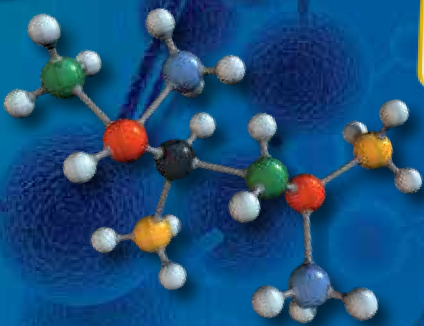
EXPERIMENT MANUAL

CHEMISTRY C500



Please observe the safety information, the advice for supervising adults on page 1, the safety rules on page 6, the information about hazardous substances (chemicals) and their environmentally sound disposal on page 7, the safety for experiments with batteries on page 8, and the first aid information on the inside front cover.

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.

WARNING — Chemistry Set. This set contains chemicals 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.

THAMES & KOSMOS

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Thames & Kosmos, 89 Ship St., Providence, RI, 02903, USA | 1-800-587-2872 | www.thamesandkosmos.com

First Aid Information

→ In case of eye contact: Wash out eye with plenty of water, holding eye open if necessary. Rinse from the nose outwards. 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. For example, move person into another room with open windows or outside.

→ In case of skin contact and burns: Wash affected area with plenty of water for at least 10 minutes. Cover burns with a bandage. Never apply oil, powder, or flour to the wound. Do not lance blisters. For lager burns, seek immediate medical help.

→ In case of doubt, seek medical advice without delay. Take the chemical and its container with you.

→ In case of injury always seek medical advice.

→ 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 germ-free, dry first-aid bandage. Foreign objects such as glass splinters should only be removed from the wound by a doctor. Seek medical advice if you feel a sharp or throbbing pain.

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

Notes on Disposal of Electrical and Electronic Components:
The electronic components of this product are reusable For the sake of the environment, do not throw them into the household trash at the end of their lifespan. They must be delivered to a collection location for electronic waste, as indicated by the following symbol:
Please contact your local authorities for the appropriate disposal location.

Keep the packaging and instructions, as they contain important information.

Dear Parents and Supervising Adults

Chemistry C500 will provide your child a first look at this fascinating science. It is natural to have questions about the safety of a kit that contains chemicals. The experimental equipment and the experiments in this kit meets U.S. and European safety standards, which specify the safety requirements for chemistry experiment kits. These standards impose obligations on the manufacturer, such as forbidding the use of any particularly dangerous materials. The standards also stipulate that adults should assist their children with advice and assistance in their new hobby. Therefore please take a look through this instruction manual and pay particular attention to the

→ **Safety Rules** on page 6,
→ **Information about hazardous substances (chemicals)** on page 7,
→ **Safety for experiments with batteries** on page 8,
→ **First aid information** on the inside front cover, and the
→ **Safety information** accompanying each experiment.

Advice for Supervising Adults

→ **A.** Read and follow these instructions, the safety rules and the first aid information, and keep them for reference.
→ **B.** The incorrect use of chemicals can cause injury and damage to health. Only carry out those experiments which are listed in the instructions.
→ **C.** This experimental set is for use only by children over 10 years.
→ **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 (e.g. tartaric acid), alkalis (bases, e.g. sodium carbonate) and flammable liquids (denatured alcohol).
→ **F.** The area surrounding the experiment 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.

Emphasize to your child the importance of following all of this information, 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.

While experimenting, please be careful not to let the chemicals come into contact with the skin, eyes, or mouth. Do not inhale chemical dust, vapors or powder. It is also important not to let the chemicals, or the solutions prepared with them, to get into the hands of small children.

When performing chemistry experiments, it is important to wear suitable clothing (e.g. an old smock and smooth fingered gloves) and the safety goggles. Please be sure to get any required equipment and chemicals ready before starting an experiment.

After completing the experiments, he or she should clean up the work area and thoroughly wash his or her hands.

We wish you and your young chemist a lot of fun and success with the experiments!

What's in your experiment kit

Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
☐	1	Empty bottle for litmus solution (for production instructions, see p. 16)	1	772510
		including safety cap with dropper insert	1	704092
☐	2	Litmus powder, 1g	1	772502
☐	3	Potassium hexacyanoferrate(II), 4g	1	772505
☐	4	Ammonium iron(III) sulfate, 5g	1	772507
☐	5	Sodium carbonate, 12g	1	772504
☐	6	Tartaric acid, 6g	1	772512
☐	7	Test tubes	3	062118
☐	8	Double-headed measuring spoon	1	035017
☐	9	Dropper pipettes	2	232134
☐	10	Rubber stopper	1	071078
☐	11	Safety glasses	1	717019
☐	12	Lid remover	1	070177
☐	13	Clip for 9-volt battery	1	042106

Please check all the parts against the list to make sure that nothing is missing. If you are missing any parts, please contact Thames & Kosmos customer service.

Additional things you will need:

Tealight candle, plate, knife, thin paintbrush or ink pen, yellow paper, white coffee filter or blotting paper, iron nail, matches, 9-volt battery, bar soap, liquid soap, shower gel, denatured alcohol (methylated spirits), light-colored table vinegar, table salt, lemon, sparkling water, distilled water, water, paper towels

Any materials not contained in the kit are marked in *italic script* in the "You will need" boxes.

CONTENTS

CHECK IT OUT

You will find supplemental information on pages 14, 22, 26, 34, 41, and 48.

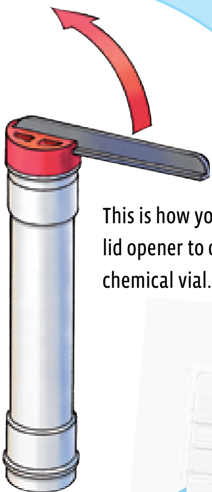
Your lab station

Chemicals

Your experiment kit contains five chemicals: litmus powder, which you will use to prepare the required litmus solution, along with sodium carbonate, potassium hexacyanoferrate(II), ammonium iron(III) sulfate, and tartaric acid. That sounds complicated — but with a little practice you will be able to pronounce the names quite easily, particularly if you read them often in the manual.

Chemical vials

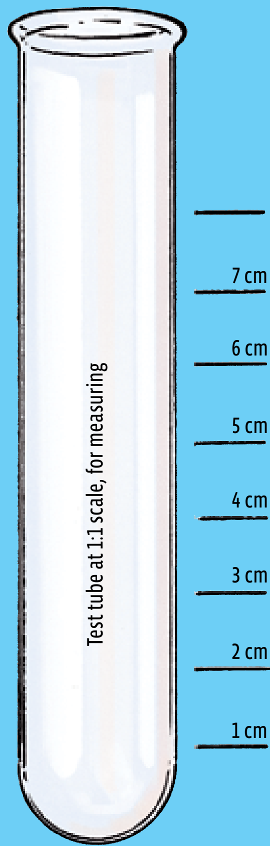
The chemical vials have one large chamber for larger quantities and a smaller one for chemicals needed only in small amounts. Fill levels are determined by what you will need as well as by standards pertaining to chemistry kits. The uniform size of the vials is necessitated by the size of the labels containing the information required by law. To open the chemical vials, use the lid opener.



This is how you use the lid opener to open a chemical vial.

Tip:

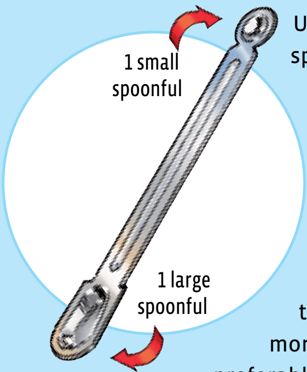
When you open a vial, sometimes a little of the chemical substance will stick to the lid and fall on your hand or the work surface. You can prevent this by banging the bottom of the vial several times against the work surface before opening it.



Test tubes

To carry out your chemical reactions, you will be using test tubes — just like a real chemist. Set filled test tubes into the provided openings in the lab station, as shown to the left. Use the rubber stopper to close a test tube whose contents you have to shake. When you shake it, keep your thumb pressed against the stopper. Don't forget to clean the stopper before using it to shake a different chemical.

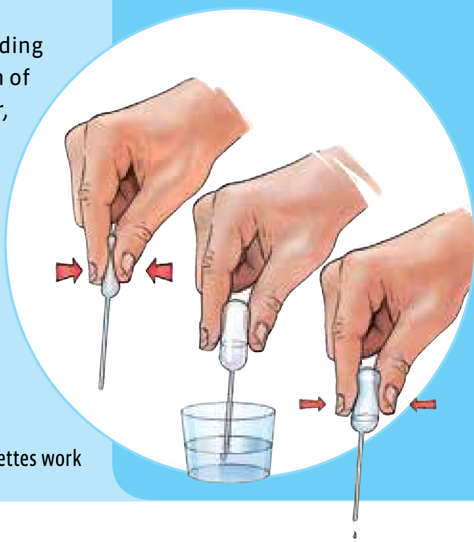
Measuring spoon



Use the double-headed measuring spoon, which has a large end and a small end, to take chemicals from the vials. A “large” spoonful means one level scoop from the larger end, while a “small” spoonful means a level scoop from the small end. Sometimes a “spoon tip” will be enough, meaning no more than half of the small end, or preferably even less. Always make sure you close the vial immediately after each use!

Dropper pipettes

You will be using the dropper pipettes when adding liquids drop by drop. Squeeze the upper section of the pipette between your thumb and forefinger, and dip the pipette tip into the liquid. As soon as you release the pressure, the liquid will rise up the pipette. You can then add the liquid drop by drop by applying light pressure. Rinse the pipette thoroughly after each use (fill several times with water, shake, and squeeze out).



How the dropper pipettes work

Safety Rules

Before beginning any of these experiments, please read carefully through the following list. Make an effort right from the start to work properly, so you can avoid any possible risks.

When you use liquid food products (such as vinegar, lemon juice, and mineral water) for an experiment, transfer the required amount to a clean container, such as a yogurt cup. Keep this separate from the original container and any kitchen items used for cooking and eating.

1. **Read these instructions before use, follow them and keep them for reference.**
   Pay special attention to the quantity specifications and the sequence of the individual steps. Only perform experiments that are described in this instruction manual.
2. **Keep young children, animals and those not wearing eye protection away from the experimental area.**
3. **Always wear eye protection.** If you wear corrective eyeglasses, you will need protective goggles for those who wear corrective eyeglasses. When working, wear appropriate protective clothing, like an old smock and smooth fingered gloves.
4. **Store this experimental set out of reach of children under 10 years of age.**
5. **Clean all equipment after use.**
6. **Make sure that all containers are fully closed and properly stored after use.** Carefully close the chemical vials after use and return them to their places in the experiment kit.
7. **Ensure that all empty containers are disposed of properly.**
8. **Wash hands after carrying out experiments.**
   Chemicals that accidentally get onto your skin must be rinsed off immediately under running water.
9. **Do not use any equipment which has not been supplied with the set or recommended in the instructions for use.**
10. **Do not eat or drink in the experimental area.** Do not use any eating, drinking, or other kitchen utensils for your experiments unless it is specifically recommended. Any containers or equipment you use in your work should not be used in the kitchen afterwards.
11. **Do not allow chemicals to come into contact with the eyes or mouth.**
12. **Do not replace foodstuffs in original container. Dispose of immediately.** If you are investigating food products (such as table salt or vinegar), transfer the required quantity into a clean, empty container (do not use the double-headed measuring spoon for this). Make a note on the container of what it contains and the date it was filled.
13. The tealight candle required for some of the experiments has to be placed on a fire-resistant surface (such as an old plate). Extinguish the flame after the experiment has ended, if not earlier, and extinguish it if you have to leave the experiment area even just for a moment.
14. During experiments with open flame, be sure that there are no flammable objects or liquids nearby. Keep a bucket or box of sand ready in case you need to put out a fire. If the fire can't be extinguished right away, notify the fire department immediately.
15. Any filled container or experimental apparatus that has to remain standing for a longer period of time has to be labeled and stored out of the reach of children and animals.
16. Get any additionally required materials ready before starting an experiment.
17. Handle breakable materials (e.g., the glass test tubes) carefully.

Also note the information on the chemical vial labels, the information about hazardous substances on page 7, and the safety notes accompanying the individual experiments. With additionally required materials, also take note of the warnings on their packaging.

Information about hazardous substances

Please note the hazard statements (blue) and precautionary statements of the hazardous substances contained in this chemistry experiment kit. The following overview also presents the pictograms and the signal words for the chemicals you will be using, and identifies the hazards associated with each substance.

Ammonium iron(III) sulfate
EG-Nr. 233-382-4, 5 g (0.18 oz.)
Not a hazardous substance.
Obtain special instructions before use. (Refer to this manual.)

Potassium hexacyanoferrate(II)
EG-Nr. 237-722-2, 4 g (0.14 oz.)
Not a hazardous substance.
Obtain special instructions before use. (Refer to this manual.)
Harmful to aquatic life with long lasting effects. Avoid release to the environment. Comply with the instructions on page 37.

WARNING

Sodium carbonate
EG-Nr. 207-838-8,
Index-Nr. 011-005-00-2,
12 g (0.42 oz.)
Harmful if inhaled. – Causes serious eye irritation.
Avoid breathing dust/fume/gas/mist/vapors/spray. – Use only outdoors or in a well-ventilated area. – IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention. – IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/physician if you feel unwell.

WARNING

Tartaric acid
EG-Nr. 201-766-0, 6 g (0.21 oz.)
Causes serious eye irritation.
Wash skin thoroughly after handling. – Wear protective gloves/ eye protection/ face protection. – IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. – If eye irritation persists: Get medical advice/ attention.

How to dispose of waste?

The relatively small amounts of chemicals contained in this experiment kit will not pose any great danger to the environment. You can dispose of leftover solid substances in the household garbage, along with filter papers coated with chemical solutions (wear protective gloves). Pour liquids down the drain (rinse with water afterwards). Please note the tip on page 37 for economical use of potassium hexacyanoferrate.

WARNING!
Store locked up. Keep out of reach of children. This applies to all children except for the experimenting child who is being instructed and supervised by an adult.
IF SWALLOWED: Get immediate medical advice/ attention and have product container or label of chemical substance at hand.

For the sake of environmental protection: Dispose of contents/containers (of no-longer-needed chemicals) to a hazardous waste disposal location.

Safety for experiments with batteries

- WARNING! Only for use by children aged 10 years and older. Instructions for parents or other supervising adults are included and have to be observed. Keep the packaging and instructions as they contain important information.
- For some experiments, you will need a 9-V type 6LR61 square battery, which could not be included in the kit due to its limited shelf life. Press the battery clip equipped with red and black wires onto the battery.
- Have an adult check your experimental setup before performing the experiment.
- Non-rechargeable batteries are not to be charged. They could explode.
- Rechargeable batteries are only to be charged under adult supervision.
- Rechargeable batteries are to be removed from the toy before being charged.
- Exhausted batteries are to be removed from the toy.
- Dispose of used batteries in accordance with environmental provisions, not in the household trash.
- The supply terminals of the battery clip are not to be short-circuited: Neither the battery wire contacts nor the wires connected to them should touch each other. Make sure there is no unintended short circuit due to conductive metal objects, such as coins or a keychain. A short circuit can cause the wires to overheat and the battery to explode.
- Don’t throw batteries into the fire and don’t store them near heat sources.
- Avoid deforming the batteries.
- Never perform experiments using household current. You know that you should never insert any objects into the wall socket holes. The high voltage can be extremely dangerous or fatal!
- Don’t use any voltage source other than the specified battery, including a power supply unit.
- After you are done experimenting, remove the battery clip from the battery.
- Warning! Do not manipulate the protective device in the battery compartment (PTC). This could cause overheating of wires, eruption of batteries and excessive heating.

Instructions for using the safety glasses

Instructions for use for the safety goggles (Art.-Nr. 717019)
Manufacturer Frame: Georg Schmerler GmbH & Co. KG / Reitweg 7 / 90587 Veitsbronn / Germany
Manufacturer Lens: IPB NV / Steenovenstraat 30 / 8790 Waregem / Belgium
Certification Office: ECS GmbH – European Certification Service / Hüttfeldstr. 50 / 73430 Aalen, DE / Germany / Notified Body Number: 1883

GSF – Safety goggles comply with the Regulation (EU) 2016/425 on personal protective equipment (PPE), are design tested, and bear the CE symbol. The Model 610 in this kit is suitable for protection against mechanical dangers.

Identification of the frame:
GSF = Code letter of manufacturer
166 = Number of the standard
S = increased robustness
CE = EC Conformity symbol

Identification of the safety lenses:
IPB = Code letter of manufacturer
1 = Optical class
S = increased robustness

If frame and lens have differing certification marks in regards to S, F, B, or A, the lower of the two applies. Wearers with extremely sensitive skin may experience allergic reactions upon contact with some materials. There are no spare parts or additional components available for this model. If damaged please discard the safety goggles and discontinue use. Eye protectors used for protection against high-speed particles that are worn over standard ophthalmic spectacles may transmit impacts, thus creating a hazard to the wearer. If protection against high-speed particles at extreme temperatures is required then the selected eye protector should be marked with the letter T immediately after the impact letter, i.e. FT, BT, or AT. Otherwise the eye protector should only be worn and used at room temperatures.

Accessories: No accessories are available for this product.
Storage: Store in a dry and dust free place at room temperature.
Cleaning: Clean with clear water and household detergent. (Do not use solvents!) Avoid strong scrubbing as it can cause scratches.
Disinfection: Product can be disinfected with all regular commercial disinfectants.
Disposal: Pay attention to national regulations when disposing.
Length of usage: Do not use longer than 5 years after purchase date.
Warnings: Dispose of the goggles immediately if damaged. Only use eye protection lenses with optical class 1. Do not repair damaged safety goggles.
Limitations of use: These safety goggles in particular are not suitable for high-speed particles (e.g. cartridge tools), laser beam, temperatures above 55 °C, stray light arches, fusion metals, infectious substances, or organisms.

Declaration of Conformity: A Declaration of Conformity according to Regulation (EU) 2016/425 on PPE and the Directive 2001/95/EC on general product safety is available for this product on the following web address: http://thamesandkosmos.com/declarations/declaration-717019.pdf

Effervescent Powder

You are probably familiar with those little effervescent powder packets that foam and bubble as soon as you sprinkle them into water. And you certainly know how baking powder can make a home-baked cake light and delicious.

In the following pages, you will learn exactly what it is that makes a drink effervescent and a cake light and fluffy.

EXPERIMENT 1

Beautiful bubbles

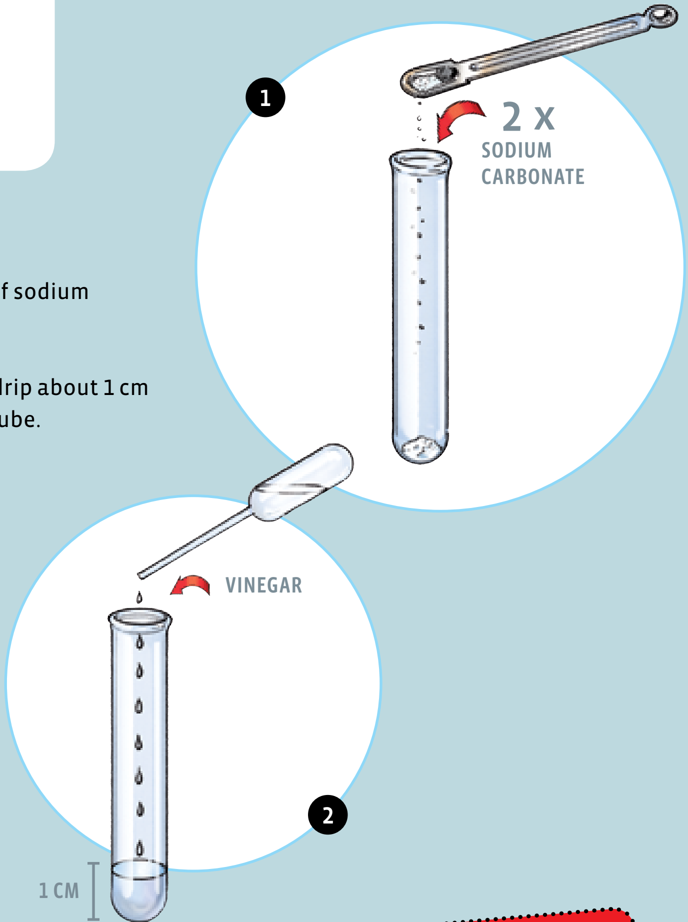
YOU WILL NEED

→ test tube
→ measuring spoon
→ sodium carbonate
→ *cup of white vinegar*

HERE'S HOW

1. Place 2 large spoonfuls of sodium carbonate in a test tube.

2. Then use the pipette to drip about 1 cm of vinegar into the test tube.
   What do you see?



→ WHAT'S HAPPENING?

Vinegar is an acid. If you combine this acid with sodium carbonate, carbon dioxide gas escapes from the mixture. It's this gas that makes the solution foam up.

Safety Note: For sodium carbonate, note the "Information about hazardous substances" on page 7!

EXPERIMENT 2

Where's the foam?

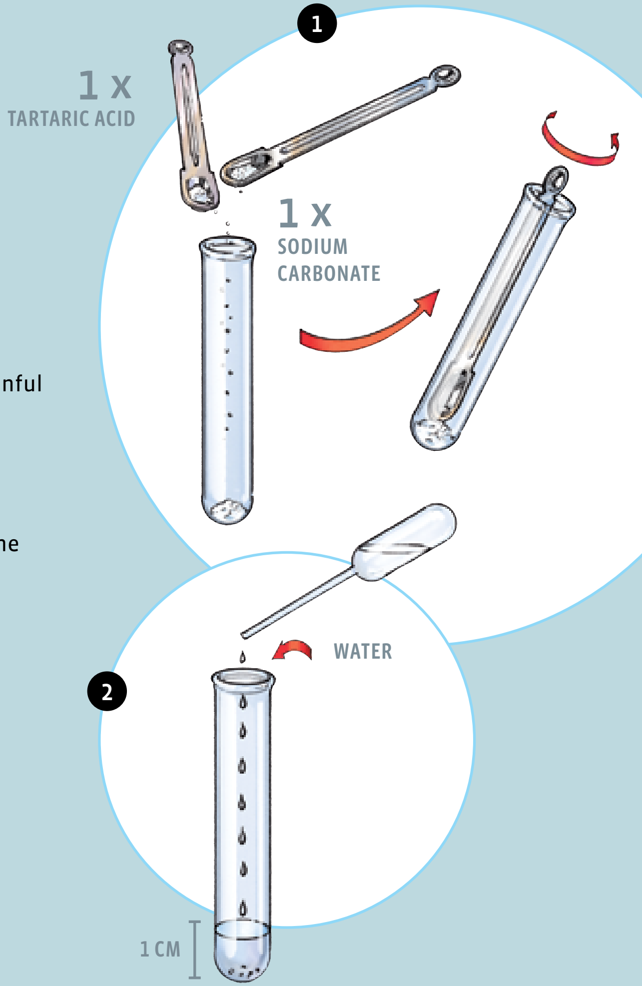
YOU WILL NEED

→ **test tube**
→ **measuring spoon**
→ **sodium carbonate**
→ **tartaric acid**
→ ***cup of water***

HERE'S HOW

1. In a dry test tube, mix 1 large spoonful of sodium carbonate with 1 large spoonful of tartaric acid.
   Is anything happening yet?

2. Then add about 1 cm of water to the mixture.
   What do you see now?



Safety Note: For sodium carbonate and tartaric acid, note the "Information about hazardous substances" on page 7!

→ WHAT'S HAPPENING?

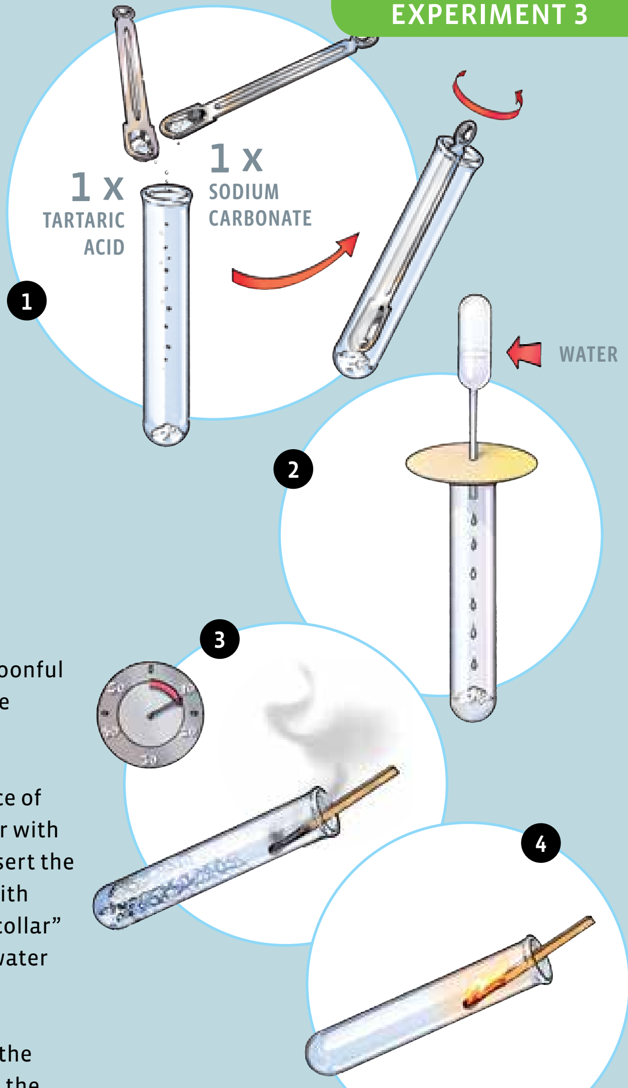
In a mixture of fine, dry sodium carbonate and tartaric acid crystals, nothing happens. The mixture only starts to foam once you add water.

EXPERIMENT 3

Flame out!

YOU WILL NEED

- → 2 test tubes
- → measuring spoon
- → dropper pipette
- → sodium carbonate
- → tartaric acid
- → *matches*
- → *cup of water*
- → *paper*
- → *scissors*



HERE'S HOW

1. In a dry test tube, mix 1 large spoonful of sodium carbonate with 1 large spoonful of tartaric acid.

2. Cut a circular shape out of a piece of paper. Punch a hole in the center with the tip of a ballpoint pen and insert the pipette into it. Fill the pipette with water and set it along with its "collar" onto the test tube. Slowly drip water into the test tube.

3. Wait about 10 to 15 seconds for the foam to subside a little. Remove the pipette. Now hold a burning match in the test tube.
   Does it keep burning?

4. Perform the same "match test" with an unused, fresh test tube.
   What happens?

Safety Note: For sodium carbonate and tartaric acid, note the "Information about hazardous substances" on page 7!

→ WHAT'S HAPPENING?

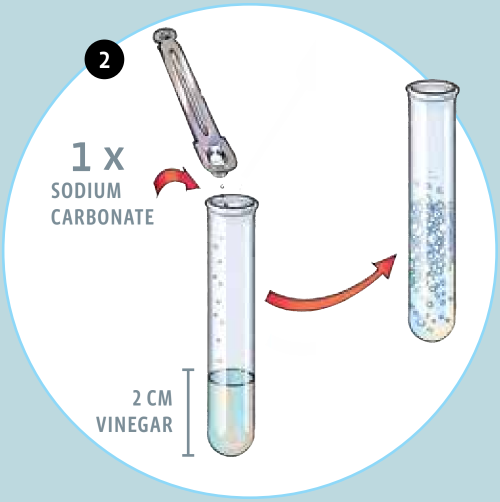
For the match to burn, it needs oxygen, which is contained in the air. The carbon dioxide produced in the first test tube, however, is heavier than air and therefore pushes the air out of the test tube. So the match flame is lacking in oxygen, and it goes out.

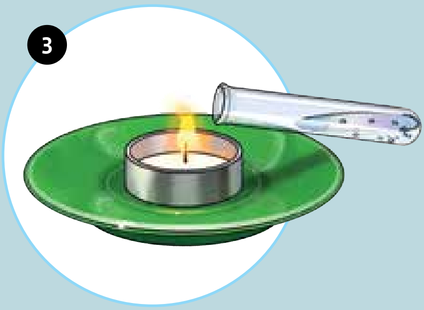
EXPERIMENT 4

The invisible fire extinguisher

YOU WILL NEED

→ test tube
→ measuring spoon
→ sodium carbonate
→ *tealight candle*
→ *fireproof surface (small plate)*
→ *cup of white vinegar*





HERE'S HOW

1. Place the tealight candle on a fireproof surface, such as a small ceramic plate. Light the candle.

2. Fill the test tube with 2 cm of white vinegar. Add 1 large spoonful of sodium carbonate to the test tube. Keep the test tube steady and upright as the foam forms.

3. As soon as the reaction has calmed down and the column of foam shrinks, carefully tilt the test tube next to the candle flame, as if you are pouring the air out of it. Do not allow any of the liquid in the test tube to spill out. The illustration shows you how to do it best. Does the flame go out, as if by magic?

→ WHAT'S HAPPENING?

The flame is extinguished by the carbon dioxide gas, because it spreads out like a carpet over the tealight, smothering the flame.

Safety Note: For sodium carbonate, note the "Information about hazardous substances" on page 7!

Keyword: Baking Powder

A light and fluffy cake is a wonderful thing. But without a certain ingredient, it won't turn out well. The magic ingredient? Baking powder. The most important components of baking powder are sodium bicarbonate ("baking soda" in everyday terms) and an acidifier. What happens in the batter is similar to what you saw in the test tube. The baking soda and the acidifier start to interact. What comes out of it is carbon dioxide gas, which bubbles through the batter. The heat in the oven intensifies the reaction even more. Lots of little pores appear in the batter to make it light and fluffy.

You can also see what's going on by adding a shot of vinegar to some baking powder — the mixture will foam up dramatically. The baking soda quickly reacts to the acidic vinegar solution and carbon dioxide is created.

Note:
Carbon dioxide gas is heavier than air. Its ability to displace air due to its greater weight can be dangerous in cellars or caves. There is no risk of suffocation here, though.

CHECK IT OUT

Greenhouse Effect

Earth is surrounded by a protective envelope known as the atmosphere, which holds in a portion of the heat radiated by the sun. Just like the panes of glass in a greenhouse, this protective envelope is responsible for the fact that our planet has a pleasant average temperature of 15 °C. (Otherwise, it would be bitterly cold: a mere –18 °C!)

The atmosphere is composed of gases, some of which are responsible for the greenhouse effect and are therefore known as greenhouse gases. The best-known greenhouse gas is carbon dioxide. All kinds of activities involving combustion, such as driving a car or truck, heating a house, or generating electricity at a coal-fired power plant, cause an extra portion of carbon dioxide to get into our atmosphere. That alters our protective envelope, which starts to store too much heat. The temperature on Earth increases, with consequences that we can't even predict today. Global warming is threatening to bring about profound changes in our Earth's climate.

What's clear is that we have to save energy. It's better to get on a bike than drive a car. Don't turn the heat up too high and don't let appliances keep running on standby power when they're not in use. That's how we can preserve our protective envelope.

Acids and Bases

Not everyone enjoys biting into a lemon. For many, the fruit is too sour. A lemon contains citric acid. You may have noticed that black tea will change color when you add lemon juice.

In this chapter's experiments, you will learn what's going on with these color changes and how bases or "alkalis" are involved in the soap we use.

Litmus solution

YOU WILL NEED

→ test tube
→ measuring spoon
→ stopper
→ pipette
→ bottle with safety cap
→ litmus powder
→ *denatured alcohol*
→ *cup of water*

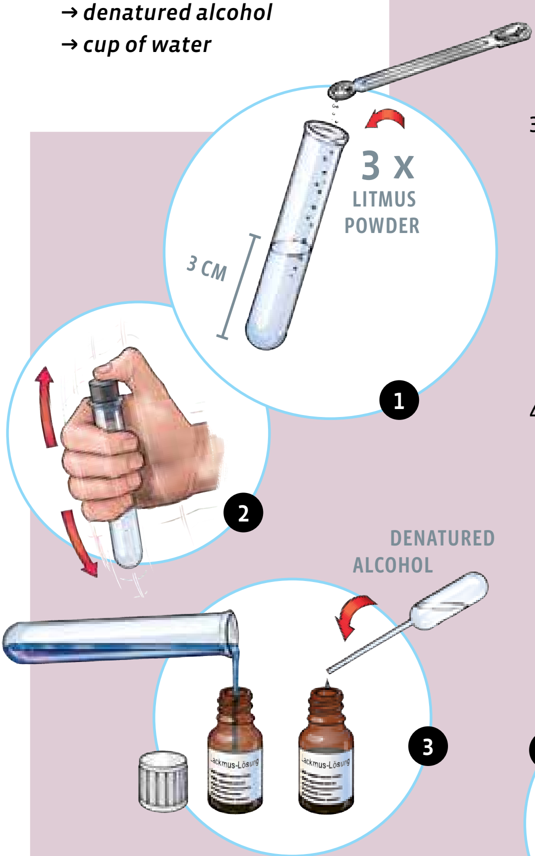
HERE'S HOW

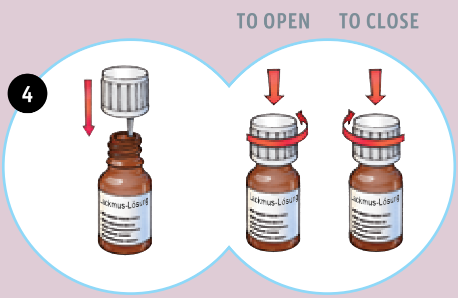
1. Measure 3 small spoonfuls of litmus powder into a test tube filled with 3 cm of water.

2. Seal the test tube with the stopper, shake, and let the sealed test tube sit for 1 day in a location where it will be out of the reach of young children.

3. Now carefully and slowly pour the deep blue solution into the brown bottle. Do not stir up the insoluble dark residue in the test tube. Throw it into the household garbage. Half a test tube of denatured alcohol added to the solution will make it keep longer — ask your parents to take care of this part for you.

4. Now put the safety cap with the dropper insert onto the bottle and close it. You can securely open and re-close the litmus solution container by simultaneously turning and pushing. Have an adult help you with this.





Warnings for denatured alcohol:
Highly flammable liquid and vapor. Keep away from heat/sparks/open flames/hot surfaces. – No smoking. – Keep container tightly closed.

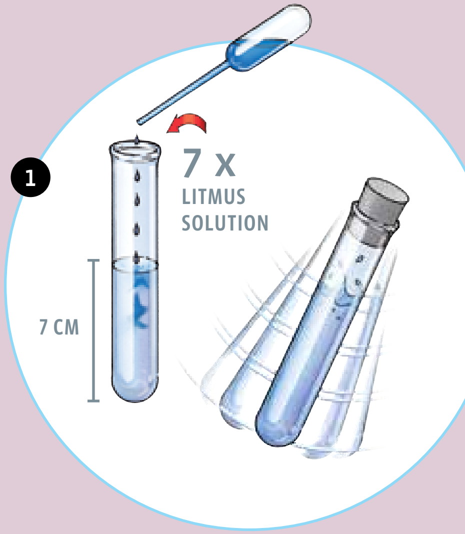
Request to parents: Keep the denatured alcohol locked away, and add the alcohol to the litmus solution yourself.

EXPERIMENT 6

Turn blue into red

YOU WILL NEED

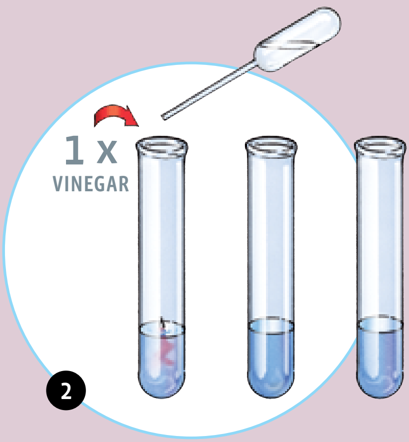
→ 3 test tubes
→ stopper
→ pipette
→ litmus solution
→ *cup of white vinegar*
→ *cup of water*



HERE'S HOW

1. Fill a test tube with 7 cm of water and use the pipette to add 7 drops of litmus solution. Close the test tube with the stopper and shake.

2. Divide the solution among three test tubes. You will need one now, and the other two for the next experiment. Use the pipette to add 1 drop of vinegar to one of the test tubes. Shake it a little. What do you see?



Note:
Litmus is made of a mixture of materials. It only has a limited shelf life. The dry powder should have an earthy smell. You should be able to make three partial portions of litmus solution with the quantity of powder included here.

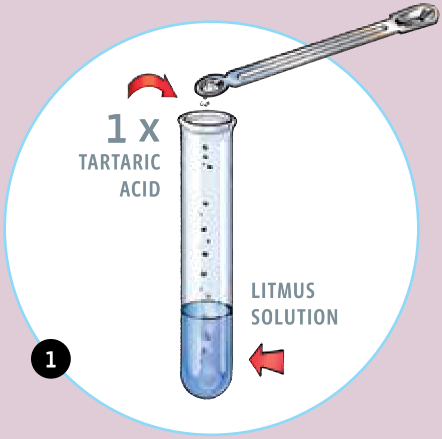
→ WHAT'S HAPPENING?

The acid in the vinegar brings about a color change. The blue litmus solution turns light red.

Another color change?

YOU WILL NEED

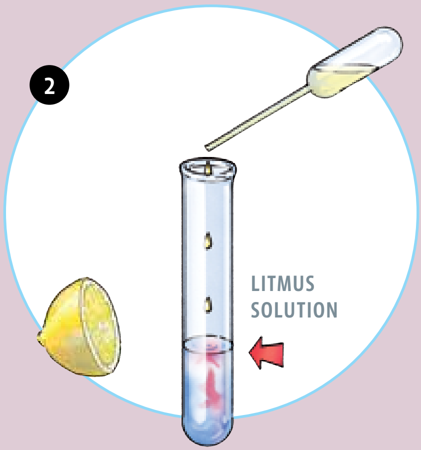
→ 2 test tubes with litmus solution from Experiment 6
→ measuring spoon
→ tartaric acid
→ *cup*
→ *lemon, lemon squeezer*



HERE'S HOW

1. Add 1 spoon tip tartaric acid to a test tube of litmus solution. Swirl the test tube a little. Is there a color change?

2. Will it also work with fresh-squeezed lemon juice?
   Use a juice squeezer to squeeze half a lemon and add the juice to a clean, washed yogurt container. Now add a few drops of the lemon juice to the litmus solution in the remaining test tube.



→ WHAT'S HAPPENING?

When you swirl the test tube, you get another color change to light right. And it works just as well with the tartaric acid as with the lemon juice.

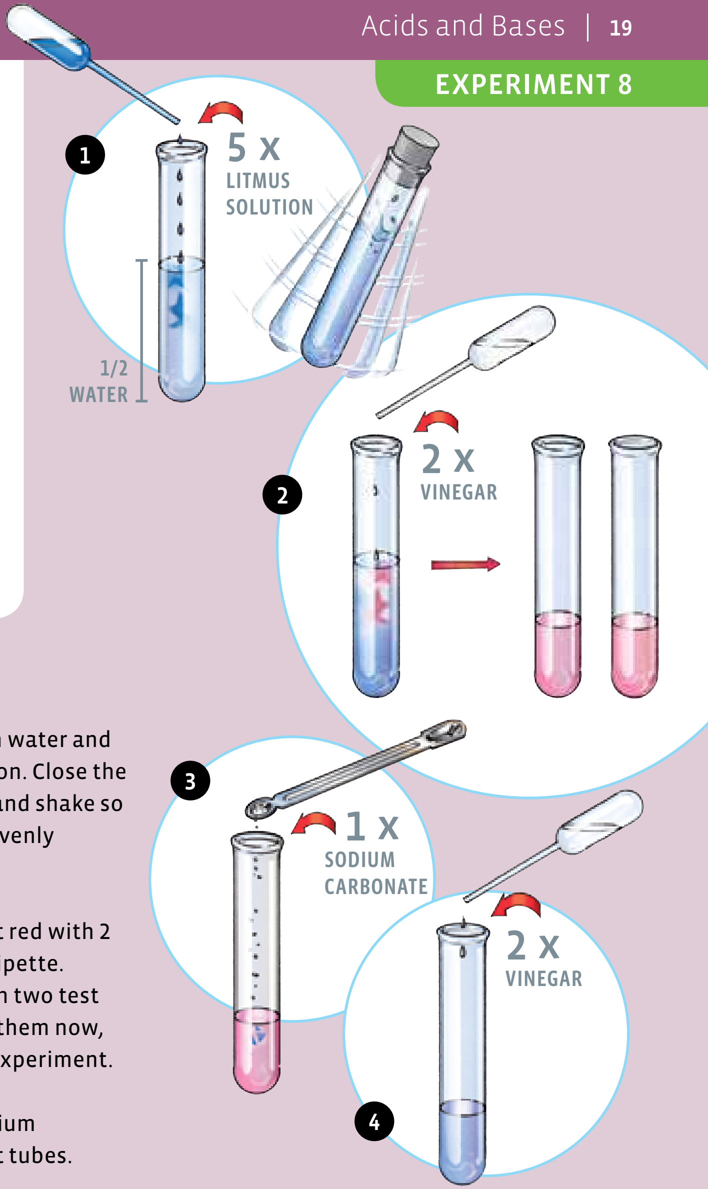
Safety Note: For tartaric acid, note the "Information about hazardous substances" on page 7!

EXPERIMENT 8

First blue, then red

YOU WILL NEED

- → 2 test tubes
- → measuring spoon
- → stopper
- → pipette
- → litmus solution
- → sodium carbonate
- → tartaric acid
- → *cup of white vinegar*
- → *cup of water*



HERE'S HOW

1. Fill a test tube halfway with water and add 5 drops of litmus solution. Close the test tube with the stopper and shake so that the litmus solution is evenly distributed.

2. Color the blue solution light red with 2 drops of vinegar from the pipette. Divide the solution between two test tubes. You will need one of them now, and the other for the next experiment.

3. Add 1 small spoonful of sodium carbonate to one of the test tubes. Shake the solution a little.
   What do you see?

4. Now add 2 drops of vinegar with the pipette.
   What do you see now?

Safety Note: For sodium carbonate and tartaric acid, note the "Information about hazardous substances" on page 7!

→ WHAT'S HAPPENING?

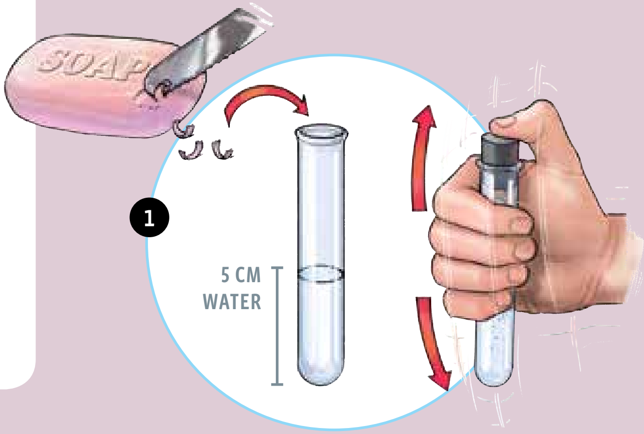
The litmus dye is apparently unharmed by all this to and fro. Instead, it indicates whether acid (light red) or base or alkali (blue) has the upper hand. Some alkali (sodium hydroxide, or soda lye) is created when the sodium carbonate dissolves in water.

EXPERIMENT 9

Soap turns it blue

YOU WILL NEED

→ test tube
→ stopper
→ pipette
→ litmus solution
→ *knife*
→ *bar of soap*
→ *cup of white vinegar*
→ *cup of water*

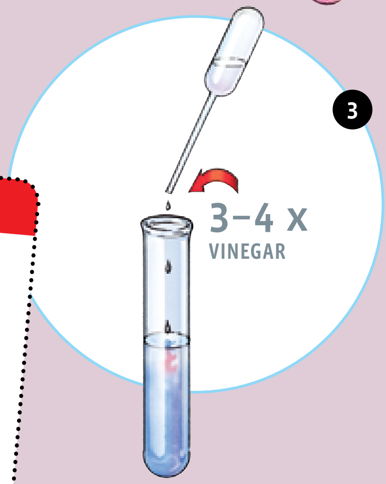


HERE'S HOW

1. Use a knife to scrape a few shavings off a piece of soap, and shake the shavings together with 5 cm of water in a test tube.

2. Add the soap solution to the rest of the red litmus solution from Experiment 8. What do you see?

3. Now, use the pipette to add a few drops of vinegar to this solution.



→ WHAT'S HAPPENING?

Soapy water, just like solutions of many washing and cleaning agents, behaves similarly to sodium carbonate: some sodium hydroxide or soda lye is created when the soap is dissolved. It's this sodium hydroxide that is responsible for the blue coloring of the red litmus solution. You can use a little vinegar to change it back, though.

EXPERIMENT 10

Care to see a magic trick?

YOU WILL NEED

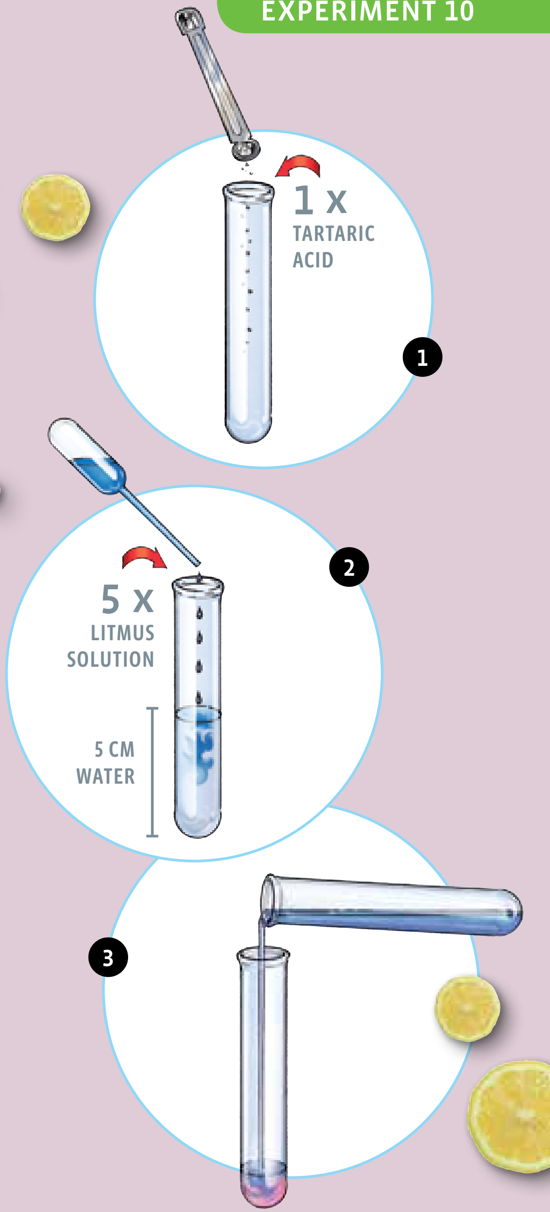
- → 2 test tubes
- → measuring spoon
- → litmus solution
- → tartaric acid
- → *cup of water*

HERE'S HOW

1. Before the audience enters, get a test tube ready by adding 1 small spoonful of tartaric acid to it. From several feet away, your audience won't be able to tell that there's anything in it.

2. While the audience is watching, make some "blue ink." Fill a second test tube with 5 cm of water and add 5 drops of litmus solution (do not let the audience see the litmus bottle). Shake! Ready? Now mumble your mysterious magic spell: "Listen, ink, to my magic cry, turn to red in the blink of an eye!"

3. As you do that, pour the "blue ink" into the "empty" test tube and gently swirl the test tube.



→ WHAT'S HAPPENING?

All the spectators will be astounded by your ability to turn the blue ink red.

Safety Note: For tartaric acid, note the "Information about hazardous substances" on page 7!

CHECK IT OUT

KEYWORD: LITMUS

Litmus dye is obtained from lichens. You may have seen lichens in the woods. They can be found growing on tree bark or branches, or covering rocks.

PLANT DYES

→ There are many plant dyes, like litmus, that react to acids and bases by turning color. This kind of dye is found in black currants, cabbage, elderberries, violet flowers, and black tea. All of these dyes have a similar chemical structure.

Kitchen Excursion: Tracking down acids and bases with red cabbage

→ Cut a red cabbage leaf into little pieces. Add the pieces to a pot with ¼ liter water. Now boil the red cabbage pieces for about 5 minutes under the supervision of an adult. → Let everything cool completely! → Pour some of the cabbage broth into a clean yogurt container. Then divide the cabbage broth between two test tubes. → Add a little sodium carbonate to one test tube, and add a little vinegar to the other. → Do you see the difference in color?

Note:
Acids turn blue litmus solution red. Bases turn red litmus solution blue. The litmus solution is an indicator (from Latin "indicare," to show or display) for acids and bases.

Still Water and Sparkling Water

Some people only like still water, while others prefer sparkling. Part of the appeal of sparkling water comes from the bubbles, but part also comes from its slightly acid taste. That mild acidity comes from carbonic acid.

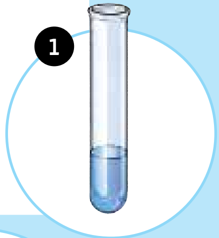
As you can readily imagine, it's possible to test for carbonic acid chemically.

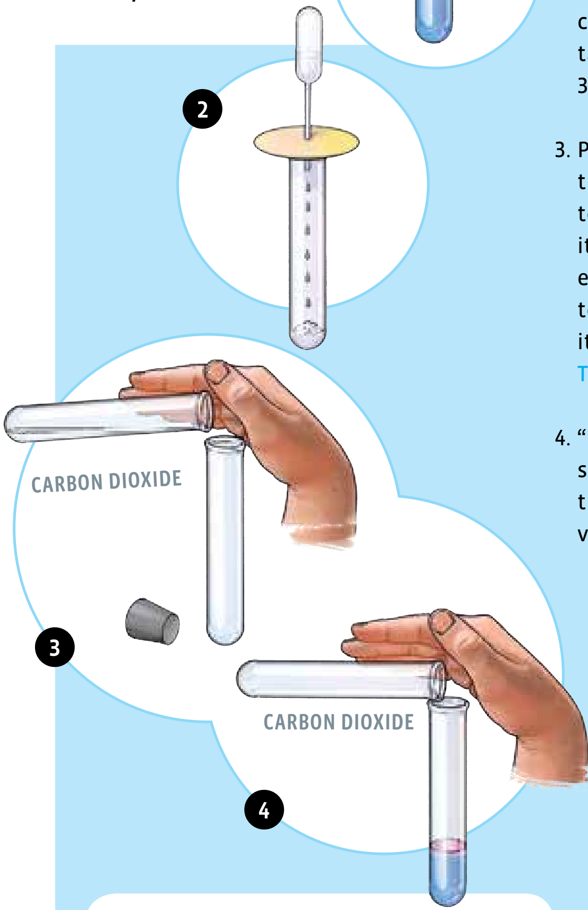
EXPERIMENT 11

Magic trick with “sour” air

YOU WILL NEED

- → 3 test tubes, with stopper
- → measuring spoon
- → dropper pipette *with paper collar*
- → litmus solution
- → sodium carbonate
- → tartaric acid
- → *cup of water*





HERE’S HOW

You might have to practice this trick a little. If you want to perform it in front of an audience, first complete steps 1–3.

1. Add 5 drops of litmus solution to 2 cm of water in the first test tube, and shake it a little.

2. In the second test tube, prepare some carbon dioxide from sodium carbonate and tartaric acid as you learned in Experiment 3. Insert the stopper so nothing can escape.

3. Pour the carbon dioxide into the third test tube. Don’t let any of the liquid get into the test tube, though. Hold one hand in front of it so as little carbon dioxide as possible escapes. Quickly insert the stopper into the test tube with the carbon dioxide and keep it ready.
   The presentation can start here.

4. “Pour” the carbon dioxide onto the litmus solution in the first test tube. Close the test tube with the rubber stopper and shake vigorously.

→ WHAT’S HAPPENING?

Carbon dioxide dissolves in water, producing carbonic acid. The “magic air” turns the blue litmus solution red.

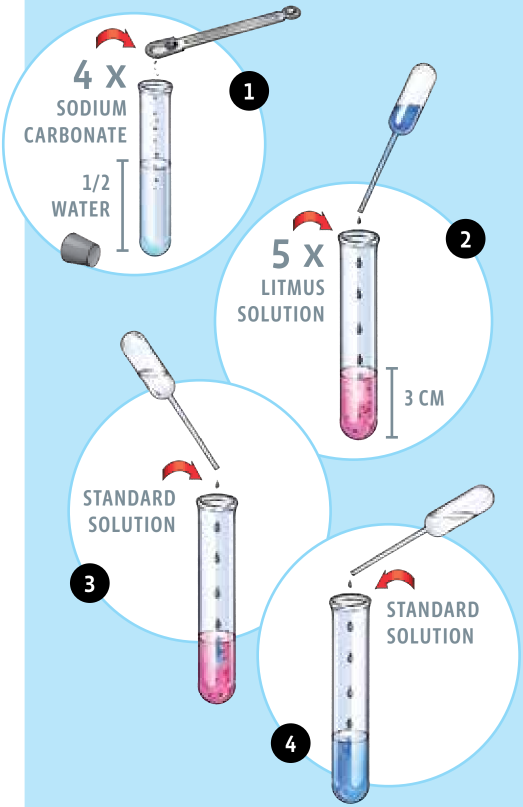
Safety Note: For sodium carbonate and tartaric acid, note the “Information about hazardous substances” on page 7!

EXPERIMENT 12

Color change

YOU WILL NEED

→ 2 test tubes, with stopper
→ pipette
→ measuring spoon
→ litmus solution
→ sodium carbonate
→ *cup of sparkling mineral water*
→ *cup of stale, flat mineral water (let it sit out for a day)*
→ *cup of plain bottled water*
→ *2 cups of tap water*



Safety Note: For sodium carbonate, note the "Information about hazardous substances" on page 7!

HERE'S HOW

1. Dissolve 4 large spoonfuls sodium carbonate in a test tube filled halfway with tap water. Insert the stopper and shake vigorously to dissolve all the sodium carbonate. This is your "standard solution."

2. Pour 3 cm of mineral water into the second test tube and ad 5 drops of litmus solution. Does the color of the solution change?

3. Now drip some of the standard solution into the test tube from the pipette. Keep track of the number of drops! Lightly swirl the test tube.
Do you see the "blue clouds" that appear and disappear again as you swirl the liquid?

4. Keep adding drops of the standard solution until a distinct blue color is still recognizable after 10 seconds. Take note of the number of drops you used! Repeat the experiment with stale mineral water and plain bottled water.

→ WHAT'S HAPPENING?

There is carbonic acid in mineral water, which turns the litmus solution red. The standard solution is a base, and gradually cancels out the effect of the acid. The more acid there is in the mineral water, the more standard solution you have to add for the color to change.

CHECK IT OUT

ACIDIC, NEUTRAL, ALKALINE

In Experiment 12, you kept adding the standard solution and counting the drops until you saw the color switch from red to blue. It's easy to explain what caused the color change. As long as there is still some carbonic acid present in the mineral water, it cancels out the effect of the added standard solution. True, there will be a temporary blue color at the spot where the drop falls, since there will be an excess of sodium carbonate here. When you swirl the liquid, though, it mixes things evenly, so the excess acid gets the upper hand again. Only when the effect of the acid is cancelled out by the alkaline effect of the standard solution does the excess of sodium carbonate result in a stable blue color.

Chemists refer to this process as neutralization. The term comes from the Latin word *neuter*, meaning "neither one." When the quantity of alkali is exactly as much as the amount of acid, the reaction of the solution is neither acidic nor alkaline, but neutral.

Liquid gas?

It's possible to get a liquid gas by applying pressure. You might have a beverage carbonating appliance at home, a device you can use to make refreshing sparkling water out of plain drinking water. In the rear part of the device there is a cartridge or charger filled with liquid carbon dioxide kept under high pressure. When the cartridge valve is opened, which releases the pressure, a portion of the carbon dioxide turns to gas again and bubbles through the water in the screwed-on bottle. It's a great solution for people who don't like to lug around cases of bottled water.

Note:
When the quantity of alkali exactly equals the quantity of acid, the reaction of the solution is neither acidic nor alkaline, but neutral. When the acidic effect is cancelled out by the addition of a base, or an alkaline effect is cancelled out by the addition of an acid, it is called **neutralization**.

Soap or Body Wash

Bar soap, shower gel, liquid soap — we wash our hands with whatever we find by the sink. But not all soap is alike, and not all water is alike either.

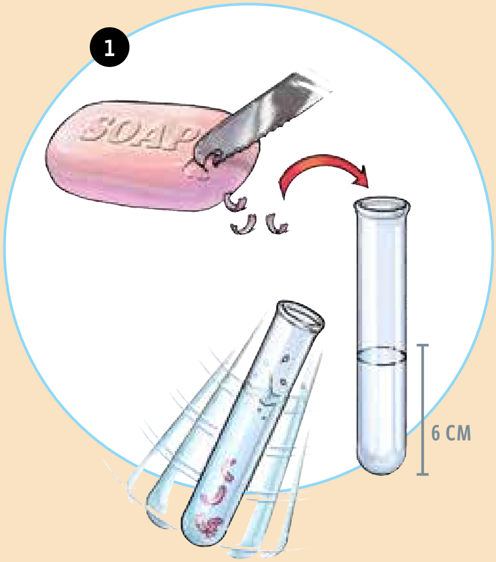
The next few experiments will reveal some of the differences to be discovered.

EXPERIMENT 13

To foam or not to foam?

YOU WILL NEED

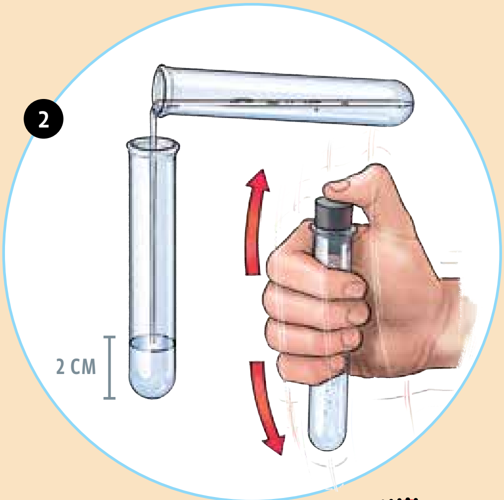
→ 2 test tubes
→ stopper
→ *knife*
→ *bar of soap*
→ *2 cups of tap water*
→ *cup of rainwater*
→ *cup of distilled water*



HERE'S HOW

1. Use a knife to scrape a few shavings off a piece of soap, and add the shavings to a test tube with about 6 cm of water in it. Carefully swirl the test tube to make the soap dissolve, but not enough to make it foam. You will need this solution for some of the "soap experiments" to come.

2. Add 2 cm of the soap solution to a fresh test tube, insert the stopper, and shake vigorously.
   What do you see?



If it doesn't foam up, your tap water is rather "hard." In that case, try repeating step 2 with rainwater or distilled water.

→ WHAT'S HAPPENING?

"Hard" water contains large amounts of soluble compounds, particularly calcium hydrogen carbonate (calcium bicarbonate). When combined with soap, this calcium compound forms insoluble lime soap, which has no cleaning power. This kind of soapy water has none of the foam formation required for cleaning.

EXPERIMENT 14

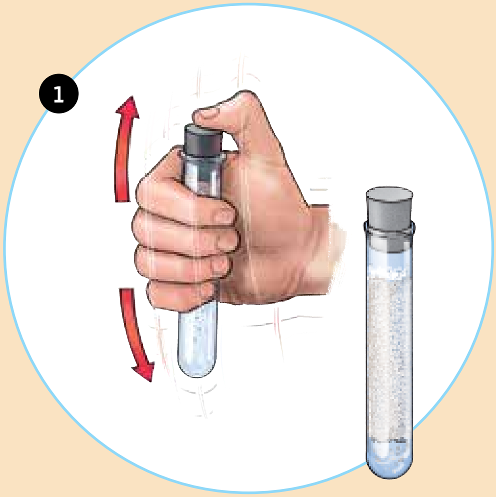
Out of foam

YOU WILL NEED

→ test tube
→ stopper
→ *soap solution*
→ *cup of flat mineral water*

HERE'S HOW

1. Pour 2 cm of soap solution (from Experiment 13) into a test tube, insert the stopper, and shake until you get some foam.



2. Pour some mineral water into a yogurt container and add double the quantity of mineral water to the foam solution. Does the foam hold up?

→ WHAT'S HAPPENING?

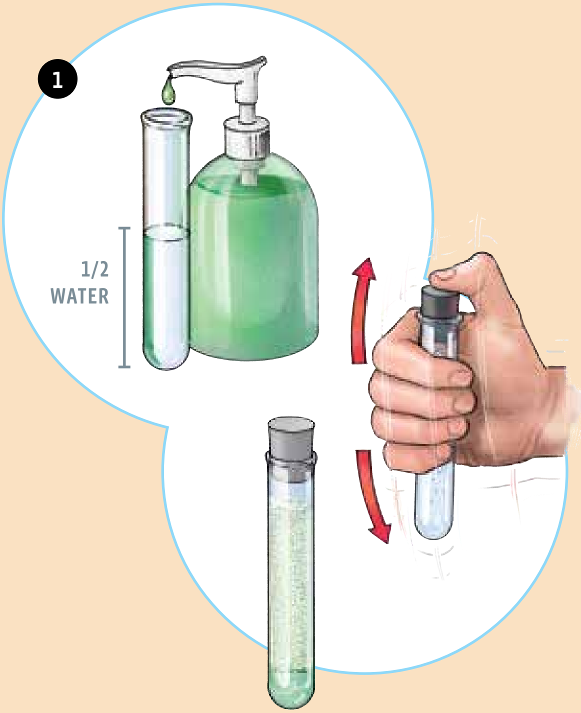
The column of foam collapses, and you will find a crumbly substance on the surface of the liquid. That's lime soap. So mineral water contains minerals, as the name implies. It contains soluble calcium hydrogen carbonate, among other things.

EXPERIMENT 15

The foam is back!

YOU WILL NEED

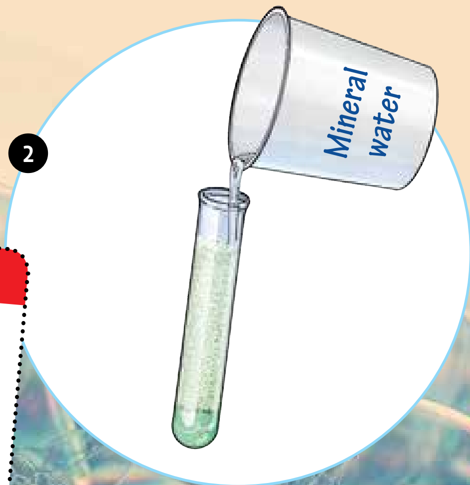
→ 1 test tube
→ stopper
→ *liquid soap or shower gel*
→ *cup of mineral water*
→ *cup of tap water*



HERE'S HOW

1. Add 1 drop of the liquid soap to a test tube filled halfway with water, insert the stopper, and shake.
   Does the solution foam up?

2. Now add a little mineral water.
   What happens to the foam?



→ WHAT'S HAPPENING?

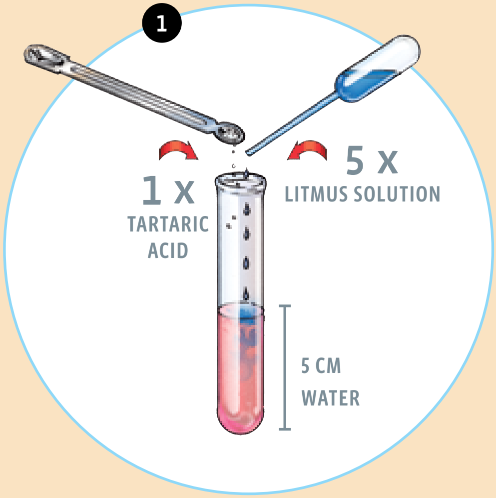
You'll get a lot of foam even if your tap water is "hard." And when you add mineral water, the foam still won't go away. Modern liquid soaps replace conventional soap with detergents that won't form insoluble lime soap with the mineral materials in "hard" water, so their cleaning power and foam formation are not affected.

EXPERIMENT 16

Washing without lye

YOU WILL NEED

→ 1 test tube
→ measuring spoon
→ stopper
→ litmus solution
→ tartaric acid
→ *liquid soap or shower gel*



HERE'S HOW

1. In a test tube, mix 5 cm of water, 5 drops of litmus solution, and 1 spoon tip of tartaric acid.

2. Add 1 or 2 drops of liquid soap and mix the solution.
   Does the color change?

→ WHAT'S HAPPENING?

Unlike with the soap solution in Experiment 9, you will get no blue color here. Solutions of conventional soaps have an alkaline effect due to the strong lye used to make them. In modern liquid soaps, on the other hand, strong alkalis are balanced by strong acids.

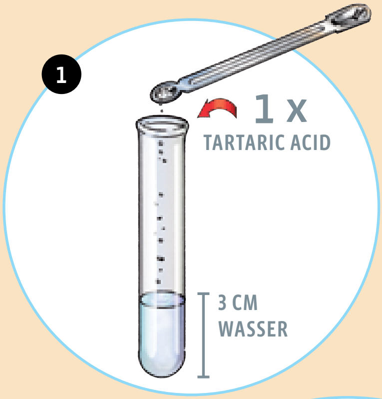
Safety Note: For tartaric acid, note the "Information about hazardous substances" on page 7!

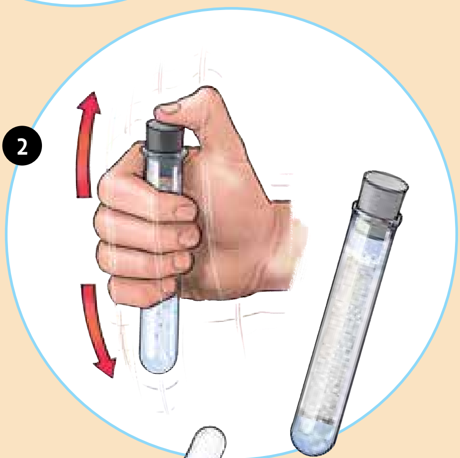
EXPERIMENT 17

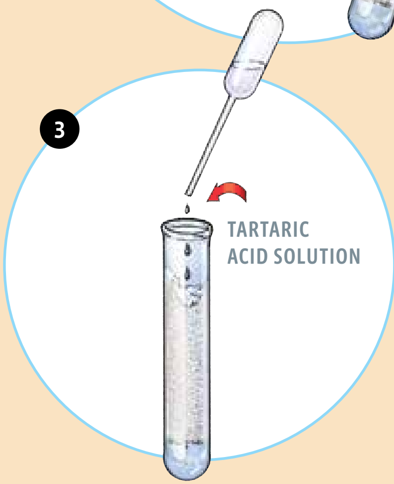
Acid against foam

YOU WILL NEED

→ 2 test tubes
→ measuring spoon
→ stopper
→ soap solution
→ tartaric acid
→ *cup of water*







HERE'S HOW

1. First dissolve a small spoonful of tartaric acid in 3 cm of water in a test tube. You will also need this solution for the next experiment.

2. Fill some soap solution (from Experiment 13) into a test tube, insert the stopper, and shake until you get some foam.

3. Drip a little of the tartaric acid solution from step 1 into the soap solution. What does the foam do?

→ WHAT'S HAPPENING?

The foam collapses and the solution turns cloudy. After a little while, a crumbly substance collects on the liquid's surface. That isn't lime soap, but insoluble fatty acids that are separated out by the acid.

Safety Note: For tartaric acid, note the "Information about hazardous substances" on page 7!

EXPERIMENT 18

This time, the foam stays

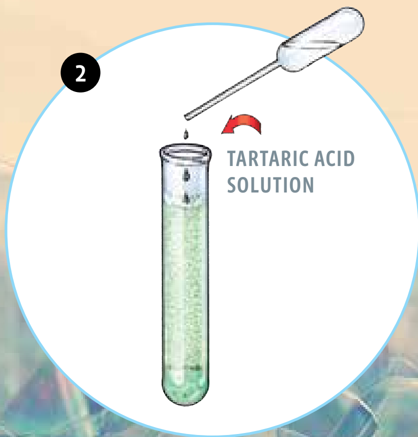
YOU WILL NEED

→ test tube
→ stopper
→ tartaric acid solution
→ *liquid soap or shower gel*
→ *cup of water*

HERE'S HOW

1. Place 1 or 2 drops of liquid soap in a test tube filled with 5 cm of water, insert the stopper, and shake until some foam forms.

2. Add some of the tartaric acid solution from Experiment 17 to the soap solution.
   What happens to the foam?



→ WHAT'S HAPPENING?

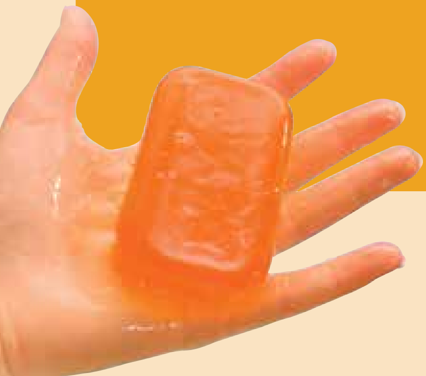
The foam remains, and no crumbly substance appears. The reason? The acids contained in modern liquid soaps, unlike fatty acids, are water-soluble. So they won't separate out when you add an acid.

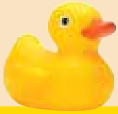
Safety Note: For tartaric acid, note the "Information about hazardous substances" on page 7!

CHECK IT OUT

Keyword: Soap

Soap is made by boiling fats with an alkali. The ancient Egyptians made soap 4,000 years ago by boiling alkaline potash (plant ash) with oils. These soaps, however, were generally used for medicinal purposes. After that, soap was used for cosmetic applications, such as in hair pomades. Only later, in the 19th century, was soap production refined. There were finally sufficient quantities of raw materials such as olive oil and alkaline materials such as soda ash for soap to be produced in large quantities at a low price, so everyone could afford it.





SOFTENERS FOR THE WASHING MACHINE

It's not just something you *can* do, it's something you *have to* do. Modern washing detergents can handle hard water, but soluble calcium compounds can still cause problems. They decompose during the washing process. The resulting calcium deposits don't just increase electricity consumption, they can also damage the heating elements. Special water softeners "capture" the soluble calcium compounds so they can't cause any harm.

Prussian Blue and Invisible Ink

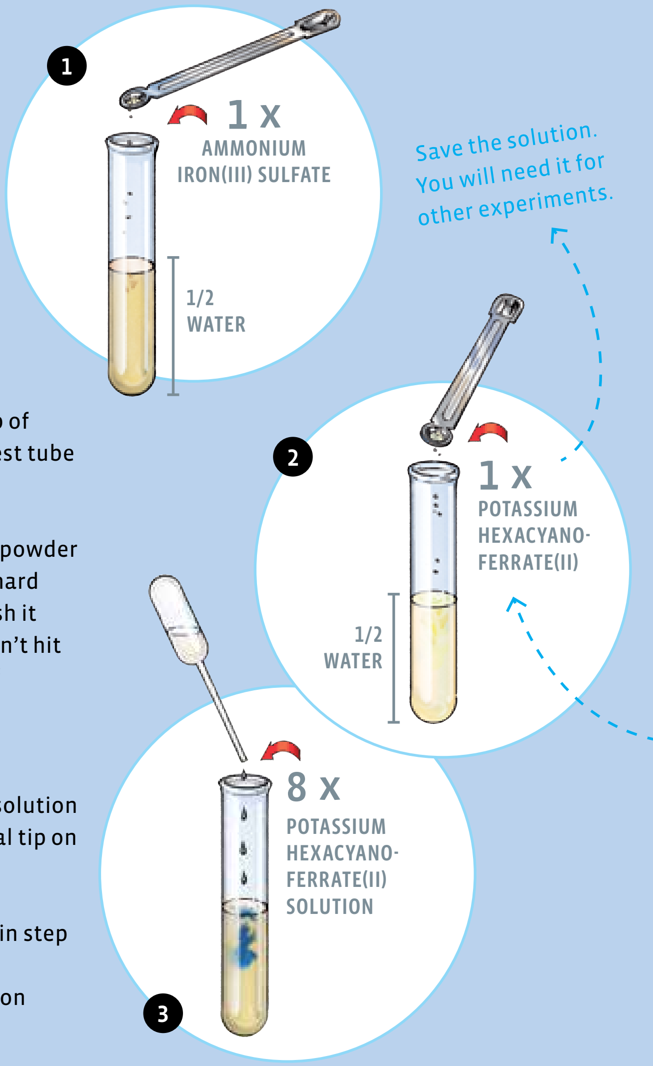
In these exciting experiments, you will learn about the best way to write top-secret messages and the chemistry behind invisible inks.

EXPERIMENT 19

Prussian blue

YOU WILL NEED

→ 2 test tubes
→ measuring spoon
→ pipette
→ ammonium iron(III) sulfate
→ potassium hexacyanoferrate(II)
→ *cup of water*



HERE'S HOW

1. Dissolve one very small spoon tip of ammonium iron(III) sulfate in a test tube filled halfway with water.

   If the ammonium iron(III) sulfate powder has solidified into a block, use a hard object (such as a hammer) to crush it between two sheets of paper. Don't hit it, though, just press and grind. If possible, have an adult help you.

2. In a second test tube, prepare a potassium hexacyanoferrate(II) solution as described in the environmental tip on page 37.

3. Now take the solution you made in step 2, and add 8 to 10 drops to the ammonium iron(III) sulfate solution from step 1.
   Does the color change?

   You will need to keep the solution for the next experiment.

Safety Note: For ammonium iron(III) sulfate and potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7! For potassium hexacyanoferrate(II), also note the environmental tip on page 37!

→ WHAT'S HAPPENING?

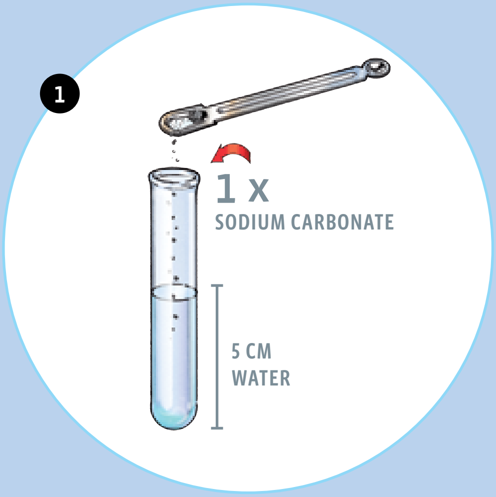
Ammonium iron(III) sulfate and potassium hexacyanoferrate(II) will combine to form a deep blue solution. This beautiful blue pigment is known as "Prussian blue."

EXPERIMENT 20

Erasing the blue

YOU WILL NEED

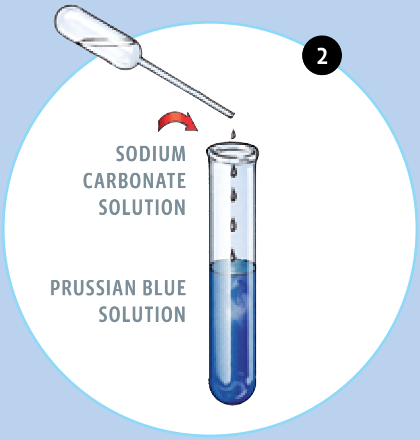
→ test tube
→ measuring spoon
→ sodium carbonate
→ prussian blue solution from Experiment 19
→ potassium hexacyanoferrate(II)
→ *cup of water*



HERE'S HOW

1. In a test tube, dissolve 1 large spoonful of sodium carbonate in 5 cm of water.

2. Use the pipette to add sodium carbonate solution drop by drop to the Prussian blue from Experiment 19.
Does the blue color stay?



Environmental tip:

Potassium hexacyanoferrate(II) is harmful to aquatic organisms, so as little of it as possible should be allowed to get into the water system (see note on page 7). Here's a tip: Dissolve one spoon tip of potassium hexacyano-ferrate(II) in a test tube filled halfway with water. Store the solution in a clean, labeled vial. Then, take just the required amount from the vial (usually, just a few drops) when you need it. That way, you won't have to prepare a new batch for every experiment. The blue residue produced in the experiments should be rinsed down the drain with some sodium carbonate and a lot of water.

→ WHAT'S HAPPENING?

Potassium hexacyanoferrate(II) is an indicator for iron. The experiment shows, though, that the solution being tested can't have an alkaline reaction, since Prussian blue is unstable in an alkaline solution.

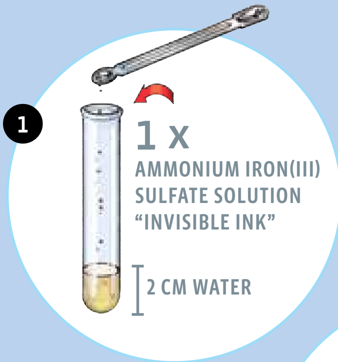
Safety Note: For sodium carbonate, note the "Information about hazardous substances" on page 7!

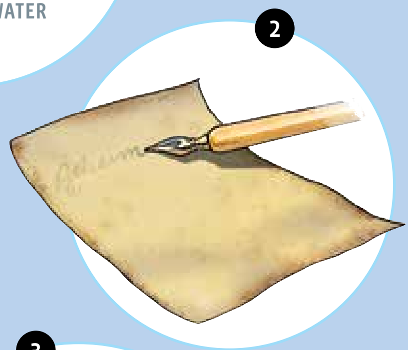
EXPERIMENT 21

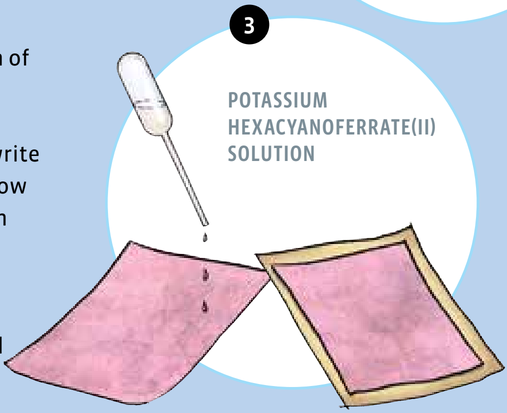
Invisible ink

YOU WILL NEED

- → 2 test tubes
- → measuring spoon
- → pipette
- → ammonium iron(III) sulfate
- → potassium hexacyano-ferrate(II) solution from Experiment 19
- → *nib pen or paint brush*
- → *yellowish paper*
- → *blotting paper*
- → *cup with water*







HERE'S HOW

1. Dissolve a small spoonful of ammonium iron(III) sulfate in 2 cm of water.

2. In letters that are not too small, write a brief secret message on the yellow writing paper with the ammonium iron(III) sulfate solution. Let the "invisible ink" dry.

3. The recipient of your message will just need to soak a sheet of blotting paper with potassium hexacyanoferrate(II) solution (simply drip the solution on the paper with the pipette) and lay the paper over the message.
   What happens to the secret writing?

→ WHAT'S HAPPENING?

When the recipient lifts off the blotting paper, the secret message will show up in a clear blue color.

Safety Note: For ammonium iron(III) sulfate and potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7! For potassium hexacyanoferrate(II), also note the environmental tip on page 37!

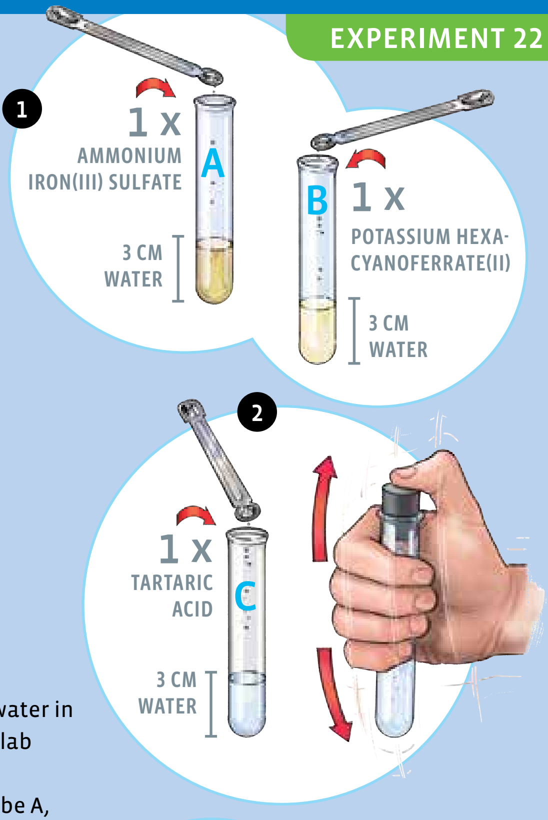
Blotting paper soaked with chemical solutions should only be touched with protective gloves!

EXPERIMENT 22

Now things get colorful!

YOU WILL NEED

→ 3 test tubes
→ measuring spoon
→ stopper
→ ammonium iron(III) sulfate
→ potassium hexacyanoferrate(II)
→ tartaric acid
→ *marker*
→ *cup of water*



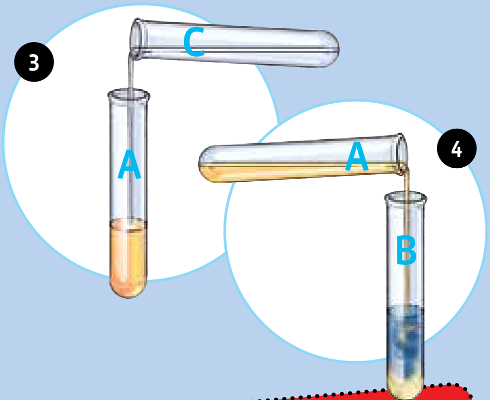
HERE'S HOW

1. Mark one test tube with an "A" and a second one with a "B." Pour 3 cm of water in each test tube, and set them in your lab station. Add a small spoon tip of ammonium iron(III) sulfate to test tube A, and a small spoon tip of potassium hexacyano-ferrate(II) to test tube B — just a few crystals in each case.

2. In the third test tube, "C," dissolve a small spoonful of tartaric acid in 3 cm of water. Insert the stopper and shake well!

3. Pour the colorless tartaric acid solution into test tube A. Insert the stopper and shake thoroughly!
   What color is your solution?

4. Now pour the golden yellow solution from step 3 into test tube B.
   Does the color change?



Safety Note: For tartaric acid, ammonium iron(III) sulfate, and potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7! For potassium hexacyanoferrate(II), also note the environmental tip on page 37!

→ WHAT'S HAPPENING?

The golden yellow solution is created by the action of tartaric acid on iron compounds. The blue solution, of course, is Prussian blue, which is more stable in acidic solutions than in alkaline ones.

EXPERIMENT 23

Nothing's happening!

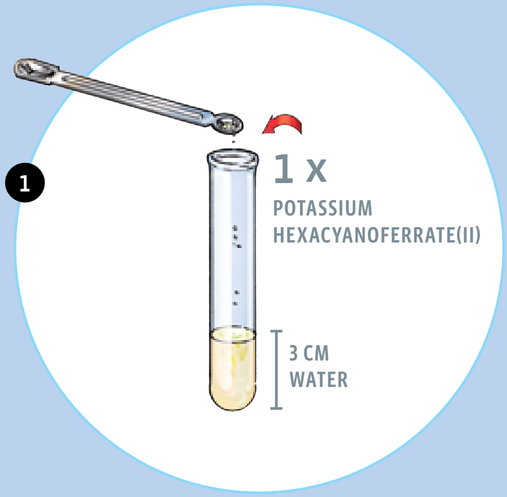
YOU WILL NEED

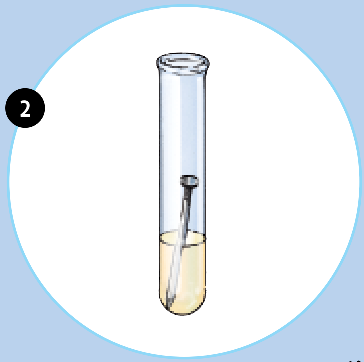
→ 1 test tube
→ measuring spoon
→ potassium hexacyanoferrate(II)
→ *shiny iron nail*
→ *cup of water*

HERE'S HOW

1. Dissolve 1 spoon tip of potassium hexacyanoferrate(II) in 3 cm of water.

2. Place an iron nail in the solution.
   Does anything happen?





→ WHAT'S HAPPENING?

Nothing is happening. A lot of chemical reactions only take place in aqueous (water-based) solutions. Potassium hexacyanoferrate(II) only reacts to dissolved iron, such as the iron in an ammonium iron(III) sulfate solution.

Safety Note: For potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7 and the environmental tip on page 37!

CHECK IT OUT

Accidental Blue

A paint maker named Johann Diesbach created Prussian blue "by mistake" in 1706. Diesbach was actually working on making a red pigment. Unfortunately, he ran out of lye, so he had a colleague lend him a substitute. But instead of the desired red, he ended up with a blue pigment. The lye was evidently contaminated with something. From this accidental discovery, Prussian blue later became a huge success.

Prussian blue is still used today, such as in printing inks, carbon paper, and in the plastics industry. In analytical chemistry, the Prussian blue reaction is a method commonly used as a test for iron.

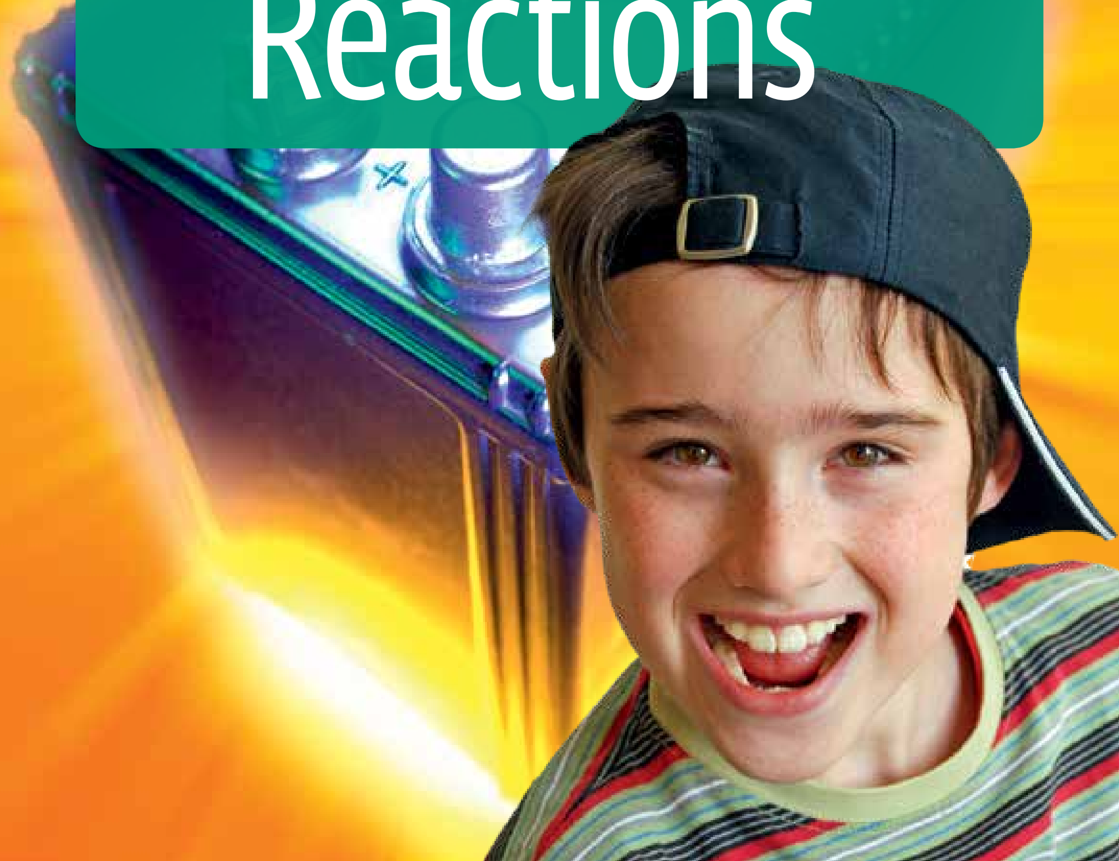
INVISIBLE INK
FROM THE KITCHEN

Do you have to write a secret message quickly? And does it have to reach your friend right away? You won't always have ammonium iron(III) sulfate and potassium hexacyanoferrate(II) on hand. You're more likely to have a lemon, some light-colored table vinegar, or an onion. The easiest way to get onion juice is by squeezing some onion pieces with a garlic press. Now onion juice, vinegar, and lemon juice will be your invisible inks.

For writing, use a nib pen or a feather with the tip cut off at an angle. After the ink dries, you won't be able to see the writing. To turn it visible again, simply hold the paper above (but not directly on) a heater or hot plate with a pair of barbecue tongs.

It’s inside the remote control of a toy car and in the smoke detector on the ceiling. Almost everyone has a 9-volt battery at home. A useful little battery like this can do a lot of other things too — like dissolve iron and copper. And as you can imagine, it’s possible to test for those dissolved metals.

Electrochemical Reactions

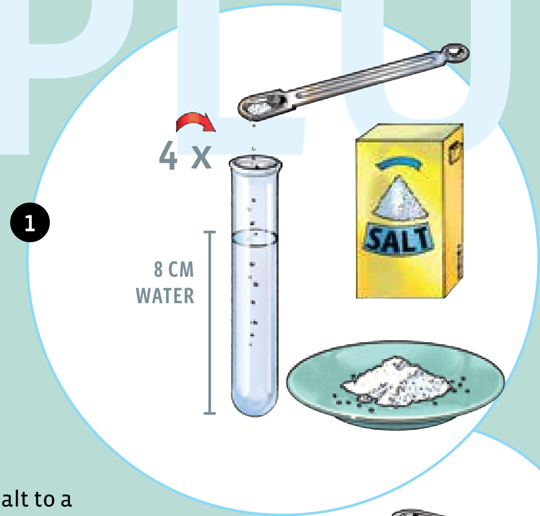


EXPERIMENT 24

Dissolving iron

YOU WILL NEED

→ 1 test tube
→ measuring spoon
→ stopper
→ battery clip
→ *9-volt square battery*
→ *table salt*
→ *cup of water*



HERE'S HOW

1. Add 4 large spoonfuls of table salt to a test tube filled with about 8 cm of water. Insert the stopper and shake until all the salt is dissolved.

2. Then fill the test tube almost to the rim with water and set it in your lab station. Bend the double-headed measuring spoon as shown in the illustration and suspend it in the solution.

3. Immerse the end of the black wire (negative terminal) of the battery clip in the solution. Press the metal prong of the red wire (positive terminal) against the spoon.

   Be careful not to let the black wire's metal prong touch the spoon. That would cause a short circuit!

What do you see happening at the positive and negative terminals?

→ WHAT'S HAPPENING?

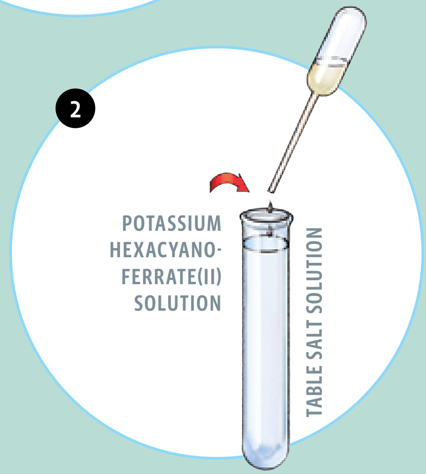
There are bubbles of gas at the black wire, and you will see yellow clouds descending gently from the spoon. What could that be?

EXPERIMENT 25

The proof is blue

YOU WILL NEED

→ 1 test tube
→ measuring spoon
→ stopper
→ battery clip
→ pipette
→ potassium hexacyanoferrate(II) solution from Experiment 19
→ *9-volt square battery*
→ *table salt*
→ *cup of water*



HERE'S HOW

1. Prepare a table salt solution as you did in Experiment 24, and then fill the test tube with water again. Set the test tube in your lab station.

2. Use the pipette to add a few drops of the potassium hexacyanoferrate(II) solution to the salt solution.

3. Arrange the measuring spoon and wires as you did in Experiment 24, and watch the negative and positive terminals.

→ WHAT'S HAPPENING?

After a few seconds, you see blue clouds coming off the end of the spoon and sinking to the bottom of the test tube. The Prussian blue indicates iron is being dissolved there. The electrical power has extracted some iron from the measuring spoon. At the tip of the black wire, tiny bubbles form.

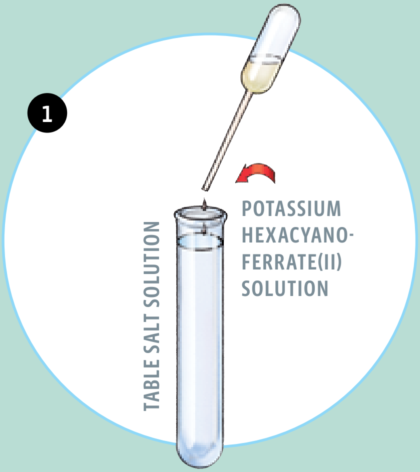
Safety Note: For potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7 and the environmental tip on page 37!

EXPERIMENT 26

Dissolving copper

YOU WILL NEED

→ measuring spoon
→ stopper
→ battery clip
→ pipette
→ potassium hexacyano-ferrate(II) solution from Experiment 19
→ *9-volt square battery*
→ *table salt*
→ *cup of water*
→ *paper towel*

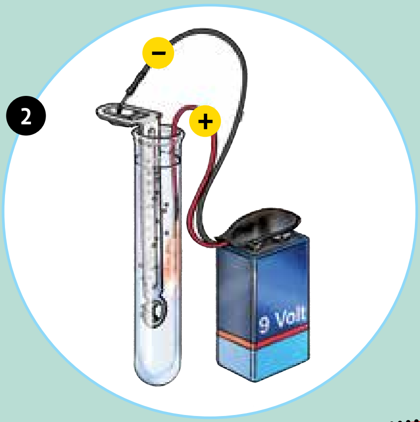


HERE'S HOW

1. As in the last experiment, prepare a table salt solution containing a few drops of potassium hexacyanoferrate(II) solution.

2. Switch the negative and positive terminals as shown in the illustration. Now, the negative terminal is on the measuring spoon, while the exposed end of the red wire, the positive terminal, is immersed in the solution. Is the reaction different from in Experiment 24?

   At the end of the experiment, use a paper towel to clean the copper-containing metal prong at the end of the red wire.

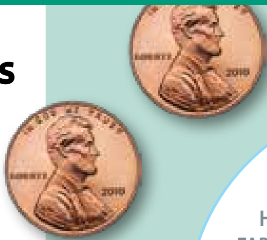


Safety Note: For potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7 and the environmental tip on page 37!

→ WHAT'S HAPPENING?

As soon as the current flows, bubbles of gas rise up from the measuring spoon. Meanwhile, little brown clouds sink from the red wire to the bottom of the test tube. The wires are made of copper. When current flows through them, some of the copper dissolves and combines with potassium hexacyanoferrate(II) to form the brown clouds, which consist of copper hexacyanoferrate.

Electrified coins



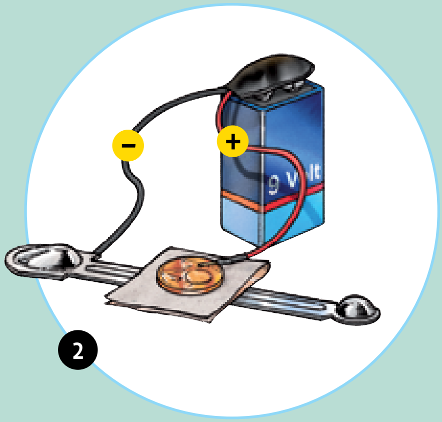
YOU WILL NEED

- → measuring spoon
- → battery clip
- → pipette
- → potassium hexacyano-ferrate(II) solution from Experiment 19
- → *white coffee filter or white blotting paper*
- → *9-volt square battery*
- → *copper penny*
- → *table salt*
- → *cup with water*

HERE'S HOW

1. Prepare a table salt solution as you did in Experiment 25. Add a few drops of the potassium hexacyanoferrate(II) solution. Soak a piece of blotting paper with this solution mixture.

2. Next, assemble the experimental setup shown in the illustration. Wait about 10 seconds. Then lift up the coin.
   Do you notice anything on the blotting paper?



→ WHAT'S HAPPENING?

One-cent pieces are made of zinc coated with a thin layer of copper. As long as that coating hasn't worn off, you will see a brownish impression left behind on the blotting paper. The reaction is the same as in Experiment 26.

Blotting paper soaked with chemical solutions should only be handled with safety gloves.

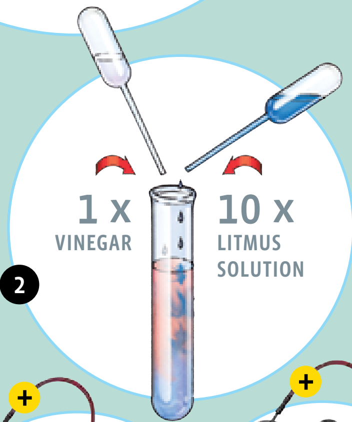
Safety Note: For potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7 and the environmental tip on page 37!

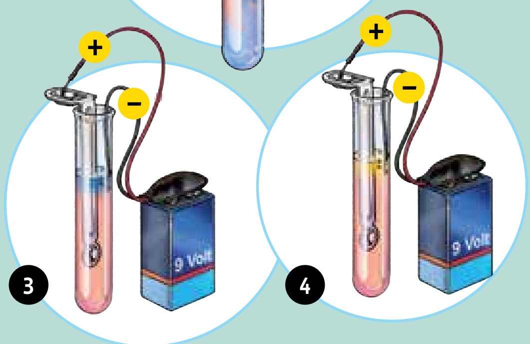
EXPERIMENT 28

Red litmus colored blue

YOU WILL NEED

→ 1 test tube
→ measuring spoon
→ stopper
→ battery clip
→ pipette
→ litmus solution
→ *9-volt square battery*
→ *table salt*
→ *cup of white vinegar*
→ *cup of water*





HERE'S HOW

1. Add 2 large spoonfuls of table salt to a test tube filled with about 7 cm of water, insert the stopper, and shake.

2. Use the pipette to add 10 drops of litmus solution and 1 drop of vinegar, which will give you a red-colored solution.

3. Use the same experimental setup as in Experiment 24. The negative terminal should not be immersed too deeply in the table salt solution. As soon as the current flows and gas production starts, keep an eye on the surface of the liquid. What do you see?

4. Keep the battery connected so the current continues to flow. Does anything change?

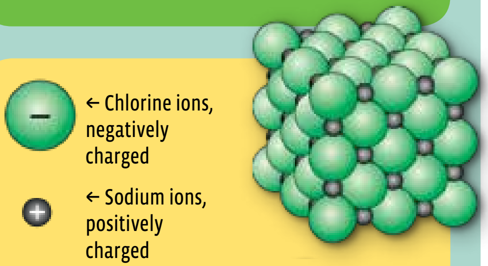
Safety Note: For potassium hexacyanoferrate(II), note the "Information about hazardous substances" on page 7 and the environmental tip on page 37!

→ WHAT'S HAPPENING?

Near the surface of the liquid, you will be able to see a clear blue color that comes and goes, meaning an alkaline reaction is occurring there. If you wait a little longer, the solution will turn yellow.

TABLE SALT CRYSTALS UNDER THE LENS

Table salt is a compound of the elements sodium and chlorine, and is therefore called sodium chloride. Sodium and chlorine — like all elements — are composed of tiny particles known as atoms. In a table salt crystal, the sodium atoms have a positive electrical charge, and the chlorine atoms have a negative charge. They are held together by these opposite charges, in the arrangement shown in the illustration. ↓



CRYSTALS BREAK DOWN

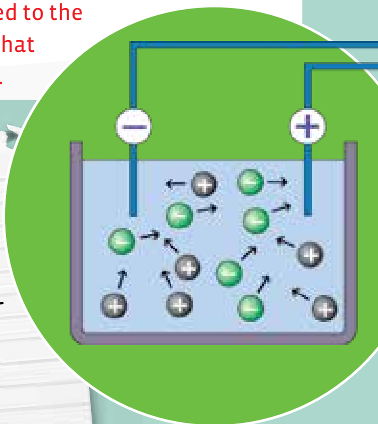
When table salt is dissolved in water, the crystals become decomposed into positively-charged sodium atoms and negatively-charged chlorine atoms. If the two terminals of a current source, such as a battery, are immersed in the solution, the positively-charged sodium atoms migrate to the negative terminal, and the negatively-charged chlorine atoms migrate to the positive terminal.

CHECK IT OUT

Reactions at the poles

The metals dissolve at the positive terminal. On the measuring spoon, you get iron ions, and you get copper ions at the wire's copper-containing contact pin. As the chlorine ions migrate there, they combine to form metal chlorides. Then, you get the observed blue or brown coloration with potassium hexacyanoferrate(II).

The positive sodium ions migrate to the negative pole, where a decomposition of water takes place, with hydrogen as one of the products of decomposition. That's what you see bubbling up from the negative terminal. The other decomposition product combines with the sodium ions to form sodium hydroxide, or soda lye. That's what caused the temporary blue coloration of the red litmus solution in the last experiment. After a short while, the chlorine bleached the litmus pigment. That's what led to the yellow color that you saw next.



Note:
Since charged atoms migrate to the oppositely-charged pole, they are known as ions (from the Greek word meaning "to go").

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1st Edition 2011

Experiments: Kurt Waselowsky; Revision: Dr. Heike Herrmann
Project direction: Ita Meister, Kristin Albert; Product development: Elena Ryvkin
Design and layout: Atelier Bea Klenk, Klenk/Wiedau-Lorenz
Illustrations: Atelier Bea Klenk, Oliver Marraffa
Photos: Stephen Sweet, front cover; Kasia Biel, front cover; Uladzimir Bakunovich, front cover; Foto-Ruhrgebiet, p. 1; picsfive, p. 2, 4, 6, 7, 14 bottom left, 17, 22 middle right, 26 bottom left, 37, 48, back cover; Bertold Werkmann, p. 3 top left, 14 upper right; anna, p. 3 top right, 27 top left, 34 top; Blend Images, p. 3 middle left, 15 top; Andrzej Tokarski, p. 3 middle left, 21, 22 bottom left; matttilda, p. 3 middle right, p. 35, p. 41; anna liebiedieva, p. 3 bottom left, 23 top; Infinite XX, 27 top right; Michael Kempf, p. 8/9; ott, p. 14 top left; ferkelraggae, p. 14 middle; ktsdesign, p. 15; Sebastian Duda, p. 15 bottom right; Neokan, p. 21 top left, 24; arahan, p. 21 top left; Kaarsten, p. 22 top; Elenathewise, p. 22 middle, Teamarbeit p. 22 middle right; Robert Kneschke, p. 26 bottom; Jürgen Acker, p. 26 right; cantor pannetto, p. 27 bottom; HP_Photo, p. 27; Anna Khomulo, p. 30 bottom, 33 bottom; Johanna Goodyear, p. 34 bottom right; Snezana Skundric, p. 35 top; Gina Sanders, p. 35 top right, p. 41 top right; Alx , p. 37; Marco Rullkötter, p. 38, 41 top left; Les Cunliffe, p. 42 middle; Vasilyev Dmitry, p. 42; sizta, p. 42 bottom right; Taffi, p. 46; Orlando Florin Rosu, p. 48; proffelice, back cover (all previous www.fotolia.com); Oliver Klasen, Stuttgart, cover, p. 1 top left; Michael Flaig, pro-studios, Stuttgart, p. 2 top; Friedrich Werth, werthdesign, Horb-Betra, p. 4 top, 26 middle; Degussa AG, Hanau-Wolfgang, p. 41 bottom left

Packaging design and layout: Atelier Bea Klenk, Klenk /Riedinger
with use of the following photos: Stephen Sweet, Kasia Biel, Uladzimir Bakunovich; Bertold Werkmann, Blend Images, Infinite XX; ott; Johanna Goodyear; Gina Sanders; Alx; ktsdesign; HP_Photo (all previous www.fotolia.com); Nick Rowe, www.gettyimages.com; Oliver Klasen, Stuttgart; Michael Flaig, pro-studios, Stuttgart

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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

We reserve the right to make technical changes.

Printed in Germany / Imprimé en Allemagne

665012-03-161019