Describe what you see.

Vitamin C is a substance known as an **anti-oxidant** (something that stops oxidation). Do your observations agree with this?

Chapter 9 - The chemistry of some gases 9d - Sulphur dioxide

Experiment 9.21 — The preparation of sulphur dioxide

- sodium thiosulphate
- sodium hydrogen sulphate solution
- universal indicator paper
- test tube
- test tube holder or wooden clothes peg
- clay pot

This is another gas with a very strong sharp smell. **Do not increase the quantities over those given here**.

Have ready a piece of wet universal indicator paper.

Mix ¼ measure of sodium thiosulphate and ½ measure of sodium hydrogen sulphate with 1cm of water. Add a piece of clay pot.

Heat the contents of the test tube, they will go milky as sulphur is produced. Hold the universal indicator paper in the top of the tube. It will go red showing that an acid gas is being produced. This is sulphur dioxide.

Carefully smell the sulphur dioxide. DO NOT TAKE A DEEP BREATH - it is not a pleasant smell.

Experiment 10.1 — The preparation of a solution of iodine

- potassium iodide
- sodium hydrogen sulphate solution
- hydrogen peroxide solution
- test tube
- dropping pipette
- label

If you still have your solution of iodine from Experiment 2.5 you do not need to do this experiment.

Dissolve 1 measure of potassium iodide in 2cm of sodium hydrogen sulphate solution in a test tube. Add 10 drops of hydrogen peroxide solution with the dropping pipette.
A yellow-brown solution of iodine is formed. Half fill the test tube with water. **Label the tube - THIS IS VERY IMPORTANT.**

Experiment 10.2 — Testing for iodine with starch

- iodine solution
- starch solution
- test tube
- dropping pipette

In Experiment 2.4 an invisible message written with starch solution turned blue when dipped in iodine solution. The formation this blue colour with starch is a very sensitive test for iodine.

Add 4 drops of iodine with the dropping pipette to ½ a test tube of water, followed by 4 drops of starch solution. Use laundry spray starch (see Experiment 2.4) or the starch solution prepared in the next experiment. The solution turns deep blue.

Experiment 10.3 — Starch from a potato

- iodine solution
- starch solution
- a potato
- test tube
- dropping pipette
- saucepan

Many foods contain starch, it is an important part of our diet.

Cut a small potato into small pieces. Put these into a small saucepan and just cover with water. Boil for 5 minutes. Pour off the liquid.

Repeat Experiment 10.2 using the potato liquid as the starch.
The solution turns blue showing that this liquid contains starch.

You can put a few drops of your iodine solution onto the cut surface of a potato. Do you get a blue colour?

See if you can find any starch in other foods (for example in bread and in breakfast cereals). Boil a little of the food with water in a saucepan, and after cooling the liquid test it as in Experiment 10.2.

Experiment 10.4 — The reaction of iodine with sodium thiosulphate

- sodium thiosulphate
- iodine solution
- test tube
- dropping pipette

Dissolve ¼ measure of sodium thiosulphate in about 2cm of water in a test tube. Add iodine solution with the dropping pipette. The iodine colour disappears as each drop falls into the sodium thiosulphate solution.

Continue adding the iodine drop-by-drop and eventually all the sodium thiosulphate is used up and the yellow-brown iodine colour remains.

Experiment 10.5 — Testing for vitamin C

- iodine solution
- starch solution
- vitamin C tablet
- 3 test tubes
- dropping pipette

Vitamin C is an important vitamin. It is present in many foods, particularly citrus fruits.

Put 4 drops of starch solution into ½ a test tube of water. Add 4 drops of your iodine solution. The dark blue solution produced is your test solution for vitamin C.

Crush a vitamin C tablet as in Experiment 9.21 and dissolve it in 3cm of water in a test tube.

Put 2cm of the blue test solution into another test tube and add the vitamin C solution drop-by-drop using the dropping pipette. The blue colour will quickly disappear as the iodine reacts with the vitamin C.

Try adding drops of lemon juice or orange juice to a sample of the test solution. Do they contain vitamin C?

You can test any food for vitamin C with this test.

Chapter 10 - Some iodine chemistry

Experiment 10.6 A clock reaction

- potassium iodide
- sodium thiosulphate
- hydrogen peroxide solution
- sodium hydrogen sulphate solution
- starch solution
- 2 test tubes
- conical flask
- white paper

The reactions of iodine with starch and of iodine with sodium thiosulphate in the experiments above can be combined in a very clever chemical reaction that you can use to amuse and amaze your friends. Like all good magicians try out this experiment on your own before showing it to someone else.

It is very important that you use the quantities given here if this experiment is to work.

Dissolve 1 measure of potassium iodide and ¼ measure of sodium thiosulphate in water in a test tube and add water to fill the test tube. This is solution A.

In a second test tube mix 2cm hydrogen peroxide solution and 2cm sodium hydrogen sulphate solution and add water to fill the test tube. This is solution B.

Measure 2cm of solution A in a test tube, put it into the conical flask and add 4 drops of starch solution (either spray starch or potato starch). Add 2cm of solution B from its test tube. The solution in the flask will be clear.

Stand the conical flask on a sheet of white paper and wait.

After about 30 seconds the solution suddenly turns blue.
This is called a clock reaction.

What is happening here is that iodine is being produced as in Experiment 10.1. This is immediately reacting with the sodium thiosulphate as in Experiment 10.4. Eventually all the sodium thiosulphate is used up and some iodine remains in the conical flask. This then reacts with the starch as in Experiment 10.2 to give the blue colour.

If you warm the tubes of solutions A and B, by holding them in hot water, before mixing the blue colour will appear in a shorter time.

If this experiment does not work it is most likely that you have too much sodium thiosulphate (or too little potassium iodide) in solution A. Make new solutions and try again.

Chapter 11 - Some sugar chemistry

Experiment 11.1 Heating sugar

- sugar
- small evaporating spoon

Put 1 measure of sugar in the small evaporating spoon and heat it over the burner flame until nothing further happens. Put the HOT SPOON in the tin lid to cool. Describe what happens. The black residue left in the spoon is carbon. This is because sugar contains a lot of carbon.

In Experiments 8.7 and 8.8 you heated tartaric and citric acids. These are similar to sugar but contain less carbon. Was there any carbon residue left when they were heated?

Experiment 11.2 Heating a mixture of sugar & sodium hydrogen carbonate

- sugar
- sodium hydrogen carbonate (sodium bicarbonate)
- small evaporating spoon

Thoroughly mix 1 measure of sugar with 1 measure of sodium hydrogen carbonate (sodium bicarbonate) on a sheet of paper. Put the mixture into the small evaporating spoon and heat until nothing further happens. Put the spoon on the tin lid to cool. Describe what happens.

The sugar is forming carbon as in Experiment 11.1. At the same time the sodium hydrogen carbonate is forming carbon dioxide gas. This is blowing up the carbon to give the very light residue which you have.

Experiment 11.3 Using sugar to produce copper from copper oxide

- sugar
- sodium hydrogen carbonate (sodium bicarbonate)
- copper oxide
- sodium hydrogen sulphate solution
- small evaporating spoon
- beaker
- conical flask

Repeat Experiment 11.2 but use 2 measures of sugar and 1 measure of sodium hydrogen carbonate (sodium bicarbonate) this time. Also mix in 1 measure of copper oxide. Very thoroughly mix the 3 substances together and put the black powder in the small evaporating spoon. Heat the spoon until nothing further happens. Put the spoon on the tin lid to cool.

When the spoon is cold, knock the residue of it onto a piece of paper and crush it to a fine black powder. Put this into the conical flask and add about ½ a test tubeful of your sodium hydrogen sulphate solution. Boil the solution for 2 to 3 minutes. Make a holder for the conical flask from a piece of folded paper as in Experiment 5.4.

Pour the liquid into the beaker and carefully look at the residue left in the conical flask through the bottom of the flask. In amongst the black solid will be shiny particles of copper metal that have been produced from the copper oxide.

Experiment 11.4 — Preparation of Fehling's solution

- **copper sulphate**
- **tartaric acid**
- **sodium hydroxide solution**
- **3 test tubes**

To be able to test sugars in the next 3 experiments we need a special test solution called **Fehling's solution**.

Dissolve 1 measure of copper sulphate in 4cm of water in a test tube. This is solution A.

Dissolve ½ measure tartaric acid in 4cm of your sodium hydroxide solution in a second test tube. This is solution B.

When required in the following experiments you mix equal volumes of solutions A and B in a third test tube. This is Fehling's solution. It is a blue liquid.

Experiment 11.5 — Testing for glucose

- **Golden Syrup**
- **Fehling's solution**
- **teaspoon**
- **beaker**
- **2 test tubes**
- **test tube holder or wooden clothes peg**
- **clay pot**

Glucose is one type of sugar. It is present in many foodstuffs such as barley-sugar and Golden Syrup. Glucose reacts with Fehling's solution.

Using a clean teaspoon put ¼ teaspoonful of Golden Syrup into your beaker and add ½ a test tubeful of hot water. Stir until the Golden Syrup has all dissolved.

Put 1cm of the Golden Syrup solution into a test tube and make Fehling's solution by mixing 2cm of each of solutions A and B prepared in Experiment 11.4 in a second test tube.

Add the Fehling's solution to the Golden Syrup solution. Add a piece of clay pot and boil the solution. What happens?

A green precipitate forms in the solution and this rapidly turns orange as a copper oxide is formed. This is a test for glucose and other sugars known as reducing sugars.

Is the copper oxide formed here the same as the copper oxide supplied with this Chemistry Lab?

Experiment 11.6 — Testing for sucrose

- **sugar**
- **Fehling's solution**
- **2 test tubes**
- **test tube holder or wooden clothes peg**
- **clay pot**

The sugar that we are familiar with is sucrose.

Repeat Experiment 11.5 replacing the 1cm of Golden Syrup solution with 1 measure of sugar dissolved in 1cm of water in a test tube. What happens this time when you boil the solution?

Nothing happens because sucrose is not a reducing sugar.

Experiment 11.7 — The conversion of sucrose to glucose

- **sugar**
- **sodium hydrogen sulphate solution**
- **sodium hydroxide solution**
- **Fehling's solution**
- **universal indicator paper**
- **2 test tubes**
- **dropping pipette**
- **test tube holder or wooden clothes peg**
- **clay pot**

Sucrose can be converted to glucose by boiling it with an acid.

Dissolve 1 measure of sugar in 1cm of your sodium hydrogen sulphate solution in a test tube. Add a piece of clay pot and boil the solution gently for 5 minutes. Hold the test tube well above the flame to **gently** boil the solution.

Allow the solution to cool and add Fehling's solution as in Experiment 11.5. As you have used an acid with the sugar you need to now test the solution with universal indicator paper to be sure that it is alkaline. The universal indicator paper should be blue-violet. If the solution is acid (the universal indicator paper is red) then add small quantities of your sodium hydroxide solution drop-by-drop with the dropping pipette, and testing the solution with universal indicator paper, until it becomes alkaline.

Add a piece of clay pot and boil the solution. The solution will go green and then orange copper oxide is formed showing that a reducing sugar is now present. Some of the sucrose has been converted into glucose.

Experiment 11.8 — Large sugar crystals - making rock candy

- **sugar**
- **heatproof glass container**
- **saucepan**
- **beaker**
- **strong thread**
- **large piece of clay pot**
- **pencil**

This last experiment is a treat to celebrate that you have now carried out all the experiments in this booklet. (You have done them all haven't you?)

In Chapter 3 you made crystals of a number of different chemical substances. Here you will make a large crystal which you can eat.

You will need the help of an adult for this experiment as you have to make a large quantity of very hot sugar solution.

Get a large glass container into which you can safely put hot sugar solution. A 1 pint Pyrex glass kitchen measuring jug is ideal. A jam jar is not suitable as the hot sugar solution may crack it.

Fill the container with water to within 3cm of the top and measure this volume of water. You can use your beaker to do this, keep filling the beaker with the water 100ml at a time and count how many beaker-fulls there are.

You need to put ½ of this volume of water into a saucepan and add 2½ times as much sugar (by volume) as water. If, for example, you do use a kitchen measuring jug then when it is filled to within 3cm of the top it contains 500ml. So you would put 250ml of water and 625ml (note measured by volume) of sugar into the saucepan.

Heat and stir the mixture of sugar and water until it boils. Once it boils STOP STIRRING and continue boiling gently for 2 minutes. This sugar syrup is VERY HOT. Let it cool for 5 minutes and then pour it carefully into the glass container. It should almost fill it. When the syrup is cool enough to handle move the container to a place where you can easily see it. Cover it with a piece of kitchen roll to keep out dust, flies, etc. Leave for 2 or 3 days by which time there should be some sugar crystals on the bottom (and maybe floating on the top) of the container. If none have formed put a sprinkle of sugar into the syrup.

Experiment 11.8 — Large sugar crystals - making rock candy (continued...)

When some sugar crystals have formed, pour off the syrup into a temporary container and get a lump of the sugar crystals. This will be your **seed crystal**. Pat it dry with kitchen roll and tie a piece of strong thread around it.

Wash the sugar out of the container, dry it and put the syrup back into it. Hang the seed crystal from a pencil resting across the top of the glass container as in the diagram in Experiment 3.8. The seed crystal wants to hang in the middle of the container.

The next part is the most difficult. **Let the syrup solution stand for two or more weeks WITHOUT TOUCHING IT**. If you move the container it may spoil the experiment. Day by day you should see the seed crystal grow into a large irregular lump of sugar candy.

When you can wait no longer remove the sugar candy from the syrup. Do this in a sink as there will be a lot of sticky sugar syrup to throw away. Quickly wash the syrup off the crystals and pat them dry with kitchen roll. Keep the candy in a dish and eat it a little at a time, but remember that sugar is very bad for your teeth, so don't eat too much and thoroughly clean your teeth afterwards.

Results of the Experiments

1.1 The copper sulphate, sodium chloride and sugar are soluble, the calcium carbonate and pepper are insoluble.

1.2 Sodium sulphate dissolves fairly quickly in both cold and warm water, but the one in warm water takes the least time. Most chemicals increase in solubility the hotter the solvent.

1.5 Blue crystals of copper sulphate.

2.1 Lemon juice creates brown writing.

2.2 Iron sulphate creates brown writing.

2.3 Yellow-green writing.

2.4 Blue writing.

3.1 Copper sulphate - rhombohedral crystals.

3.2 Aluminium potassium sulphate - rhombohedral crystals.

3.3 Sodium sulphate - long needle-like crystals.

3.4 Sodium chloride - cubic crystals.

3.5 Magnesium sulphate - long needle-like crystals.

3.6 Ammonium chloride - long thin fern-like crystals.

3.7 Crystals of sodium thiosulphate immediately grow out from the added crystal. Very soon the liquid in the test tube is one big solid crystal. (To remove it you need to heat the test tube again and pour the liquid into a clean beaker. The solid formed can be kept in its container for other experiments).

3.9 Aluminium potassium sulphate contains water of crystallisation, sodium chloride and sodium sulphate do not.

3.10 Anhydrous copper sulphate is white. When water is added it becomes blue hydrated copper sulphate.

4.1 Black food colouring has blue, yellow and red bands on the chromatogram from top to bottom. Green food colouring has blue and yellow bands on the chromatogram from top to bottom. Green food colouring contains Tartrazine (a yellow colouring) and Green S (a bluegreen colouring). Black food colouring contains the same two dyes as green and also contains Carmoisine (a red food colouring). The chromatograms agree with this.

4.2 Different black inks may be made up of different dyes. "Parker Quink" black ink has an upper thin blue band, an orange band and a large blue band. This indicates that it is made up of two different blue dyes and an orange one. Another black ink that we have tested has a dark blue and a dark green band. One black felt-tipped pen that we have tested contained purple and yellow dyes, another contained blue and dark red dyes. Few felt tip pens are made up of just one dye. The only one that we have found is red.

5.5 Citric acid has this name because it was found to be the main acid in citrus fruits like lemons, oranges, limes and grapefruits.

5.7 The colours for red cabbage indicator in acid and alkali are almost identical to litmus. It is red in acid solution and blue in alkali solution. Turmeric is yellow in acid solution and orange in alkaline solution.

5.9
1. strong acid.
2. weak or strong alkali.
3. strong alkali.
4. strong alkali.
5. weak acid.
6. weak or strong acid.

7. weak or strong acid.
8. weak alkali.
9. weak acid.
10. weak acid.

5.10 1. Lemon juice is a weak acid. It contain citric acid.

2. Vinegar is a weak acid. It contains ethanoic acid.

3. Sparkling water is a weak acid. It contains dissolved carbon dioxide gas. This forms carbonic acid with water.

4. Laundry detergent is a strong alkali. It contains sodium carbonate.

5. A vitamin C tablet is a weak acid. Vitamin C is an acid called ascorbic acid.

6. Aspirin is a weak acid.

7. Sugar is neutral.

8. None of the chemicals in spirit drinks are acid or alkaline; they are neutral.

5.12 Dark green in sodium hydrogen carbonate solution. Yellow in citric acid solution. Blue-violet in sodium carbonate solution. Red-orange in sodium hydrogen sulphate solution. Sodium hydrogen carbonate is a weak alkali, citric acid is a weak acid, sodium carbonate is a strong alkali and sodium hydrogen sulphate is a strong acid.

6.3 Iron + sodium hydrogen sulphate $\longrightarrow$ hydrogen + iron sulphate + sodium sulphate.

6.4 Aluminium reacts slowly with acid to give hydrogen gas. Copper does not react. The order of reactivity of the metals with acid is magnesium (most reactive), iron and zinc, aluminium, copper (least reactive).

6.5 Aluminium reacts rapidly with sodium hydroxide solution to give hydrogen gas. The word equation for the reaction is: aluminium + sodium hydroxide $\longrightarrow$ hydrogen + sodium aluminate + water. Aluminium also reacts with sodium carbonate solution to give hydrogen gas.

6.6 The magnesium reacts with water. The reaction may be slow at first but as the magnesium reacts it cleans its own surface and the speed of the reaction increases.

6.7 Blue copper sulphate is in the solution. After filtering it is in the filtrate.

6.8 Some indigestion tablets fizz because they contain both an alkali, such as sodium hydrogen carbonate (sodium bicarbonate), and an acid, such as citric acid. When the tablet is added to water the two chemicals dissolve and react together to give carbon dioxide gas.

7.4 Iron(II) hydroxide precipitate is green. When it reacts with oxygen in air it gives brown iron(III) hydroxide.

7.7 The nail has became coated in brown copper metal. The iron has replaced copper in the copper sulphate to form iron sulphate.

7.8 The iron sulphate crystals are green. (You have some in the Chemistry Lab set). The word equation for the reaction is: iron + copper sulphate $\longrightarrow$ copper + iron sulphate.

7.9 The magnesium ribbon turns brown as it gets coated in copper metal. After some time there is a brown-black precipitate of copper in the test tube.

7.10 The aluminium replaces the copper. Initially the aluminium is not very reactive (it has an oxide coating on it) and reaction takes place at the cut edges. Brown copper is clearly seen along the edges of the aluminium foil. Eventually most of the aluminium reacts and it disintegrates. Aluminium sulphate is formed. The word equation for the reaction is: aluminium + copper sulphate ⟶ copper + aluminium sulphate.

7.11 The word equation for the reaction is: zinc + copper sulphate ⟶ copper + zinc sulphate. You can add a little acid to the zinc carbonate, it will fizz as carbon dioxide is produced.

7.12 Yes magnesium does replace iron. The word equation for the reaction is: magnesium + iron sulphate ⟶ iron + magnesium sulphate.

7.13 Aluminium replaces iron, but not as readily as does magnesium. The word equation for the reaction is: aluminium + iron sulphate ⟶ iron + aluminium sulphate. Magnesium is the most reactive and copper the least reactive metal.

8.1 Copper reacts with oxygen in the air to give black copper oxide. Inside the envelope the copper is still bright and shiny. It has got hot but oxygen cannot get to it to form copper oxide.

8.2 Iron reacts to give black iron oxide.

8.3 The iron filings burn to iron oxide. They are so small that they burst into flame and sparkle as they fall through the burner flame. "Sparkler" fireworks contain iron filings.

8.4 It does not obviously oxidise, but if the aluminium foil is thin enough it melts.

8.5 Magnesium burns to give white magnesium oxide ash.

8.6 The copper carbonate darkens as it decomposes giving off carbon dioxide gas and leaving black copper oxide on the evaporating spoon. You could dissolve the copper oxide in acid to give a blue copper salt.

8.7 Tartaric acid melts, the liquid boils, there is a little vapour and virtually no black carbon residue in the evaporating spoon.

8.8 Citric acid melts and boils. There is a lot of white smoke that catches fire. The small amount of black carbon residue is light and fluffy.

8.9 The ammonium chloride disappears from the bottom of the test tube and condenses on the cool upper part of the test tube.

9.1 The lime water turns milky showing that you are blowing carbon dioxide gas through it.

9.2 The lime water slowly turns milky showing that air contains carbon dioxide gas.

9.3 The universal indicator goes yellow showing that carbon dioxide is a weak acid in solution. 9.4 Universal indicator solution is yellow showing that sparkling water is a weak acid.

9.5 The lime water rapidly turns milky showing that carbon dioxide gas is being expelled from the sparkling water.

In Experiment 9.4 the indicator is put into the solution. In this experiment the carbon

dioxide gas is boiled out. Other acids that might have been added to the fizzy soft drink do not boil out of the solution, and so do not spoil this experiment.

9.6 The lime water goes milky showing that carbon dioxide is produced in the flame. The black deposit is carbon. Tiny carbon particles, called soot, are produced in many flames where air or oxygen is not mixed with the other fuel. A candle, for example, burns with a similar sooty flame.

9.7 The lime water rapidly turns milky showing that carbon dioxide gas is produced.

9.10 The indicator is blue-violet. Ammonia is a strong alkali.

9.12 The oxygen in air turns the green iron(II) hydroxide into brown iron(III) hydroxide as in Experiment 7.4.

9.13 Aluminium hydroxide is a white precipitate.

9.14 The oxygen has reacted with the iron filings to form iron oxide.

About 1/5 of the test tube fills with water. This has replaced the oxygen so air is about 1/5 oxygen. The main gas left is nitrogen. The iron filings have gone black-brown as they rust.

9.15 The nail in the dry tube remains bright and shiny. The nail in the boiled water will also be bright and shiny if all the air has been removed from the water. The two nails in the crystallising dishes will be rusting. That with sodium chloride should show more rust than that in water only. For iron to rust both water and oxygen are necessary. Rust is an iron hydroxide. The word equation for the reaction is: iron + oxygen + water ⟶ hydrated iron oxide (rust).

9.17 The glowing splint readily reignites in the oxygen gas. The iron sulphate helps the hydrogen peroxide to decompose into oxygen and water. It is a catalyst. The clay pot is there to provide sharp points on which the oxygen bubbles can form so they come smoothly out of the solution.

9.18 The green solution goes brown. The colour changes are the same as in Experiment 9.12. In both experiments green iron(II) is being converted into brown iron(III).

9.19 Yes the blue colour disappears.

9.20 The cut apple quickly browns in air (some varieties of apple quicker than others). That with vitamin C on it does not go brown. The oxidation by the oxygen in air is stopped by the vitamin C.

10.5 Lemon juice and orange juice both contain vitamin C, and decolourise the test solution.

11.1 The sugar melts and boils and burns leaving a large amount of carbon residue in the evaporating spoon. Tartaric and citric acids leave much less carbon residue.

11.5 The orange copper oxide formed from the copper sulphate in the Fehling's solution is different from the black copper oxide supplied. The black oxide is copper(II) oxide. The orange oxide is copper(I) oxide.