EXPERIMENT MANUAL

KIDS FIRST CRYSTALS, ROCKS & MINERALS

Please observe the safety information, the first aid information (inside front cover), the advice for supervising adults on page 4, the safety rules on page 5, and the information regarding the handling of the chemicals and their environmentally sound disposal on pages 6 to 9.

WARNING. Not suitable for children under 8 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 8 years old. Eye protection for supervising adults is not included.

WARNING — Chemistry Set. This set contains chemicals and 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.

THAMES & KOSMOS

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First Aid Information

FIRST AID...
...in case any accidents should happen during experimentation.

- ››› **In case of eye contact:** Wash out eye with plenty of water, holding eye open if necessary. 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 larger burns, seek immediate medical help.
- ››› **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.
- ››› **In case of doubt, seek medical advice without delay.** Take the chemical and/or product and its container 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.

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

An Experiment to Hit the Ground Running

What happens when the mineral magnetite is brought near the compass? Try it and see for yourself!

Magnetism

WANT MORE?
Let's get started on our experiments with crystals, rocks, and minerals ...

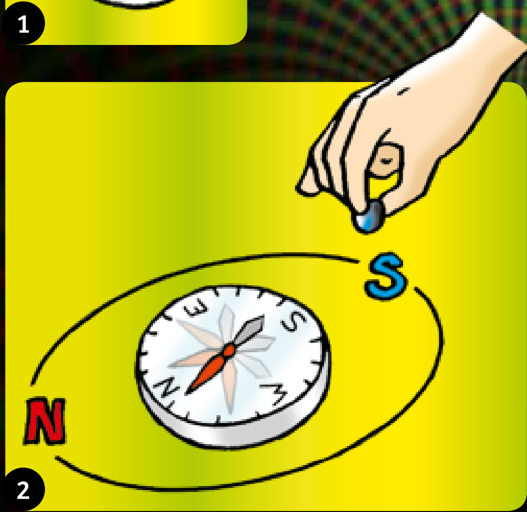
YOU WILL NEED

- Compass
- Minerals

HERE'S HOW

1. Place the compass on the table and notice how the needle stands still.
2. Pass the minerals, one after another, by the compass without touching it. Which one makes the needle move? Rotate the mineral around the compass. How does the needle react now?


1



2

Important:
For all experiments, always wear the appropriate eye protection!

ABOUT MAGNETITE

Hardness	Density
5-6	5

This important ore is, like hematite, a compound of iron and oxygen, but in a different composition. It is strongly magnetic — hence its name. This is the mineral that led to the discovery of magnetism thousands of years ago, and it was used to make the first compasses. Many living organisms (certain birds, bees, and bacteria) have tiny magnetic particles in their bodies that they can use to sense Earth's magnetic field.

WHAT'S HAPPENING?

The compass needle identifies magnets, because it is itself a small magnet with a north and a south pole. It reacts to magnetite because this mineral is magnetic. For that reason, the compass needle always turns its opposite end toward the magnetite as you rotate the piece around it. Like poles repulse each other, and unlike ones attract each other.

Hematite, on the other hand, acts like an iron nail: it is simply attracted by the magnetite. Your other minerals are all nonmagnetic.

Your magnet might also possibly react to the limestone. That would mean that the limestone contains natural iron compounds that have become embedded in it.

Geologists use tests including this one to identify rocks and minerals according to their different properties.

››› KIT CONTENTS

GOOD TO KNOW! 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 at:

techsupport@thamesandkosmos.com

First, check all the labels to make sure you have the right chemicals.

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

What's inside your experiment kit:

Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
❍	1	Potassium hexacyanoferrate (III), 10 g	1	770 695
❍	2	Citric acid, 10 g	1	032 132
❍	3	Copper sulfate, 8 g	1	033 242
❍	4	Potassium aluminum sulfate, 50 g	2	771 061
❍	5	Gypsum (calcium sulfate), 500 g	1	770 800
❍	6	Food coloring, blue	1	705 725
❍	7	Double-ended measuring spoon	1	035 017
❍	8	Safety lid opener	1	070 177
❍	9	Display box	1	705 726
❍	10	Wooden spatula	1	000 239
❍	11	Measuring cup, large	2	087 077
❍	12	Lid	1	087 087
❍	13	Measuring cup, small	2	061 150
❍	14	Plastic pipette	2	232 134
❍	15	Safety goggles	1	717 019
❍	16	Bag of rocks: granite, limestone, basalt, marble, pumice	1	772 781

✔	No.	Description	Qty.	Item No.
❍	17	Bag of minerals: calcite, pyrite, hematite, quartz crystal, bornite, fluorite	1	772 785
❍	18	Magnetite	1	772 783
❍	19	Soapstone	1	772 784
❍	20	Geode mold	1	708 119
❍	21	Compass	1	706 355
❍	22	Magnifying lens	1	311 137
❍	23	Sandpaper	1	700 881
❍	24	Die-cut sheet	1	709 564
❍	25	Paper sheet/rock cycle	1	709 565
❍	26	Wooden stick	1	020 042

You will also need: Distilled water (about 1 liter), self-adhesive labels, paper, pencil, adhesive tape, paper towels, pot holders, small old cooking pot (20 cm diameter) or tea kettle, empty jam or honey jars with lids (about 200 ml), empty yogurt cups (250 ml), small rock with rough surface, all-purpose glue, scissors, old newspapers, sandpaper, black ink or watercolor paint, rubber balloon, hammer, cup or plate made of light-colored ceramic or porcelain with an unglazed (rough) area, penknife, iron or steel nail, copper penny, 2-3 boxes of matches, yarn and nylon thread, table salt, tealight candle, small cardboard box, sand, food coloring or watercolor paints (red, blue, and yellow), deep dish, storage box, marker, paper

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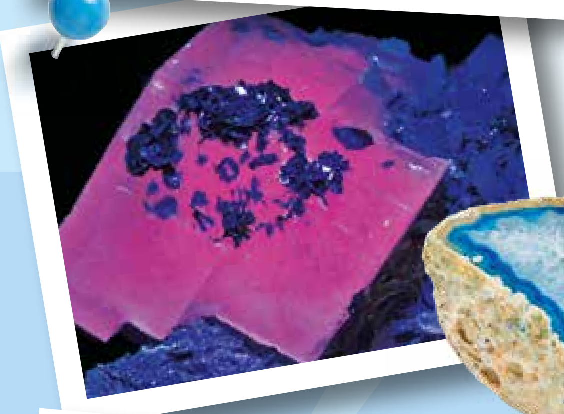
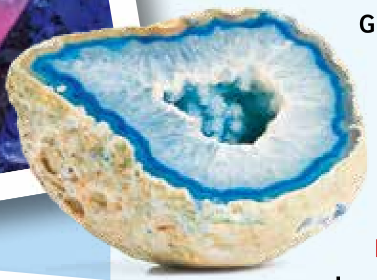




TIP!
You will find supplemental information in the Check It Out sections on pages 19, 27, and 31-32.

So nothing goes wrong: A word to parents

TIP!
Additionally required items from your household or from the supermarket or drug store are highlighted in *italic script* in the individual experiments. Before your child begins the experiments, he or she should carefully read through everything that will be required and make sure to have all the materials ready.

Advice for supervising adults

Dear Parents,

This experiment kit offers children an easy way to learn about crystals and how they are formed. In addition, children will learn simple methods for studying rocks and minerals, and learn a lot about these building blocks of our planet in the process.

It is natural to have questions about the safety of a kit that contains chemicals. The experimental equipment 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 substances. The standards also stipulate that adults should assist their children with advice and assistance in their new hobby.

A. Read and follow these instructions, the safety rules and the first aid information, and keep them for reference. Please observe the information about dangerous substances (chemicals) and their environmentally sound disposal.

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. For use under adult supervision. Keep this chemical toy set out of reach of children under 10 years old.

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, safety information, and the possible hazards with the child or children before commencing the experiments. Particular attention should be paid to the safe handling of hot water, citric acid, the other chemicals and chemical solutions.

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.

G. Substances in non-reclosable packaging (potassium alum packets) should be used up (completely) during the course of one experiment, i.e. after opening the package.

H. 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.

Hot water is used in the production of crystal salt solution. You should devote special care to handling it safely and assist your child when help is needed. Make sure there is no fire risk when heating water on the kitchen stove!

While experimenting, please be careful not to let the crystal salts and chemicals come into contact with the skin, eyes, or mouth. It is also important not to let the crystal salts, their solutions, or especially the finished crystals get into the hands of young children. They could mistake them for candies and put them into their mouth.

The dye powder will color things very intensely and may cause stains that can't be washed out of clothing. Keep all tablecloths, curtains, and carpets away from the experiment area. The child should wear old clothes when working.

The work area should not be in the kitchen, as chemicals should be kept strictly separate from foods and kitchen equipment. A cool basement room would be ideal. Do not use any containers or tools in the kitchen after you have used them for growing crystals.

Always get any required equipment and chemicals ready before beginning an experiment. The safety goggles are especially important!

We hope you and your child have a lot of fun growing crystals!

Basic rules for safe experimentation (safety rules)

Stop! Read this first, before you begin!

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.

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

2. Keep young children and animals away from the experimental area.

3. Always wear eye protection. If you war corrective eyeglasses, you will need protective goggles for those who wear eyeglasses. When working, wear appropriate clothing.

4. Store this experimental set and final crystal(s) 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.

7. Ensure that all empty containers and non-reclosable packaging are disposed of properly.

8. Wash hands after carrying out experiments.

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. And also do not smoke.

11. Do not allow chemicals to come into contact with the eyes or mouth. Handle breakable material (e.g. the glass jars) carefully.

12. Do not replace foodstuffs in original container. Dispose of immediately (in the garbage or down the drain).Do not consume any leftover foodstuffs.

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

14. Do not grow crystals where food and drink is handled or in bedrooms.

15. Take care while handling with hot water and hot solutions.

16. Ensure that during growing of the crystals the container with the liquid is out of reach of children under 10 years of age.

17. Never work alone. An adult should always be present. Also, pay attention to the information on the chemical labels, the "Information on handling chemicals" on page 6, as well as the safety information provided with the individual experiments (for example, having to do with handling hot liquids).

18. Be particularly careful with hot burners, and don't forget to turn them off after use! Do not inhale hot vapors!

19. 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. All filled containers should be labeled with the container's contents.

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

21. Always hold containers of hot materials such that their openings are pointing away from yourself or others.

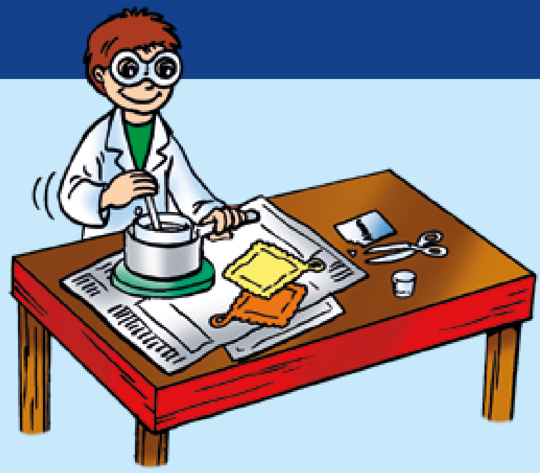
22. Pay special attention to the quantity specifications and the sequence of the individual steps. Only perform experiments that are described in this instruction manual.

23. With additionally required products (such as all-purpose glue) also take note of the warnings on their retail packaging. And observe the information on the chemical vials and packages and the information on handling the chemicals.

24. When experimenting with open flame, be sure that there are no flammable objects or flammable liquids nearby. Extinguish all flames after completing the experiments if not before, but also if you leave the experiment area even just briefly. The tealight candle must be placed on a fire-resistant surface (e.g., an old saucer).

25. Have a bucket or box with sand ready for extinguishing any fires. If the fire cannot be extinguished right away, contact the fire department immediately.

››› TIPS



Practical tips for growing crystals

Safety ...

... is the number one priority. Before each experiment, always read all of the instructions. Only use materials specified in the manual. It is pointless and quite possibly dangerous to experiment with unknown chemicals. Do not bring the materials you are handling into contact with your body, particularly with your eyes or mouth.

Always wear your safety goggles when handling chemicals! Be particularly careful with hot burners, and don't forget to turn them off after use!

If any chemicals get onto your skin by mistake, rinse them off immediately under running water.

When experimenting, be careful not to inhale dust or powder of chemicals.

When handling plaster, follow these safety rules:

› **Do not place the materials in the mouth.**
› **Do not inhale dust or powder.**
› **Do not apply to the body.**

Information about hazardous substances

How they are labeled and how to properly handle them

In the following, we provide you with a list of the chemicals contained in this kit that have been classified as hazardous substances. For each substance, the list shows hazard statements (in blue) and precautionary statements for avoiding the hazards. In the margin, you will find the corresponding red-outlined hazard pictograms and the signal word WARNING.

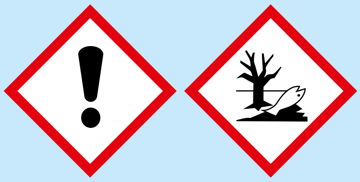
You will also find this labeling on the outside packaging and on the labels of the chemical vials.

Calcium sulfate (plaster)
Avoid breathing dust. Do not get in eyes, into the mouth or on skin. Do not apply to the body. Do not ingest.

Citric acid
Avoid breathing dust. Do not get in eyes or on skin.

Potassium aluminium sulfate (potassium alum)
Avoid breathing dust. Do not get in eyes or on skin.

Potassium hexacyanoferrate(III)
Avoid release to the environment.

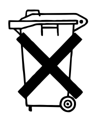


WARNING
Copper(II) sulfate
Harmful if swallowed. - Causes serious eye irritation. - Causes skin irritation. - Very toxic to aquatic life with long lasting effects.
Wash skin thoroughly after handling. Do not eat, drink or smoke when using this product. Avoid release to the environment. Wear eye protection/ face protection. Wear protective gloves. IF SWALLOWED: Call a POISON CENTER/doctor if you feel unwell. Rinse mouth. IF ON SKIN: Wash with plenty of soap and water. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If skin irritation occurs: Get medical advice/ attention. If eye irritation persists: Get medical advice/attention. Take off contaminated clothing and wash before reuse. Collect spillage. Dispose of contents/ container to an approved waste disposal plant. Obtain disposal instructions on page 9 in the manual.

››› WARNING! The following applies to all chemicals: Store locked up. Keep out of reach of children. This primarily applies to young children, but also to older children who — unlike the experimenter — have not been appropriately instructed by adults.

The following precautionary statement applies as well: 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.



Your experiment area ...

... should be set up in a quiet room. If there are any young children or pets in the house, the room should be lockable so they can't get to the chemicals or knock over your crystal-growing jars. Also, the temperature in the room shouldn't fluctuate too much (no full sun through the windows, for example), since the solubility of the substances is temperature-dependent and unwanted heating can cause already-formed crystals to dissolve again.

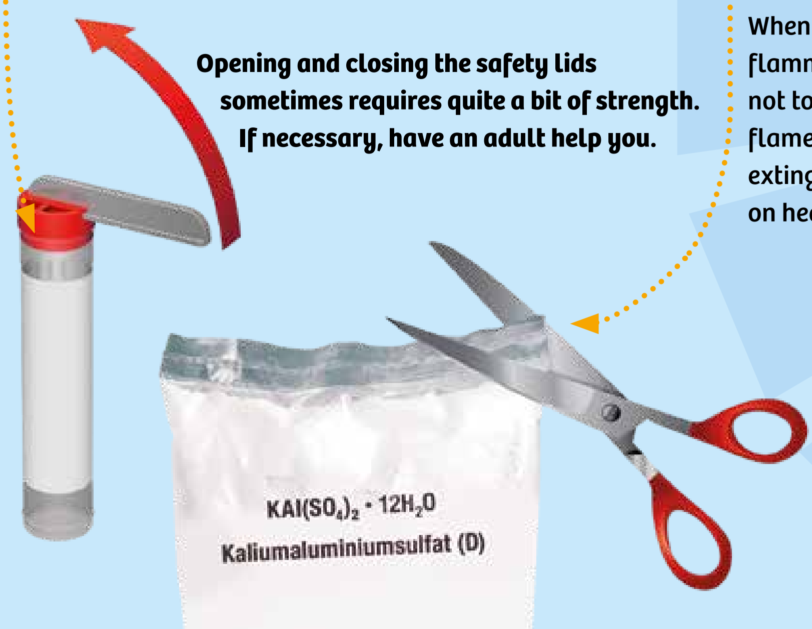
The kitchen is not appropriate for your experiments, since there is too great a risk that chemicals will get into foods or that someone will inadvertently swallow these substances by mistaking them for food. In addition, the kitchen temperature will vary a lot during the course of a day, especially when someone is cooking.

A cool, quiet, and lockable basement room is much more suitable. And don't forget to clean up after your experiments and to wipe the work surface clean.

The **chemical vials** hold the hazardous substances.

The illustration shows how to open the safety lids using the **lid opener** (part no. 070177) provided with the kit. Sometimes when you open them, a little of the chemical gets stuck to the lid and can fall onto your hand or the work surface. You can prevent that by banging the vial a few times on the work surface before opening it. After you have taken what you need from the vial, close it again immediately.

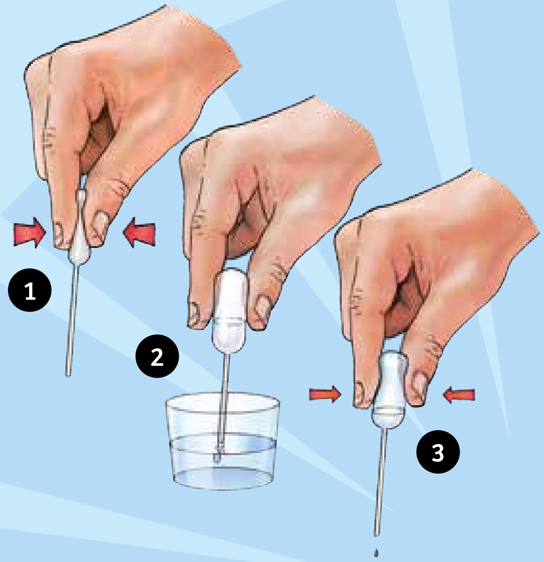
Opening and closing the safety lids sometimes requires quite a bit of strength. If necessary, have an adult help you.



Ask an adult to help you open the **plaster packet** and the **chemical packets** with a pair of scissors; never with your teeth! Don't cut it in such a way that the label is lost.

The alum packet should be completely used up during the experiment. Close the plaster bag immediately after use with a clip or a piece of tape, and keep it in a safe place.

When you want to add liquids drop by drop, the **pipette** will come in handy: Squeeze the upper part of the pipette between thumb and forefinger and dip the end into the liquid (image, step 1). As soon as you release pressure on the bulb, the liquid rises into the pipette (step 2). Then, you can gradually let the liquid out drop by drop by applying careful pressure to the bulb (step 3).



When working with open flame, be sure there are no flammable objects, such as curtains, nearby. Be careful not to let loose sleeves, scarves, or your hair get into the flame. Tie up your hair. Keep a bucket of sand or fire extinguisher ready for extinguishing fire. Place lit candles on heat-resistant surfaces only.

›› › TIPS

For growing the crystals ...

... you will need some additional containers. The best kinds to use are empty jelly jars, washed clean and dried well. You can also use a few of these containers to collect crystal residues or leftover solutions of the used substances. You have to be sure to **label the jars clearly.** Self-adhesive labels are ideal, marked with a pencil (ink would get smeared by water), and then covered over with transparent tape to protect them from water. If you want to dry the contents, all you have to do is remove the lid for a few days. A warm location, such as a spot near a heater or radiator, will speed up evaporation. Just be sure that the container is stable and out of the reach of young children and pets!

Water

You can make your crystal solutions using regular tap water. However, **distilled water** works better. Distilled water can be purchased from the supermarket or drugstore. Tap water contains impurities depending on the region and origin of the water. These are completely harmless, or even healthy, for people to drink, but they can hinder the growth of crystals.

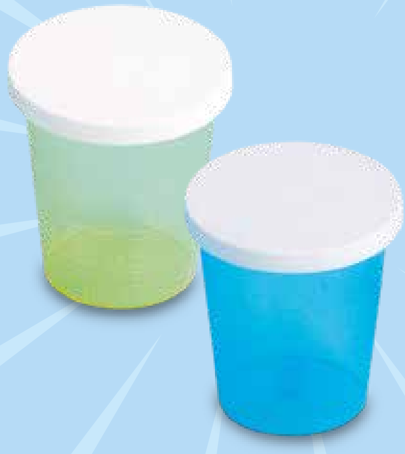
When heating the solutions ...

... you must not set your growing containers directly on a burner or gas flame. This would make glass containers crack and break, and plastic containers would melt.

Instead, get an old cooking pot, around 20 cm in diameter, and fill it with a few centimeters of tap water. The water level should be slightly lower than the level of liquid in the growing container. Heat the water on the burner to just below the boiling point.

Carefully carry the pot to your work area (ideally, have an adult help you), and set it on a trivet. Now place your growing jar in the pot and stir its contents with a wooden spatula. The water will warm the jar contents, and the crystal salt will soon dissolve and completely disappear.

If the salt does not dissolve well, take the growing container out of the pot with a pot holder and heat the water on the burner again, and then try to dissolve the salt one more time. **Caution!** Do not burn yourself with the hot water or on the pot, and don't forget to turn the stove off again.

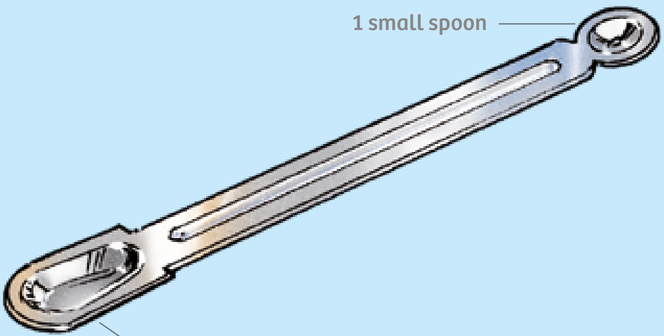


Always have an adult help you when heating water or solutions! Do not work alone!

Also, be very careful not to burn yourself or scald yourself with hot water, and don't spill any crystal salt solutions! Don't inhale the vapors that comes off the crystal salt solutions when you heat them!

The quantity of water ...

... that you will need for your experiments is indicated in milliliters, or ml for short. Use the **large measuring cup** to measure precise quantities of water. It has a scale on its side with ml marks on it. Its total capacity is 125 ml. To measure the amount of crystal salt required for each experiment, use the **double-headed measuring spoon.** In the instructions, the quantities are indicated in "spoons" or "spoonfuls."



During crystallization ...

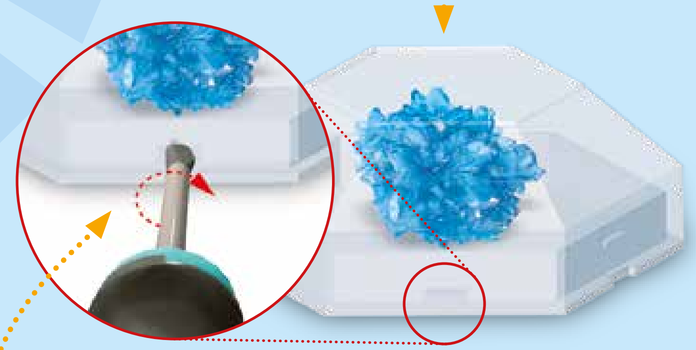
... your experimental setup should be left to stand in a protected place.
Please note: All experiment jars should be marked with a label indicating exactly what they contain. Cover them with a thin cloth (such as a handkerchief) secured over the opening with a rubber band. This will prevent dust and dead insects from falling in.

NOTE:
You will need safety goggles in every experiment. They will not be specifically listed in the "You will need" section!

Make absolutely sure that young children and pets have no access to the chemicals!

Check every day and push upward-growing crystals back into the jar.

You can save your finished crystals in the display box included in the kit.



Tip! First test the empty box's closure. The depression on the lower side has to click together with the matching part of the lid. To open it, insert a screwdriver into this slit, and turn carefully. The lid will lift.

Cleanliness ...

... is just as important in chemistry as in the kitchen. Immediately following your experiment, always clean your work area and whatever containers you have used. Fresh dirt is easier to clean off than dried-on dirt! Then rinse the containers thoroughly with clean water and dry them with a paper towel, which you should then throw away in the trash.

Waste ...

... will also, of course, be produced during your experiments. You can dispose of gypsum in your household garbage after it has dried. In the quantities used here, potassium aluminum sulfate, also known as alum, can be rinsed down the drain with a lot of water. Copper sulfate and potassium hexacyanoferrate (III) residues, on the other hand, will have to be collected and delivered to a special hazardous waste facility, since they should not get into the water system — copper sulfate is particularly toxic to aquatic organisms.

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.

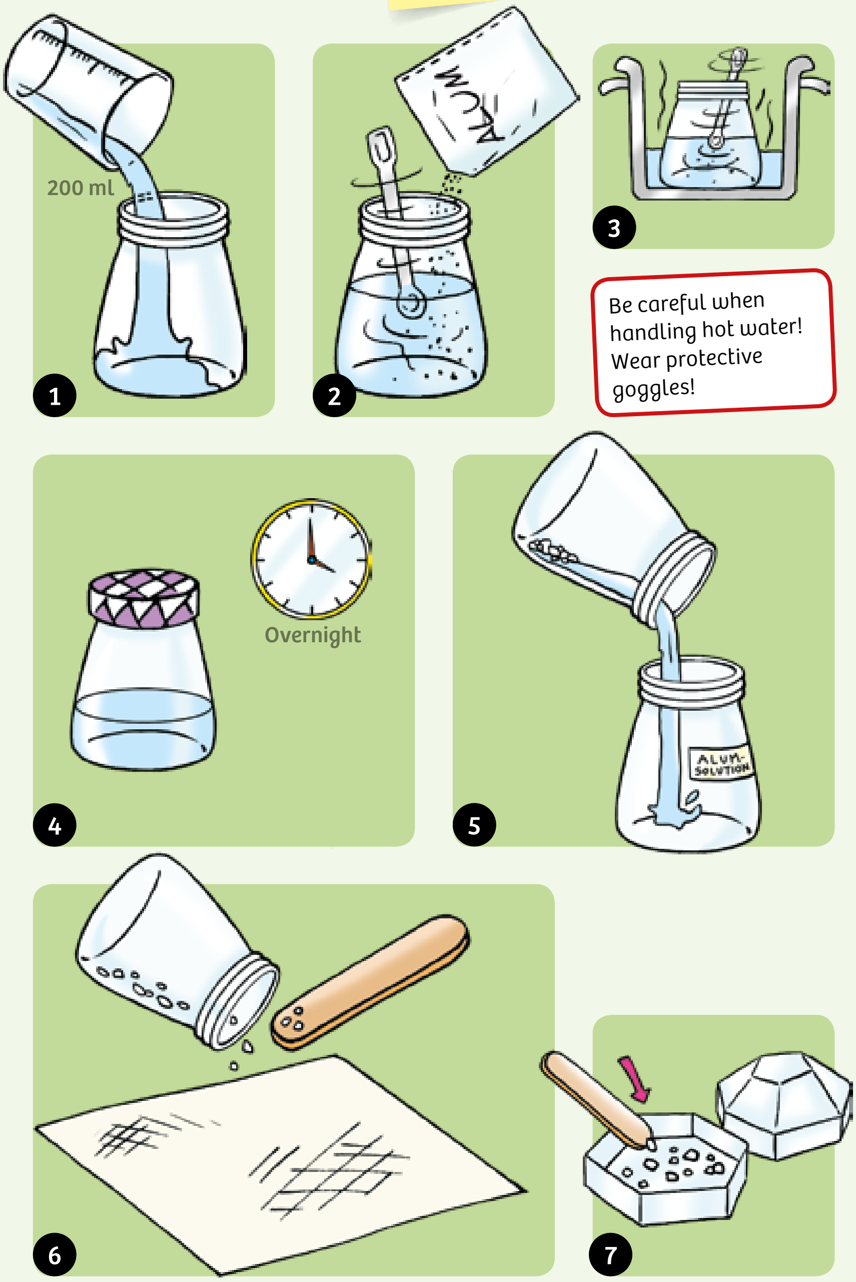
Declaration of Conformity: A Declaration of Conformity according to Regulation (EU) 2016/425 on PPE and the Directive 2001/95/EC on general product safety is available for this product on the following web address: http://thamesandkosmos.com/declarations/declaration-717019.pdf

Homemade Crystals

Some minerals display very special qualities: they form cubes, sharp needles, crooked squares, octagons, or other complicated shapes with smooth faces that sparkle in the light. Some glow with blue, green, or red colors. Others are as colorless as ice, and just as clear. These regular shapes are called crystals. The most beautiful crystals are very sought after and valuable.

EXPERIMENT 1

Important:
For all of the experiments, wear your safety goggles!



Cooling method

YOU WILL NEED

› **Large measuring cup**
› **Double-ended measuring spoon**
› **50 g Potassium aluminum sulfate (alum powder)**
› **Wooden spatula**
› **Display box**
› *Distilled water*
› *Pot of hot water (40-50 °C, 100-120 °F)*
› *Paper towels*
› *2 Empty glass jelly jars with lids*
› *Sheet of paper*
› *Pencil*

HERE'S HOW

1. Use the measuring cup to measure 200 ml of distilled water and pour it into the empty jelly jar.
2. Add the alum powder and stir. Even after you have stirred for a long time, a large part of the alum will remain undissolved at the bottom.
3. Set the jar into the pot of hot water and resume stirring. Now everything dissolves.
4. Screw the lid onto the jar, and place it in a quiet place for a few hours. A lot of crystals will form.
5. Pour the solution into the second jar. Label the jar and save it for the next experiment.
6. Shake the small crystals onto a paper towel with the help of the wooden spatula. Let them dry and select a few large and pretty crystals.
7. Put them in the display box and close it well (see page 9). You will need them later when you make your geode.

WHAT'S HAPPENING?

When a solid substance — such as the alum in this case — dissolves, water pushes between its smallest component parts (molecules) and releases them from their compounds. These building blocks are then floating around individually in the water. Since they are very tiny, you can't see them. With many substances, their ability to dissolve increases with temperature (a well-known exception is table salt). A solution that can't dissolve anything further at a certain temperature is called **saturated.** When the solution cools off it becomes **supersaturated,** and the excess alum separates out in the form of crystals. This cooling method provides crystals very rapidly.

TIP !
If the resulting crystals are not big enough, you can put them back into the solution, warm it up again, and then wrap the cooling jar with a thick towel so that it cools more slowly. Larger crystals will form when the solution cools more slowly.

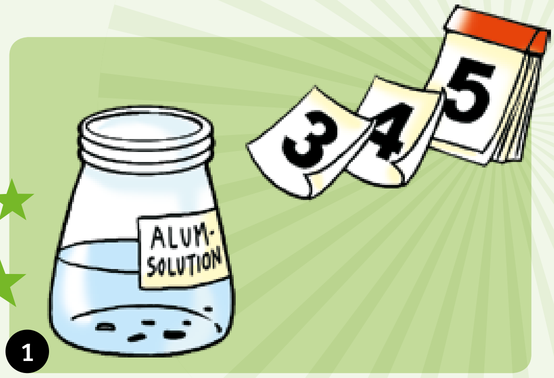
Evaporation method

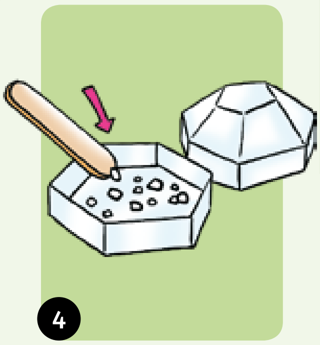
YOU WILL NEED

› **Double-ended measuring spoon**
› **Display box**
› **Small measuring cup**
› **Wooden spatula**
› **Alum solution from the previous experiment**
› *Paper towels*

HERE'S HOW

1. Start with the jar of alum solution from the previous experiment. Let the jar of solution stand for a few days in a warm location.
2. The water will evaporate and the alum will become deposited on the bottom in the form of pretty, clear crystals.
3. Remove the small crystals from the jar using the wooden spatula and place them on a sheet of paper towel. Let them dry.
4. Put them in the display box and close it well (see page 9). You will need them later when you make your geode.





ABOUT ALUM

Potassium aluminum sulfate, known as alum for short, is obtained from certain rocks through a leaching process. It has been used for millennia as, for example, an ingredient for dying materials, to stanch minor wounds, and most commonly in the production of leather and paper.

WHAT'S HAPPENING?

When the water evaporates, the building blocks join back together again. And since that happens rather slowly, they look for the best place to collect. In this way, particularly beautiful crystals will gradually develop — at least, if they have enough room and don't get in each other's way. This evaporation method is one of the best procedures for producing large, nicely shaped crystals.

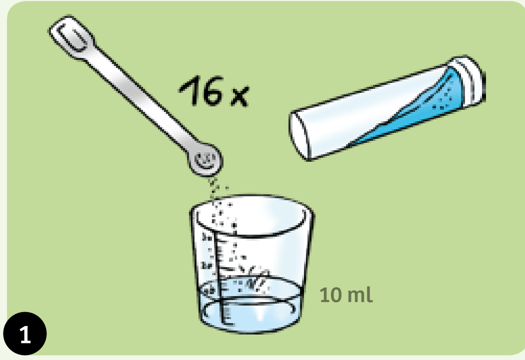
EXPERIMENT 3

Crystals of blue

YOU WILL NEED

› **Copper sulfate**
› **Small measuring cup**
› **Double-ended measuring spoon**
› **Wooden spatula**
› **Display box**
› *Old glass jelly jar*
› *Distilled water*
› *Sheet of paper*
› *Pencil*

For copper sulfate, note the information about hazardous substances on page 6.



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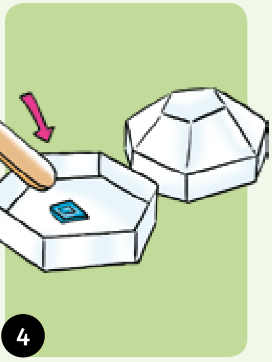
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5

HERE'S HOW

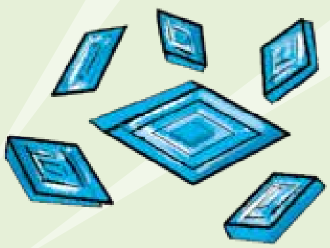
1. Dissolve 16 small spoonfuls of copper sulfate in 10 ml water.
2. Let the solution stand uncovered for a few days in a protected location. It will evaporate and form blue crystals with a characteristic shape. Use the paper and pen to make a label for the solution.
3. After the crystals have formed, pour the solution into a jelly jar and label it.
4. Take out the prettiest crystals with the help of the measuring spoon, and save them in your box.
5. The rest of the solution has to evaporate completely. Return the dry copper sulfate to the vial.

WHAT'S HAPPENING?

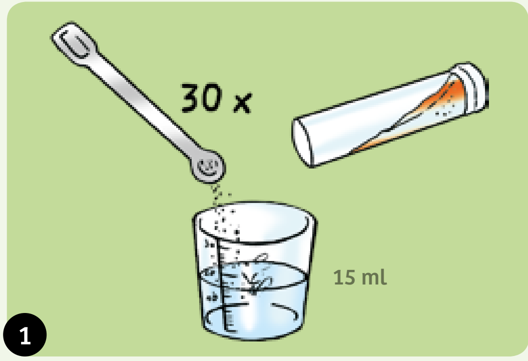
Copper sulfate forms clear blue crystals. They look like someone grabbed a brick by one corner and pulled it lengthwise.

ABOUT COPPER SULFATE

The blue substance is produced from copper sulfate in large quantities, and serves as a pesticide in wine production and to combat algae in swimming pools — it is a powerful poison to microorganisms. This copper salt is also used to copper coat objects and to clean copper metal.



Blood-red shapes



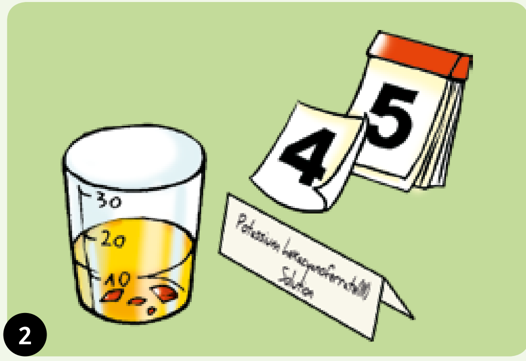
TIP!
Caution — this crystal solution causes stains.

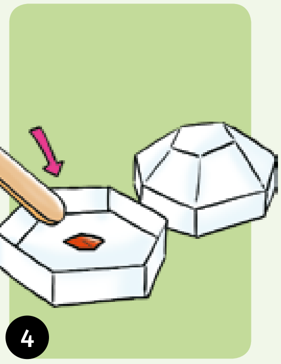
YOU WILL NEED

- **Potassium hexacyanoferrate (III)**
- **Small measuring cup**
- **Double-ended measuring spoon**
- **Wooden spatula**
- **Display box**
- *Old glass jelly jar*
- *Distilled water*
- *Sheet of paper*
- *Pencil*

ABOUT POTASSIUM HEXACYANO-FERRATE (III)

Prussian red has an iron atom in its molecule to thank for its color. It is used, for example, in photography, for the production of architecture blueprints, for wood stains, and as a hardening agent for steel. It is also a very sensitive indicator for iron compounds, a quality that will help you in the next experiment.





HERE'S HOW

1. Dissolve 30 small spoonfuls of potassium hexacyanoferrate (III) in a small measuring cup with 15 ml water.
2. Leave the yellow solution to stand uncovered for a few days in a protected place. It will form deep red crystals. Use the paper and pen to make a label for the solution.
3. After the crystals have formed, pour the solution into the jelly jar and label it.
4. Use the wooden spatula to pull out the prettiest crystal for your display box.
5. Let the remaining solution completely evaporate, and return the dry potassium hexacyanoferrate (III) to the vial.

WHAT'S HAPPENING?

In fact, potassium hexacyanoferrate (III) does form beautiful, deep-red crystals out of an intensely yellow solution.

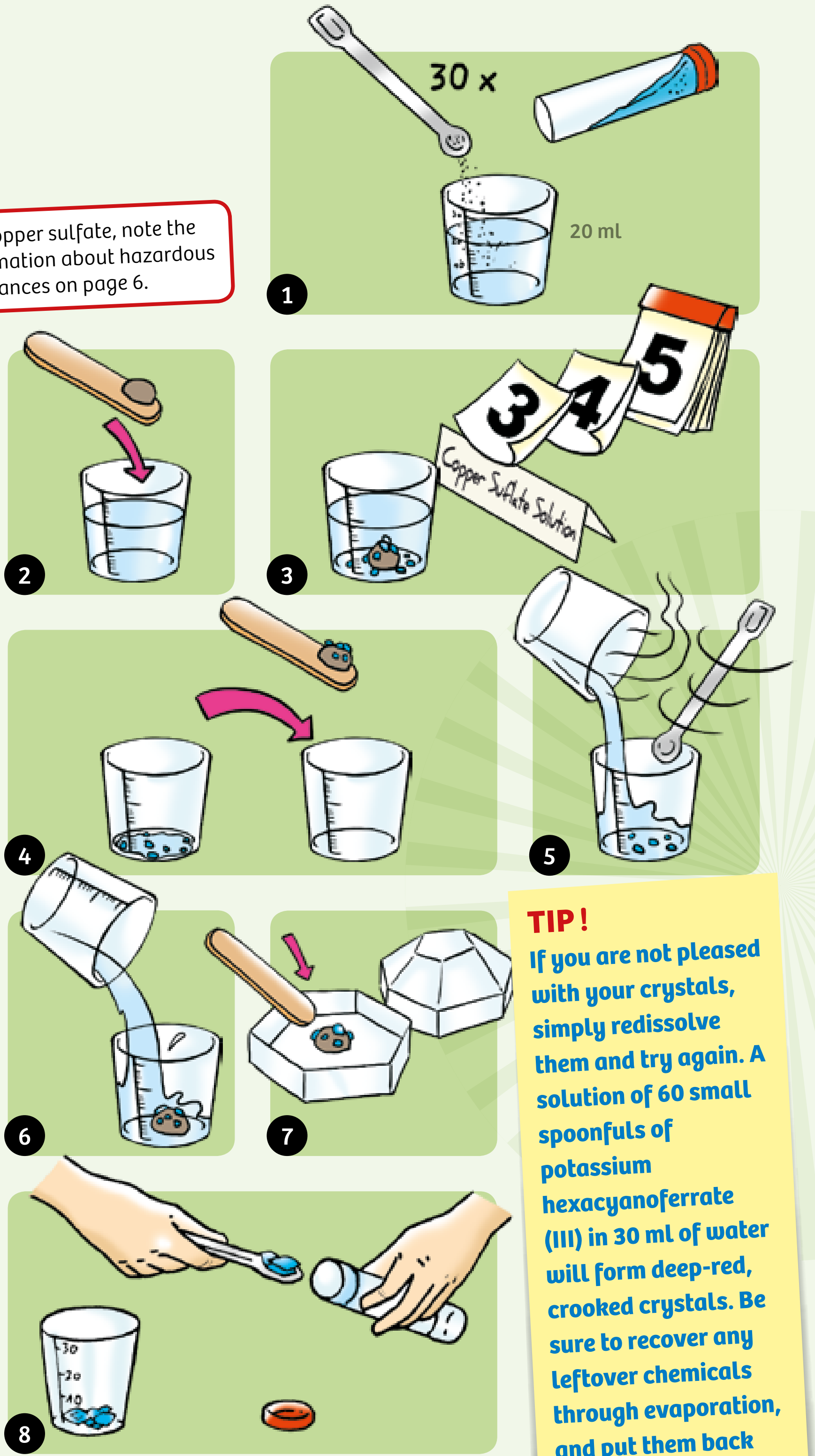
EXPERIMENT 5

Artificial mineral layer

YOU WILL NEED

- **2 Small measuring cups**
- **Copper sulfate**
- **Double-ended measuring spoon**
- **Wooden spatula**
- **Display box**
- *Small rock with a rough surface*
- *Distilled water*
- *Sheet of paper*
- *Pencil*

For copper sulfate, note the information about hazardous substances on page 6.



HERE'S HOW

1. Dissolve 30 small spoonfuls of copper sulfate in a small measuring cup with 20 ml water.
2. Place the granite rock in it. The rock should be completely submerged.
3. Let the container stand uncovered for a few days in a safe spot where younger children and pets cannot get to it. Use the paper and pen to make a label for the solution. Blue crystals will form. Most of them will be lying on the bottom, but if you're lucky there will be some on the rock.
4. If so, pull the rock out carefully with the help of the spatula, and put it in the second measuring cup.
5. Redissolve the crystals remaining in the first cup with a little warm distilled water. Be sparing with the water: The solution has to be absolutely saturated, or the crystals on the rock will dissolve again!
6. Pour the solution over the rock again so that it is completely covered. Let crystals form.
7. When you are done, remove your crystal specimen, let it dry, and place it in your display box.
8. Let the rest of the solution evaporate, and return the copper sulfate to the vial.

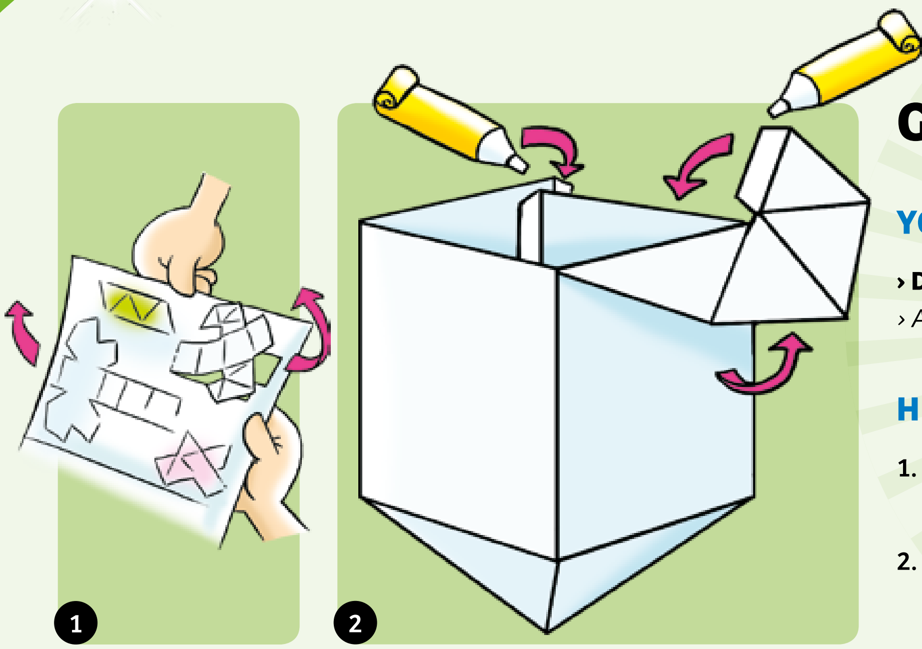
TIP!

If you are not pleased with your crystals, simply redissolve them and try again. A solution of 60 small spoonfuls of potassium hexacyanoferrate (III) in 30 ml of water will form deep-red, crooked crystals. Be sure to recover any leftover chemicals through evaporation, and put them back into their storage containers.

WHAT'S HAPPENING?

Crystals like to deposit themselves on the rough surface of a rock — as they do in nature — and form beautiful shapes there over the course of days or weeks. The copper sulfate crystals are particularly impressive in their color and form.

EXPERIMENT 6



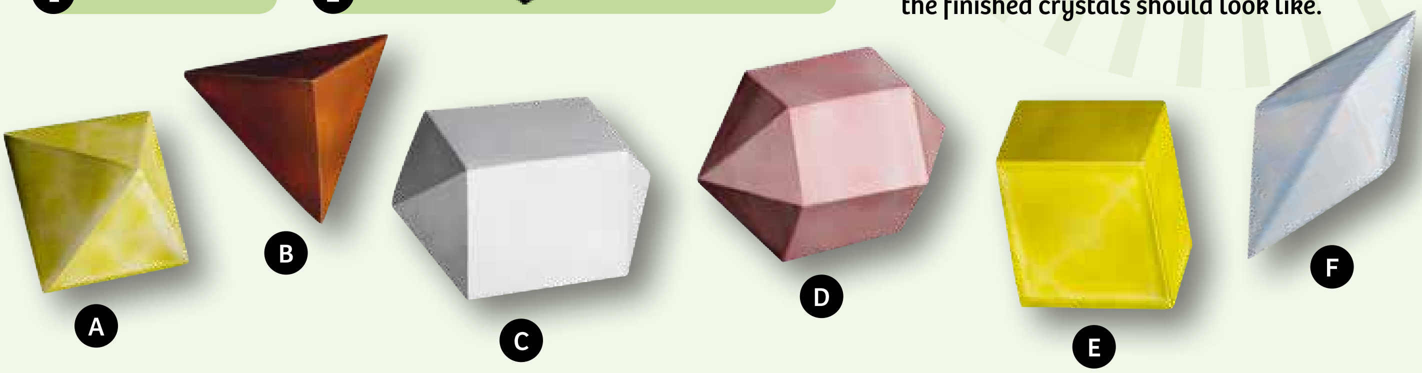
Giant crystal models

YOU WILL NEED

› **Die-cut sheet with crystal shapes**
› *All-purpose glue*

HERE'S HOW

1. Remove the crystal shapes from the die-cut sheet.
2. Fold the shapes and glue together the specified edges. The images show you what the finished crystals should look like.



WHAT'S HAPPENING?

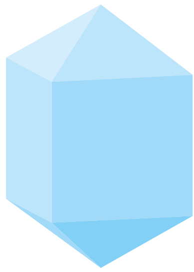
A Octahedron

Fluorite and pyrite crystallize in this form.

B Tetrahedron

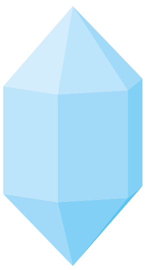
This form is found in zinc ore (sphalerite).

C Tetragonal prism with double pyramid



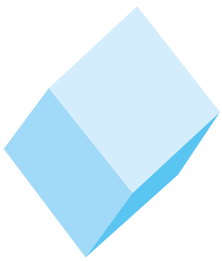
Minerals such as rutile, the precious stone zircon, and the tungsten scheelite have this form.

D Hexagonal prism with double pyramid



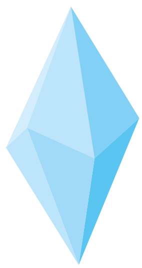
Quartz crystallizes in this form when it hardens at high temperatures.

E Rhomboid



This very common crystal form is found in calcite.

F Scalenohedron



Magnesite crystallizes in this form.

EXPERIMENT 7

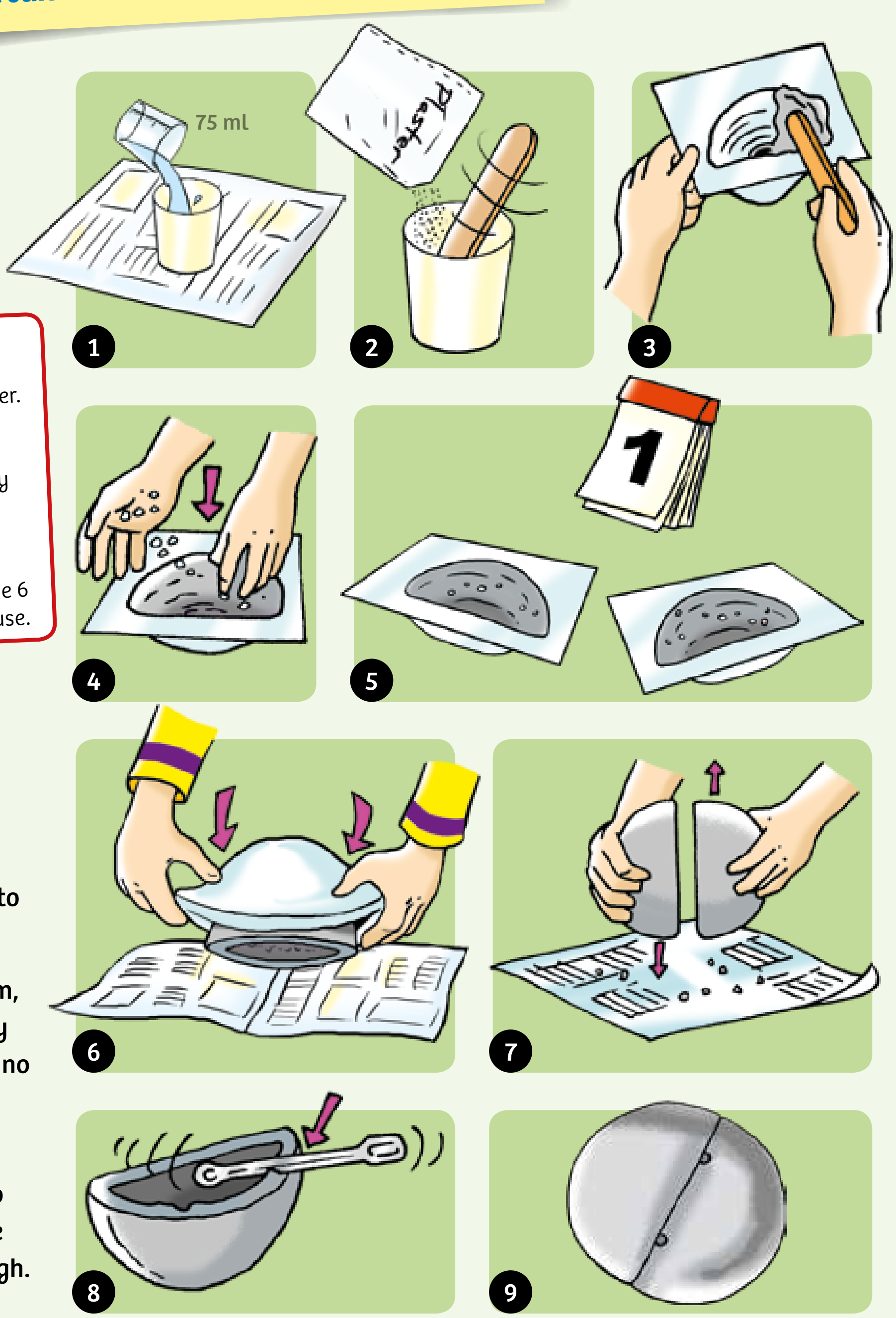
TIP !
Read the instructions through carefully first, get everything ready, and be speedy while you work, because otherwise the plaster will harden too quickly.

The geode takes shape

YOU WILL NEED

- **Plastic geode mold**
- **Plaster gypsum**
- **Wooden spatula**
- **Large measuring cup**
- **Measuring spoon**
- **Alum seed crystals from Experiments 1 and 2**
- **Sandpaper**
- *All-purpose glue*
- *Empty yogurt cup*
- *Black ink or watercolor paint*

Caution: Plaster can cause dust. Do not inhale dust or powder. Do not place the materials in the mouth. Do not apply to the body. Wash hands after use. Follow the safety information on page 6 before and during use.



HERE'S HOW

1. Cover your work surface with old newspapers. Pour 75 ml of cold water into the empty yogurt container.
2. Fill the large measuring cup with gypsum, and mix it with the water; stir thoroughly with the wooden spatula, until there are no more clumps of gypsum.
3. Pour the plaster mixture into the molds. Spread the mixture up along the walls to create a cavity in the middle. This will be easy as long as the mixture is thick enough. The walls of the geode shouldn't be too thin, or the geode will break after it hardens. The upper edge in particular has to be at least 5 mm (0.2 in) thick, because you will be setting the other half on it later on.
4. Before the plaster has hardened, sprinkle half of the seed crystals that you already grew into various locations in the hollow area of your geode half, and press them lightly into the plaster. Repeat steps 1 through 4 to make the second geode half.
5. Let the geode halves dry for a whole day.
6. Carefully remove the geodes halves from their molds.
7. Smooth the edges of the geode halves with the sandpaper, and check to see that their edges line up by setting them against each other.
8. Use the measuring spoon to scrape two small holes in one geode half, spaced about 2 cm (1 in) apart. The hole diameter should be just large enough for the thin pipette tube to fit into it. You will later add the crystal growing solution through these holes.
9. Glue together the two halves with the all-purpose glue, leaving the holes unobstructed. Let the geode dry well. To make the joint between the two halves as unnoticeable as possible, you can smooth it a little more with the sandpaper, or spread more plaster on it.

TIP !
If you want the geode to be dark gray on the outside, add a few drops of ink or black watercolor paint to the water.

EXPERIMENT 8

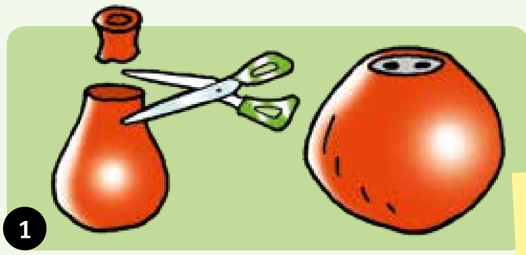
Filling the geode

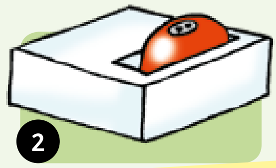
YOU WILL NEED

- **Cardboard kit tray**
- **Homemade plaster geode shell**
- **50 g Potassium aluminum sulfate (alum)**
- **Dye powder**
- **Double-ended measuring spoon**
- **Large measuring cup**
- **Small measuring cup**
- **Pipette**
- *Rubber balloon*
- *Old glass jelly jar*
- *Distilled water*
- *Scissors*
- *Pot of hot water*
- *Hammer*

HERE'S HOW

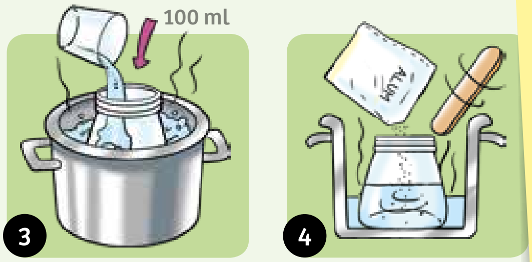
1. Cut the balloon near the opening. The hole has to be big enough so that you can pull the balloon over the geode, leaving the top few millimeters with the holes uncovered. The balloon should lie smooth against the sides of the geode.
2. Set the geode in the empty cardboard tray with the holes facing up.
3. Fill the jelly jar with 100 ml water and set it in the pot with hot water already in it.
4. Pour the entire contents of the alum packet into the jar. Stir until everything is dissolved. You may have to reheat the water if it cools during this process. When everything is dissolved, add a little more alum. It is important that a few undissolved crumbs of alum remain after you have stirred for a long time — that means that the solution is good and saturated.
5. Cut off the tip of the pipette.
6. Use the shortened pipette to inject the slightly cooled alum solution into the hollow center of the geode. Use just one of the two holes — the other lets air escape. Add enough of the solution to fill the geode.

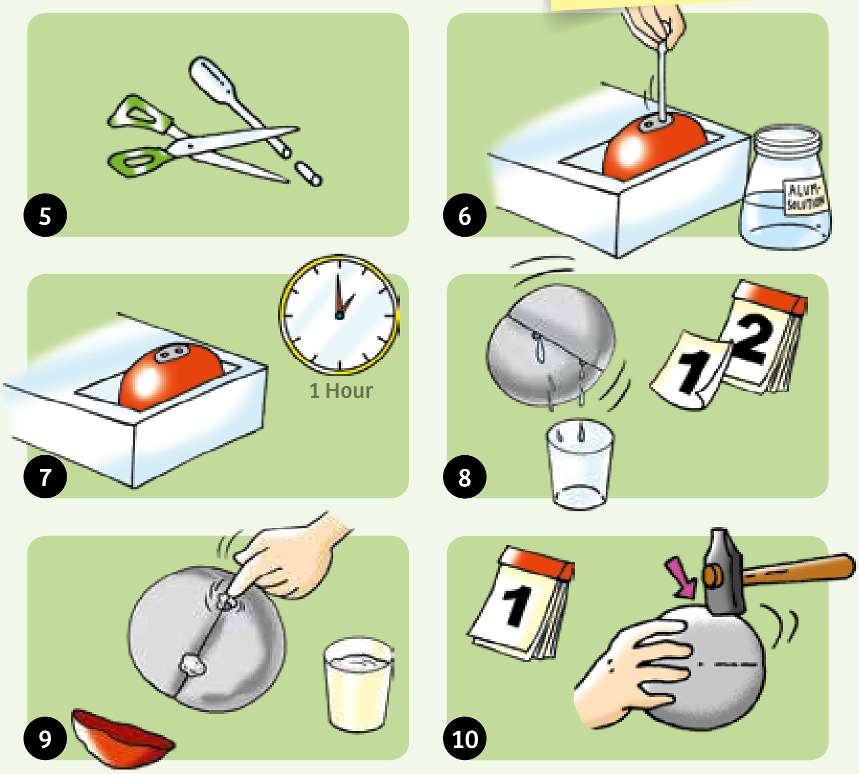




TIP!

If you want colored crystals instead of white ones, dissolve about five small spoonfuls of the blue dye in the hot alum solution. Caution: The dye can stain things!





7. The solution will cool off, and the plaster will soak some of it up, causing the level to drop. So after an hour, top off the geode with more of the saturated solution.
8. Now let the geode sit undisturbed for two days so it can form its crystals in peace. After two days, empty the excess solution from the geode into the measuring cup.
9. Carefully remove the balloon, and seal the holes with a little freshly prepared plaster. Be sure that it is thick and gooey enough, or it will drip into the hollow inside. Let the geode dry one more day on a paper towel.
10. Now it's time to open the geode with a careful blow of the hammer.

CHECK IT OUT

WHAT ARE GEODES?

Crystals can form in small or large spaces inside rocks. Crystal-filled rocks and hollow spaces of this type are called **geodes,** which is derived from a Greek word meaning "earthlike." Natural geodes form slowly over long periods of time, hidden inside rocks. In the previous experiment, you made a model of a geode that formed much faster!

MINERALS

Rocks that have a uniform chemical composition are called **minerals.** Almost all minerals have specific, identifiable crystal structures — regular shapes the repeat over and over.

TIP!

A whole, intact geode can make a nice gift. You can get extra gypsum (plaster or plaster of Paris mix) in a hobby store, and you can order more alum from online chemical suppliers.

EARTH PROVIDES US WITH A WEALTH OF VALUABLE AND USEFUL MATERIALS:

Building materials: rock, clay, and sand

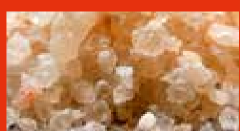
Energy sources: coal and oil

Ore for refining into metals

Precious gems: diamonds and rubies

Sulfur is a raw material for the chemical industry.

Lime for cement production



Rock salt for seasoning

ROCKS

While pure minerals are rather rare, there are huge quantities of rocks, such as granite and limestone, in Earth's crust — they actually make up the majority of it. **Rocks** are composed of a mixture of various minerals, and the type and quantity of these minerals determines the type of rock. You will find samples of a few important types of rocks in this kit.

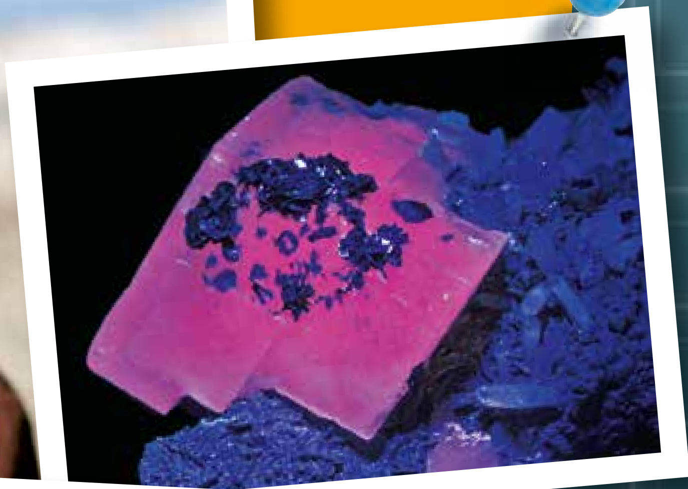
Did you know ...

... THAT THE WORD "CRYSTAL" COMES FROM THE GREEK LANGUAGE?

Over 2,000 years ago, the Greeks imagined certain colorless crystals that they found in the mountains to be a kind of permanent water ice — an ice that at one time had frozen so deeply that it would never melt again. The Greeks called this water ice *"krystallos,"* and they also gave the same name to these colorless objects. You will find a quartz crystal in this experiment kit.

Minerals in the Research Lab

There are at least 4,000 different types of minerals. It's the mineralogist's job to recognize them and tell them all apart. To do that, mineralogists use an array of methods, including investigating color, hardness, and chemical, magnetic, and electrical properties, as well as crystal shapes with the help of highly advanced analysis equipment. You can carry out a series of your own simple tests to identify minerals.



EXPERIMENT 9

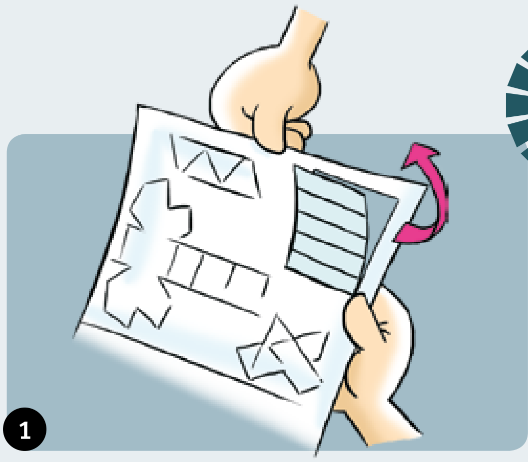
Organizing your collection!

YOU WILL NEED

› **Name cards from the die-cut sheet**
› **Rock and mineral specimens**
› *Box with small compartments or sheet of paper and marker*

HERE'S HOW

1. Remove the name cards from the die-cut sheet.
2. Find a box with at least 13 small compartments, like a jewelry storage box. Or you can simply use a sheet of paper with 13 squares drawn on it. Arrange your rock and mineral samples with their name cards in the small compartments or squares on the paper. The photos below will help you match the specimen with its name.



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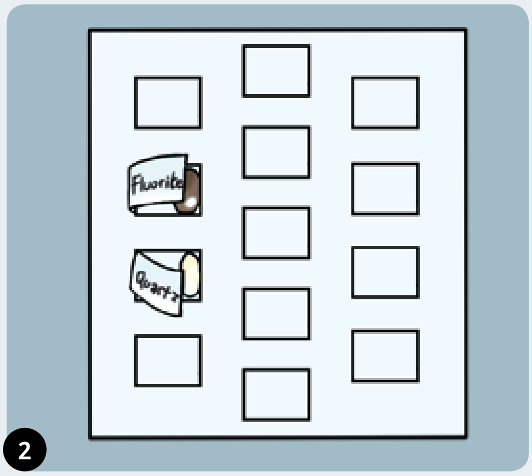


2

ABOUT PYRITE

Hardness	Density
6	5

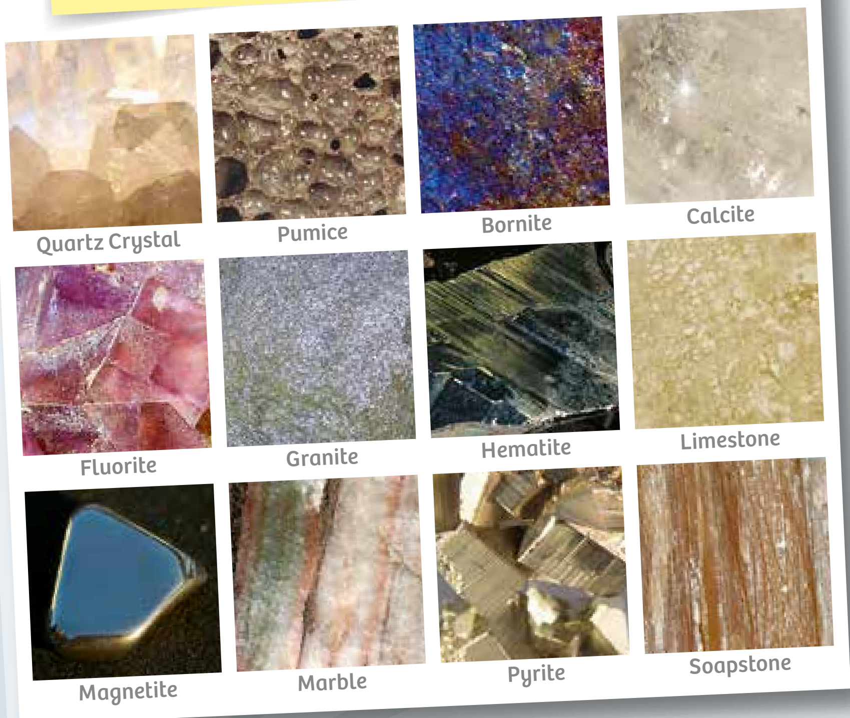
This yellow, shiny metallic mineral is a compound of iron and sulfur, and often appears in the form of pretty cubes. It has often been confused with gold, hence the common name "fool's gold." It is useful in small quantities in the chemical industry as a raw material in the production of sulfur.

WHAT'S HAPPENING?

The **color** of a mineral is the first valuable indication of its identity. One of the minerals contained in your kit is yellowish, another may have a dark-gray or a greenish blue sparkle. In reality, though, the color is only a poor indicator: many minerals get their colors from the presence of very small amounts of other materials, so the same mineral can actually show up in many different colors. A well-known example is the mineral quartz: a plain quartz crystal is colorless and rose quartz is pink. When it is light brown, it's called smoky quartz, and when it is purple, it's called amethyst. Your fluorite can be violet or light green. So, much more important than the color, which can be influenced by incidental impurities, is the streak color of a mineral.

TIP!
If you aren't sure which specimen is which, the tests on the following pages will help you find out.

Basalt



EXPERIMENT 10

Color and streak

YOU WILL NEED

› **Mineral specimens**
› **Magnifying lens**
› *Cup or plate made of light-colored ceramic or porcelain with an unglazed (rough) area.*

HERE'S HOW

1. Porcelain dishware is usually glazed and therefore smooth. But on the underside it has a rough, unfinished, unglazed area. You will use this area to determine the streak color. Vigorously rub each of the minerals across a fresh spot of unglazed porcelain. Use the magnifying lens to investigate the colors of the resulting streaks.

WHAT'S HAPPENING?

The **streak color** is the color of the fine powder residue of the mineral that rubs off on the porcelain.

- Colorless minerals → White (and thus barely visible) streak
- Yellow-shining pyrite → Greenish black streak
- Hematite → Reddish brown streak
- Bornite → Greenish black streak
- Magnetite → Black streak

The experiment clearly shows that the streak color isn't always the same as the color of the actual mineral.

ABOUT SOAPSTONE

Hardness	Density
1	2.7

This soft, greasy-feeling, water-repellent mineral contains the elements magnesium, silicon, and oxygen, and has been used for centuries in sculptures and carved works of art. Today it has many industrial uses including as a gentle water-repellent abrasive, with harder types used as a material in oven manufacturing because they hold heat well.

ABOUT HEMATITE

Hardness	Density
5-6	5

This black compound of iron and oxygen is one of the earliest iron ores to be used by humans. Even Stone Age people used reddish colored ground hematite powder in their cave paintings. This mineral is also the source of the red coloration of many rocks, such as red sandstone. Polished hematite is used as a gemstone.

ABOUT QUARTZ CRYSTAL

Hardness	Density
7	2.6

Quartz is one of the most common materials in Earth's crust, and it is a component of many rocks. Even sand is composed mostly of grains of quartz. Quartz has many uses — in manufacturing the computer chip material silicon, in glass and porcelain production — and its hardness makes it a useful abrasive. In addition, many gemstones consist of quartz of various colors, such as amethyst (purple), citrine (yellow), rose quartz (pink), agate (multiple stripes), and jasper (blood red).

EXPERIMENT 11

The hardest part

YOU WILL NEED

› **Minerals**
› *Iron nail, steel nail, or penknife*
› *Copper penny*

HERE'S HOW

1. Find the smoothest spot on each mineral sample, and try scratching it first with your fingernail, then with the edge of the coin, and finally with the iron and steel nails. This is how your test a mineral's **hardness.**

WHAT'S HAPPENING?

With the soapstone, even your fingernail will leave a faint mark, as will the copper coin with calcite. Fluorite and bornite can only be scratched with the iron nail or something harder. Hematite, magnetite, and pyrite can be scratched with the steel nail, but quartz will withstand even the penknife. Only an adult should use the knife.

ABOUT CALCITE

Hardness	Density
3	2.8

This is the name for a crystallized form of limestone. Limestone is actually formed of tiny calcite crystals, making it one of the most common minerals of all — entire mountain ranges are made of calcite. Many sea creatures build their shells out of calcite too. Due to its low hardness and sensitivity to acids, calcite is hardly ever used as a gemstone. It has a greasy sheen.

ABOUT FLUORITE

Hardness	Density
4	3

This mineral, which is a compound of the chemical elements calcium and fluorine, forms wonderful octahedrons. It comes in lots of different colors depending on the impurities in it. It is used in extractive metallurgy, as a chemical raw material, and — in the form of artificially grown crystals — in the production of high-grade optical lenses.

ABOUT BORNITE

Hardness	Density
4	4

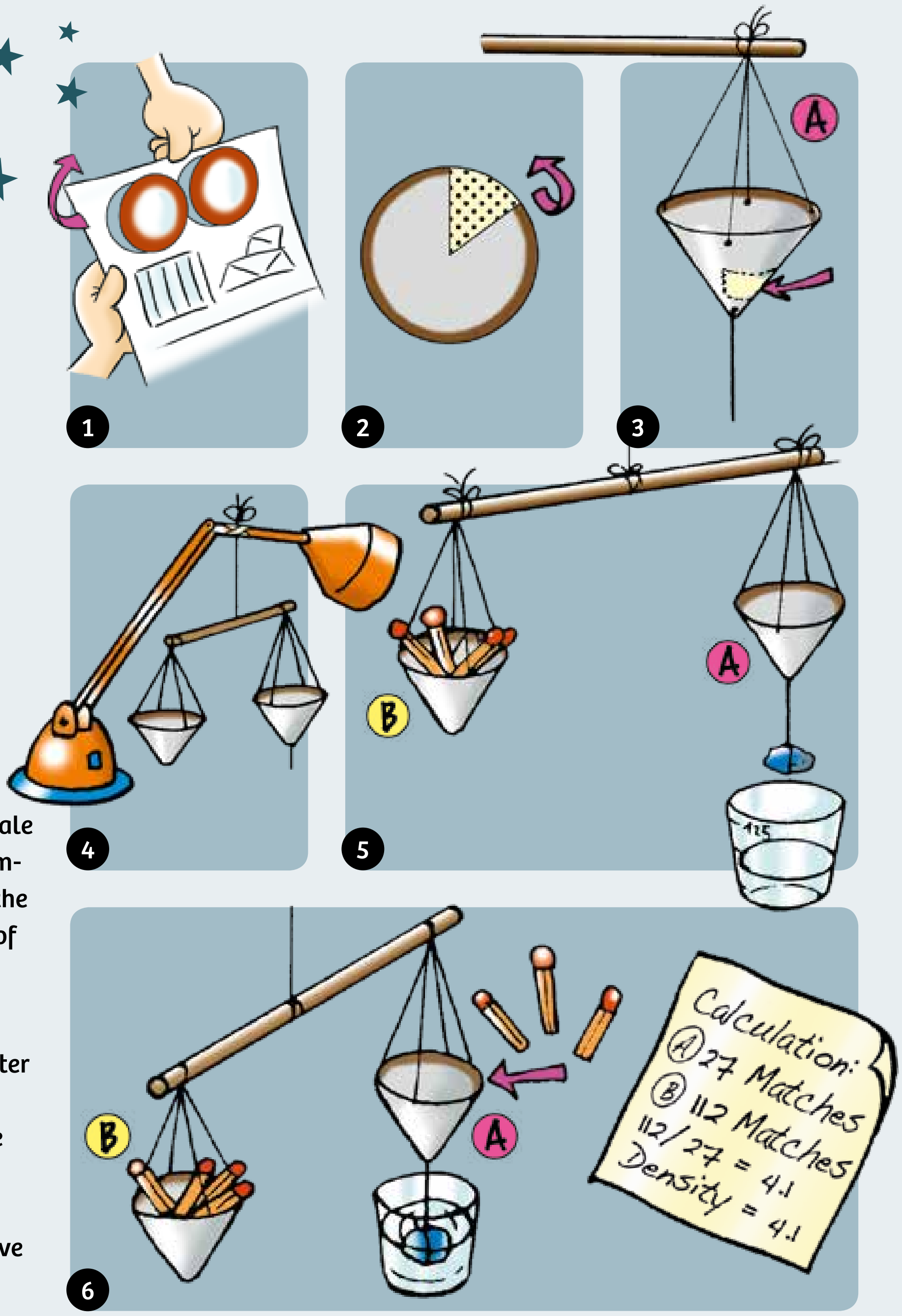
This ore, also known as chalcopyrite (the Greek word *chalkos* means "copper"), contains copper and iron bonded with sulfur. It is considered to be one of the most important copper ores because it occurs in large quantities in some places. When it is exposed to the elements, it can form bright colors that look like the colors of an oil spill on water.

EXPERIMENT 12

More or less dense

YOU WILL NEED

› **Large measuring cup**
› **Weighing scale from the die-cut sheet**
› **Wooden stick**
› **Minerals**
› *2 or 3 Boxes of matches*
› *Paper and pencil*
› *Adhesive tape, all-purpose adhesive*
› *Yarn or string, scissors*



HERE'S HOW

First, assemble the scale.

1. Remove the parts from the die-cut sheet.
2. Tape the scale pans together into cones.
3. Thread a 10-cm-long (4 in) piece of yarn through the prepunched center hole of scale A, and secure it with tape. Thread a 15-cm-long (6 in) piece of yarn through each of the scale pan holes. Secure the ends of each of the four sections of yarn to the end of the stick above it.
4. Tie another piece of yarn to the exact center of the stick, securing it with a drop of all-purpose glue, and use it to hang the scale from a desk lamp or another similar support. It should hang freely, with the scale pans about 15-20 cm (6 to 8 in) above the table surface. Adjust the scale pans until they are perfectly balanced, and then secure them with tape.

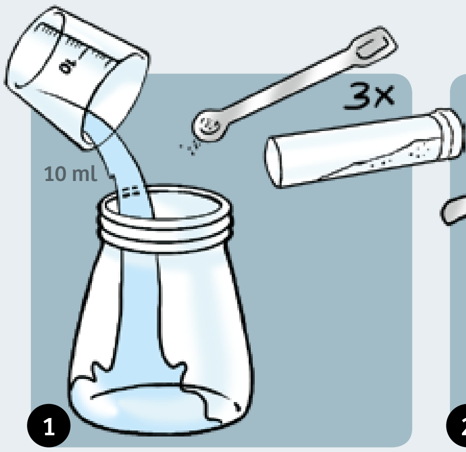
Now for the actual measurement:

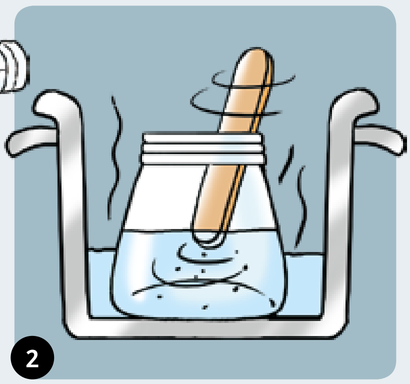
5. Secure one mineral sample to one of the scale pan's yarn (A) with some glue. In the other pan (B), place as many matchsticks as is necessary to balance the scale.
6. Fill half the measuring cup with water, and submerge the mineral sample in it. Be sure there are no air bubbles sticking to it! The scale is now unbalanced, so place as many matchsticks into scale pan (A) as is necessary to balance the scale when the mineral sample is fully submerged in water.
7. Count each of the groups of matchsticks, and divide the number from B by the number from A. The result is the density of the mineral sample. Example: 112 matchsticks on B, 27 matchsticks on A. 112 divided by 27 gives you 4.1 — so the density is 4.1.
8. Using this method, measure all the minerals contained in the kit.

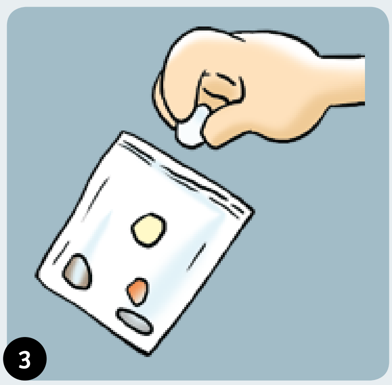
WHAT'S HAPPENING?

With this procedure for determining density, you don't even have to know the weight of the individual matchsticks — they all just have to weigh the same. It turns out that the density is around 3 for minerals such as calcite and fluorite, and the ores have much higher densities of around 5. But what is **density** in the first place? See page 27.

EXPERIMENT 13







Important:
For all of the experiments, wear your safety goggles!

Telltale gas production

YOU WILL NEED

- › **Small measuring cup**
- › **Double-ended measuring spoon**
- › **Pipette**
- › **Citric acid**
- › **Mineral calcite**
- › **Limestone**
- › **Magnifying lens**
- › **Wooden spatula**
- › *Water*
- › *Old glass jelly jar*
- › *Penknife*
- › *Hot water in a pot*

For citric acid, note the information about hazardous substances on page 6.

HERE'S HOW

1. Dissolve three small spoonfuls of citric acid in 10 ml of water in the jelly jar.
2. Place the jelly jar in the pot of hot water. Stir until everything is dissolved.
3. Find the calcite specimen in the bag of minerals. It is a milky, whitish mineral — not to be confused with the transparent quartz crystal.
4. Scrape a few small chunks off of the calcite and place them in the small measuring cup.
5. Drip the warm citric acid solution over the calcite pieces with the pipette. Observe with the magnifying lens how little gas bubbles are released from the calcite chunks.

TIP!
If no gas bubbles are released, then you might have the wrong mineral. Repeat steps 4 and 5 again with a different mineral from the bag. Or take the limestone from the second bag and try the experiment with that.

WHAT'S HAPPENING?

Calcite is a chemical compound of the element calcium with carbonic acid. Strong acids, such as the warm citric acid, release the carbonic acid in the form of carbon dioxide, hence the effervescence. This **chemical test** is used to identify minerals.

EXPERIMENT 14

Test for iron and sulfur

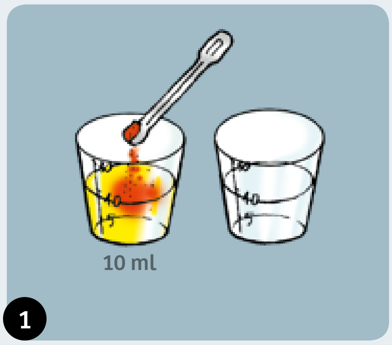
YOU WILL NEED

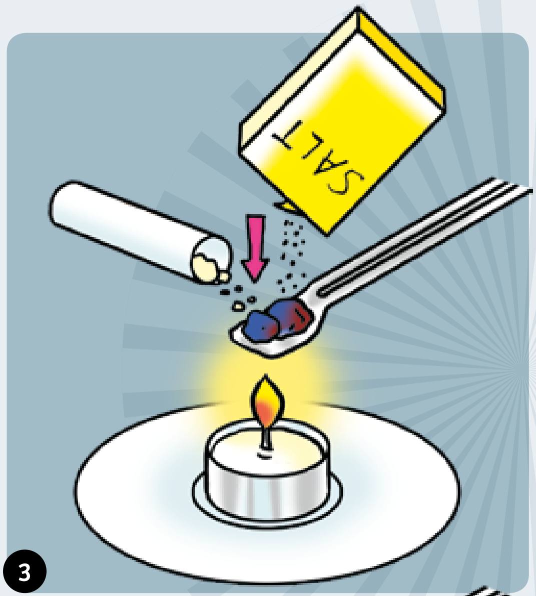
- **Measuring spoon**
- **Bornite**
- **Pyrite**
- **Citric acid**
- **Potassium hexacyanoferrate (III)**
- **2 Small measuring cups**
- *Table salt*
- *Tealight candle*
- *Distilled water*
- *Penknife*
- *Fireproof surface (e.g., an old saucer)*

For citric acid, note the information about hazardous substances on page 6.

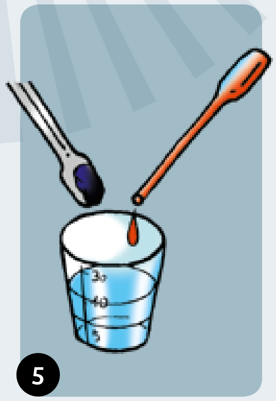
HERE'S HOW

1. In a small measuring cup, dissolve one spoonful of potassium hexacyanoferrate (III) in 10 ml of water. Fill half of the other measuring cup with water.
2. With an adult's help, use the knife to scratch off a few little chunks of bornite, and place them in the large scoop of the double measuring spoon.
3. Add a few grains of citric acid and table salt, and carefully heat this for a few seconds over a tealight candle flame. During the experiment, leave a window open to ventilate the room.
4. The citric acid will melt, and you will get a dark, bubbling mass with vapor bubbles escaping from it. Heat this melted mass another 15 seconds. The strange smell that you perceive comes from the sulfur gases released from the bornite.
5. After heating it for a few seconds, dunk the melted mass into the measuring cup with water, where it will dissolve. Use the pipette to drip a little potassium hexacyanoferrate (III) solution into it. The liquid will turn blue.
6. Repeat the experiment with small chunks of pyrite.





Leave a window open to ventilate the room! Do not inhale the gas!



WHAT'S HAPPENING?

The citric acid-table salt mixture dissolves both of the ores, which only strong acids are otherwise able to do, and releases pungent-smelling sulfur gas. In addition, water-soluble iron compounds are created, which form an intensely blue dye with the potassium hexacyanoferrate (III), as is characteristic of iron. Of course, magnetite also contains iron, but it is too hard to shave pieces off of.

CHECK IT OUT

Did you know ...

... THAT MINERALS DIFFER SIGNIFICANTLY IN HARDNESS?

Over 170 years ago, the mineralogist Friedrich Mohs developed a hardness scale using 10 minerals with different degrees of hardness, extending from soft talc to the super-hard diamond. Mineralogists use the Mohs scale to this day whenever they investigate the hardness of minerals with the scratch test. Still, the Mohs scale is not all that reliable: Hardness grades 3, 4, and 5 are hardly different from one another, and levels 5 and 6 show drastic jumps in hardness. With a hardness level of 10, a diamond is actually about 1,000 times harder than quartz.

Hardness	Mineral	Tool
1	Talc	Can be scraped with fingernail
2	Gypsum	Can be scratched with fingernail
3	Calcite	Can be scratched with a copper coin
4	Fluorite	Can be easily scratched with a knife
5	Apatite	Can be scratched with a knife
6	Feldspar	Can be scratched with a steel file
7	Quartz	Scratches window glass, creates sparks when struck with steel
8	Topaz	
9	Corundum	
10	Diamond	

The largest rough diamond ever found was from South Africa and weighed 621 kg.

WHAT IS DENSITY?

You must have noticed by now that even though the ore samples are about the same size as the other minerals, they are much heavier. Density, or the weight of a substance of a certain size, is an important distinguishing feature of minerals. Water has a density of one, as one cubic centimeter of water (corresponding to a cube 1 cm in length along each edge) weighs exactly one gram. Your minerals, on the other hand, have higher densities than that. Pure iron, has a density of 7.5. Lead is 11, and gold is 19.

Rocks: Building Blocks of Our Earth

Rocks consist of a mixture of various minerals. The type and amount of these minerals depends on the particular type of rock. Rocks are more common than minerals — the entire Earth is composed of them, after all. There are many kinds of rocks, but they can all be organized into three groups depending on how they are formed: Sedimentary, igneous, and metamorphic.

EXPERIMENT 15

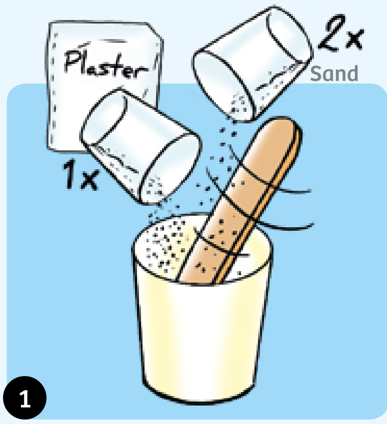
Plaster layers

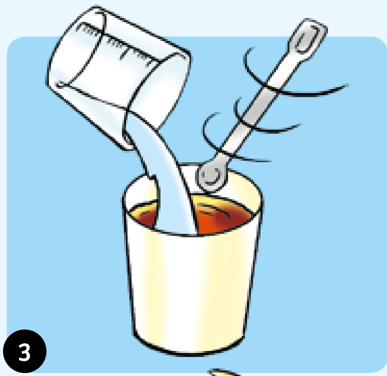
YOU WILL NEED

- **› Small measuring cup**
- **› Plaster gypsum**
- **› Food coloring, blue**
- **› Wooden spatula**
- **› Double-ended measuring spoon**
- *› Small cardboard box*
- *› Sand*
- *› Red, blue, and yellow food coloring or watercolor paints*
- *› Empty yogurt cups*

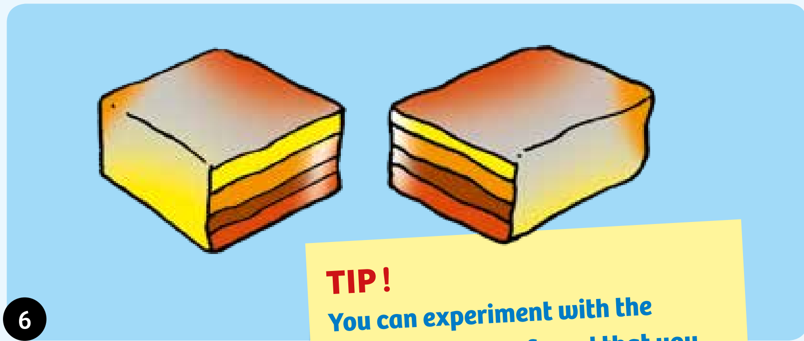
HERE'S HOW

1. In the yogurt container, stir together some sand with half the quantity of gypsum.
2. Add three to five spoonfuls of red coloring, two spoonfuls of blue coloring, and a little yellow coloring.
3. Mix everything together thoroughly and slowly add water until you get a reddish brown mush.
4. Pour this into the cardboard box and let it harden.
5. Repeat this mixing process with different color ingredients or without coloring, and gradually layer the sand and gypsum mixtures on top of one another. Let the plaster harden overnight in the box.
6. Break apart the rock tablets, and roughen the surface a little to make it look more realistic.





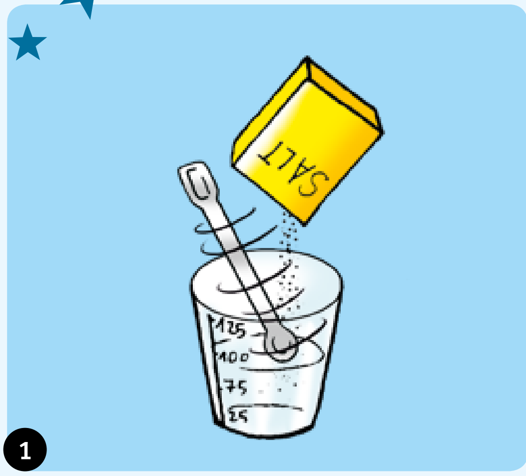
TIP!
Let each new layer of plaster harden well before adding the next layer on top of it.



TIP!
You can experiment with the different colors of sand that you might find near where you live.

WHAT'S HAPPENING?

Over time, sand that has been deposited by water can become compressed and solid. The cause is usually the mineral lime that has penetrated and cemented the grains of sand together. This type of rock is called **sedimentary rock.** With gypsum and some food coloring, you have replicated this process and created artificial sandstone similar to the naturally colored sandstone of the Arizona desert. The gypsum cements the grains of sand together, and the dyes imitate the reddish brown iron compounds found in actual red sandstone.



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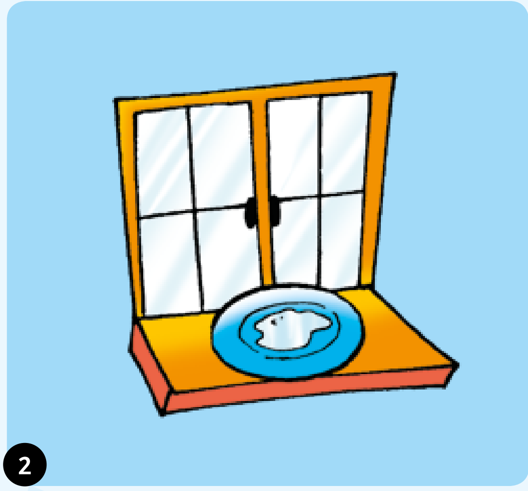


2

Rock salt deposits

YOU WILL NEED

› **Large measuring cup**
› **Double-ended measuring spoon**
› *Table salt*
› *Deep dish*

HERE'S HOW

1. Fill half of the measuring cup with water, and stir enough salt in it to make a saturated solution.
2. Pour this homemade "seawater" into the deep dish, and place the dish in a warm spot, such as on a radiator or heat vent. After a few days, the water will evaporate and leave behind a solid layer of white salt.

WHAT'S HAPPENING?

In many regions of Earth, vast stores of salt lie deep underground. The rock salt deposits come from sections of sea that were isolated from the oceans and evaporated under a hot sun. Storms washed dust over the salt deposits, and sometimes the sea would return and form new salt layers as it subsequently evaporated again, and ultimately other layers covered the salt as well. The experiment modeled this process. As the water evaporated, the salt that was dissolved in it was left behind.

CHECK IT OUT

METAMORPHIC ROCK: SOUVENIR FROM PRESSURE AND FIRE

Many parts of Earth's crust are in movement — usually so slowly that we don't even notice it. As they rise and fall, stones that were on the surface are thrust into the depths, where they are exposed to the heat and high pressure prevailing there. In the process, they undergo great changes and even turn into new kinds of rock, collectively known as **metamorphic**, which means "changing in form."

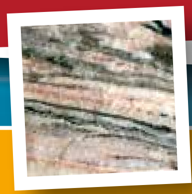
Igneous rock:

FORMED IN THE FIRES OF THE DEEP

We live on a ball of glowing-hot rock covered with a cool and solid crust that is only a few miles thick. It's no wonder, then, that most of Earth's crust is made of rocks that used to be liquid-hot at one time or other. This type of rock is called **igneous rock.**

Igneous rock is made when molten magma cools and solidifies inside Earth, or when molten lava cools and solidifies after it spews out of volcanoes onto Earth's surface. When formed inside Earth, it is called **intrusive** and when formed at the surface, it is called **extrusive.**

Together, igneous and metamorphic rocks make up about 90-95% of Earth's crust.



ABOUT SOAPSTONE AND MARBLE

In your rock collection, the soapstone belongs to the metamorphic category, as does the light gray dolomitic marble, which comes from a magnesium-rich calcium rock (dolomite).

ABOUT GRANITE

Hardness	Density
5-7	2.6-2.8

The granular rock chunk in your kit is granite. It is the granularity to which this rock owes its name, which comes from the Latin word *granum*, meaning grain. Granite was formed when liquid-hot rock (magma) cooled off and hardened far beneath Earth's surface. That happened very slowly, so the mineral components had time to organize themselves into fairly large crystals. Study your granite chunks with the magnifying lens: you can clearly see these crystals. They are made of the minerals feldspar, quartz, and mica.

ABOUT PUMICE

Hardness	Density
5	2.4

You could call pumice the Styrofoam® of the rock world. It is created when gas-rich lava is explosively expelled and cools so quickly as it flies through the air that the bubbles of gas cannot escape. The trapped gas bubbles make the pumice so light that it can even float on water — try it! Pumice is used in the production of heat-insulating lightweight concrete blocks.

ABOUT BASALT

Hardness	Density
6-7	3

Sometimes, liquid-hot rock reaches Earth's surface. It gushes out of the crater of a volcano, flows for a distance, and cools off and hardens into solid rock. This is how the dark gray chunks of basalt were formed. Since it hardened quickly, its components didn't have time to form large crystals. So if you look with the magnifying glass, all you can see is a fairly uniform gray mass. Basalt is very hard, and serves as a building material for paving stones and houses. Sometimes it can form six-sided columns as it hardens.

CHECK IT OUT

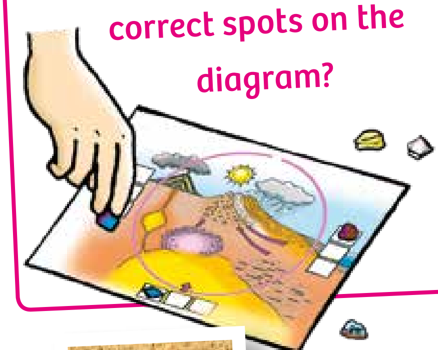
The rock cycle

The various rock categories are transformed over the course of cycles lasting millions of years. Igneous rocks such as basalt, granite, and pumice are exposed to the elements and turn to sedimentary rocks. Others change into metamorphic rocks.

When continents start to drift toward each other, they often compress the ocean deposits lying between them and push them upward into folded mountain ranges — which is how the Alps, the Himalaya, and many other well-known mountain ranges formed. Of course, in time they will wear down and form new sedimentary rocks.

Then, some deposits get back into Earth's depths again, are melted, and form new igneous rocks. This completes the cycle.

Test yourself! Can you put your rock samples in the correct spots on the diagram?



ABOUT LIMESTONE

Hardness	Density
2-4	2.8

The dark brown limestone in your kit formed millions of years ago from seawater. The lime in it, which is actually white, was colored dark by clay impurities. Its basic component, though, is tiny crystals of calcite. Try testing whether the limestone dissolves in acid.

SEDIMENTARY ROCK: WEATHERED AND DEPOSITED

Not even mountains last forever. Rain, frost, and wind attack the rock and carry it off piece by piece. Rivers and streams wash chunks away and wear them down to gravel, sand, and mud. In places where the water flows more slowly, these materials settle as deposits, or sediment — particularly at the mouths of rivers and in the ocean.

In time, many different layers will accumulate, and the pressure and heat will press them together into solid rock called sedimentary rock. These can also be materials that have formed out of and been deposited by ocean water, such as limestone and salt — and the limestone and diatomaceous shells of billions of tiny sea animals.

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