EXPERIMENT MANUAL

KIDS FIRST CHEMISTRY SET

THAMES & KOSMOS

WARNING. Not suitable for children under 8 years. For use under adult supervision. Read the instructions before use, follow them and keep them for reference.

WARNING — Chemistry Set. This set contains chemicals and/or parts that may be harmful if misused. Read cautions on individual containers and in manual carefully. Not to be used by children except under adult supervision.

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Thames & Kosmos UK Ltd, Goudhurst, Kent, TN17 2QZ, United Kingdom | 01580 212000 | www.thamesandkosmos.co.uk

IMPORTANT INFORMATION

Safety Rules

Please observe these safety rules, the advice for supervising adults on pages 4-5, the safety rules on page 8, the information regarding the handling of plaster and household chemicals and their environmentally sound disposal on page 7, and the first aid information on this page.

- Contains plaster (gypsum) which requires careful handling.
- Read the instructions before use, follow them and keep them for reference.
- Do not allow plaster or other examined household substances to come into contact with any part of the body, particularly the mouth and eyes.
- For plaster and other examined household substances:
  Do not place the material in the mouth.
  Do not inhale dust or powder.
  Do not apply to the body.
- Keep younger children under the specified age limit and animals away from the activity area.
- Store chemical toys out of reach of young children.
- Wash hands after carrying out activities.
- Clean all equipment after use.
- Do not use any equipment which has not been supplied with the set or recommended in the instructions for use.
- Do not eat, drink or smoke in the activity area.
- Handle glass test tubes and other additionally required items made of glass carefully. Do not use broken test tubes or glassware. Throw away broken test tubes and glassware.

First Aid Information

- In case of eye contact: Wash out eye with plenty of water, holding eye open. Seek immediate medical advice.
- 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 skin contact and burns: Wash affected area with plenty of water for at least 10 minutes.
- In case of cuts: Do not touch or rinse with water. Do not apply any ointments, powders, or the like. Dress the wound with a clean, dry first-aid bandage. Foreign objects (e.g. glass splinters) should only be removed by a doctor. Seek the medical advice if you feel a sharp or throbbing pain.
- In case of doubt, seek medical advice without delay. Take the chemical and/or product) together with the container with you. For household substances, take the retail packaging with you.
- In case of injury always seek medical advice.

Poison Control Centers (United States)

In case of emergency, your nearest poison control center can be reached everywhere in the United States by dialing the number:

1-800-222-1222

Local Hospital or Poison Centre (Europe)

Record the telephone number of your local hospital or poison centre here:

Write the number down now so you do not have to search for it in an emergency.

WARNING! Parts in this kit have functional sharp points, corners, or edges. There is a risk of injury. Keep packaging and instructions as they contain important information.

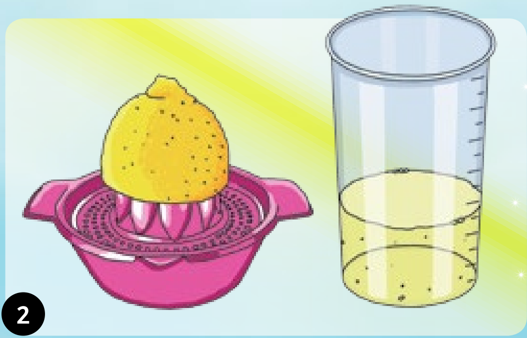
An experiment to help you hit the ground running

Give it a try and prepare to be surprised!

The color in tea

YOU WILL NEED

- **Large measuring cup**
- *6 Tea bags (black tea)*
- *Instant coffee*
- *2 Tea glasses or cups*
- *Lemon and lemon squeezer*
- *Paintbrush, white paper*



HERE'S HOW

1. Ask an adult to pour hot water from the tea kettle into 2 tea glasses or cups, about 2 cm deep. Add 6 tea bags to one cup, and 2 teaspoons of instant coffee powder to the other. Stir well and let everything cool.
2. Squeeze the juice out of a lemon and pour the juice into the measuring cup.
3. Take the tea bags out of the cup. Now take a paintbrush and paint a picture (of a toad, for example) with the dark-colored water.
4. Paint a few more designs on the already-applied paint and let everything dry. Then, use the paintbrush to drip lemon juice here and there. What happens?
5. Finally, you can use the darker coffee liquid to paint other details such as the eyes.
6. Pour all the liquids down the drain and rinse with water.

WHAT'S HAPPENING?

The dye in the coffee and the tea can be used as paint. The lemon juice, by contrast, removes color from the paper wherever it is applied, leaving behind light-colored spots. The citric acid in the lemon juice acts like a bleaching agent.

››› KIT CONTENTS

GOOD TO KNOW! If you are missing any parts, please contact Thames & Kosmos customer service.

Any materials not included in the kit are indicated in *italic script* under the "You will need" heading.

What's in your experiment kit:

Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
❍	1	Plaster (gypsum)	1	770 800
❍	2	Measuring spoon	1	035 017
❍	3	Narrow measuring cup (100 mL)	1	701 206
❍	4	Large measuring cup (200 mL)	1	702 810
❍	5	Sheet of labels	1	046 020
❍	6	Plaster mold (for test tube stand)	1	702 776
❍	7	Rubber stopper	1	071 078
❍	8	Test strips (pH)	5	702 811
❍	9	Magnifying lens	1	311 137

✔	No.	Description	Qty.	Item No.
❍	10	Petri dish with lid	1	702 184
❍	11	Pipette	2	232 134
❍	12	Test tube	3	062 118
❍	13	Filter paper, round	15	702 842
❍	14	Vial with spoon built into the lid	3	702 781
❍	15	Funnel	1	702 215
❍	16	Bendable drinking straw	1	712 081
❍	17	Wooden spatula	1	000 239

You will also need: Several screw-top jars with lids (jelly jars); sugar; powdered sugar; rock sugar; salt; rock salt, dishwasher salt or pure sea salt; tweezers; non-permanent felt-tip pens; pencil; wooden sticks; clothespins; string; multi-colored candy-coated chocolates (such as M&M's®); charcoal tablets (or barbecue charcoal); fresh lemon; lemon juicer; household vinegar; transparent plastic bag; red cabbage; baking soda (sodium bicarbonate); bar soap; dish soap; limestone, marble, egg- or seashells; baking powder; tealight candle; matches or lighter; heat-resistant support (e.g., old saucer); mineral water; drinking glasses; sand; teaspoon and tablespoon; metal spoon; fresh grapes; effervescent powder or tablets (vitamin tablets); glass bowl; plastic container with lid; hammer; aluminum foil and plastic wrap; bottle with lid; hair dryer or paper towels; cutting board; black cardboard; corn starch; scissors; long matches; cotton swab.

››› CONTENTS

TIP!
Find additional information on the "Check It Out" pages:
Page 17, 25, 36, 37, 44, 45, and 49

EXPERIMENTS

Advice for Supervising Adults

Dear Parents,

With this experiment kit, you will be accompanying your child on an introductory exploration of the fascinating world of chemistry. Please support your child in his or her first chemical experiments and help him or her with both advice and in physically performing experimental steps when help is needed.

Please read and follow these instructions as well as the safety rules, the first aid information, and the information regarding the handling of plaster and household chemicals and their environmentally sound disposal. Please keep this information for reference.

A. This chemical toy is not suitable for children under 8 years. For use under adult supervision. Keep this chemical toy set out of reach of children under 8 years old.

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

C. Incorrect use of chemicals (plaster and household chemicals) can cause injury and damage to health. Only carry out those activities which are listed in the instructions.

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

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

F. The area surrounding the activity should be kept clear of any obstructions 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 working area should be cleaned immediately after carrying out the activity.

Emphasize to your child the importance of following all instructions and warnings, and the importance of carrying out only those experiments that are described in this manual. Inform your child, but do not frighten him or her — there's no need for that.

››› Devote special care to information about the safe handling of acids (such as lemon juice and household vinegar) and bases (such as solutions of baking soda or soaps) and to experimenting with open flame and hot liquids.

››› A special "laboratory" will not be necessary for these simple experiments. A sturdy table with a washable, heat-resistant surface is good enough. It should be well lit and ventilated, equipped with a nearby water tap, and not too close to any stored foods. The surroundings should be free

of all obstacles. Always get any required equipment and chemicals ready before beginning an experiment. Your child should wear old clothes (or an old smock). After completing the experiments, he or she should pick up and clean the work area and thoroughly wash his or her hands.

››› Be careful not to let the chemicals get into the hands of young children.

››› Always take appropriate precautions when experimenting with open flame! Always place the tealight candle on a fire-resistant surface, such as an old saucer.

Make sure that there are no flammable materials near the experiment location, such as curtains, tablecloths, or carpets.

››› Your child should not wear loose sleeves, a shawl, or a scarf while experimenting, and long hair should be tied back. Never let candles burn unsupervised, and don't forget to extinguish them after an experiment. Keep a bucket or box of sand ready in case of emergencies.

We hope you and your child have a lot of fun doing these experiments!

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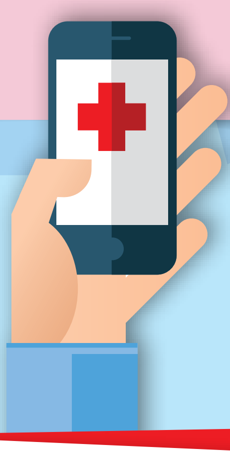


The ABC's of Experimenting

With this experiment kit, you will be able to research simple chemical reactions from everyday life and analyze them in your mini-lab, just like a real chemist.

To do this, you will also need a stand for your test tubes, which you will make out of plaster. Most of the experiments will be performed in the test tubes. You will be using sugar and salt to learn how to measure liquids precisely and add them drop by drop, and you will be making all sorts of interesting observations in the process. You will find out how to create your own crystals and how to paint chemical pictures on filter paper using water.

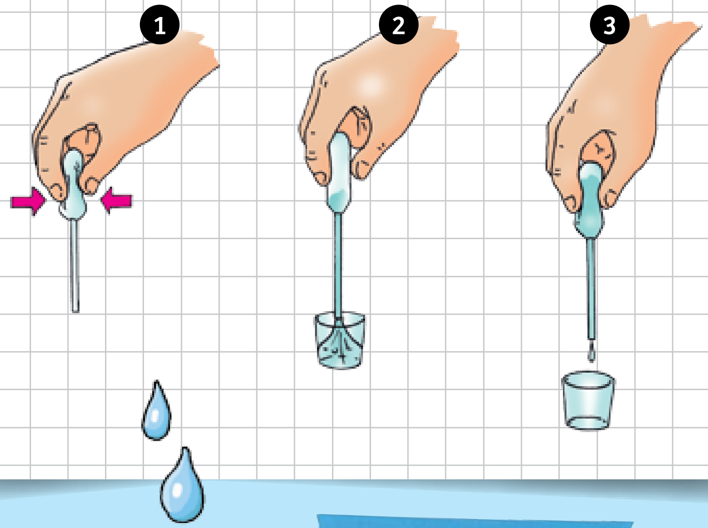
Other experiments will show you what happens when you combine household vinegar with baking powder, and what a "chemical tongue" is. You will also learn why sparkling water sparkles.

Some of the materials are not contained in the experiment kit box, since they can be easily found in your house (see page 2). For those materials, the kit provides plastic containers with a spoon built into the lid. The experiments will tell you what to put into these containers, which should then be labeled in accordance with their contents. In a laboratory, it is always important to label everything accurately. Take your samples from the container and never from the original package. After finishing an experiment, do not pour any leftovers back into the container.

A chemistry lab has rules that any young researcher should also know about. They are important even though the experiments in this manual are not dangerous.

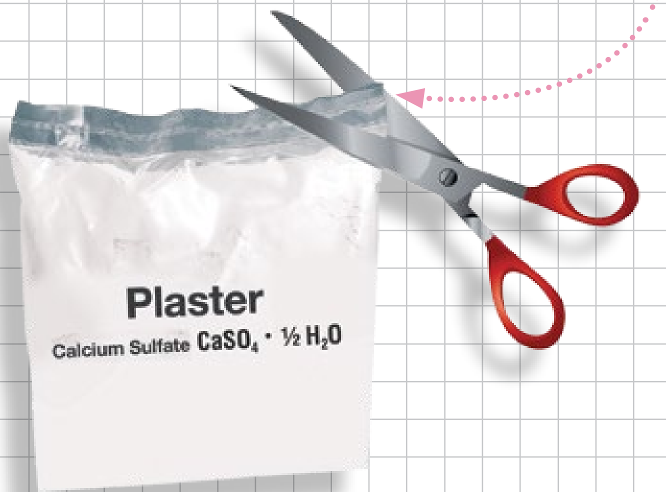
How to use the pipette

1. Squeeze the upper part of the pipette between your thumb and forefinger and dip the pipette tip into the liquid.
2. As soon as you release the pressure, the liquid will rise up the pipette.
3. By squeezing carefully, you can make the liquid drip slowly out again.



How to open the plaster pouch

Cut open the plaster pouch at the corner with scissors. Do not use your teeth. After use, immediately re-close the pouch with a clip or a piece of tape, and keep the pouch in a safe place.



TIP!
Additional items that you will need to get from your household or from a supermarket or drug store are indicated in *italic letters* in the individual experiments.
Before beginning an experiment, read the instructions carefully to see what materials will be required so that you can get them ready.

How to dispose of waste

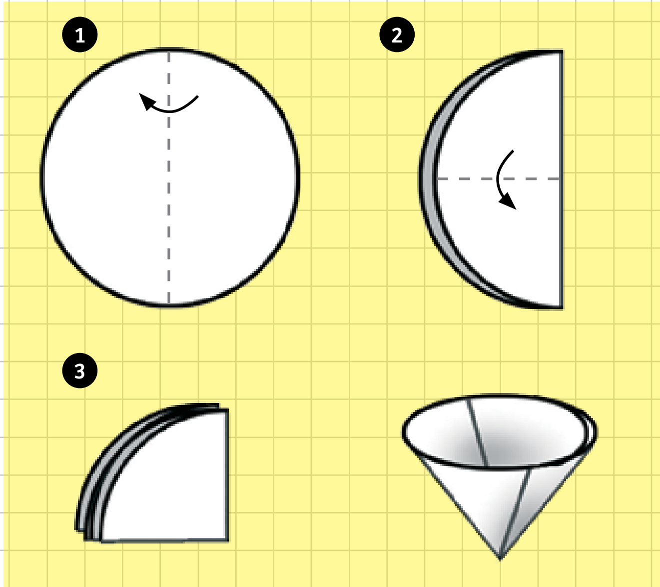
Leftover plaster can be disposed of in the household garbage, after allowing any still-wet mixture to dry or harden on some newspaper. Quickly clean your containers after all experiments, so substances don't harden in them. Any liquids can be poured down the drain (rinse them down with plenty of water).

Any other chemicals required for the experiments, such as baking powder, can be poured down the drain with plenty of water. Please dispose of leftover solids in the household garbage.

How to filter

To perform filtration, you will need a funnel and one of the round filters.

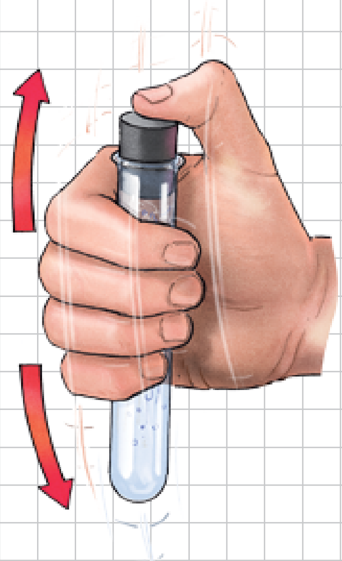
1. Fold the filter down the middle.
2. Fold the resulting semicircle again.
3. This will give you a little cone. Set the filter cone in the funnel and moisten it with a little water to help it stick to the sides of the funnel.



Handling the rubber stopper

Always insert the stopper carefully in the test tube to avoid any breakage.

When shaking the test tube, always keep your thumb firmly on the stopper!



Safety Rules

The first thing a researcher does is to get an overview of what he or she will be doing. All of the experiments described in this manual can be performed without risk, as long as you conscientiously adhere to the advice and instructions. Read through the following information very carefully. Think about everything that you will need. Always pay attention to the safety notes that accompany an experiment.

1. Read these instructions before use, follow them and keep them for reference.

2. Keep younger children under the specified age limit and animals away from the activity area.

3. Store chemical toys out of reach of young children.

4. Wash hands after carrying out activities.

5. Clean all equipment after use.

6. Do not use any equipment which has not been supplied with the set or recommended in the instructions for use.

7. Do not eat, drink or smoke in the activity area.

8. Make sure that all containers are fully closed and properly stored after use.

9. Ensure that all empty containers are disposed of properly.

10. Do not allow chemicals to come into contact with the eyes or mouth.

11. Do not replace foodstuffs in original container. Dispose of immediately.

12. Do not apply any substances or solutions to the body.

13. Regarding plaster (gypsum) powder: Do not place the material in the mouth. Do not inhale dust or powder. Do not apply to the body.

14. Make sure that the plaster package is fully closed and properly stored in the experimental kit after use.

15. Ensure that the empty plaster package is disposed of properly.

16. Store this experimental set and the additional materials out of reach of children under 8 years of age, e.g. in a cabinet that can be locked.

17. Carefully prepare your work area for the experiments. Clear off the table and gather everything you will need.

18. Always leave your work area in clean condition. Always pay attention to proper disposal of any residues.

19. Always work slowly and carefully. Do not stir up plaster dust and do not squirt or spill any solutions. If you get something in your eye by mistake, such as a squirt of lemon juice or vinegar, rinse out your eye with plenty of water. Have an adult help you.

20. When experimenting, wear old clothes that can take a little abuse, or wear something over your clothes (such as an apron or old shirt).

21. Take care while handling with hot water or hot solutions. Store solutions out of the reach of small children (under 8 years of age).

22. When experimenting with candles, always take the necessary fire precautions. Always place the candle on a fire-resistant surface, such as a saucer. Never allow candles to burn unattended, and always extinguish them after the experiment.

23. Pay special attention to the quantity specifications and the sequence of the individual steps. Only perform experiments that are described in this instruction manual.

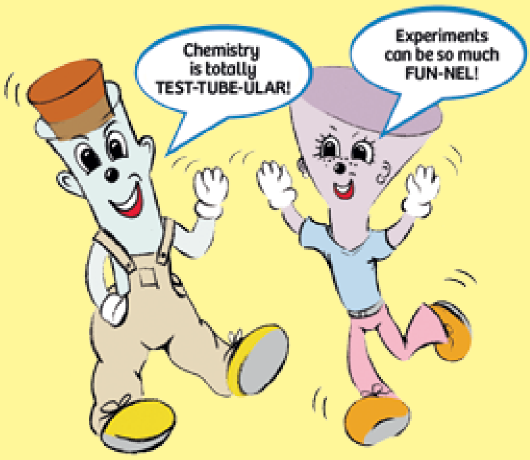
24. Do not use any eating, drinking, or other kitchen utensils for your experiments. Any containers or equipment used in your experiments should not be used in the kitchen afterward.

25. Immediately wipe up any spills with a paper towel to avoid leaving any stains.

26. If chemicals should come in contact with eyes, mouth, or skin, follow the first aid advice (inside front cover of this manual) and contact a doctor if necessary.

If you have any questions about the experiments, your parents or older siblings will be able to help you.

Now let's get started. Have fun with the experiments!



Kids First Chemistry Set

A dictionary would tell you that chemistry is the science of the composition, properties, structure, and reactions of matter. But what does that really mean? It means that chemistry is the organized study of all materials: what they are made of, how they are put together, how they come apart, why they behave the way they do, and why they are the way they are.

Everything — all the matter in the universe — is a chemical or is made of chemicals that can be studied in chemistry. That sounds like a lot, doesn't it? So how do the scientists who study chemistry, called chemists, keep it all straight? Well, they break things down into smaller and smaller categories, organizing them by their properties.

Take sugar for example. Regular table sugar is a material called sucrose. Sucrose is actually made of three other materials that you've probably heard of: hydrogen, carbon, and oxygen. These are called elements, and are categorized by their properties.

The smallest unit of an element is called an atom. An element consists of one atom or multiple atoms that are all exactly the same. You can't break an atom down any further without changing its properties. But atoms can be broken down into smaller components that do have different properties from each other: protons, neutrons, and electrons.

However, all protons in the world are the same as each other, as are neutrons and electrons, no matter what atom they're a part of. It's as if you built houses out of blocks, and there were three types of blocks: blue, green, and red. Towns with only one house or many of the same houses represent elements, individual houses represent atoms, and the blue, green, and red blocks represent protons, neutrons, and electrons.

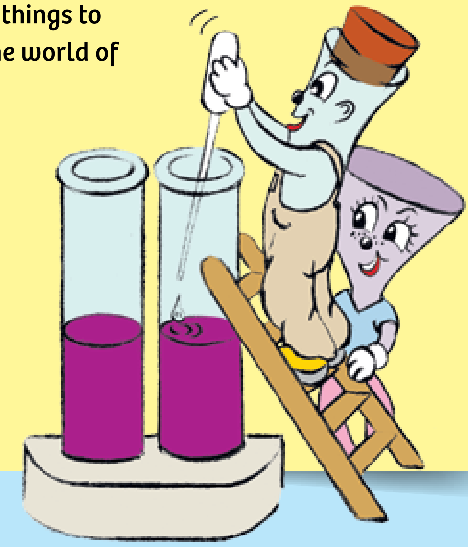
At this time, there are only about 118 known elements. So everything you see is made of only these 118 elements. In fact, about 20 of these elements are not found naturally on Earth and have only been made artificially in a lab, so we're talking less than 100 different building blocks for everything on Earth!

How do so few parts come together to make so many different things, that interact in so many different ways? Answering this question is what chemistry is all about.

This kit lets kids experience the fascination of chemistry with hands-on experiments in five labs: the color lab, the crystal lab, the analytic lab, the acid lab, and the gas lab.

Let's get started! You will be amazed by all the things to be discovered in the world of chemistry!

And we wish you lots of fun with all your discoveries.



Test tube stand made of plaster

You can make a test tube stand for your experiments using the material supplied in the experiment kit.

YOU WILL NEED

- › **The large and the narrow measuring cups**
- › **Wooden spatula**
- › **Blue plaster mold**
- › **Plaster**
- › **Self-adhesive labels**
- › *Water*
- › *Scissors*
- › *Large screw-top jar with lid*
- › *Pen*

HERE'S HOW

1. Cut one corner of the plaster pouch and measure 150 mL plaster powder into the large measuring cup. Measure 90 mL water into the narrow measuring cup.
2. Pour the water over the plaster powder in the large measuring cup. Stir the mixture with the wooden spatula until everything is mixed evenly.
3. Transfer the plaster mixture into the plaster mold.
4. Spread the surface smooth so the bottom of the stand will be flat and the stand will be steady. Watch how the plaster changes, and check its temperature with your finger.
5. After 2–3 hours, you can remove the test tube stand from the mold. First bend the sides of the mold out a little and press carefully on the mold's bottom.
6. Pour the rest of the plaster into a tightly closeable screw-top jar, write "plaster" on a label, and stick the label on the jar.

1

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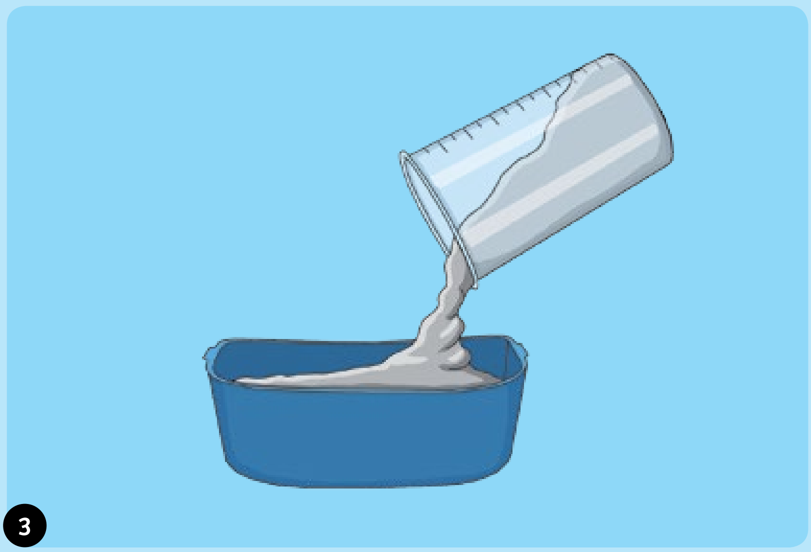

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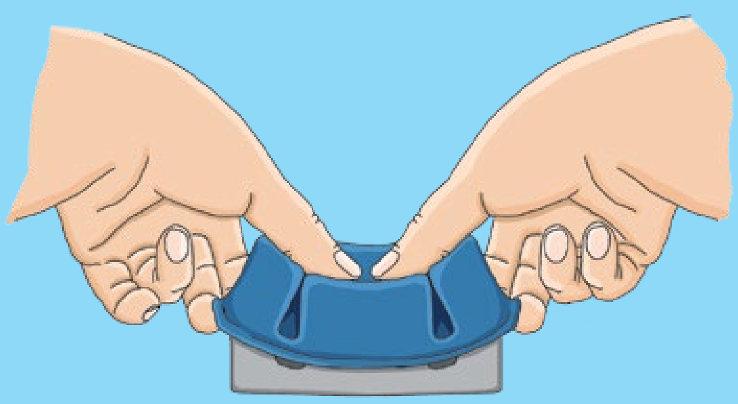
7. Loosen dried plaster residues from the measuring cup and the mold by bending carefully, and add them to the household garbage. Rinse your tools under the tap, let them dry on a paper towel, and return them to the box once they have dried.



5

In principle, plaster is not hazardous to your health. But when the powder is inhaled or swallowed, it is possible for hard clumps to form in the lungs or stomach. Therefore:

WARNING! Not suitable for children under 8 years. For use under adult supervision. Read the instructions before use, follow them and keep them for reference. Do not place the material in the mouth. Do not inhale dust or powder. Do not apply to the body.

6

TIP!
For some of the experiments in this manual, you will need a second test tube stand, so it is best to make two of them right away.

WHAT'S HAPPENING?

When you combine plaster powder and water, it creates lots of tiny crystals that interconnect to make a sort of woven mesh, thereby forming a solid mass. The technical language for this kind of hardening process is to say that the plaster "sets." This simple chemical reaction produces heat — as you can feel with your finger.

Crystal Lab: Mysterious Formations

Crystals are fascinating miracles of nature. They form cubes, pointed needles, warped rectangles, or octagons and other complicated shapes with smooth surfaces that sparkle in the light.

EXPERIMENT 1

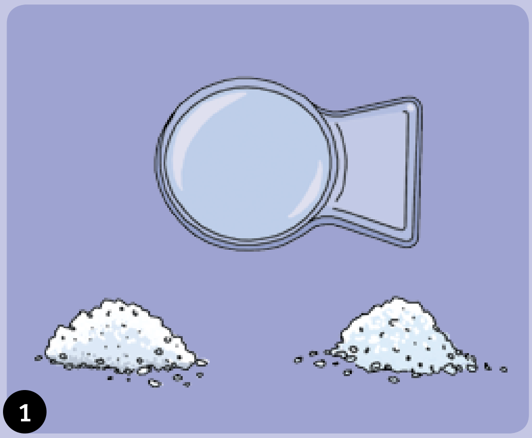
Can water make sugar and salt disappear?

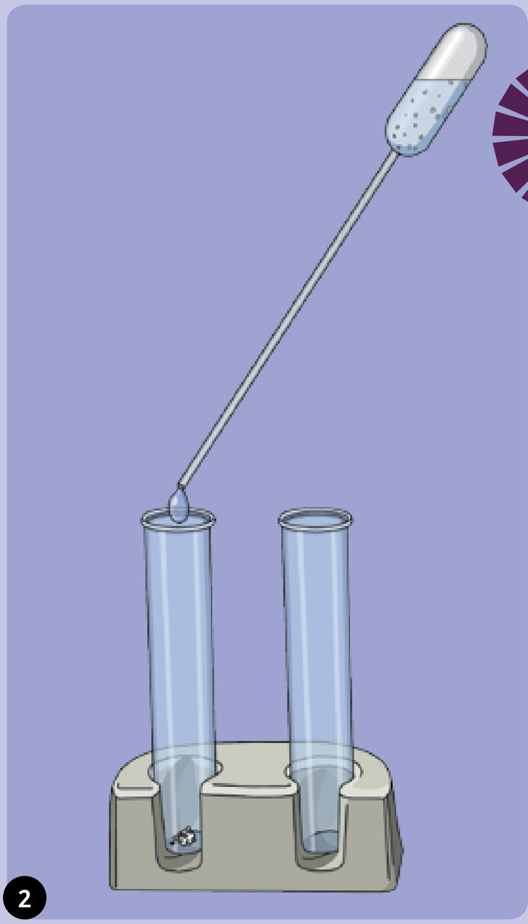
YOU WILL NEED

- › **2 Test tubes**
- › **Test tube stand**
- › **Pipette and magnifying lens**
- › **Measuring spoon**
- › **Large measuring cup** *with water*
- › *Sugar and salt from the kitchen*

HERE'S HOW

1. At first glance, sugar and salt look pretty similar. Examine them carefully under the magnifying lens and try to detect a difference.
2. Set two clean test tubes in your test tube stand. Place a large measuring spoon of sugar in one of the test tubes. Then, use the pipette to add some water. Count the exact number of drops added. Observe what happens to the sugar. Swirl the test tube from time to time as you add the water. How many drops do you have to add before you can no longer see the sugar?
3. Perform the same experiment with the salt. What difference do you notice? When salt and sugar have become invisible, does that mean that they have disappeared? Also investigate whether you can dissolve more or less sugar in warm water. Save both solutions for the next experiment.





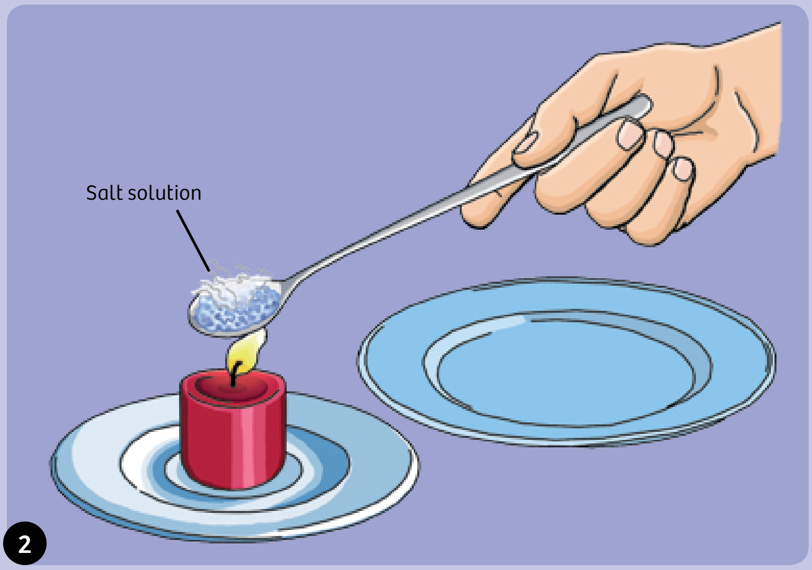
>>> WARNING! Never leave the magnifying lens in the sun. Fire danger! Never look directly into the sun, either with your naked eye or through the lens. You could blind yourself!

NOTE!

If you dissolve so much salt (or sugar) in water that some remains undissolved at the bottom of the container, meaning that the solution cannot absorb anymore, you might say that it is "full." When a solution cannot dissolve any more of a substance, it is called a "saturated solution" by chemists.

WHAT'S HAPPENING?

The solubility of various substances in water depends on their composition. Salt and sugar, for example, are built out of different building blocks, so they also behave differently when you dissolve them. Neither of them will actually disappear, though. As a rule, most substances, such as household sugar, will dissolve more quickly and in greater quantities in hot water than in cold water. Table salt, however, is an exception. Its solubility hardly depends at all on the temperature.



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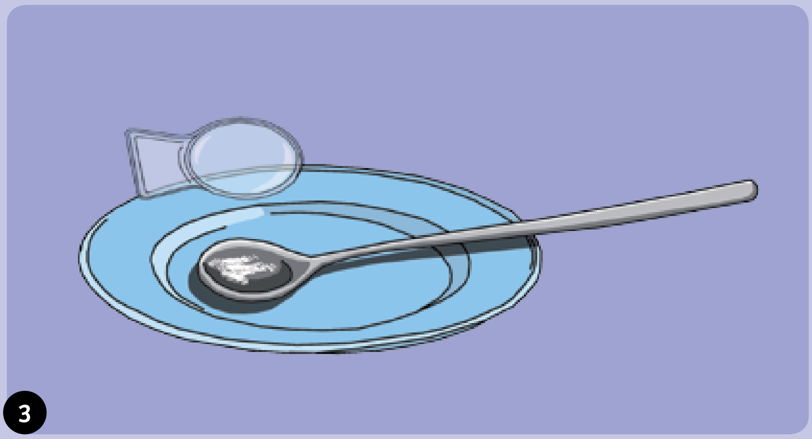
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Evaporating the salt and sugar solutions

YOU WILL NEED

- **Magnifying lens (note safety information on p. 13),**
- *Salt and sugar solutions from Experiment 1*
- *Old ice cream spoon or tablespoon made of metal*
- *Tealight candle, old saucer*
- *Plate*
- *Lighter or matches*

HERE'S HOW

1. Perform this experiment with the help of an adult. Set the tealight candle on the saucer, and have the adult light it.
2. Hold the long metal spoon filled with salt solution just over the flame. This will let you carefully evaporate the salt water from the spoon. A long spoon is necessary so the handle doesn't get too hot.
3. Set the hot spoon on the plate and blow out the candle. Examine the result under the magnifying lens. What happens when you evaporate sugar water? Try it! Just be careful, because the sugar solution might spit.

WHAT'S HAPPENING?

When you evaporate the salt solution over the candle flame it leaves behind a white coating in the spoon, because the salt quickly crystallizes out. With the sugar, on the other hand, things look different. You gradually get a brown caramel coloration. Eventually, the sugar mass will even carbonize and burn.

EXPERIMENT 3

Making salt crystals

If you study salt and sugar under the magnifying lens, you will see little cube-shaped crystals (salt) or crystals with slanted edges (sugar). With a little patience and care, you will be able to make larger salt crystals that are particularly beautiful.

YOU WILL NEED

- **The narrow and the large measuring cups**
- **Test tube stand and test tube**
- **Petri dish with lid, measuring spoon, funnel**
- **Filter paper and sheet of labels**
- *Tweezers, water, screw-top jar*
- *Rock salt, pure sea salt, or dishwasher salt (not regular table salt), rock sugar*

HERE'S HOW

1. Fill the large measuring cup with about 25 mL of water. While stirring, dissolve so much salt in it that some remains undissolved on the bottom of the cup.
2. Assemble a filter out of filter paper.
3. Filter the salt solution into the narrow measuring cup and fill the Petri dish halfway with the filtrate.
4. Set the dish in a quiet place and cover it with a piece of filter paper. After one to two days, crystals will separate out of the solution and accumulate on the bottom of the dish.
5. To make larger crystals, remove the prettiest ones with the tweezers and place them in the lid of the Petri dish. Filter the remaining solution again through a filter into a test tube.
6. Add this solution to the large crystals in the Petri dish lid. Set the lid in a quiet place again. This way, you will eventually get big, beautiful crystals. Compare their shape with that of the rock sugar.
7. Dispose of residues in the household garbage.

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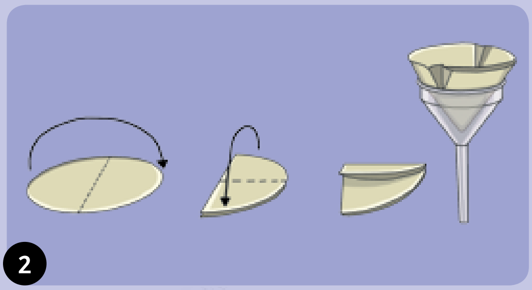

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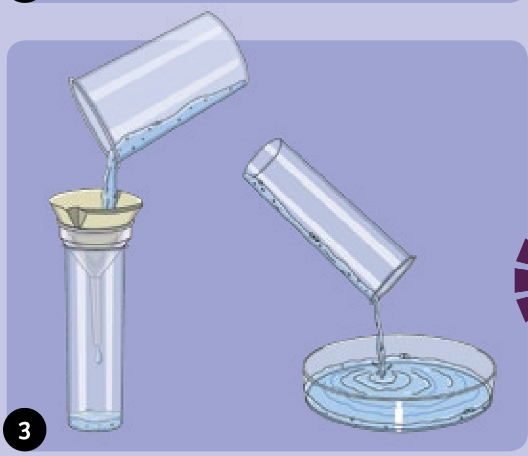

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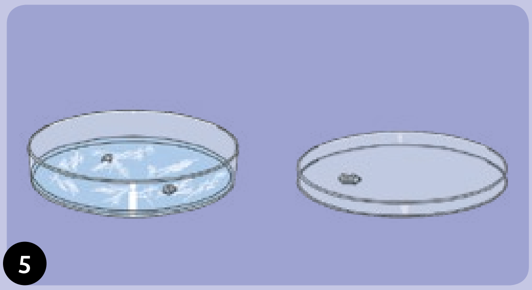

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6

TIPS!

Ordinary table salt contains additives that interfere with crystal growth. So it's best to use rock salt or pure sea salt, which contain no additives. Dishwasher salt will also work, if you can find it.

For filtering, you can also use round coffee filters or cut your filters out of cone filters (using the Petri dish as a template).

"Filtrate" is the name for the filtered liquid.

WHAT'S HAPPENING?

If water evaporates out of a saturated salt solution, the solution will end up with an excess of salt. That gradually results in the formation of little cube-shaped salt crystals. If you regularly remove the smallest secondary crystals and keep using only the bigger ones, you can grow beautiful crystals.

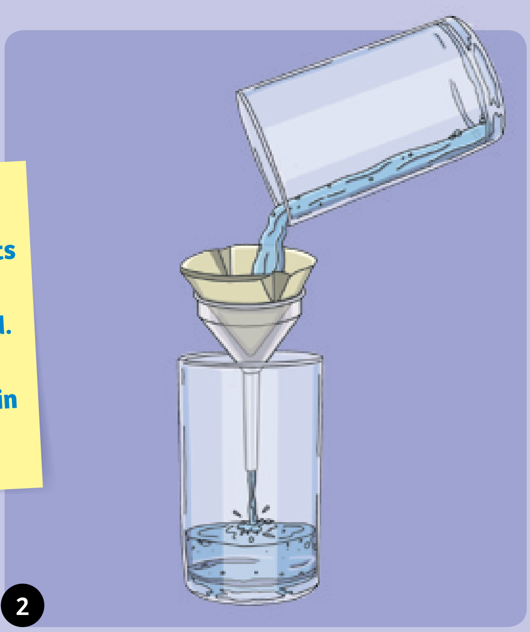
Sugar stick and rock candy

You can't grow sugar crystals simply by evaporating a saturated solution. But you can do it by cooling a hot sugar solution.

WARNING! The sugar stick and rock candy are not suitable for eating, because experiment kit tools and materials are used to make them.

TIP!
If your growing experiments do not succeed, the solutions are not saturated. Always use a solution in which sediment remained in the vessel.

1



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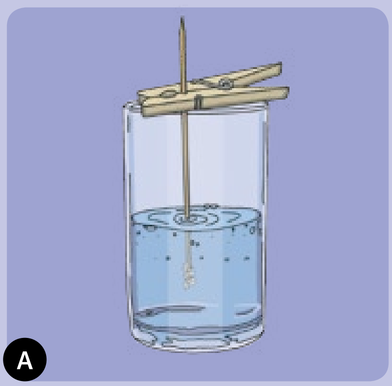

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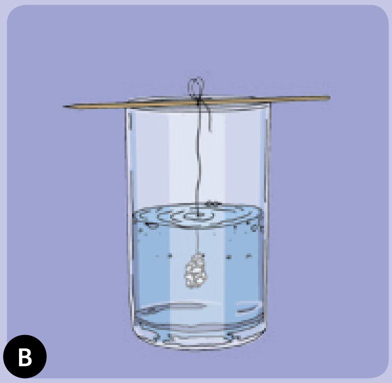


B

YOU WILL NEED

› **Funnel and filter paper**
› *Narrow drinking glasses*
› *Two wooden sticks (such as wooden skewers)*
› *Clothespin and thin thread*
› *Sugar and rock sugar from the kitchen*
› *Hot tap water and spoon*

HERE'S HOW

1. Pour hot tap water into a drinking glass and dissolve enough sugar in it that a sediment of undissolved substance remains.
2. Filter the solution into a second drinking glass. You have a saturated sugar solution. At this point, you have two options:

A: Make a sugar stick

1. Use a clothespin to suspend a stick in the hot solution.
2. Set the drinking glass in a cool, quiet place and cover it with filter paper.

B: Grow rock candy sugar crystals

1. Tie one end of some string around a piece of rock sugar, and tie the other end of the string to a wooden stick. Lay the stick across the rim of the glass so the rock sugar is suspended in the solution.
2. Cover the drinking glass with a piece of filter paper and set it in a quiet place. Every week, remove any little crystals that start to form separately from the big one. To do this, you can start by taking the big crystal out of the solution and pouring the solution into a different glass, leaving the little crystals behind.
3. Then set the large crystal back into the solution. If necessary, make a new solution.

WHAT'S HAPPENING?

Since sugar dissolves much better in hot water than in cold water, you can make crystallized sugar by cooling a hot-saturated sugar solution. It is important that the hot solution really cannot dissolve any more sugar, so you know that it is actually saturated. When the solution cools slowly, large sugar crystals form on the stick or string.

CHECK INTO IT

What does the word "crystal" mean?

Many thousands of years ago, curious people discovered unusually shaped stones in the mountains, which immediately stood out due to their strangely regular forms. Some were astonishingly colorful, while others were as colorless as ice and just as transparent. The Greeks gave the latter colorless, transparent material the same name as their word for water ice, which was "krystallos." Our word "crystal" comes from this Greek word.

THE WORLD'S LARGEST SALT SEA

Bolivia's Sala de Uyuni, with an area of 12,000 square kilometers, is the largest salt sea in the world. But it isn't just salt for eating and for industry that is found here. Inside and underneath its salt crust, there is a salt solution containing a valuable raw material: lithium. This is a mineral element that is primarily used in the electronics and automotive industries. The Sala de Uyuni contains over 50% of the world's lithium supply — an estimated 4.5 million tons. So in the highlands of Bolivia, one of South America's poorest countries, there lies a veritable treasure trove — one that may sooner or later give Bolivia a "white golden" future.

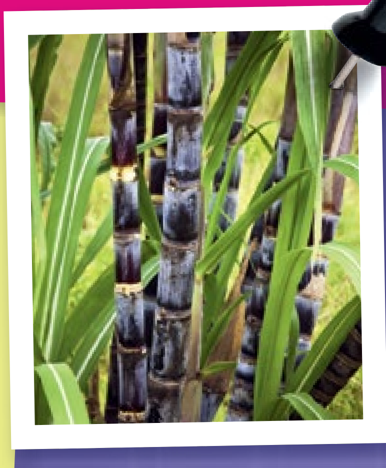
ARE CRYSTALS RARE?

Almost every solid substance is made of crystals — including rocks, metals, and ice. It's just that the crystals are usually so tiny that you can only see them under high-powered microscopes. Only rarely are they large and well formed. If you look at sugar and salt under a magnifying lens, for example, you can see their little crystals. For rock sugar or rock candy, on the other hand, you don't need a magnifying lens. The size of the crystals generally depends on how much time they had to grow: The more slowly a crystal grows, the larger and prettier it will be.

White gold

Hundreds of years ago, sugar was already being obtained from sugar cane, a plant that only grows in the tropics. At first this "white gold," as sugar was also known, was transported from India to other parts of the world such as Europe. In 1747, the Prussian chemist Marggraf discovered that the common beet also contains a lot of sugar, and his student Franz Achard continued to tinker with the process of producing sugar from beets. In 1801, the first beet sugar factory was built. Soon, sugar was so cheap that anyone could afford to have it in great quantities.

"White gold" is a metaphor for (white) substances that are viewed as "gold" (in the sense of something valuable) due to their preciousness. In earlier times, salt and porcelain were also known as white gold.



Color Lab: Mixing, Separating, and Dissolving

What would our world be like without colors? Everything would be so sad and gray! Colors make our world seem friendlier and more alive. They accompany us every day and influence us more than we imagine. In this chapter, you will learn how carbon can wash away colors and how chocolate candy coatings can reveal what colors they're made of.

EXPERIMENT 5

Painting colorful pictures with water

In addition to sugar and salt, water can also dissolve coloring dyes. You can use water to change dots, lines, and designs drawn with a felt-tip pen into interesting new pictures.

YOU WILL NEED

- › **Filter paper**
- › **Pipette**
- › **Petri dish**
- › **Narrow measuring cup** *with water*
- › *Non-permanent felt-tip pens*
- › *Pencil*

HERE'S HOW

1. Use the pencil to make a dot in the center of the filter paper. Use various-colored non-permanent markers to write your name in a circle around the dot, or to draw a design.
2. Lay the filter paper over the open Petri dish, and use the pipette to take water from the cup and drip a few drops onto the pencil dot.

   After each drop, wait for it to be absorbed by the paper before adding the next one. Be careful not to let a puddle form! The paper should become damp almost all the way to the edge.
3. Now let the filter paper dry. Can you detect any differences between the colors?

1

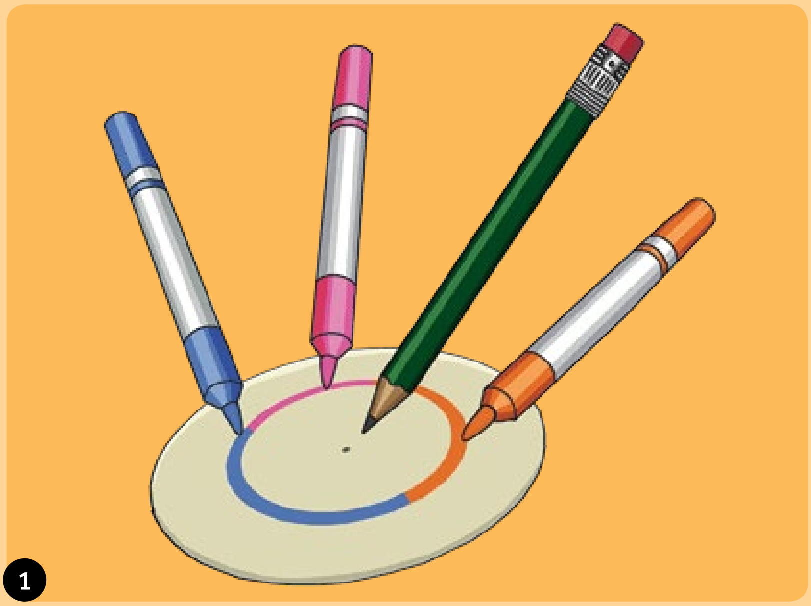
2

TIP!
You can try drawing two or three pencil dots on the filter paper and drawing colored designs around them, and dripping water on the various dots in turn. You will probably be able to think of other possibilities for creating interesting pictures! What happens if you try doing the experiment with a line made out of various colors (with all the colors drawn on top of each other)?

WHAT'S HAPPENING?

The water-soluble dyes in the felt-tip pens are carried along in the filter paper by the water as it moves. Some colors are held more tightly by the paper than others. That results in color mixtures becoming separated into their component parts again. This important method of chemical analysis, technically known as **chromatography**, also results in lots of pretty, colorful patterns.

Color racetrack

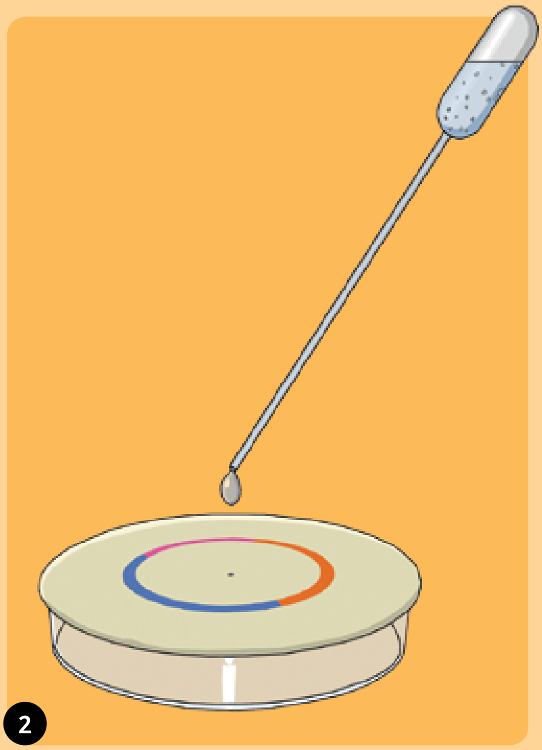


YOU WILL NEED

- **Filter paper**
- **Pipette**
- **Petri dish**
- **Narrow measuring cup** *with water*
- *Non-permanent felt-tip pens*
- *Pencil*

HERE'S HOW

1. Make a pencil dot in the center of the filter paper. Around this dot, at a distance of about 2 cm, draw a circle. Thickly color the line with various felt-tip pens, so it ends up having several colors.
2. Lay the paper over the Petri dish, and slowly drip water onto the pencil dot with the pipette again. Which color wins the race?



WHAT'S HAPPENING?

As in the previous experiment, the water-soluble dyes in the pens are carried along by the water as it moves through the paper. Some colors are held more tightly by the paper than others, which results in the mixed dyes being separated into their component colors. This chemical analysis method is called "chromatography," which literally means "color writing."

EXPERIMENT 7

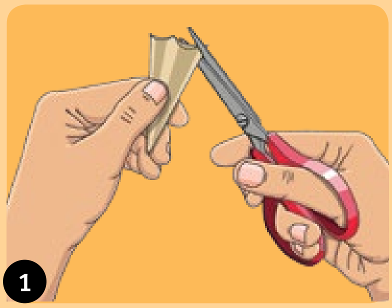
The magical black flower

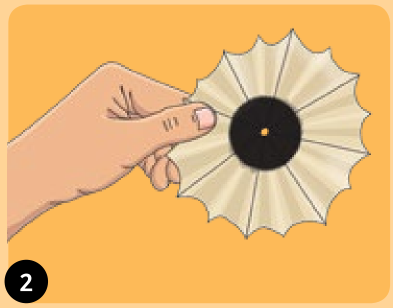
YOU WILL NEED

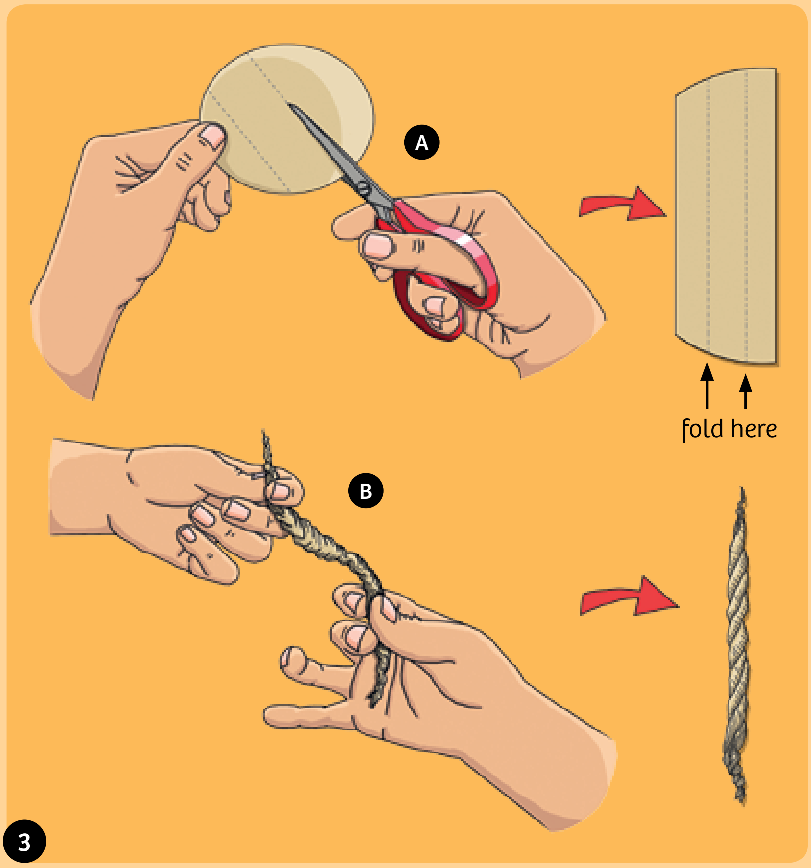
› **Filter paper**
› **Test tube stand and test tube**
› *Non-permanent black felt-tip pen or marker*
› *Scissors*
› *Water*

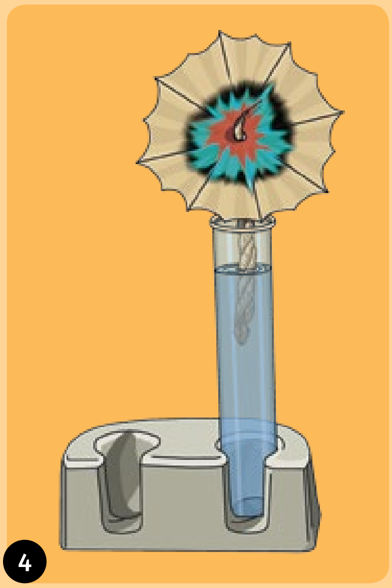
HERE'S HOW

1. Fold the filter paper in half, then in quarters, and finally in eighths. With scissors cut two arcs into the edge. Unfold the paper.
2. With the black felt-tip pen or marker, make a solid black circle in the center of the filter paper (about 1 cm in diameter). When the ink has dried, carefully cut a hole in the center of the black circle with scissors. Your flower is ready.
3. Make the flower's stem from another piece of filter paper. Cut a 2-cm wide strip from the filter paper and fold it several times along the long dimension. Twist it around itself, so that it becomes tightly wound. Insert the stem into the hole in the flower from the bottom. The flower is ready.
4. Fill the test tube halfway with water and put the flower stem into it. Observe what happens.









WHAT'S HAPPENING?

The water is pulled up through the filter paper stem into the flower and outward to the edge. The black ink is pulled and separated into its individual color components. Black ink is not just black; it is composed of pigments of different colors and particle sizes, which are transported by the water through the porous paper at different speeds.

TIP!
You can make magic flowers with different colored markers.

EXPERIMENT 8

The colors in candy shells

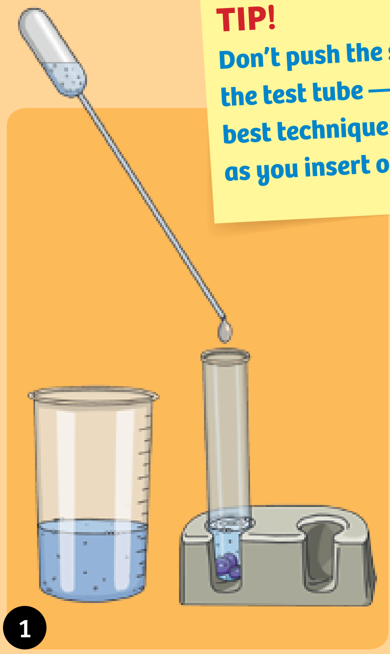
YOU WILL NEED

- **Filter paper**
- **2 Pipettes, petri dish**
- **2 Test tubes and test tube stand**
- **Rubber stoppers**
- **Narrow measuring cup** *with water*
- *Candies with multicolored candy shells such as M&M's®, pencil*

HERE'S HOW

1. Drop three M&M's (or six mini-M&M's) of the same color (ideally, one of the darker colors) into a test tube. Use a pipette to add just enough drops of water to barely cover the M&M's.
2. Insert the stopper in the test tube and shake until the M&M's are almost white.
3. Pour off the colored solution into a second test tube, leaving the M&M's behind. Throw the M&M's into the garbage and clean the test tube. You will be using the colored solution in your experiment.
4. Make a dot with the pencil in the center of the filter paper, and lay the filter paper over the Petri dish.
5. Use the pipette to drip the colored solution onto the pencil dot. Wait for each drop to be absorbed by the paper before adding the next. Don't let a puddle form on the paper! When the paper is damp almost all the way to the edge, stop adding drops.
6. Let the filter paper dry. Repeat the experiment with M&M's of a different color.
7. See what happens when you add a mix of M&M's colors to the test tube. Think about what colors you would mix to create a green or purple solution.

TIP!
Don't push the stopper too hard into the test tube — it could break. The best technique is to twist the stopper as you insert or remove it.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Bonus experiment: Test other colored candies as well. Do their colors separate on the filter paper?

Dyes have to be non-toxic if they are used to color foods. You can study candy colors the same way you studied the felt-tip pen colors.

WHAT'S HAPPENING?

The liquids become colored because the water dissolves the dyes in the M&M's shells. If you mix these colored solutions, you can get new colors. For example, yellow and blue create a green solution, while blue and red create a purple one.

EXPERIMENT 9

Homemade charcoal powder

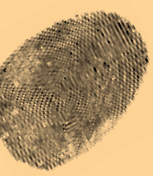
YOU WILL NEED

› *Small piece of barbecue charcoal*
› *Aluminum foil*
› *Hammer*
› *Plastic container with lid*
› *Self-adhesive label, pen*

HERE'S HOW

1. Wrap a small piece of charcoal in aluminum foil, place it on a solid, sturdy surface, and carefully break it into little pieces with a hammer. Be careful not to let the charcoal dust get on your clothes or the furniture. Preferably, have an adult help you.
2. Save the charcoal powder in a labeled plastic container.

WARNING! Do not inhale charcoal dust! Do not let it get onto clothes, carpet, or furniture!



WHAT'S HAPPENING?

The smaller the pieces of charcoal, the greater their total overall surface area. You will need this pulverized charcoal for the next experiment.

EXPERIMENT 10

Cleaning colored water with charcoal

When cleaning dirty water, you can't remove dyes just by filtering. Chemistry offers a better method using charcoal powder, which you can try in this experiment.

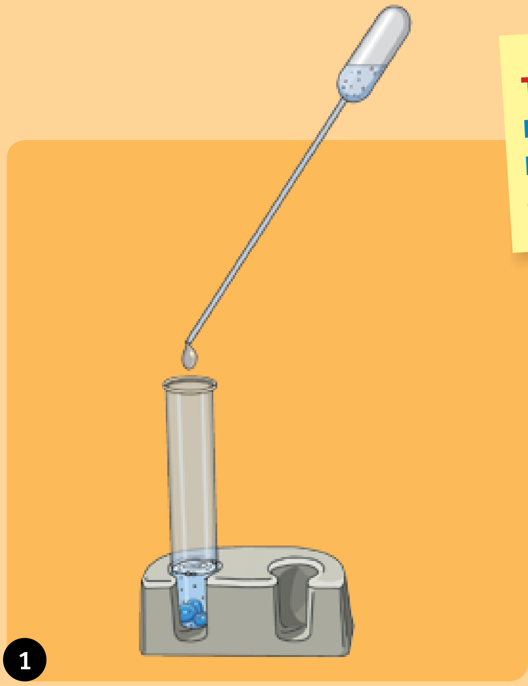
YOU WILL NEED

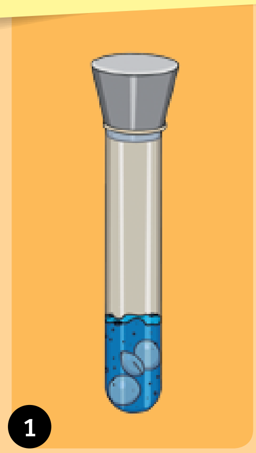
- › **Test tube stand**
- › **3 Test tubes and rubber stoppers**
- › **Funnel, filter paper, pipette, measuring spoon**
- › **Large measuring cup** *with water*
- › *Blue M&M's®*
- › *Charcoal tablets (from the drug store) or charcoal powder (Experiment 8)*

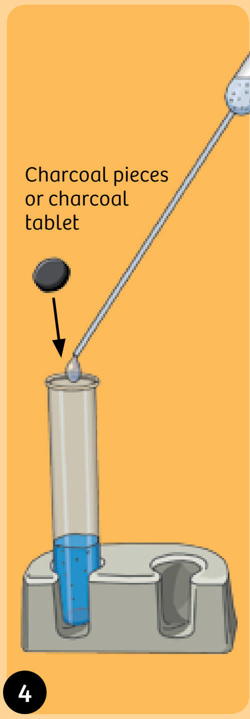
HERE'S HOW

1. Start by making a second test tube stand (for instructions, see page 10). Place three blue M&M's (or six mini-M&M's) and 20 drops of water in a test tube.
2. Insert the stopper in the test tube and shake carefully until the water turns blue and the M&M's are almost white.
3. Now, pour the colored solution into the second test tube, being careful not to let the M&M's slip in with it.
4. Use the pipette to add water to the blue solution until the level of solution in the test tube stands at about 4 cm. Add a charcoal tablet or some charcoal powder, close the test tube, and shake it gently back and forth. Wait one minute.
5. Now take the clean test tube, set the funnel in it with a piece of filter paper, and filter the black liquid. What color do you see in the test tube below? As a comparison, repeat the experiment without adding charcoal. Dispose of all residues in the household garbage.

TIP!
Don't push the stopper too hard into the test tube — it could break.







WHAT'S HAPPENING?

Charcoal powder consists of lots of granules that have a very large overall surface area, which the dye sticks to. This is a technique that can be used to remove impurities from dirty water.

CHECK INTO IT

How do you mix colors?

Red, yellow, and blue are the basic colors, or primary colors, of the color wheel. They are called that because they cannot be mixed from other colors. Secondary colors, such as green, purple, or orange, are those colors that can be created by mixing two basic colors. From any two basic colors, a lot of color gradations can be created depending on their proportions. Colors that lie opposite each other on the color wheel are called complementary colors. If you mix complementary colors together, you get gray. Black, white, and gray do not appear in the color wheel, and are called achromatic colors.

COLORFUL PSYCHOLOGY

Colors have an effect on our senses and influence our moods. Red, for example, has a stimulating and warming effect, while green is more calming. Green is the color of hope and nature. It stands for security and harmony. Yellow is the color of the sun and stands for light, optimism, and joy, so it has a cheerful effect. Blue is the color of the sky and stands for calm, trust, and relaxation.

What is activated carbon?

Activated carbon, or activated charcoal, consists mostly of carbon with a highly porous structure. The pores are interconnected like the holes in a sponge. The inner surface of 4 grams of activated carbon has a surface area approximately equivalent to the surface area of a soccer field.

Since a lot of substances stick well to carbon particles, activated carbon comes in the form of charcoal tablets for treating gastrointestinal illnesses or for detoxification, for example. In air filters, meanwhile, charcoal filters are used to capture bad odors or airborne toxins. In water filters, such as those used in aquariums, they capture bacteria and pollutants. When used in shoe inserts, they capture sweaty odors.

In the food industry, activated carbon is used to remove the color from liquids, decaffeinate coffee and tea, and remove unwanted tastes and odors from foods. It is sometimes even used as a food coloring.

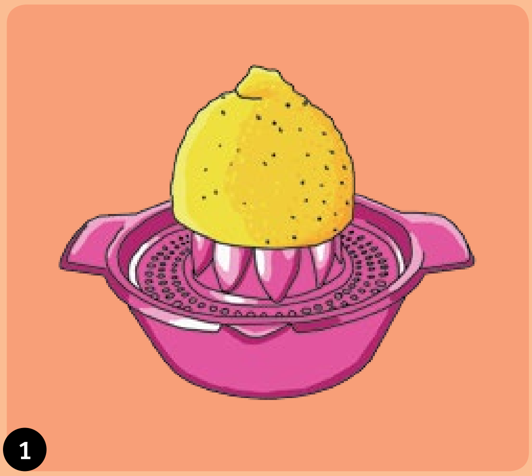
Acid Lab: Acidic, Alkaline, or Neutral

Acids are substances that taste sour or have a corrosive effect, which means that they attack other materials. They are present in many everyday substances. Acids are used, for example, to preserve foods. They are contained as a food additive in lots of drinks. You may know them as carbonic acid and citric acid. In this chapter, you will learn how to tell whether a substance is acidic, how an acid can make a rock start bubbling, and what the opposite of an acid is.

EXPERIMENT 11

Test strips as “chemical tongues”

What is it that actually tastes sour in a lemon? Are there other things that you can use to make something taste tart? To answer this question, try performing a few experiments.



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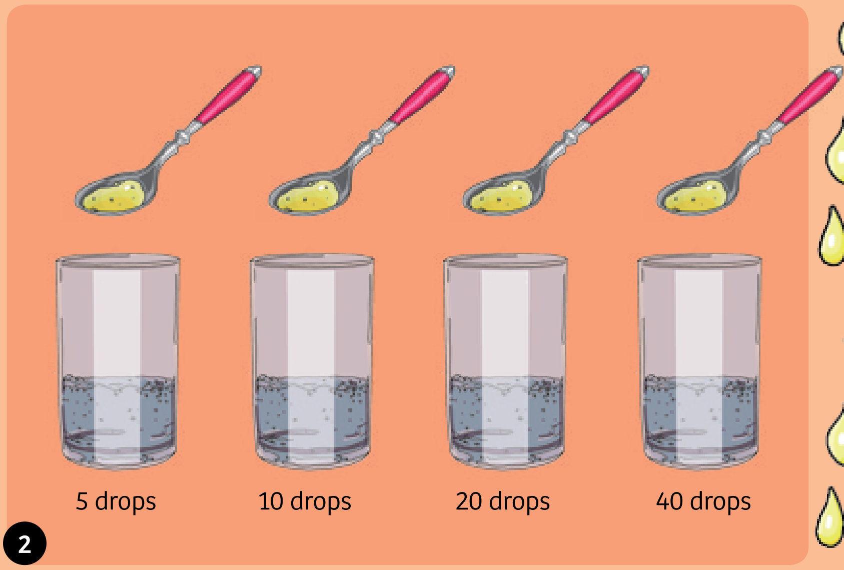
YOU WILL NEED

› **Narrow measuring cup**
› **Test strips**
› **Test tube stand**
› **Test tube**
› **Rubber stopper**
› **Labeled vial with built-in spoon**
› *4 Drinking glasses, fresh lemon, lemon juicer*
› *Household vinegar*
› *Water and pencil*
› *Teaspoon*

HERE’S HOW

1. Squeeze the juice of one lemon. Fill the glasses halfway with tap water.
2. Use the spoon to add 5 drops of lemon juice to one glass. Check the taste and the smell. Since you are using pure lemon juice and a clean drinking glass in this experiment, you are allowed to test the taste with your tongue.
3. Repeat the experiment with the other 3 drinking glasses, using the same amount of water but with 10 drops of lemon juice in one, 20 in the next, and 40 in the last one.
4. Make a note in the table when you can start smelling the lemon aroma and when you can first perceive the sour taste of the lemon in the water.
5. Continue to page 28!



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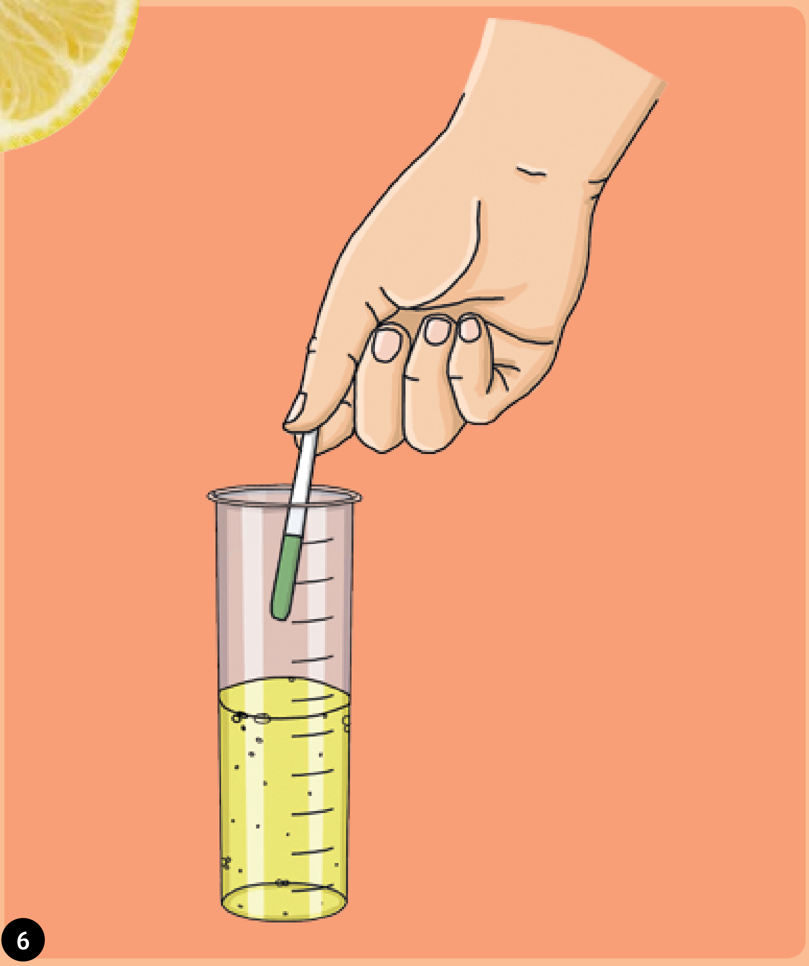
Drops of lemon	Taste	Smell	Comments
5			
10			
20			
40			

Since you are not allowed to test anything with your tongue in a chemistry lab (because there are some toxic substances there), chemists have developed different methods of analysis. One important one is the use of test strips made with a particular dye.



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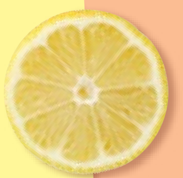
6. Dip a test strip from the kit box into the pure lemon juice and watch how it changes. Then, using a fresh test strip each time, test the solution with 5 drops, the one with 10 drops, etc. Which can detect the acid first, your tongue or the test strip? Which part of the lemon contributes the characteristic lemon aroma, the juice or the peel?

Bonus Experiment:
Dip the test strip into household vinegar. What do you see?

WHAT'S HAPPENING?

Lemon juice tastes sour because it contains about 6% citric acid, while household vinegar is sour because it contains about 5% acetic acid. We have test receptors on our tongue that are capable of perceiving acids like these. The test strip, meanwhile, is colored yellowish orange by them.

The lemon aroma comes from the peel, by the way, since that's what contains the essential oils!



EXPERIMENT 12

Red cabbage or blue cabbage?

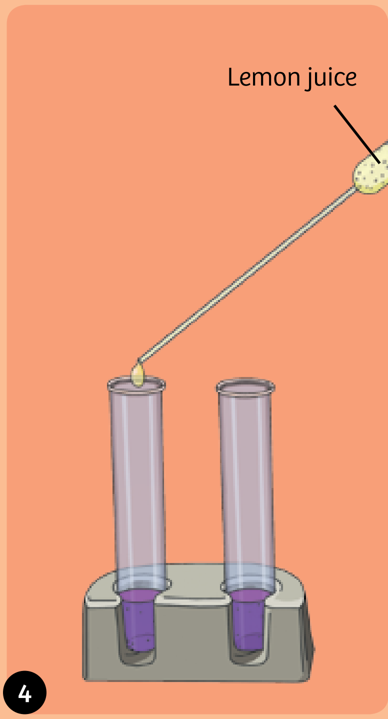
Pigments that change color when you add an acid to them are common in many plants. You can use these plants to make your own test solutions, or even your own test paper.

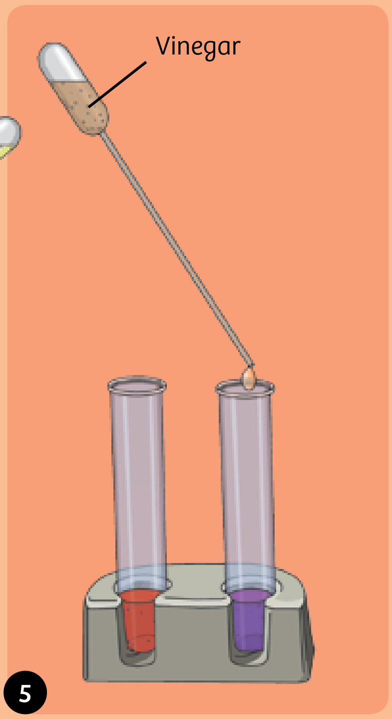
YOU WILL NEED

- **The large and the narrow measuring cups**
- **2 Test tubes and test tube stand**
- **2 Pipettes, measuring spoon**
- *Tablespoon*
- *Red cabbage*
- *Empty jelly jar*
- *Lemon juice*
- *Household vinegar and water*

HERE'S HOW

1. Add three tablespoons of red cabbage to the clean jelly jar. You can do this in the kitchen. Just be sure you didn't already use the spoon or the jelly jar for your other experiments! Just take the jelly jar with you when you proceed to your experiment area.
2. Pour 100 mL of water over the red cabbage. Stir vigorously with the measuring spoon and let sit for 30 minutes.
3. Pour about 50 mL of the red cabbage liquid into the large measuring cup and add 50 mL water.
4. Fill both test tubes 2 cm high with the red cabbage juice. Now use the pipette to add drops of lemon juice to one of the test tubes. Watch the color change.
5. Now use the other pipette to add drops of vinegar to the other test tube. What color change do you see? Compare the liquids in the two test tubes.
6. Save both test tubes with their solutions and the jelly jar of red cabbage juice for the next experiment.





WHAT'S HAPPENING?

A lot of color pigments change their color when you add an acid to them. The test strips turn yellow, and the pigment in the cabbage juice turns red. Chemists call these pigments **indicators.** You can use them to determine whether a solution is acidic, neutral, or alkaline (basic).

What is the opposite of sour?

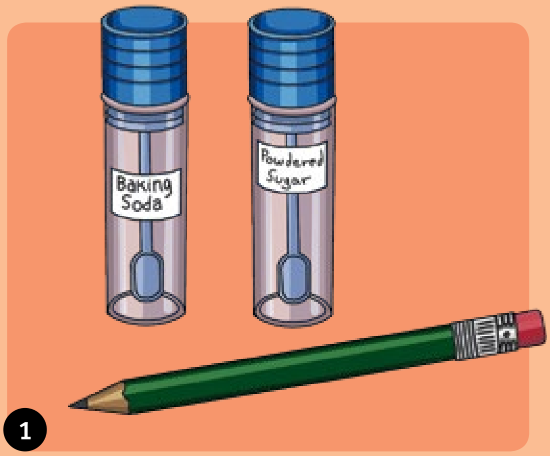
You can use the “opponents” of acids to reverse the color changes. To a chemist, these “opponents” are known as bases or alkalis, a category that also includes baking ingredients such as baking soda. You will experiment with those now.

YOU WILL NEED

› **Test tube stand**
› **2 Test tubes with the red cabbage juice from Experiment 12**
› **2 Vials with built-in spoons**
› **Self-adhesive labels**
› *Powdered sugar and baking soda (sodium bicarbonate), pen*

HERE’S HOW

1. Fill one vial with baking soda and one with powdered sugar, and label them.
2. Add a spoonful (using the spoon built into the lid of the vial) of baking soda to the first test tube from the previous experiment (the one containing the red cabbage juice with a few drops of lemon juice). Shake the test tube a little. Careful: it might foam up. Watch carefully to see what happens.
3. Also add a spoonful of baking soda to the other test tube from the previous experiment (the one containing the red cabbage juice with a few drops of vinegar), and watch what happens.
4. Clean one of the test tubes, and add a little more red cabbage juice to it acidified with a little lemon juice or vinegar. Add a spoonful of powdered sugar.
5. Compare and note your observations. The table to the left will help you get a quick overview.



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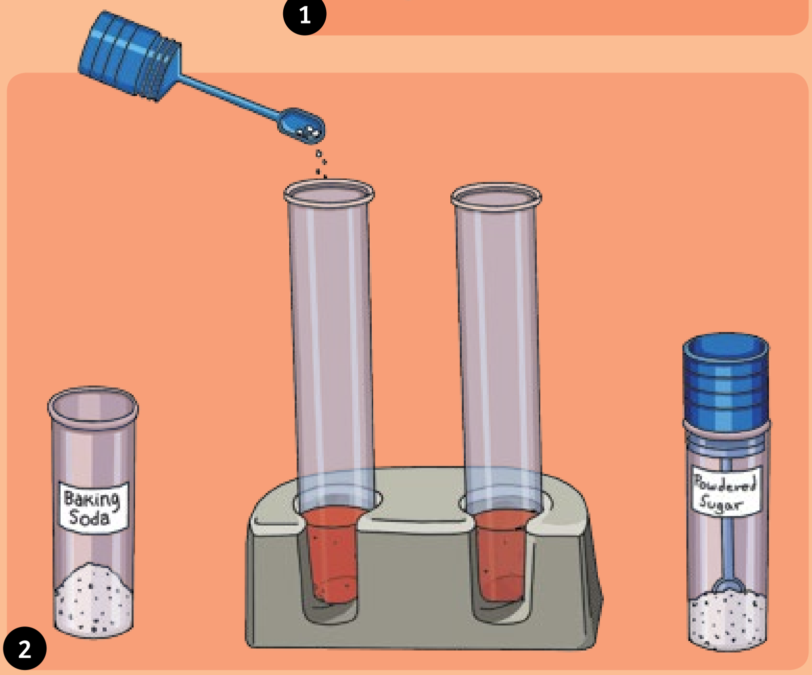

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Added	a lot of acid	a little acid	water	powdered sugar	baking soda
Color of the red cabbage juice					
	acidic		neutral		alkaline (basic)

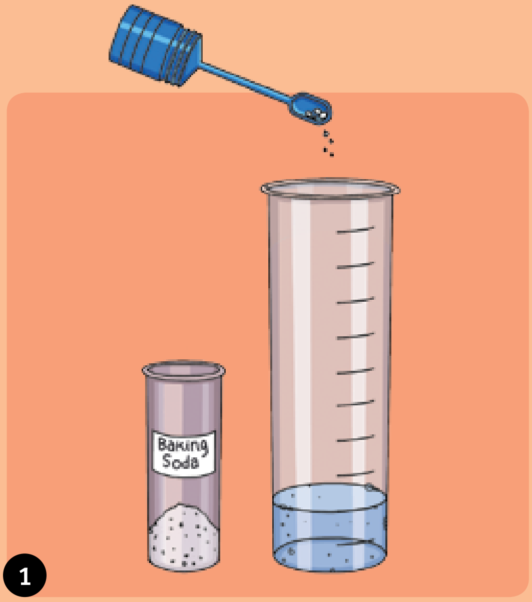
WHAT’S HAPPENING?

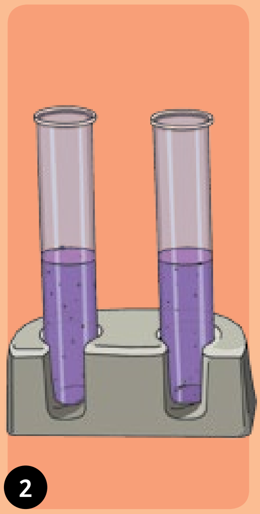
When you add one of acid’s opponents, such as baking soda (sodium bicarbonate), red cabbage juice turns blue. These substances are called “bases” or “alkalis” by chemists. The opposite of acidic is basic or alkaline. But there are also substances like powdered sugar that look almost identical to baking soda, yet they do not cause a change in the color of the indicator. These substances are called “neutral.”

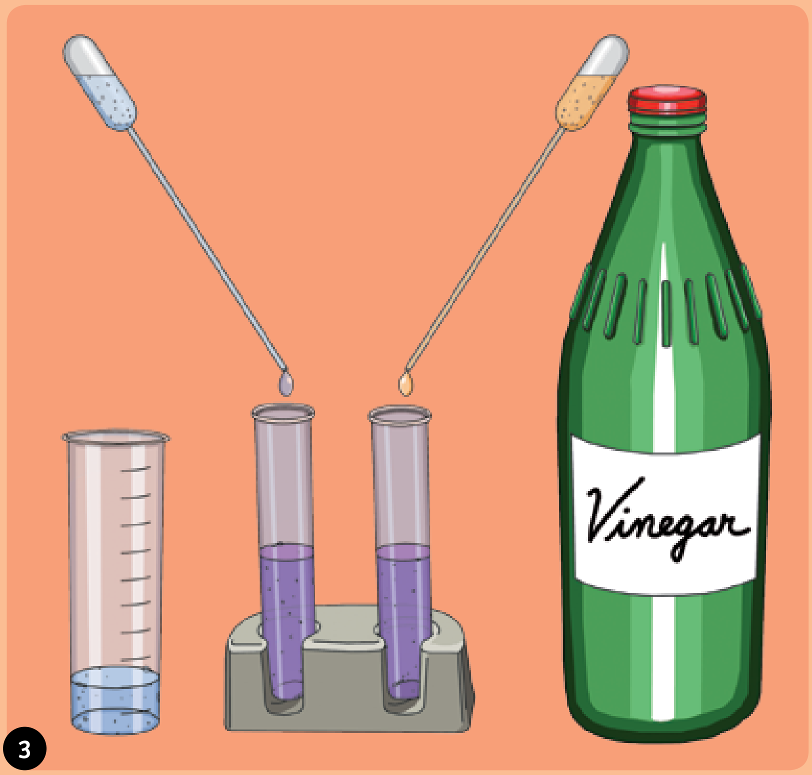
EXPERIMENT 14

Acid and alkali cancel each other out

Pigments such as red cabbage juice are well suited to act as indicators of the degree of acidity of solutions. You can use them to test the reaction of substances in water — whether the solution has an acidic reaction or an alkaline one. But just as two equally strong wrestlers may cancel out (neutralize) each other's strength, you can imagine the interaction of acids and bases: If they are equally strong, they will also cancel each other out. In technical terms, the solution will then have a neutral reaction.







YOU WILL NEED

- **2 Test tubes a test tube stand**
- **Narrow measuring cup, measuring spoon, 2 pipettes**
- *Red cabbage juice and vinegar*
- *Baking soda in vial and water*

HERE'S HOW

1. Prepare a diluted baking soda solution by placing four spoons (from the spoon built into the vial's lid) of baking soda and 20 mL water in the narrow measuring cup, and stirring until everything is dissolved.
2. Fill two test tubes about halfway with red cabbage juice.
3. Use a pipette to add 20 drops of vinegar to one test tube, and 20 drops of baking soda solution to the other. Think about how you might expect the color of the two solutions to look if you mixed them together.
4. Now, add drops of the blue baking soda solution to the red (acidic) vinegar solution in the first test tube, until you see the mixed color you expected.
5. Now try creating this mixed color in the alkaline baking soda solution in the second test tube by adding drops of vinegar or lemon juice.

WHAT'S HAPPENING?

The effect of an acid can be cancelled out — in other words, it can be neutralized — by adding a base. You can see this when the red cabbage indicator, for example, passes from red to a purplish color. And alkaline solutions (red cabbage indicator: blue) can likewise be neutralized to purple by adding acids.

EXPERIMENT 15

1

Just how acidic is ... ?

Using the red cabbage juice and applying your newly-gained knowledge of chemistry, you will now be able to analyze lots of household products such as salt, sugar, effervescent tablets, vitamin tablets, and soap or dish soap.

YOU WILL NEED

› **Test tube stand**
› **2 Test tubes**
› *Red cabbage juice (Experiment 12)*
› *Salt and sugar*
› *Effervescent tablets*
› *Vitamin tablets*
› *Soap or dish soap*
› *Cola*

HERE'S HOW

1. Add a few drops or a few granules of the household products listed above to the red cabbage solution in the test tube. Or you can first dissolve these substances in test tubes with water and then add a given number of drops of red cabbage indicator.
2. Note down your results.

TIP!
The cabbage juice will soon start to smell, so it's always best to make a fresh batch of it. You can also keep a batch of the juice for a few days in a closed, labeled container in the refrigerator.

Added	Salt	Sugar	Effervescent tablet	Vitamin tablet	Soap	Dish soap
Color of the red cabbage juice						

WHAT'S HAPPENING?

With some of the household products, you will be astonished. We don't call them "acidic," and they don't taste sour, and yet...

EXPERIMENT 16

Homemade indicator paper

Chemists often use indicator test strips for their analyses. You can make your own indicator paper using red cabbage juice and filter paper.

YOU WILL NEED

- **Large measuring cup**
- **Filter paper**
- ***Self-adhesive label***
- *Deeply colored red cabbage juice*
- *Hair dryer or paper towel*
- *Scissors, pen*
- *Small container with lid*

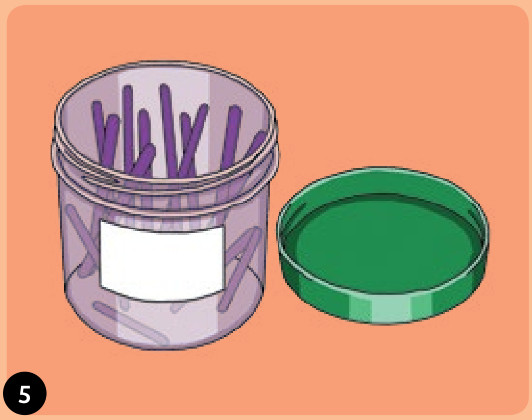
HERE'S HOW

1. Prepare a very strongly colored batch of red cabbage juice by using less water (see Experiment 12 — but just use 25 mL water!).
2. Place the filter paper into the cup with the cabbage juice in such a way that the juice can climb up it. It will take 1 or 2 hours.
3. Then, dry the colored filter paper with a hair dryer or place it on a paper towel to dry.
4. Finally, cut the dried paper into thin strips.
5. Save these strips in a labeled container that you can close tightly.


2


3


4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WHAT'S HAPPENING?

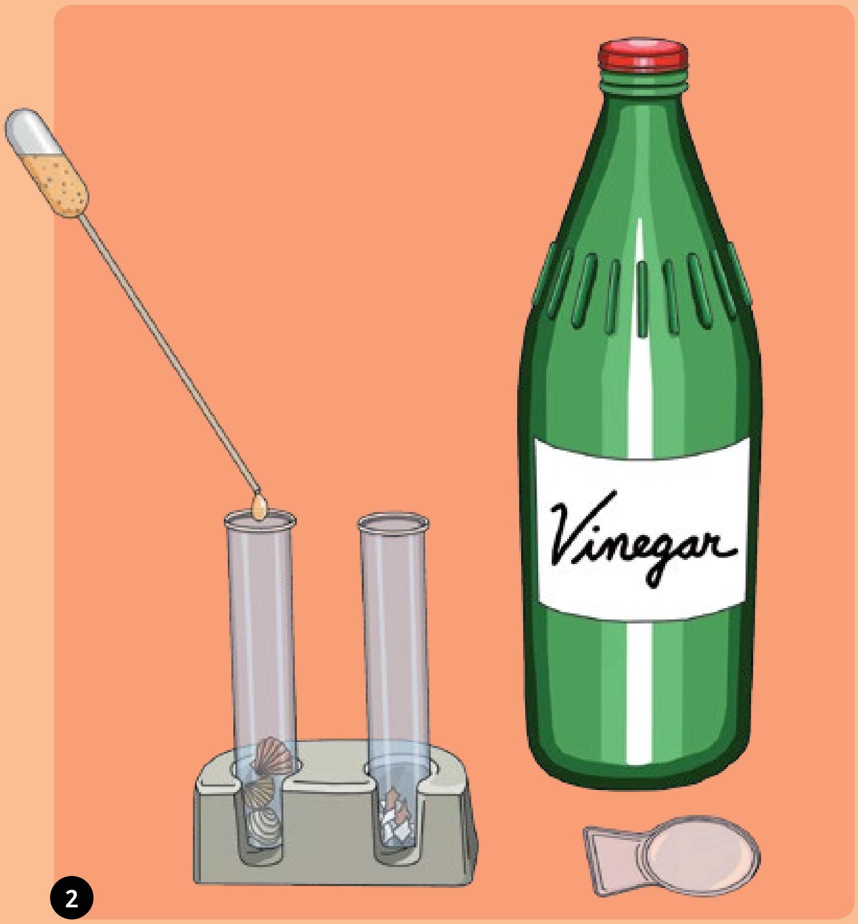
The filter paper strips soak up the red cabbage juice and you can use them to determine whether a liquid is acidic or alkaline.

Acids make rocks bubble

In the experiments with baking agents and acid, you probably noticed that gas bubbles were produced. There are lots of other materials that do this as well.

YOU WILL NEED

- **3 Test tubes**
- **2 Test tube stands**
- **Pipette**
- **Magnifying lens**
- *Various rocks (such as limestone and marble)*
- *Eggshells*
- *Seashells*
- *Household vinegar*



HERE'S HOW

1. Place small pieces of these test objects in your test tubes.
2. Use the pipette to drip vinegar onto them. You can observe the process more closely with the magnifying lens.

WARNING! Never leave the magnifying lens in the sun. Fire danger! Never look directly into the sun, either with your naked eye or through the lens. You could blind yourself!

WHAT'S HAPPENING?

Substances such as baking soda or baking powder contain a component (carbonate) that releases a gas (carbon dioxide) when heated during baking, and it's this gas that makes things like bread dough light and fluffy. The same gas is also produced when you add acids.

Eggshells, seashells, limestone, and marble also contain carbonate, which is why they foam up when you add an acid to them. This is how you can determine whether an unfamiliar substance contains carbonate.

EXPERIMENT 18

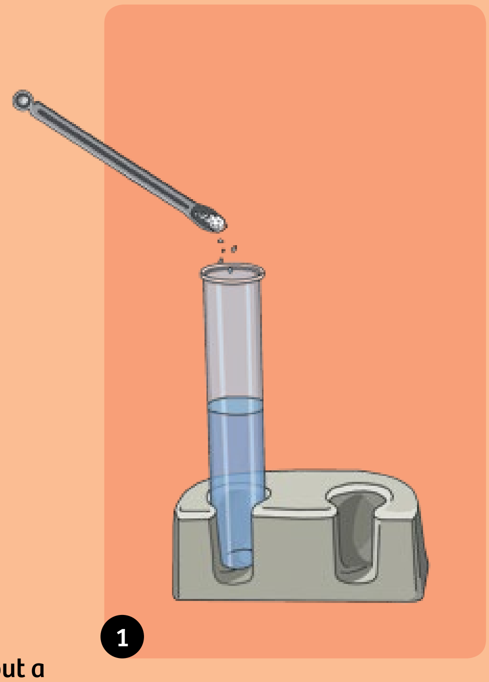
Secret message

YOU WILL NEED

- **2 Test tubes and test tube stand**
- **Measuring spoon**
- **Filter paper**
- **Petri dish**
- **Pipette**
- *Baking soda*
- *Tap water*
- *Cabbage juice*
- *Household vinegar*
- *Cotton swab*

HERE'S HOW

1. Fill a test tube half full of water and put a measuring spoonful of baking soda into it.
2. Fill a second test tube with cabbage juice to a height of two centimeters. Add a few drops of vinegar.
3. Place the filter paper on the Petri dish. With the pipette, drip the red cabbage and vinegar mixture onto the paper until it is completely colored. Then wait until it has dried completely.
4. Dip one end of the cotton swab into the baking soda solution. Use the wet end of the swab to write or draw on the dry, colored filter paper. Observe what happens.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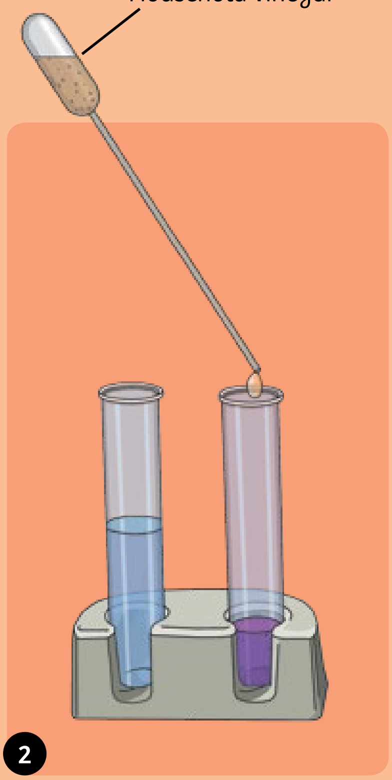

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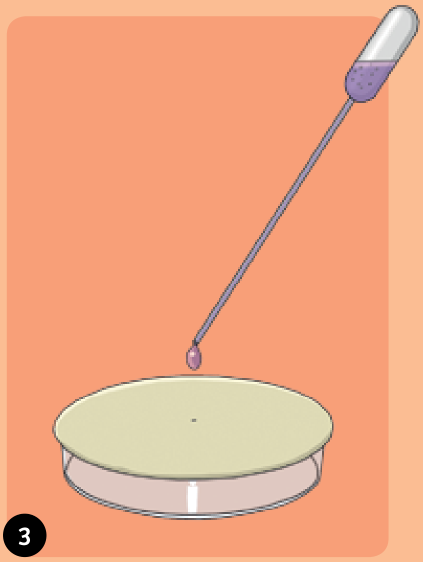
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WHAT'S HAPPENING?

When you write with the baking soda solution on the cabbage juice soaked filter paper, the writing will appear greenish, even though the solution is colorless. As you already know, cabbage juice is an indicator and can indicate whether something is acidic or basic. Because of the baking soda, the water applied to the filter paper is basic, so it discolors the indicator.

CHECK IT OUT

Basic Baking

Acids are used quite commonly in cooking, while bases are used less. Baking soda, or sodium bicarbonate, is the most common base in people's kitchens. However, it is not usually used for flavor, but rather to make gas-producing reactions for leavening dough in baked goods.

People don't seem to like the flavors of strong bases as much as acids. Bases can have a soapy taste and a slippery feel in the mouth. But bases are used in the preparation of many tasty foods.

Lye, a strong base, is used to make the distinctive dark skin of baked pretzels, and to cure foods like olives, fish, and eggs. The basic mineral lime is used to make corn tortillas and the alkaline mineral carbonate is used in the production of cocoa powder. Bases are even used to make chocolate sandwich cookies!

» ACIDS ARE GOOD! «

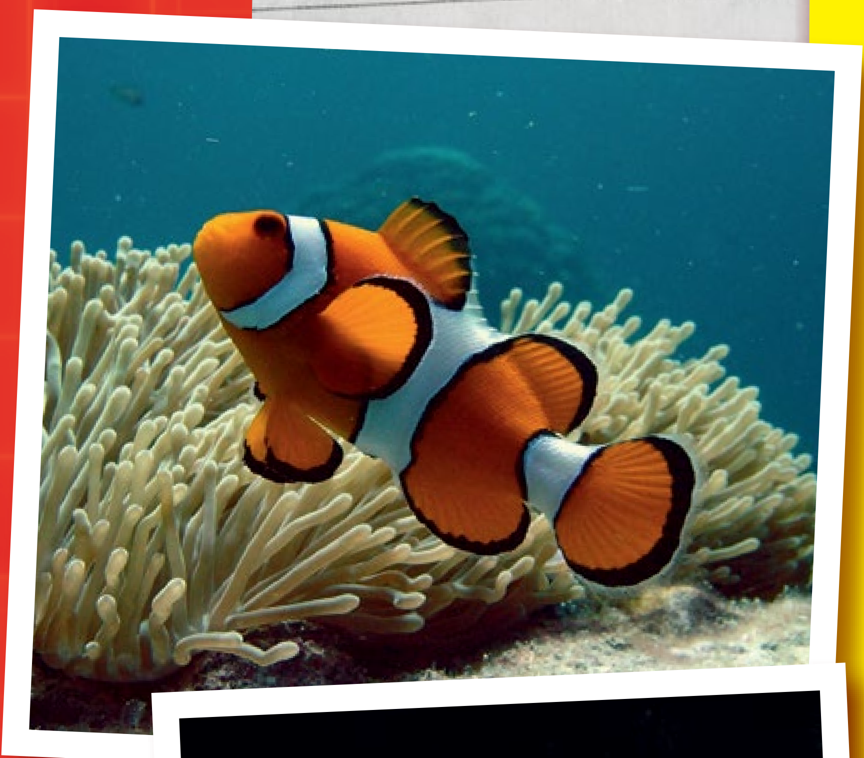
Do we like sour things because of the funny faces that people make when they bite into a lemon? Maybe so! But people have also understood for hundreds of years that sour foods can improve one's appetite. That insight may have come from experiencing their mouth-watering effects. Vinegar or citrus fruits, in other words, can stimulate your hunger and improve your mood. Today we know that a lot of acidic foods such as lemons, apple cider vinegar, and pickled vegetables can even help to maintain the body's proper acid-alkali balance, thereby protecting us from illness.

WHAT ARE INDICATORS?

Pigments that can be used to detect acids due to their color change are called indicators.

Fish do not like sour water

For fish, the acid level of their aquarium water can be a matter of life or death. It can't be too acidic or too alkaline. That's why you have to frequently check the aquarium's water quality using an indicator. You can get these indicators at any aquarium supply shop.



Gas Lab: Where Things Bubble and Hiss

Some gases have a smell, while others don't. Most gases are also colorless, completely transparent, and invisible. Without the gases in air, there would be no life on Earth. In this chapter, you will learn what the air that you breathe is made of, what it has in common with candle fumes, and what gives carbonated drinks their sparkle.

EXPERIMENT 19

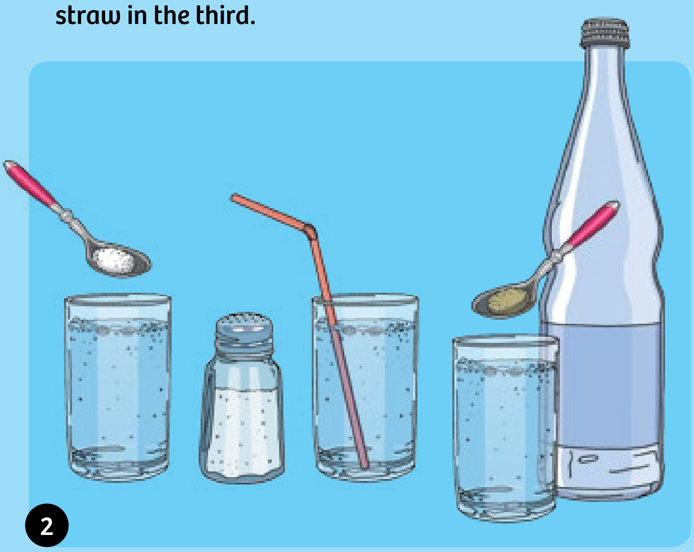
Why do bubbles bubble?

YOU WILL NEED

› **Bendable straw**
› *3 Clean drinking glasses, carbonated water*
› *Salt or sugar, sand*

HERE'S HOW

1. Fill each drinking glass (slowly!) with sparkling water.
2. Add a spoonful of salt to one of the glasses and a spoonful of sand to the second, and place the drinking straw in the third.



WHAT'S HAPPENING?

If you carefully pour sparkling water into a clean glass, it hardly bubbles at all. If you add salt or sugar, though, bubbles immediately form on the sinking crystals. You can even observe this kind of bubble formation with sand. It is especially obvious on the straw, where you can see bubbles grow before letting go and rising to the surface.

A bottle of soda only starts to bubble when you open it, and then the gas hisses and escapes from the open bottle. So there is pressure in the bottle of soda, and when you reduce the pressure, bubbles of gas are able to form. If you close the bottle, the effervescence stops because the pressure rises again.

EXPERIMENT 20

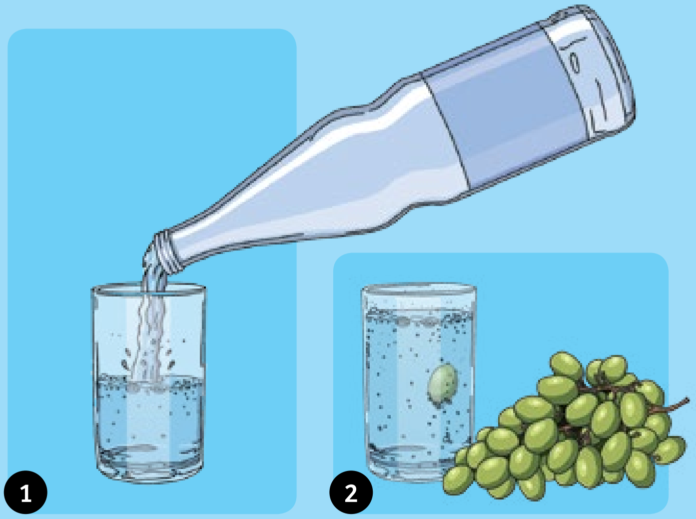
Grape elevator

YOU WILL NEED

› *Clean, tall drinking glass (water glass)*
› *Carbonated water and fresh, unwashed grapes*

HERE'S HOW

1. Fill the glass slowly (!) with sparkling water.
2. Add one or two grapes to the glass and watch what happens. Try to think of an explanation for it.



TIP!
Ideally, you should use fresh sparkling water with plenty of carbonation for your experiments — the open bottle should not have been left sitting around. Afterwards, pour the water down the drain — it shouldn't be kept for anyone to drink!

WHAT'S HAPPENING?

Bubbles form on the unwashed grapes, grow larger and larger, and then carry the grapes one by one to the surface. At the surface, the bubbles let go, the grape sinks down again, and new bubbles form as the process repeats.

EXPERIMENT 21

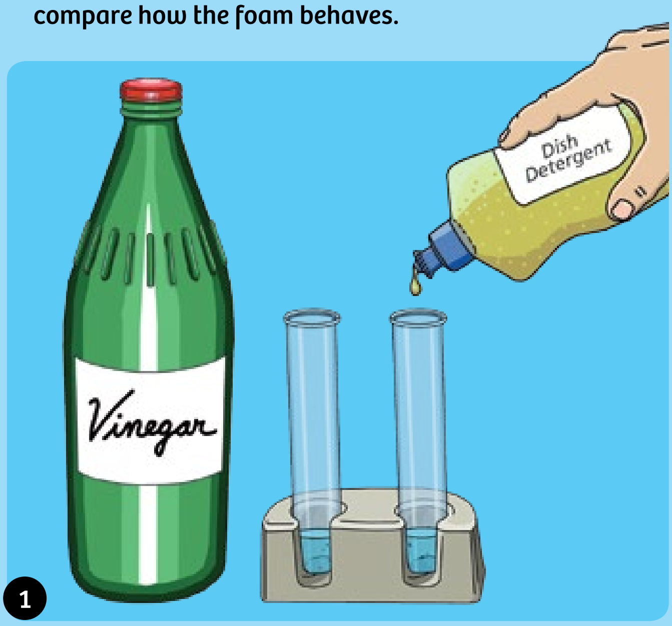
Chemical foaming

YOU WILL NEED

- **2 Test tubes and test tube stand**
- *Baking soda*
- *Household vinegar*
- *Dish detergent*
- *Water*

HERE'S HOW

1. Fill both test tubes with water to a height of one centimeter in the tube. Then add a half centimeter of vinegar to each tube. Finally drip five drops of dish detergent into one of the two tubes.
2. Add one scoop of baking soda to each test tube and compare how the foam behaves.



WHAT'S HAPPENING?

In both test tubes the solution foams up vigorously because the vinegar is an acid and the baking soda is a base. The foam quickly falls back down again in the tube without the detergent, but the foam remains stable for a longer period of time in the tube with the detergent. This stability is caused by the detergent, which surrounds the bubbles with a protective layer. The bubbles that resulted from the reaction don't contain normal air, but rather carbon dioxide formed from the reaction.

EXPERIMENT 22

Comparing water and soda

Carbon dioxide — the gas that you have created during the last experiment — is, in contrast to oxygen, non-flammable. With this experiment, you can demonstrate this difference.

YOU WILL NEED

- **2 Test tubes and test tube rack**
- *Long matches (fireplace matches)*
- *Sparkling mineral water (fizzy)*
- *Tap water*

HERE'S HOW

1. Fill one test tube half full of tap water and the other test tube half full of sparkling water.
2. Have an adult help you with this part. Light a long match and hold it in one of the tubes, so that it does not touch the liquid in it. Observe what happens. Then proceed with the other test tube in the same manner.

WHAT'S HAPPENING?

The matchstick in the test tube with the tap water continues to burn while the other goes out. The carbon dioxide released by the sparkling mineral water has suffocated the flame. Even without shaking it up, carbon dioxide is released from sparkling mineral water. This is enough to extinguish the flame.

EXPERIMENT 23

Extinguishing a candle as if by magic

As you have seen in the previous experiment, you can extinguish flames with carbon dioxide. Mixing baking soda and vinegar together creates carbon dioxide, which you can use to put out a tealight candle.

YOU WILL NEED

› *Screw-top glass jar, glass bowl*
› *Tealight candle*
› *Lighter or matches*
› *Baking soda or baking powder*
› *Household vinegar, teaspoon*

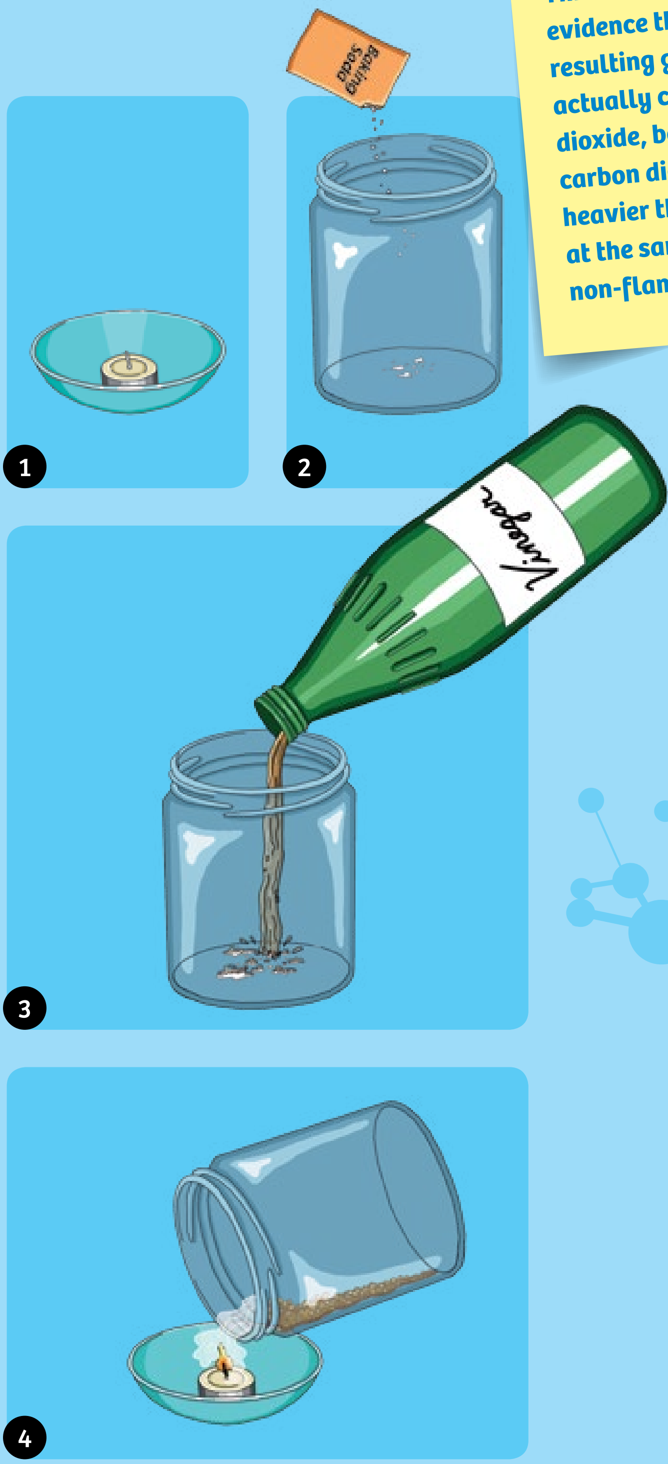
HERE'S HOW

1. Place the candle in the bowl.
2. Put 2 teaspoons of baking soda (or baking powder) in the screw-top jar.
3. Carefully pour some household vinegar onto the baking soda until it foams and wait.
4. Have an adult help you with this part. Light the tealight candle. Pour only the gas from the screw-top jar over the burning candle in the bowl. Be careful that you do not burn yourself and that no vinegar pours out of the jar.

WHAT'S HAPPENING?

When the baking soda and the vinegar react, they foam vigorously and produce carbon dioxide. When you tip the jar holding the carbon dioxide over the burning candle, the flame goes out. The invisible carbon dioxide gas flows out of the jar when it is tipped over the candle because the carbon dioxide is heavier than air and falls downward.

This test serves as evidence that the resulting gas is actually carbon dioxide, because carbon dioxide is heavier than air and, at the same time, non-flammable.



Additional Experiment

Carbon dioxide is released from other chemical reactions too. You can also try this experiment with an effervescent tablet in water. Enough carbon dioxide is released by the foaming tablet to extinguish the candle flame.

Candle goes out by itself

In this experiment, you will see that you do not necessarily need carbon dioxide to make a flame go out.

YOU WILL NEED

› *Screw-top glass jar*
› *Tealight candle*
› *Old saucer*
› *Lighter or matches*

HERE'S HOW

1. Set the tealight candle on the saucer and ask an adult to light it for you.
2. Place the screw-top jar over the tealight and observe what happens.

WHAT'S HAPPENING?

The tealight candle flame goes out after a short period of time. The oxygen — the gas required by the flame in order for it to continue to burn — is consumed by the flame. The remaining components of air (nitrogen and noble gases) are non-combustible. Although carbon dioxide is also present in small amounts in the air, it is not enough to smother the flame. It is the lack of oxygen rather than the presence of carbon dioxide that makes the flame go out.

EXPERIMENT 25

Lift the boat

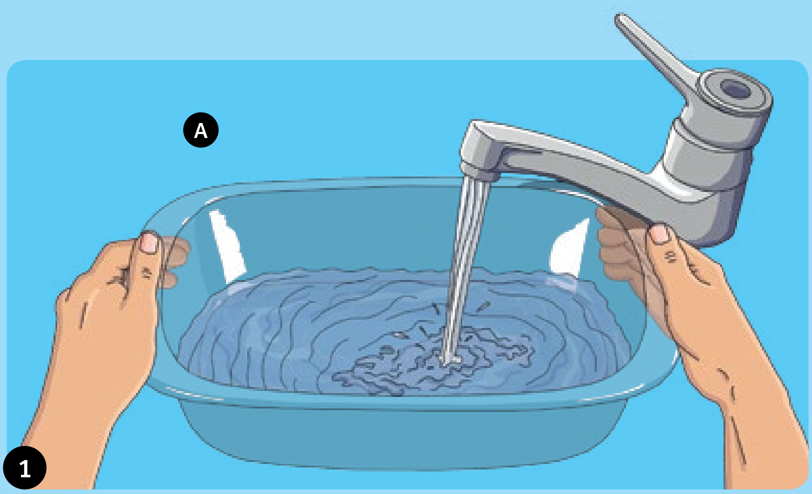
Now you know that oxygen is consumed by a flame. At the same time, carbon dioxide is produced. With this experiment you can see that something is changing in the air when a candle is burning inside the jar.

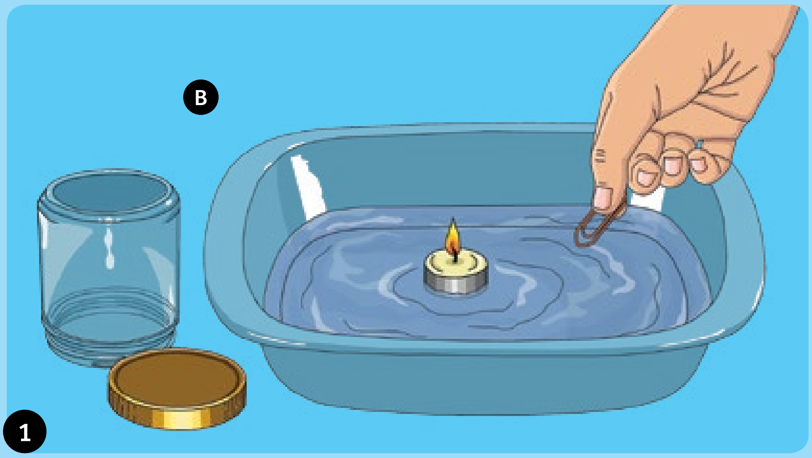
YOU WILL NEED

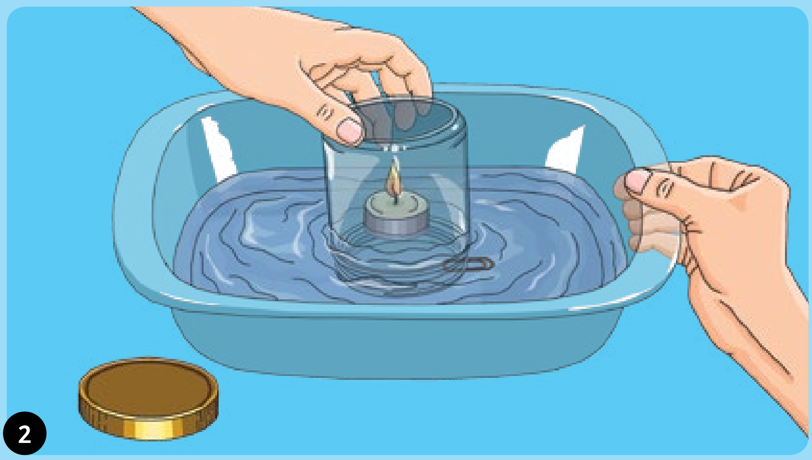
- *Large glass bowl or basin*
- *Screw-top glass jar*
- *Tealight candle*
- *Lighter or matches*
- *Paperclip*
- *Water*

HERE'S HOW

1. Fill the large bowl with water to a height of two centimeters. Float the tealight candle in the water. Ask an adult to light the candle for you. Place the paper clip beneath the tealight in the water.
2. Place the screw-top glass jar over the tealight and let it rest on the bottom of the tub so that its edge rests on the paper clip.







WHAT'S HAPPENING?

The tealight candle flame goes out after a short time because the oxygen in the jar runs out (just like in the previous experiment). The water level and thus the tealight candle rise up in the jar. With the combustion of oxygen and the formation of carbon dioxide, the mixture of gases inside the jar changes. The air now takes up less space causing water to flow into the jar from the outside to occupy the vacated space. The reason the air takes up less space relates to various physicochemical processes including the cooling of the heated air and the change in the composition of the air resulting from the combustion.

What is air made of?

The air that we need to breathe is composed of a mixture of gases, with two main components. Most of the air (four fifths) consists of nitrogen. In order to breathe, though, it's the second component that we really need — oxygen. Our bodies use oxygen to obtain energy from the food that we eat.

CARBON DIOXIDE CAN PUT OUT A FIRE

Carbon dioxide-containing fire extinguishers are useful for putting out small fires without causing the damage that can be caused by water or foam. Carbon dioxide fire extinguishers are used in chemistry labs, for example. The way these hand-operated fire extinguishers work is by displacing the oxygen that fuels the flames of a fire. In larger devices, carbon dioxide is used to push foam or powder out of the fire extinguisher.

EFFERVESCENT POWDER IN MEDICINE

In the old days, effervescent powder was used to give bitter medicine a more pleasant flavor. Bronchitis and tuberculosis, for example, used to be treated with sulfur, which tastes disgusting. When combined with effervescent powder, though, the taste was more tolerable. Effervescence is still used in medicine today, in effervescent aspirin tablets or cold medicine, for example.

How does carbon dioxide come out of mineral water?

When rain and snow fall, the water can seep through layers of earth before collecting deep underground. Carbon dioxide is produced even deeper down. When the water and carbon dioxide meet, they combine and push to the surface. It's this naturally sparkling water that certain mineral water companies collect and sell.

You can't just fill it directly into bottles, though. Instead, the escaping gas is first captured and cooled to about minus 38 degrees Celsius, turning it into liquid. That allows large quantities of carbon dioxide to be stored in tanks. To get the carbon dioxide back into the water, it has to be "thawed out" and converted into gas again. Then, it is forced back into the water under high pressure. And that's why mineral water is nice and bubbly when we finally open the bottle.

Analytic Lab: Identifying Substances

Chemists are often presented with materials that they need to identify. Because many of these substances are toxic, safety regulations must be observed (for example, never taste test a chemical with your mouth). The different characteristics of the substances are used as identification aids for such analyses. Based on these characteristics, a chemist can determine which substances are present. In this chapter, you can learn how to analyze substances.

EXPERIMENT 26

Acid detective

When baking soda (sodium bicarbonate) reacts with acids, carbon dioxide forms (the same gas that you know from the previous experiments). You can see this reaction in the bubbles that appear in the liquid.

You can now examine various liquids and test to see if they produce a bubbling acidic reaction when baking soda is added to them.

YOU WILL NEED

- **3 Test tubes and 2 test tube racks**
- **Measuring spoon**
- *Baking soda*
- *Test liquids (e.g., cola, iced tea, cooking oil, milk, lemonade, apple juice, fizzy drinks, and other liquids from your refrigerator)*

HERE'S HOW

1. Fill a test tube with one of your test liquids to a height of two centimeters in the tube.
2. With some liquids, you will observe that they are already bubbling or fizzing. To make sure you don't confuse this bubbling with a reaction to the baking soda, stir these fluids with the measuring spoon until no more bubbles can be seen. Then add a small spoonful of baking soda to the liquid and observe whether it bubbles or not.

TIP!
Sometimes you can tell if a substance is an acid just by looking at its ingredients list. You can recognize acids because they are often called either "acid" or they end in "-ate". For example, citric acid or citrate, phosphoric acid or phosphate, and so on.

1

2

WHAT'S HAPPENING?

In acidic liquids, baking soda causes bubbles to form. In non-acidic liquids, it does not cause bubbles to form. From this you can identify which liquids are acidic and which are not.

Test liquid	Cola	Iced tea	Lemonade	Fizzy drink	Milk	Cooking oil	
Is it an acid?							

EXPERIMENT 27

Powder detective

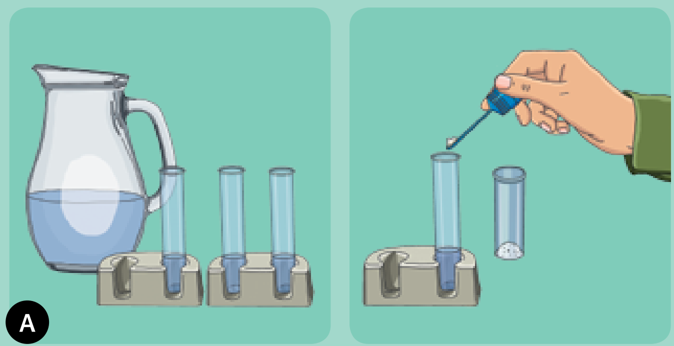
In this experiment, you can test for two properties of materials (solubility in water and gas production with an acid) and learn how you can use these properties to distinguish three identical-looking white powders.

YOU WILL NEED

- **3 Vials with built-in spoons**
- **3 Test tubes and 2 test tube racks**
- **Measuring spoon**
- *Teaspoon*
- *Powdered sugar, corn starch and baking soda*
- *Water (Experiment A)*
- *Vinegar (Experiment B)*

Have someone else put a teaspoon of powdered sugar in one vial, a teaspoon of cornstarch in another vial, and a teaspoon of baking soda in a third vial, so that you do not know which substance is in which vial.

A. Water solubility test



HERE'S HOW

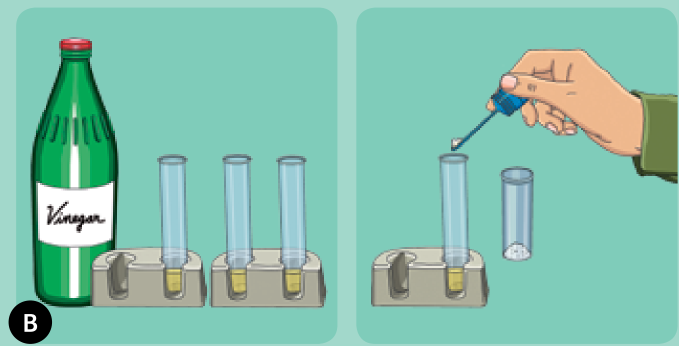
1. Fill the three test tubes with water to a height of three centimeters in the tube. Place them in the racks.
2. To each test tube, add one spoonful of one of the three white powders, making sure you put a different powder into each tube. Stir each tube. Observe how the different white powders behave in the water.

WHAT'S HAPPENING?

The powdered sugar and baking soda dissolve in water, so that nothing can be seen. The corn starch initially remains as lumps lying in the water and then creates a cloudy mixture as soon as you stir it. Now you can identify the corn starch and label the vial.

The starch particles are much larger than the sugar and baking soda particles, so they do not dissolve in water.

B. Gas production with an acid test



HERE'S HOW

1. Fill the three test tubes with household vinegar to a height of one centimeter. Place them in the racks.
2. To each test tube, add one spoonful of one of the three white powders, making sure you put a different powder into each tube. Stir each tube. Observe how the different white powders behave in the vinegar.

WHAT'S HAPPENING?

In the test tubes with the powdered sugar and the corn starch, you will not observe a bubbling reaction. The baking soda, however, reacts with the vinegar to form carbon dioxide bubbles (just like in experiment 23). Now you can identify the baking soda and label its vial. And through the process of elimination, you know the third chemical must be the powdered sugar. You have identified all three substances without needing to taste them!

Baking soda has a neutralizing effect on acids — after the reaction, the solution is no longer an acid.

CHECK IT OUT

Chemical Laboratories

In chemical laboratories, all sorts of substances are prepared, monitored, and examined. Chemists working in laboratories must follow strict safety rules because it is often necessary to deal with toxic substances. Lab coats, safety glasses, long pants, and closed shoes are obligatory for everyone who enters a laboratory. Food, drink, and cosmetics are strictly prohibited.

There are also high security laboratories where even stricter rules apply. At these, you have to go through one or more locks to get inside. The locks prevent materials from the laboratory from getting into the environment and vice versa. In addition, access is granted to only certain trained personnel.

Laboratories have different levels of security assigned to them. They are marked with the numbers 1-4. Level 4 labs are the most secure and the most dangerous. For example, deadly viruses for which there are no cures are examined in these high-security labs.

MORE THAN JUST ONE METHOD

For the chemical analysis of substances, there is usually more than just one test method because often one method will work in some situations but not in others. Therefore, it is advantageous to have an alternative test method.

To determine acidity, you know now the red cabbage indicator test (experiment 15) and the acid test (experiment 26). The red cabbage test does not work with oily liquids, because the water-soluble cabbage juice does not mix with oil and, therefore, does not display any result.

Oil does not dissolve in water.

The bubbling action of baking soda in acids only works if the acidic material is a liquid. For solids, no result shows.

Kosmos Quality and Safety

More than one hundred years of expertise in publishing science experiment kits stand behind every product that bears the Kosmos name. Kosmos experiment kits are designed by an experienced team of specialists and tested with the utmost care during development and production. With regard to product safety, these experiment kits follow European and US safety standards, as well as our own refined proprietary safety guidelines. By working closely with our manufacturing partners and safety testing labs, we are able to control all stages of production. While the majority of our products are made in Germany, all of our products, regardless of origin, follow the same rigid quality standards.

3rd Edition 2015

Concept and Text: Professor Peter Menzel (Institute of Science Education and Computer Science), University of Hohenheim, with the team from Fehling Labs Stuttgart: Sabine Frank, Werner Eisner, Karin Leuthner, Dr. Marco Spurk; Annette Vielfort, Chemical Industry Fund
Suggestions from Dr. Christa Jansen, Merck KGaA, and Dr. Marco Oetken, University of Oldenburg
The experiments in this kit were developed and tested in the Fehling's Lab. The Fehling's Lab was created as a cooperation between the University of Stuttgart, Germany and the University of Hohenheim, Germany. It combines an experimental laboratory for students with a means for teacher training and continuing education (www.fehling-lab.de).

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Manual Style Guide: Atelier Bea Klenk, Berlin
Editorial Review: Uta Kossmagk, Wiesbaden; Christiane Theis, Gärtringen
Revision of the Manual: Fine Tuning, Michaela Kienle
Manual Illustrations: Tanja Donner
Manual Photography: Martina Berg, p. 47 b; Adrien Roussel, p. 37 b; Christian Jung, p. 12 l; Hector Fernandez, p. 17 m; Lucky Dragon, p. 36 t; Jose Manuel Gelpi. p. 26 r; Mikael Damkier, p. 3 b; Jiri Hera, p. 5; Victoria, p. 37 m ; Michelle Dudley, p. 46 r; Teamarbeit, p. 33 b, p. 3 m; Sabine, p. 37 t; Ilike, p. 28 rb; Irochka, p. 26 r; elypse, p. 25 lb; picsfive, p. 1; Carmen Steiner, p. 47 m; dpaint, p. 3, 18 li; Bernd Jürgens, p. 3 m; Ervin Monn, 17 tl; barneyboogles, p.4 br; klopsboy, p. 7 l; MaFiFo, p. 8 rt; Miredi, p. 3 b, 38 l; Dušan Zidar, p. 24; Beboy, p. 3 br; joda; p. 25 r; Black Beard, p. 25 lt; Bernd p., p. 17 rt; Unclesam, p. 13; Klaus Eppele, p. 23; eyewave, p. 8 b; Reena, p. 34; frank peters; p. 28 l; diedel, p. 22; HLPhoto, p. 14; hartphotography, p. 46 tr; goodluz, p. 46 m; TrudiDesign, p. 36 lb; Leonid & Anna Dedukh, p. 12 r; Yantra, p. 3 t; photocrew, p. 28 r; ottoheuer, p. 37 t; Bromsilber, p. 18 r; illmann, p. 25 rb; L. Klauser, p. 3 m; pterwort, p. 22 m; Altin Osmanaj; p. 17 br; ALCE, p. 17 bl; UMA, p. 29; PRILL Mediendesign, p. 22; markus_marb, p. 36, p. 17 mr; vovan (all previous ©fotolia.com) Floortje's, p. 20 (©istockphoto.com); Michael Flaig, p. 2 ; Fehling-Lab, p. 9

Packaging Design Style Guide: Peter Schmidt Group GmbH, Hamburg
Packaging Photography: pro-studios, Michael Flaig, Stuttgart; Andreas Klingberg, Hamburg
Packaging Layout and Design: Illustration Rachel and Toni: Seippel & consecration communications consulting GmbH, Offenbach / Main, www.seippel-weihe.com

Editing: Ted McGuire; Additional Graphics and Layout: Dan Freitas

Distributed in North America by Thames & Kosmos, LLC. Providence, RI 02903
Phone: 800-587-2872; Web: www.thamesandkosmos.com

Distributed in United Kingdom by Thames & Kosmos UK, LP. Goudhurst, Kent TN17 2QZ
Phone: 01580 212000; Web: www.thamesandkosmos.co.uk

We reserve the right to make technical changes.

Printed in Germany / Imprimé en Allemagne

642921-03-260116