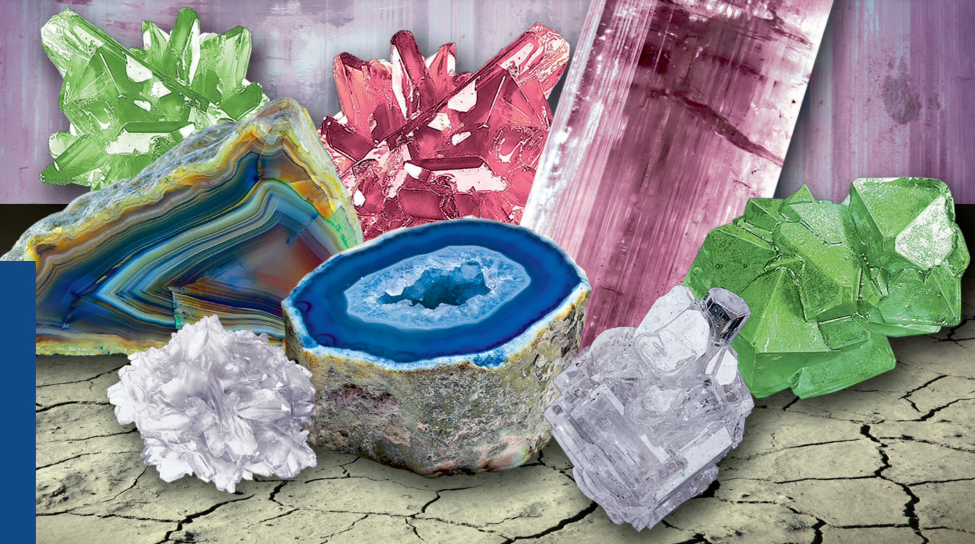
EXPERIMENT MANUAL

CRYSTALS
ROCKS & MINERALS



THAMES & KOSMOS

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

First Aid Information

In case of injury, seek immediate medical help.

1. **In case of contact with the eyes:** Rinse with plenty of water, holding the eye open if necessary. Rinse from the inside (near the nose) outward. Seek immediate medical help.

2. **In case of swallowing:** Rinse out the mouth with water, and then drink fresh water. Do not induce vomiting. Seek immediate medical help.

3. **In case of inhalation:** Get the person to a location with fresh air (e.g., into another room with open windows).

4. **In case of contact with the skin or in case of burns:** Rinse off the affected area of skin for 5 minutes with lots of water. Then cover burns with a bandage. Never apply oil, powder, or flour to the wound. Do not lance burn blisters. For more serious burns, seek immediate medical help.

5. **In case of cuts:** Do not touch or rinse with water. Do not apply any ointments, powders, or the like. Dress the wound with a clean, dry first-aid bandage. Foreign objects (e.g. glass splinters) should only be removed by a doctor. Seek the advice of a doctor if you feel a sharp or throbbing pain.

Should the symptoms persist, seek medical help without delay. With accidents involving chemicals, always take the chemical with its container to the doctor or tell the doctor the name of the chemical.

In case of emergency, contact the National Poison Control Center at:

1-800-222-1222

General Notes and Instructions for Users

Caution! Individual parts of this kit may have sharp points, corners, or edges. Do not injure yourself! Not intended for children under 3 years of age due to risk of swallowing small parts. Keep the experiment kit out of reach of young children. We reserve the right to make technical changes.

Warning!

Only for use by children 10 years of age or older. Use only under the strict supervision of adults who have familiarized themselves with the safety precautions described in the experiment kit.

Caution!

Contains some chemicals that have been categorized as hazardous to health.

Read the experiment manual before starting the experiments, follow its instructions, and keep it on hand for reference.

Do not bring the chemicals into contact with any part of your body, especially your eyes or mouth.

Keep young children and pets away from the experiments.

Store the chemicals out of the reach of young children.

Eye protection for adults is not included.

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Safety Goggle Instructions

(Item no. 052297)

Proper Usage
The safety goggles are to be used only with this experiment kit. Any other type of application is not permitted. Wear the goggles in such a way that the eye area is protected. If necessary, adjust the elastic band to the child's head circumference. The safety goggles can be used with contact lenses. Eyeglass wearers will need special safety goggles for people who wear eyeglasses.

Duration of Use
Always wear the safety goggles when performing your experiments. Not intended for long-term use. The duration of wear should not exceed the time of the experiment.

Storage
Store safety goggles at room temperature in a dry room. After the experiment, return them to their place in the kit box, to keep them from being scratched.

Cleaning
Do not clean the safety goggles when they are dry. Clean them with water and, if necessary, with a mild household liquid detergent, and dry them off with a soft towel.

Maintenance
In case of defective safety goggles or scratched lenses, exchange them for an equivalently constructed pair. Do not use damaged or defective goggles.

Inspection
Check the safety goggles to make sure they are in good condition, and replace them if they are damaged.

Warning
Some extremely sensitive individuals may under some circumstances experience an allergic reaction to skin contact with some materials, such as plastic. If this happens with the safety goggles, discontinue use immediately.

Replacement
These safety goggles are available as a replacement part.

Testing
The safety goggles are tested per EC guideline 89/686/EWG (personal protective equipment), EC guideline 88/378/EWG, and EN 71-4.

Test Lab
Certification Center 0197, TÜV Rheinland Product Safety GmbH, Am Grauen Stein, D-51105 Köln, Germany

Franckh-Kosmos Verlags-GmbH & Co. KG, Pfizerstraße 5-7, Stuttgart, Germany

Kit Contents

No.	Name	Qty.	Item No.
1.	Potassium hexacyanoferrate (III)	1	770 695
2.	Citric acid, 10g	1	032 132
3.	Copper sulfate, 8g	1	033 242
4.	Potassium aluminum sulfate, 50g	2	771 061
5.	Gypsum (calcium sulfate), 500g	1	770 800
6.	Food coloring, blue	1	705 725
7.	Double-ended measuring spoon	1	035 017
8.	Lid opener	1	070 177
9.	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	052 297
16.	Bag of rocks: granite, limestone, basalt, marble, pumice	1	772 781
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.	Balloon	2	708 265
24.	Sandpaper	1	700 881
25.	Die-cut sheet	1	708 120
26.	Paper sheet/rock cycle	1	708 200
27.	Wooden stick	1	020 042

Additional Items Needed: two empty glass jelly jars with lids, distilled water, pot of hot water (40-50 °C, 100-120 °F), paper towels, small rock with rough surface, all-purpose glue, clean empty yogurt container, black ink or watercolor paint, scissors, hammer, cup or plate made of light-colored ceramic or porcelain with an unglazed (rough) area, iron nail, steel nail, penknife, copper penny, matches, paper, pencil, tape, yarn, table salt, tea light candle, small cardboard box, sand, food coloring or watercolor paints (red, blue, and yellow), deep dish.

Table of Contents

A Word to Parents and Supervising Adults

Things you should know about this experiment kit and its use:

The Thames & Kosmos Crystals, Rocks & Minerals 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.

Of course, it is natural to have questions about the safety of a kit that contains chemicals. Improper use of chemicals can lead to injuries and other risks to health. This experiment kit is intended for the exclusive use of children over eight years of age.

The experimental equipment in this kit complies with United States and Europe safety standards for science education sets. These standards impose obligations on the manufacturer — for example, forbidding the use of any particularly dangerous materials — while also specifying that adults should assist children with advice and support in their new hobby. We are addressing this information to you so that you can understand what this involves.

- Please read through these instructions and pay particular attention to the **basic rules for safe experimentation** (page 4) as well as **first aid in case of accidents** (back page of the manual). Since children's abilities will vary within any age group, supervising adults should carefully select those experiments that are appropriate for their child.

- Before beginning the experiments, discuss the above-mentioned **safety advice**, as well as suggestions for **setting up the work place** and for **using the equipment** (see pages 6-9). You will find information about proper **disposal of waste** on page 9.

- It is important that you take appropriate safety precautions to protect against burns when heating the water on the stove.

- Emphasize to your child that he or she must read all the safety warnings and keep them on hand for reference. Perform only the experiments described in this manual.

- Share this important information with your child, but do not frighten him or her. If the instructions and safety warnings in the instruction manual are followed, it is not dangerous to make crystals. **The most important thing is do not swallow any of the chemicals in this kit.** Try not to allow them to come into contact with the body at all.

- Be absolutely sure not to let the chemical ingredients or the finished crystals get into the hands of young children (safety measure 1/2): The crystals can look like candy to a young child, and there is a risk that a child could put them in his or her mouth.

- Additionally required household materials or materials to buy at the supermarket or drug store are listed in italic script in the individual experiments. Before beginning an experiment, you and the child should read through the instructions to see what will be required, and make sure all the necessary materials are ready.

- A special "laboratory" will not be necessary to carry out these experiments. The area around the experiments should be free of obstructions and well away from food storage. It should be well lit and well ventilated, and equipped with a working sink. You should have a sturdy table or countertop with a heat-resistant surface. A cool basement room with a constant temperature is most suitable for the growing of crystals.

We wish you and your young chemists a lot of fun, and we hope you grow some really perfect crystals!

Read this before you start!

Basic Rules for Safe Experimentation

1. Read this instruction manual before starting the experiments, follow the instructions, and keep it on hand for reference. Pay special attention to the specified quantities and the sequence of individual steps. Only perform the experiments specified or suggested in this manual.

2. Keep young children and pets away from the workplace, as well as anyone who is not wearing eye protection.

3. Always wear eye protection. If you wear glasses, you will need protective goggles for eyeglass wearers.

4. Hold containers with hot contents so that their openings are not pointed toward you or other people. Do not inhale vapors that are released while heating.

5. Store the experiment kit, jars holding the solutions, and the completed crystals out of the reach of young children.

6. Clean all containers after use. Carefully close the chemical containers after use, and return them to their place in the experiment kit.

7. Only use equipment included with the kit or equipment that you are specifically asked to obtain for individual experiments.

8. Do not eat or drink while conducting experiments. Be sure that nobody else eats, drinks, or smokes in the same room. Do not use any eating, drinking, or other kitchen utensils for your experiments, unless they are specifically recommended. Always keep the experiment equipment separate from kitchen utensils, in order to avoid confusing them.

9. Do not bring any chemicals into contact with your eyes or mouth. If this should nevertheless occur, observe the first aid advice (back page of the manual), and if necessary, consult a doctor.

10. Wear appropriate work clothing. Wash your hands thoroughly after completing the experiments, and clean your work area.

11. Never work alone. An adult should always be present to supervise.

12. With experiments using open flame, be sure that there are no flammable objects or liquids nearby. Extinguish all flames after each experiment or if you are leaving the experiment area even for a short time.

13. ADULTS: Keep a bucket or box of sand ready in case you have to extinguish a fire. If the fire cannot be immediately extinguished, call 911 and contact the fire department without delay.

14. Immediately wipe up any spills, and thoroughly rinse out the cloth.

15. Label any filled containers that have to stand for a while (e.g., for materials to crystallize), and keep them inaccessible to children and animals.

16. Obtain and organize all additionally required materials before beginning an experiment.

Finally, observe the notes framed in red boxes next to experiment instructions. They point out specific risks and tell you how you can avoid them. If they refer to materials considered hazardous, an orange-colored hazard symbol is used, and you will be referred to information about hazardous materials (see page 6).

Practical Tips for Growing Crystals

Safety...

... is the first priority. So before every experiment, always read through all of the instructions. Only use materials indicated in the manual. It makes no sense, and it may be dangerous to experiment with unknown substances. Do not bring the substances you're handling into contact with your body, particularly your eyes or mouth.

When handling chemicals, always wear the safety goggles! Be especially careful with hot burners, and do not forget to turn them off after using them.

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

Information about hazardous materials

When performing chemical experiments, it is impossible to avoid substances that carry certain risks when handled improperly. In the following list, which you will also find on the labels and the packaging, we provide information about hazard warnings and safety data.

! *Caution:*

The following applies to all chemicals: Keep them locked up. They must not get into the hands of children.

This applies to young children above all but also to older children who — unlike the experimenter — have not been appropriately instructed by adults. Also follow this safety guideline: IF A CHEMICAL IS SWALLOWED: Immediately seek medical advice and/or attention and have the packaging or label available.

Calcium sulfate (gypsum)
Do not inhale dust. Avoid contact with eyes and skin.

Potassium aluminum sulfate
Do not inhale dust. Avoid contact with eyes and skin.

Copper sulfate

WARNING

Harmful if swallowed. – Causes severe eye irritation. – Causes skin irritation. – Highly toxic to aquatic organisms with long-term effect.
IN CASE OF CONTACT WITH SKIN: Wash with plenty of water and soap. – IN CASE OF CONTACT WITH EYES: Carefully rinse out for several minutes with water. If possible, remove contact lenses if present. Continue rinsing. If eye irritation persists, see medical attention. Avoid release into the environment.

Citric acid

DANGER

Causes severe eye damage. – Causes skin irritation. Do not allow to get in the eyes, on the skin or on clothing.
IN CASE OF CONTACT WITH EYES: Carefully rinse out for several minutes with water. If possible, remove contact lenses if present. Continue rinsing. Immediately call POISON CONTROL CENTER or doctor. – IN CASE OF CONTACT WITH SKIN: Wash with plenty of water and soap.

Potassium hexacyanoferrate(III)
No specific risk or safety statements apply.

Your experiment area...

... should be set up in a quiet room. If there are young children or pets in the house, the room should have a door that locks. Otherwise, you should lock away the equipment securely, for example, in a closet.

The kitchen is not suitable for your experiments, because there is too great a danger of chemicals getting into foods or of someone swallowing them by mistake. A quiet, cool, and preferably lockable basement room is more appropriate. And don't forget to clean up and wipe off your work surface when the experiments are finished.

The chemical vials have two chambers, a large one for large quantities and a small one for chemicals that are only needed in small amounts. Fill quantities are determined according to need, as well as in view of the safety standards that apply to chemistry experiment kits and chemicals.

The illustration shows how to open the safety closures using the enclosed lid opener. Sometimes when you open a vial, there will be material clinging to the lid that falls onto your hand or the work surface. You can prevent that by tapping the vial several times against the work surface before opening it. After removal of the chemical, you must close the vial again immediately. Sometimes it will require some effort to open or close the safety closure. Make sure an adult helps you.

Cut open the bags containing chemicals at one corner with a pair of scissors — never open them with your teeth. After use, reseal the bag with a paper clip or a piece of tape, and store it in a secure place.

Organize all the things on your work surface that you will need for the experiments you are going to perform. 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 ready for extinguishing fire.

Tap water…

… can be used to prepare your crystal solutions. However, distilled water from the supermarket or drug store is best for crystal growing. One liter is enough. Tap water contains impurities such as calcium, which could cloud the crystal solutions and hinder crystal growth.

To heat the solutions…

… you should never under any circumstances place your crystal growing jars directly on the burner or flame. Get an old cooking pot with a diameter of around 20 cm (8 in), and fill it a few centimeters deep with tap water. The level of water should always be slightly lower than the level of liquid in the growing vessel. Now heat the water without the growing vessel; a temperature a little hotter than a usual bath water temperature will do.

Carefully carry the pot to your work place (it's best to let an adult help you) and set it on a trivet. Now set the crystal growing jar in the pot and stir the contents with the double measuring spoon. The water will warm the contents of the jar and the crystal salt will dissolve.

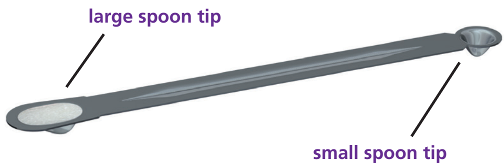
If it doesn't dissolve well, take the growing vessel out of the pot with a pot holder, heat the water over the burner a second time, and try again.

Caution! Do not burn yourself with the hot water or the pot, and do not forget to turn off the stove. Wear safety goggles! When heating water or solutions, always have an adult help you! Do not work alone! Also, be particularly careful not to burn yourself or scald yourself with hot water, and do not spill any crystal salt solutions! Do not inhale any of the vapors created when you heat the crystal salt solutions!

The quantities of water and chemicals…

… that you will need for the experiments are indicated here in milliliters, abbreviated "ml." The little double-headed measuring spoon is suitable for measuring the quantity of chemicals needed. The quantities are indicated in "spoons" or "spoonfuls."

The double measuring spoon



During crystallization…

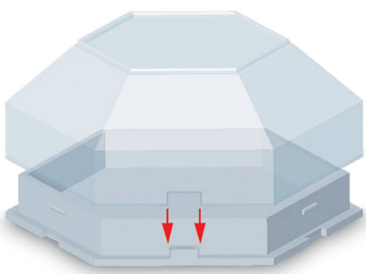
… your experimental apparatus should be left to stand in a protected place.

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.

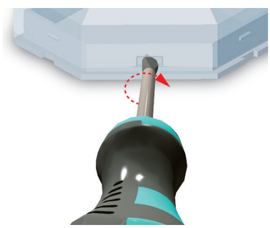
Make absolutely sure that young children and pets have no access to the chemicals! Check every couple of days and push upward-growing crystals back into the jar. Once the contents have become dry, you can put them into the storage container from the experiment kit. You can save your cultivated crystals in the box provided for them.

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.



Cleaning the containers

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.

Leftover chemicals…

… should under no circumstances be thrown away, since you can reuse them. For each crystal-growing experiment, you can simply pour the leftover solution into a clean, empty yogurt container, tape a label to it with the name of the substance, and let it sit in a warm spot for a few days. After it has dried, you can return the chemical to its corresponding vial.

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.

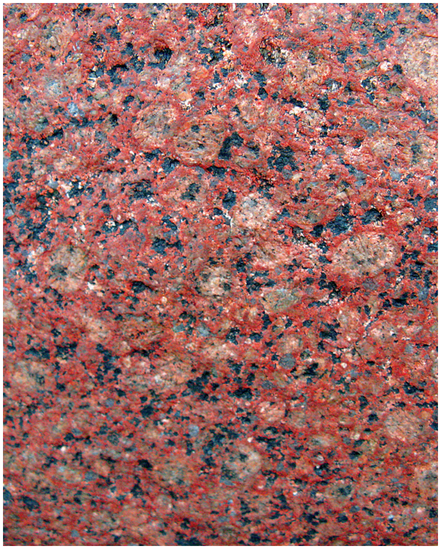
The Colorful World of Minerals and Crystals

Earth supplies us with an abundance of valuable and useful materials. Among them are energy sources such as coal and petroleum, rocks and sand for use as building materials, salt for seasoning, lime for making cement, ores for producing metals, sulfur, and other substances for raw materials in the chemical industry. And then there are the extremely beautiful materials from Earth: precious gemstones such as diamonds and rubies.

Minerals...

To the extent that these treasures from Earth possess a uniform chemical composition, they are known as **minerals**. There are around 4,000 known minerals. Most are found in the ground in only very small quantities, sometimes embedded in rocks. This kit contains some pretty minerals for you to investigate. Some of them are ores — the name for substances containing valuable metals such as iron and copper, which are obtained by mining.

Amethyst — a violet-colored version of the quartz mineral



Granite with a relatively fine grain

... and 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.

So, minerals are solids that have a uniform chemical composition.

And rocks are solids made up of combinations of minerals.

Pretty Shapes: Crystals

Some minerals display a very special quality: 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. They bear melodic names like diamond, sapphire, ruby, and amethyst. They filled the treasure chests of conquerors and decorated the crowns of emperors and kings.

A colorful collection of polished rocks and minerals

DID YOU KNOW?

The Word "Crystal" Comes from Greek

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.

Large quartz crystal

01 *Experiment*

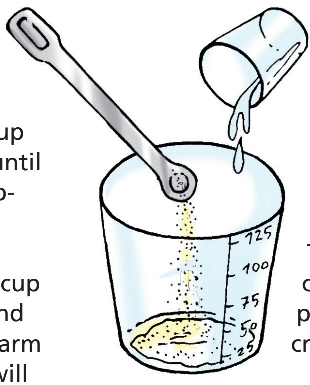
Evaporation method

A teaspoon of sugar will disappear within seconds in a cup of hot tea. The material known as potassium aluminum sulfate, referred to as alum below, will also seem to disappear in water. Ideally, the next two experiments should be performed together, so you can get to know different methods of crystallization.

You will need: large and small measuring cups, double measuring spoon, alum, safety goggles, *old glass jelly jar with lid, distilled water.*

Procedure:

1. Add 15 ml of distilled water and 10 small spoonfuls of alum into the measuring cup and stir for a while, until all the alum has disappeared.



2. Let the measuring cup with the solution stand for a few days in a warm location. The water will evaporate and the alum will become deposited on the bottom in the form of pretty, clear crystals.

When the water has evaporated, pour the alum in a labeled glass jelly jar and save it for a later experiment.

Explanation:

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. 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.

02 *Experiment*

Cooling method

Can a certain quantity of water dissolve as much alum as you want, or is there a limit? This experiment will help you find out, and in the process you will learn a faster method for growing crystals.

You will need: large and small measuring cups, double measuring spoon, remaining alum, safety goggles, *distilled water, pot of hot water (40-50 °C, 100-120 °F), paper towels, 2 empty glass jelly jars with lids.*

Procedure:

1. Use the measuring cup to measure 200 ml of distilled water and pour it into the empty jelly jar. Add the rest of the powder and stir. Even after you have stirred for a long time, a large part of the alum will remain undissolved at the bottom.

2. Set the jelly jar into the pot of hot water and resume stirring. Now everything dissolves.

3. Screw the lid onto the jar, and place it in a quiet place for a few hours. A lot of crystals will form.

4. Pour the solution into the second jelly jar, and let it dry completely. Label the jar, and save it for Experiment 8.

5. Shake the small crystals onto a paper towel with the help of the measuring spoon. Let them dry and select 12 large and pretty crystals. Put them in the little box and close it well (see page 9). You will need them later when you make your geode.

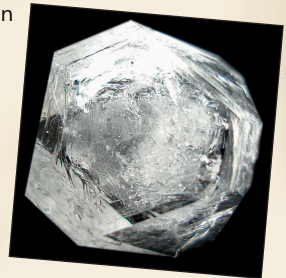
Explanation:

With many substances, their ability to dissolve increases with temperature (a well-known exception is table salt).

– Fact Sheet –

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.



Alum crystal

For example, 100 ml of water at room temperature (20 °C, 68 °F) will dissolve just 12 grams of alum. At 40 °C (104 °F), it will dissolve 25 grams, and at 60 °C (140 °F), 58 grams. A solution that can't dissolve anything further at a certain temperature is called **saturated**.

When the solution cools off — or when the water evaporates, as in the last experiment — it becomes **supersaturated**, and the excess alum separates out in the form of crystals. This cooling method provides crystals very rapidly, although they won't look as pretty as with the evaporation method.

03 *Experiment*

Crystals of blue

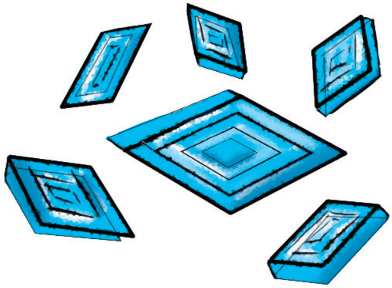
The crystals of blue copper sulfate have a different color from those of alum, and have a really unusual shape as well.

Copper sulfate
is hazardous to health and to the environment. See the information on page 6!

You will need: copper sulfate, small measuring cup, double measuring spoon, safety goggles, *old glass jelly jar, distilled water.*

Procedure:

1. Dissolve 16 small spoonfuls of copper sulfate in 10 ml water. Let the solution stand uncovered for a few days in a protected location. It will evaporate and form blue crystals with a characteristic shape.



2. After the crystals have formed, pour the solution into a jelly jar, take out the prettiest crystals with the help of the measuring spoon, and save them in your box.

3. The rest of the solution has to evaporate completely. Return the dry copper sulfate to the vial.

– Fact Sheet –

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.


Copper sulfate crystal

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

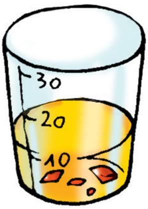
04 Experiment

Blood-red shapes

The third substance for making crystals has the name potassium hexacyanoferrate (III). It's also known by the name Prussian red, which is easier to remember.

You will need: potassium hexacyanoferrate (III), small measuring cup, double measuring spoon, safety goggles, *old glass jelly jar, distilled water.*

Procedure:
1. Dissolve 30 small spoonfuls of potassium hexacyanoferrate (III) in a small measuring cup with 15 ml water. Leave the yellow solution to stand uncovered for a few days in a protected place. It will form deep red crystals.



2. After the crystals have formed, pour the solution into the jelly jar and use the measuring spoon to pull out the prettiest crystal for your box.

3. Let the remaining solution completely evaporate, and return the dry potassium hexacyanoferrate (III) to the vial.

Explanation:
In fact, potassium hexacyanoferrate (III) does form beautiful, deep-red crystals out of an intensely yellow solution. But be careful: it can stain things.

– Fact Sheet –

POTASSIUM HEXA-CYANOFERRATE (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.

Potassium hexacyanoferrate (III) crystal

05 Experiment

Artificial mineral layer

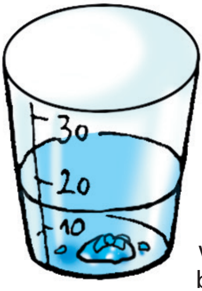
In nature, crystals often grow on rocks. Mineral collectors call these mineral layers. You can easily create such layers yourself by letting one of your chemicals crystallize out on a rock.

You will need: 2 small measuring cups, copper sulfate, double measuring spoon, safety goggles, *small rock with rough surface, distilled water.*

Copper sulfate
is hazardous to health and to the environment. See the information on page 6!

Procedure:

1. Dissolve 30 small spoonfuls of copper sulfate in a small measuring cup with 20 ml water, and place the granite rock in it — it should be completely submerged. Then let the container stand uncovered for a few days in a safe spot where younger children and pets cannot get to it..



2. 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. If so, pull the rock out carefully with the help of the measuring spoon, and put it in the second measuring cup.

3. Redissolve the deposited crystals in a little warm distilled water and pour it along with the rest of the solution over the rock — it should always be completely covered. But be sparing with the water: The solution has to be absolutely saturated, or the crystals on the rock will dissolve again!

4. When you are done, remove your crystal specimen, let it dry, and place it in your treasure box.

Copper sulfate crystals that have grown on a rock

Mineral layer with alum crystals

5. Let the rest of the solution evaporate, and return the copper sulfate to the vial.

Explanation:

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. If you are not pleased with your crystals, simply redissolve them and try again.

Supplemental experiments

Transparent crystals: To get light-colored crystal coatings using the same method, dissolve 20 small spoonfuls of alum in 20 ml of water in a warm water bath, and place a rock that you have found yourself into the solution.

For red crystals: 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.

06 *Experiment*

Giant crystals

Growing large crystals requires a lot of material and takes a long time — and even then, it's difficult to get well-formed crystals. But you can make various special crystal shapes out of paper. The drawings show what the completed crystals should look like.

You will need: die-cut sheet, *all-purpose glue.*

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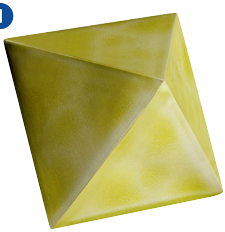

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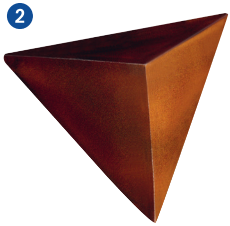

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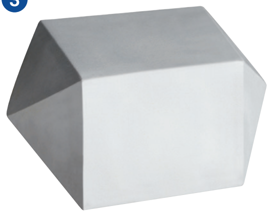

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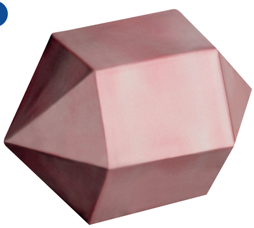

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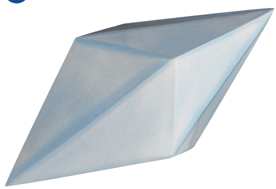


Explanation:

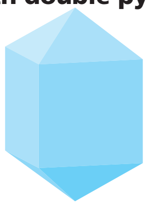
1 Octahedron

Fluorite and pyrite crystallize in this form.

2 Tetrahedron

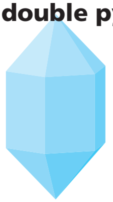
This form is found in zinc ore (sphalerite).

3 Tetragonal prism with double pyramid



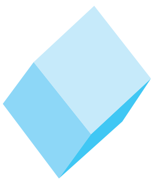
Minerals such as rutile, the precious stone zircon, and the tungsten scheelite have this form.

4 Hexagonal prism with double pyramid



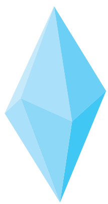
Quartz crystallizes in this form when it hardens at high temperatures.

5 Rhomboid



This very common crystal form is found in calcite.

6 Scalenohedron



Magnesite crystallizes in this form.

Treasures Growing in the Shadows

Crystals can form in small or large bubbles in rock. Crystal-filled rocks and hollow spaces of this type are called geodes, which is derived from a Greek word meaning "earthlike." You can make your own geodes, although you will have to follow the instructions carefully if you want your geode to look nice — because the crystals inside will be growing out of your sight.

Agate geode

07 *Experiment*

The geode takes shape

In nature, geodes are made of solid rock. Yours, on the other hand, will be made of plaster. You will create two halves that you will then glue together. Read the instructions through carefully first, get everything ready, and be speedy while you work, because otherwise the plaster will harden too quickly.

You will need: gypsum, wooden spatula, large measuring cup, double measuring spoon, alum seed crystals that you grew, sandpaper, *all-purpose glue, clean empty yogurt container, black ink or watercolor paint.*

! *Caution:*
Gypsum can produce dust — do not inhale it! Do not put the material in your mouth, and do not put it on your hands! Wash hands after use. Before beginning the experiment, read the safety instructions on pages 6 and 7.

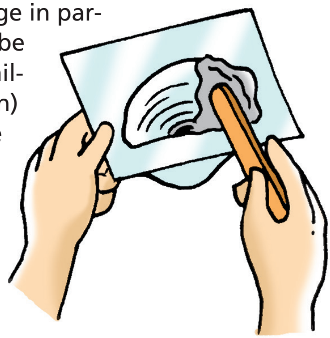
Procedure:
1. Cover your work surface with old newspapers. Pour 75 ml of cold distilled water into the empty yogurt container.

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.

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.

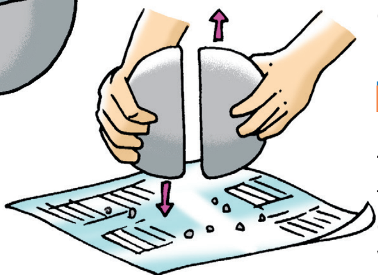
4. Spread the mixture up along the walls to create a hollow in the middle. This will be easy as long as the mixture is thick and gooey. The walls of the geode shouldn't be too thin, or the geode will break after it hardens. The upper edge in particular has to be at least five millimeters (0.2 in) thick, because you will be setting the other half on it later on.



5. 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 the process to make the second geode half.

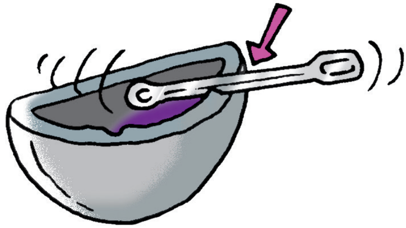
6. Let the geode halves dry for a day, and then carefully remove them from their molds.

7. Smooth the edges of the geode halves with the sandpaper, and check to see how their edges line up by setting them against each other.



You can also rub them against each other until they fit together smoothly without any gaps.

8. Use the double 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 a little more plaster on it.

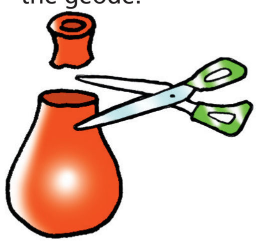
08 *Experiment*

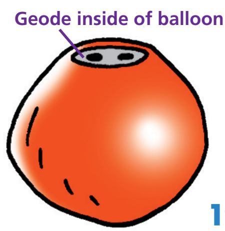
Filling the geode

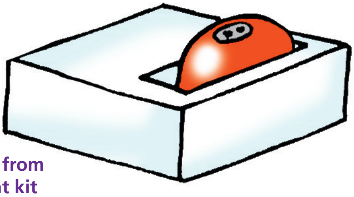
You will need: homemade geode, alum from Experiment 1, dye powder, double measuring spoon, large measuring cup, small measuring cup, pipette, balloon, safety goggles, *distilled water, scissors, pot with hot water, hammer.*

Procedure:

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.







Foam tray from experiment kit

2. Set the geode in the empty polystyrene tray with the holes facing up.

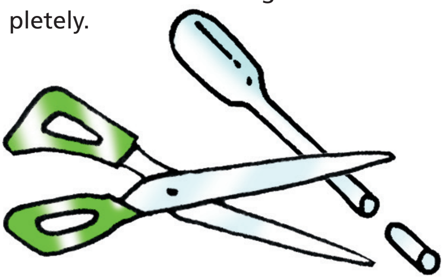
3. Fill the large measuring cup with 100 ml water and set it in the pot with hot water already in it.

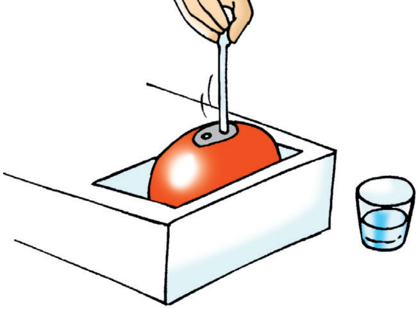
4. Fill the small measuring cup with alum, and shake the alum into the large measuring cup. Stir until everything is dissolved. You may have to reheat the water if it cools during this process. When everything is dissolved, add a little more alum. It is important that there still be a few undissolved crumbs of alum after you have stirred a long time — that means that the solution is good and saturated.

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!

5. Cut off the tip of the pipette, and use the shortened pipette to inject the slightly cooled alum solution into the hollow center of the geode. Just use one of the two holes — the other serves to let air escape. Add enough of the solution to fill the geode completely.

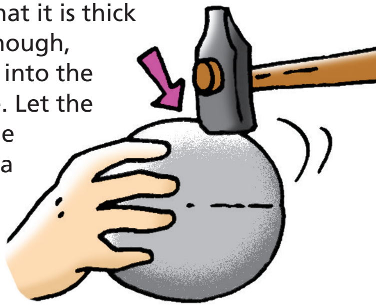




6. The solution will cool off during the next few minutes, and the plaster will also soak some of it up. That means that the level will drop. So after a few hours, refill the geode with more of the saturated solution.

7. Now let the geode sit undisturbed for two days so it can form its crystals in peace.

8. After two days, empty the excess solution from the geode into the measuring cup. 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.

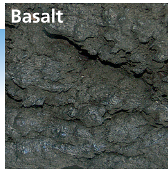


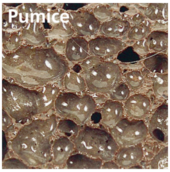
9. Now it's time to open the geode with a careful blow of the hammer. There is enough material to make another geode.

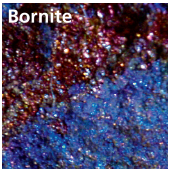
Tip:

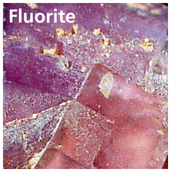
A whole, intact geode also makes a nice gift. You can get extra gypsum (plaster or plaster of Paris mix) in a hobby store, and you can order more alum from online chemical suppliers.

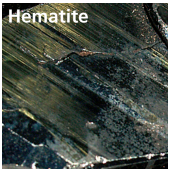
Minerals in the Research Lab

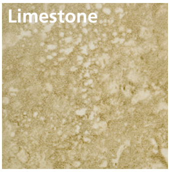


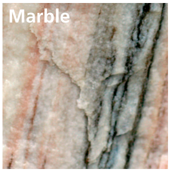


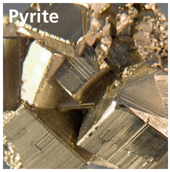












There are at least 4,000 different types of minerals. It's the mineralogist's job to recognize them and tell them all apart. To do that, mineralogists use an array of methods, including investigating color, hardness, and chemical, magnetic, and electrical properties, as well as crystal shapes with the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

Organizing Your Collection

First, organize your rock and mineral samples with their name labels in the little compartments of the polystyrene insert. The photos will help you. If you aren't sure which is which, the following tests will help you find out.

09 *Experiment*

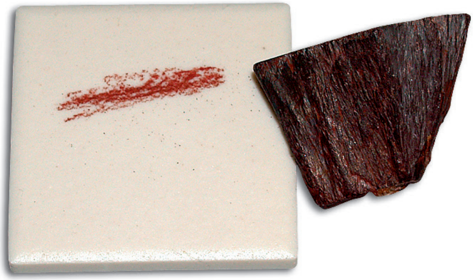
Color and streak color

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.

You will need: mineral specimens, magnifying lens, *cup or plate made of light-colored ceramic or porcelain with an unglazed (rough) area.*

Procedure:

Porcelain dishware is usually lightly 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.



Hematite shows reddish brown streaks

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.

Explanation:

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.

– Fact Sheet –

PYRITE

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.

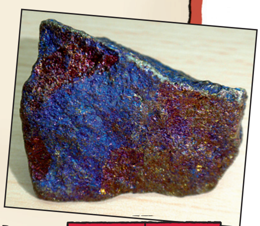
Pyrite

HARDNESS 6
DENSITY 5

– Fact Sheet –

BORNITE

This ore, also known as chalcopyrite (the Greek word *chalkos* means "copper"), contains copper and iron bonded with sulfur. It is considered to be among 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 similar to the colors of an oil spill on water.



Bornite

HARDNESS 4
DENSITY 4

– Fact Sheet –

HEMATITE

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.

Hematite

HARDNESS 5-6
DENSITY 5

10 Experiment

The hard thing about it

A lot of minerals are very different in terms of their degrees of **hardness**.

You will need: minerals, *iron nail, steel nail or penknife, copper penny.*

Procedure:

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. 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 crystal will withstand even the penknife. Only an adult should use the penknife in this experiment. Be careful while handling the sharp penknife!

Explanation:

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.

– Fact Sheet –

QUARTZ CRYSTAL

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).

Quartz crystal

HARDNESS	DENSITY
7	2.6

– Fact Sheet –

FLUORITE

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.

Fluorite

HARDNESS	DENSITY
4	3

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 8 9 10	Quartz Topaz Corundum Diamond	Scratches window glass, creates sparks when struck with steel

Mohs scale of mineral hardness

– Fact Sheet –

SOAPSTONE

Soapstone

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.

11 Experiment

More or less dense

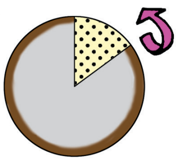
You must have noticed by now that even though the ore samples are about the same size as the other minerals, they are much heavier. **Density**, or the weight of a substance of a certain size, is an important distinguishing feature of minerals. Water has a density of one, as one cubic centimeter of water (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.

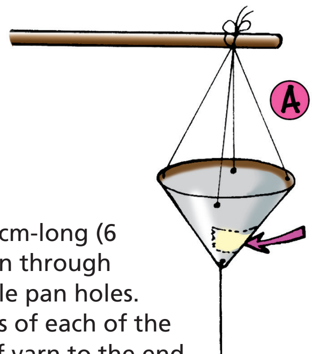
You will need: large measuring cup, weighing scale from the die-cut sheet, wooden stick, *2 or 3 boxes of matches, minerals, paper, pencil, tape, yarn, scissors, all-purpose glue.*

Procedure:

First, assemble the scale.

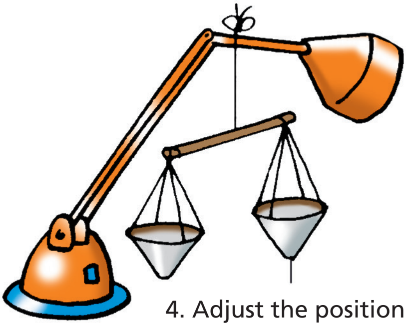
1. Tape the scale pans together into little cones. Thread a 10-cm-long (4 in) piece of yarn through the prepunched center hole of scale A, and secure it with tape.





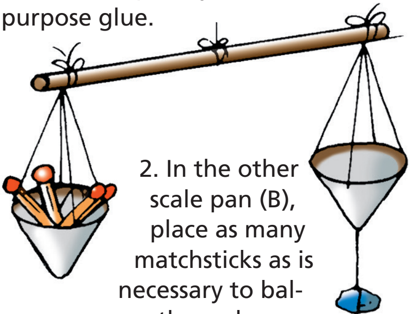
2. Thread a 15-cm-long (6 in) piece of yarn through each of the scale pan holes. Secure the ends of each of the four sections of yarn to the end of the stick above it.

3. 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 has to be able to hang freely, with the scale pans about 15-20 cm (6 to 8 in) above the table surface.



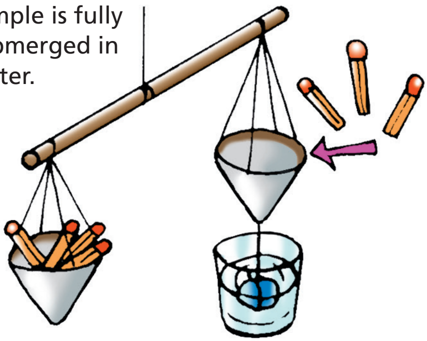
4. Adjust the position of the scale pans until the scale is perfectly balanced, and then secure them with tape so they don't slide.

Now for the actual measurement:
1. Secure one mineral sample to one of the scale pan's yarn with some all-purpose glue.

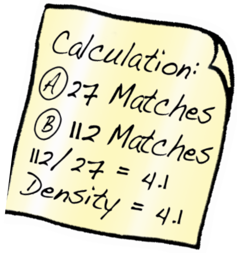


2. In the other scale pan (B), place as many matchsticks as is necessary to balance the scale.

3. 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 bring the scale back into balance when the mineral sample is fully submerged in water.



4. 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.



5. Using this method, measure all the minerals contained in the kit.

Explanation:
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. Pure iron, has a density of 7.5. Lead is 11, and gold is 19.

12 Experiment

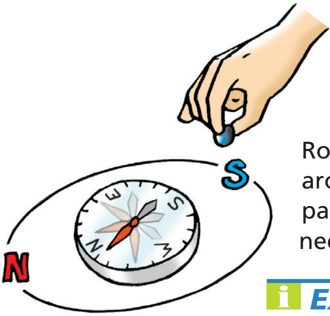
Magnetism

If a mineral is **magnetic**, this is an important clue to its identity, because only a few minerals have this property. Test whether any of your rocks or minerals is one of them.

You will need: compass, minerals.

Procedure:
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?

Explanation:

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 inside it.

13 Experiment

Telltale gas production

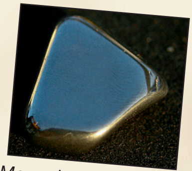
Many minerals can only be identified with certainty by a chemical analysis, which can require a lot of effort. But there are also simple tests, one of which can be used to identify calcite.

Citric Acid
Citric acid is an irritant.
See the information on page 6!

– Fact Sheet –

MAGNETITE

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.


Magnetite

HARDNESS	DENSITY
5-6	5

You will need: small measuring cup, large measuring cup, double measuring spoon, pipette, citric acid, magnifying lens, safety goggles, *distilled water, penknife, hot water in pot.*

Procedure:

1. Don't forget your safety goggles! Dissolve three small spoonfuls of citric acid in 10 ml of hot water in the large measuring cup. Stir until everything is dissolved.

2. Scrape a few small chunks off of the calcite, place them in the small measuring cup, and trickle the warm citric acid solution over them with the pipette. Observe with the magnifying lens how little gas bubbles are released from the calcite chunks.

Explanation:

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.

14 *Experiment*

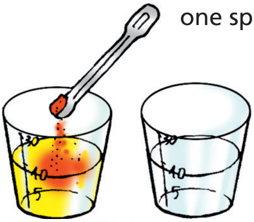
Test for iron and sulfur

These two elements are primarily found in ores, and there are simple chemical tests for them as well.

You will need: double measuring spoon, bornite, pyrite, citric acid, potassium hexacyanoferrate (III), 2 small measuring cups, safety goggles, *table salt, tea light candle, distilled water, penknife.*

Procedure:

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.



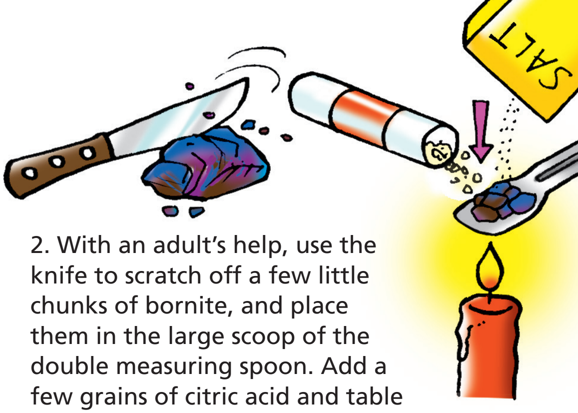
– Fact Sheet –

CALCITE

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.

Calcite

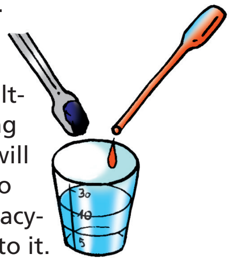
HARDNESS	DENSITY
3	2.8



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. Add a few grains of citric acid and table salt, and carefully heat this for a few seconds over a tea light or candle flame. During the experiment, leave a window open to ventilate the room. The citric acid will melt, and you will get a dark, bubbling mass with vapor bubbles escaping from it.

3. Heat this melted mass another 15 seconds. The strange smell that you perceive comes from the sulfur gases released from the bornite.

4. 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.



5. Repeat the experiment with little chunks of pyrite.

Explanation:

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.

Rocks: Building Blocks of Our Earth

Rocks are even 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.

1. Formed in the fires of the deep: igneous rock

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.

Granite

The granular rock chunks in your kit are made of 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. Over the course of millions of years, wind and water carried away the overlying layers of rock, bringing the granite to the surface.

There are many kinds of granite that come in many different colors. Granite is used primarily as a building material, with the prettier kinds used for facades and decorative elements. Measure the density of the granite. It is around 2.6 to 2.8.

Granite with wave-like structure

Basalt

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 grey chunks of basalt were formed. Since it hardened quickly, its components

Basalt columns along the coast of Northern Ireland 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. Measure the density of basalt. It is around 3.

Pumice

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 with the pumice from your kit! Pumice is used in the production of heat-insulating lightweight concrete blocks.

Pumice with characteristic porous structure

2. Worn by weather and deposited: sedimentary rock

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, of course, also the limestone and diatomaceous shells of billions of tiny sea animals.

Limestone

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.

White limestone wall

15 *Experiment*

You will need: small and large measuring cups, citric acid, double measuring spoon, magnifying lens, limestone, safety goggles, *penknife, pot with hot water.*

Procedure:

1. In the large measuring cup, dissolve three small spoonfuls of citric acid in 10 ml of water and stir until everything is dissolved.

2. Scrape a few small chunks off the limestone and pour the warm citric acid solution over them. You can see little gas bubbles rising up if you look through the magnifying lens.

Explanation:

The warm citric acid solution dissolves the limestone and releases carbon dioxide gas in the process. You can always recognize limestone rock by this kind of gas production with acids.

Sand

Sand is also a kind of sediment. Formed through the weathering of other rocks, it is an important raw material in the construction industry. There are lots of different kinds of sand in many colors. They are usually just grains of quartz, but some sands also contain other materials. Use your magnifying lens to study sand samples from near where you live or from a vacation locale.

Artificial sandstone

In time, sand that has become compressed or washed up by water can turn solid. The cause is usually limestone that has penetrated and cemented the grains of sand together.

Homemade artificial sandstone

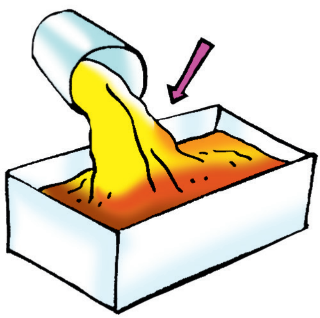
With gypsum and some food coloring, you can replicate this process and create artificial sandstone similar to the naturally colored sandstone of the Arizona desert.

16 *Experiment*

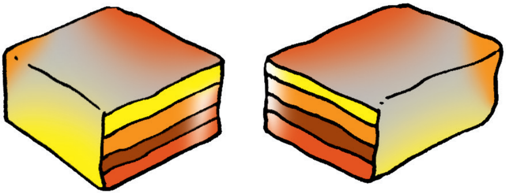
You will need: gypsum, wooden spatula, double measuring spoon, *small cardboard box, sand, red, blue, and yellow food coloring or watercolor paints, clean empty yogurt container.*

Procedure:

1. In the yogurt container, stir together some sand with half the quantity of gypsum, and add three to five spoonfuls of red coloring, two spoonfuls of blue coloring, and a little yellow coloring. Mix everything together thoroughly and slowly add water until you get a reddish brown mush. Pour this into the cardboard box and let it harden.



2. Repeat this mixing process with different color ingredients or without coloring, and gradually layer the sand and gypsum mixtures on top of one another.



3. Let everything harden well. Then break apart the rock tablets, and roughen the surface a little to make it look more realistic.

Explanation:

The gypsum cements the grains of sand together, and the dyes imitate the reddish brown iron compounds found in actual red sandstone. You can experiment with different colors of sand that you might find near where you live, or you could make a gaudily colorful rock from colored sand purchased in a hobby shop.

Red sandstone in nature

Rock salt

In many regions of Earth, vast stores of salt lie deep underground. They are deposits from former seas. This experiment shows how they were created.

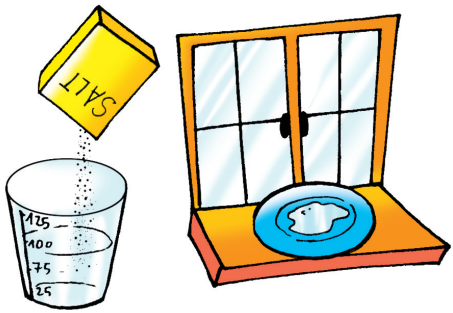
Coarse-grained rock salt

17 *Experiment*

You will need: large measuring cup, double measuring spoon, *table salt, deep dish.*

Procedure:

1. Fill half of the measuring cup with water, and stir enough salt in it to make a saturated solution. 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.



Explanation:

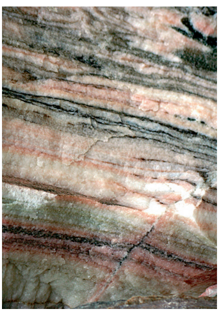
The rock salt deposits come from sections of sea that were isolated from the oceans and evaporated under a hot sun. As the water evaporated, the salt that was dissolved in it was left behind. Storms washed dust over the salt deposits, and sometimes the sea would return and form new salt layers as it subsequently evaporated again, and ultimately other layers covered the salt as well.

3. Souvenir from pressure and fire: metamorphic rock

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". For example, slate is created out of clay deposits that are subjected to high pressure, and limestone is turned into marble. In your collection, the soapstone belongs to this category, along with the light grey dolomitic marble, which comes from a magnesium-rich calcium rock (dolomite).


Slate


Soapstone


Marble

Rock cycle

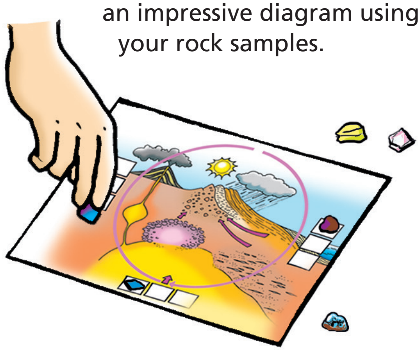
The various rock categories are transformed over the course of cycles lasting millions of years. Igneous rocks such as basalt, granite, and pumice are exposed to the elements and turn to sedimentary rocks. Others change into metamorphic rocks.

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 the Earth's depths again, are melted, and form new igneous rocks. This completes the cycle.

Diagram with actual rock

You can turn this cycle into an impressive diagram using your rock samples.



Tape or glue the paper sheet onto a large piece of cardboard and cut little slits into the premarked locations. There, insert your rock samples and hang the completed diagram in your room.