EXPERIMENT MANUAL

Crystal Growing

Cool!
Let's get started!

WARNING. Not suitable for children under 10 years. For use under adult supervision. Contains some chemicals which present a hazard to health. Read the instructions before use, follow them and keep them for reference. Do not allow chemicals to come into contact with any part of the body, particularly the mouth and eyes. Keep small children and animals away from experiments. Keep the experimental set out of reach of children under 10 years old.

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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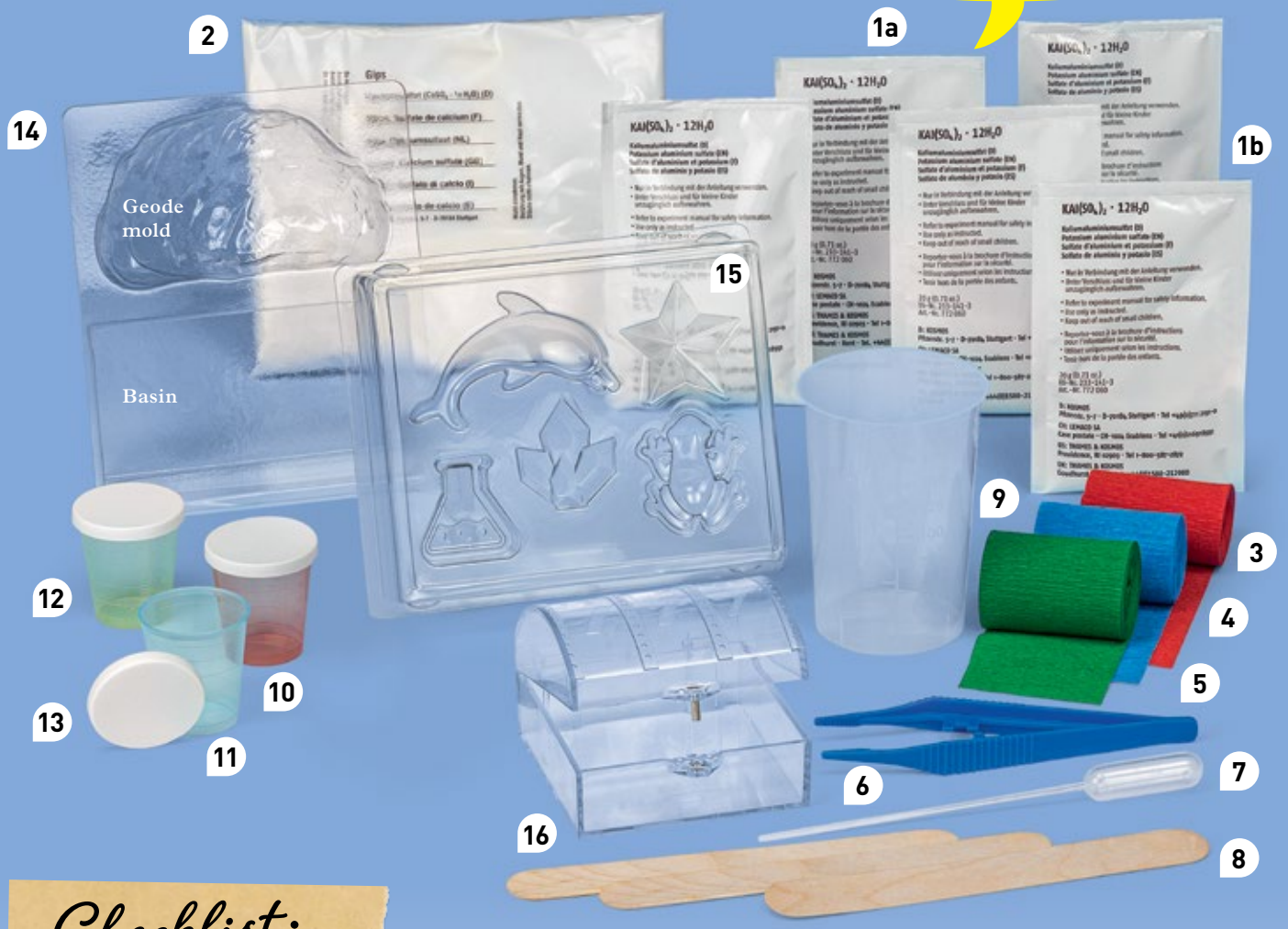
KIT CONTENTS

NOTE! 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.

What's in your experiment kit:



Checklist:

✓	No.	Description	Quantity	Item No.
		Potassium aluminium sulfate (alum):		
○	1a	50-g packet	2	771 061
○	1b	20-g packet	3	772 060
○	2	Plaster (calcium sulfate) bag	1	771 052
○	3	Red dye paper	1	719 749
○	4	Blue dye paper	1	721 573
○	5	Green dye paper	1	721 574
○	6	Tweezers	1	700 127
○	7	Pipette	1	232 134

✓	No.	Description	Quantity	Item No.
○	8	Wooden spatula	3	000 239
○	9	Large measuring cup, 200 ml	1	702 810
○	10	Red measuring cup, 30 ml	1	065 099
○	11	Blue measuring cup, 30 ml	1	065 100
○	12	Yellow measuring cup, 30 ml	1	065 101
○	13	Lid for measuring cup, small	3	061 160
○	14	Geode mold and basin	1	703 028
○	15	Mold for plaster figures	1	722 683
○	16	Treasure chest	1	700 739

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

YOU WILL ALSO NEED: *distilled water (about 1 liter), small screwdriver, pencil, transparent tape, paper towels, pot holders, small old cooking pot (20-cm diameter), empty jelly jars with lids (about 200-ml capacity), twine or nylon thread, scissors, old newspapers, empty yogurt containers, small stones, sandpaper*

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TIP

ADDITIONAL INFORMATION CAN BE FOUND IN THE CHECK IT OUT SECTIONS ON PAGES: 14, 15, 21, 26, AND 31

Yay!
Here we go!

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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 the 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

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.

IMPORTANT INFORMATION

This experiment kit is intended for children over 10 years of age.

Dear Parents and Supervising Adults,

Children want to explore, understand, and create new things. They want to try things and do it by themselves. They want to gain knowledge! They can do all of this with Thames & Kosmos experiment kits. With every single experiment, they grow smarter and more knowledgeable.

With this crystal growing set, you will accompany your child on a journey into the fascinating world of crystals.

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.

→ Read and follow these instructions, the safety rules, and the first aid information, and keep them for reference. Please observe the information regarding the handling of the chemicals and their environmentally sound disposal.

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

→ This experiment 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.

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

→ You as 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, chemicals and chemical solutions.

→ 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.

→ 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.

→ 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 hot water 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 (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 paper 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.

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

Have fun!

Dear Crystal Growers!

Read these instructions carefully. This way you can easily avoid possible dangers!

Safety Rules for Chemical Experiments

Stop! Read this first, before you begin!

All of the experiments described in this manual can be performed without risk, as long as you follow the advice and instructions. Read through the following information very carefully.

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

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

→ Store this experimental set and final crystal(s) out of reach of children under 10 years of age.

→ Clean all equipment after use.

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

→ Wash hands after carrying out experiments.

→ Do not eat or drink in the experimental area. And also do not smoke.

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

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

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

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

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

→ Ensure that during growing of the crystals the container with the liquid is out of reach of children under 10 years of age. All filled containers should have a label stating what is inside.

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

→ 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.

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

→ If chemicals should come in contact with eyes, mouth, or skin, wash affected area with plenty of water, follow the first aid advice (page 2) and contact a doctor if necessary.

→ 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 5, as well as the safety information provided with the individual experiments (for example, having to do with handling hot liquids).

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

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

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

→ With additionally required products also take note of the warnings on their packaging.

RULES FOR SAFE EXPERIMENTATION

Chemicals and Your Workspace

SAFETY

Being mindful of safety is the number one priority when experimenting. Read and ensure understanding of all of the instructions before each experiment. Only use the materials detailed in the instructions (as it is dangerous to experiment with unknown substances), and only utilize the materials as directed in this manual. Keep the materials away from your body, especially your mouth and eyes.

Be extra careful with hot stove tops, and don't forget to turn them off after use!

If a chemical accidentally makes contact with your skin, immediately rinse it off under cool, running water.

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

→ Do not place the material in your mouth.
→ Do not inhale dust or powder.
→ Do not apply to the body.

INFORMATION ON HANDLING THE CHEMICALS

Please note the following hazard and precautionary statements for the chemicals contained in this kit:

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

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

WASTE DISPOSAL

Waste will be created in the course of your experiments. You will have chemicals left over. You can rinse them down the drain with plenty of water if you don't want to collect and reuse them later on.

Ideally, though, you should collect all the leftover chemicals in a closed, clearly labeled container, which you should keep safely away from children, and eventually throw away in the household garbage. These leftover chemicals can be mixed together without any danger.

YOUR EXPERIMENT AREA

Your workspace 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. And don't forget to tidy up and clean the counter at the end of your experiments.

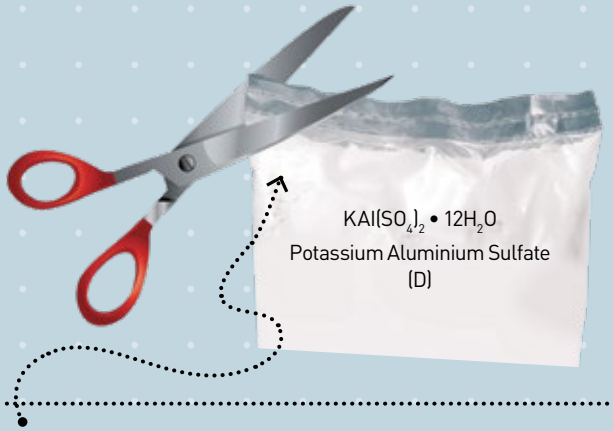
WARNING! The following applies to all chemicals: Store locked up. Keep out of reach of children. This primarily applies to young children, but also to older children who — unlike the experimenter — have not been appropriately instructed by adults.

Also follow this precautionary statement:
IF SWALLOWED: Get immediate medical advice/attention and have product container or label (of chemical substance) at hand.

Helpful Tips for Growing Crystals

RECORDING YOUR DATA

Scientists document their experiments by writing down their observations, analyzing the results, and making conclusions. This means that they write down exactly how they conduct their experiment, what they see, and what the results of the experiment are. It is important for other scientists to be able to understand how the experiment was conducted, so they can either repeat the steps to try to get the same results or take different steps to get a different result. As you experiment, keep a pen and paper handy so you can practice taking notes!

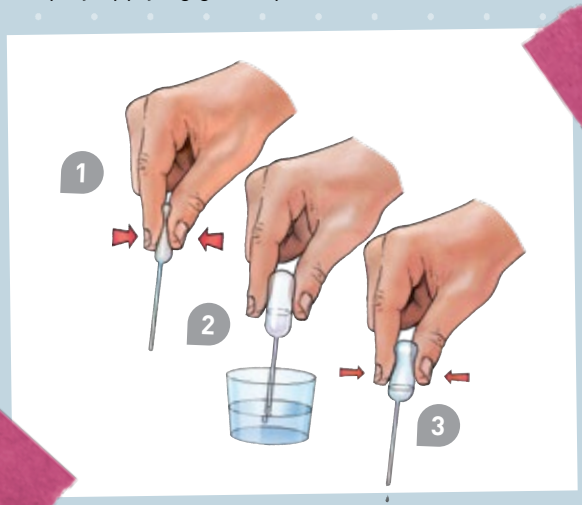


Ask an adult to help you open the plaster pouch and the chemical packets. Make sure to open the bag of plaster and the bags containing alum with a pair of scissors, NEVER with your teeth. Shake the packet so the chemicals settle at the bottom, and cut one of the top corners with the scissors. Make sure not to cut the label, so that it remains legible. Each alum packet should be used up completely during an experiment. Close the plaster bag immediately after use by folding the top over and securing it with a piece of adhesive tape or a clip. Store them in a safe place.

This jar contains ...

PIPETTING

When you want to add liquids drop by drop, the **pipette** will come in handy. Step 1: Squeeze the upper part of the pipette between your thumb and forefinger, then dip the end into the liquid. Step 2: Release the pressure on the bulb and watch as the liquid rises into the pipette. Step 3: You can gradually let the liquid out drop by drop by applying gentle pressure to the bulb.



GROWING YOUR CRYSTALS

You will need some additional containers in which to grow your crystals. The best kinds to use are empty jelly jars, washed clean and well dried. You can also use a few of these containers to collect crystal residues or leftover solutions of the used substances.

Note: All filled jars should have a label marked with the jar's contents. You must 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. **Make sure that the container is stable and out of the reach of young children and pets!**

TIPS

About the chemicals
included in this experiment kit

→ **Potassium aluminium sulfate** (potassium alum, or simply alum) crystallizes particularly easily and well.

→ **Plaster** (calcium sulfate) will be used to form the geode shells to grow crystals in, as well as other small shapes that crystals will grow on.

→ **Dye paper** is used to color the alum crystals.

The crystal salts were selected because they dissolve easily in water, crystallize quickly and well, and are relatively harmless. Nevertheless, you absolutely must pay attention to the safety instructions!

If your chemicals have formed clumps, it is not a sign of poor quality, but simply means that moisture, most likely from the air, has gotten inside the container. That will not affect the function of the chemicals. The age of your chemicals will also make no difference.

DIFFERENT TYPES OF 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 that vary 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.

STORAGE

You can save your alum crystals and other trinkets in the lockable treasure chest.

TIP

TO LOCK THE TREASURE CHEST, FIRST PUSH THE NUT INTO THE LOCK FROM BELOW. THEN ROTATE THE SCREW INTO THE NUT AND TIGHTEN IT WITH A SCREWDRIVER.

HEATING THE SOLUTIONS

To heat your solutions, you must not set your growing containers directly on a burner or gas flame. This would cause glass containers to crack or break, or plastic containers to melt.

Instead, take an old cooking pot, around five to ten inches in diameter, and fill it with an inch or two of tap water. The water level should be slightly lower than the level of liquid in the growing container. **Without the growing container in the pot,** heat the water on the burner to just below the boiling point.

Have an adult help you carefully carry the pot to your work area, and set it on a trivet. Now place your growing jar in the pot and stir its contents with a wooden spoon. 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 do not 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 vapor that comes off the crystal salt solutions when you heat them!

THE QUANTITY OF WATER

The amount 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. The measuring cup has a scale on its side with ml marks on it. Its total capacity is 200 ml. To measure the amount of crystal salt required for each experiment, use one of the small measuring cups.

An experiment to hit the ground running

What happens when you place a colorful piece of sugar in water?

A colorful sugar star

EAGER FOR MORE?
Then come along into the glittering world of crystals ...

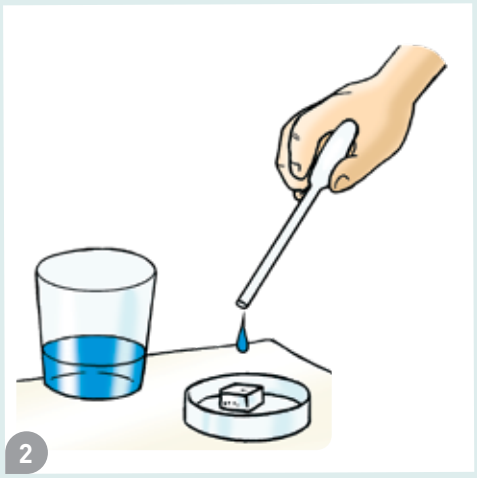
You will need

- **2 small measuring cups**
- **Lid for one small measuring cup**
- **Small piece of dye paper**
- **Pipette**
- **Wooden spatula**
- *Sugar cube*
- *Large shallow plate*
- *Tap water*
- *Paper towel*

Here's how

1. Dissolve a small piece of dye paper in some tap water.
2. Place a sugar cube in the measuring cup lid and use the pipette to carefully add 5 to 6 drops of the colored solution to it. Wait for the solution to dry.
3. Fill the shallow plate with some water and set the colorful sugar cube in its center.
4. What shape do you see?
5. Pour the colored sugar solution down the drain after the experiment and rinse the sink with water.


1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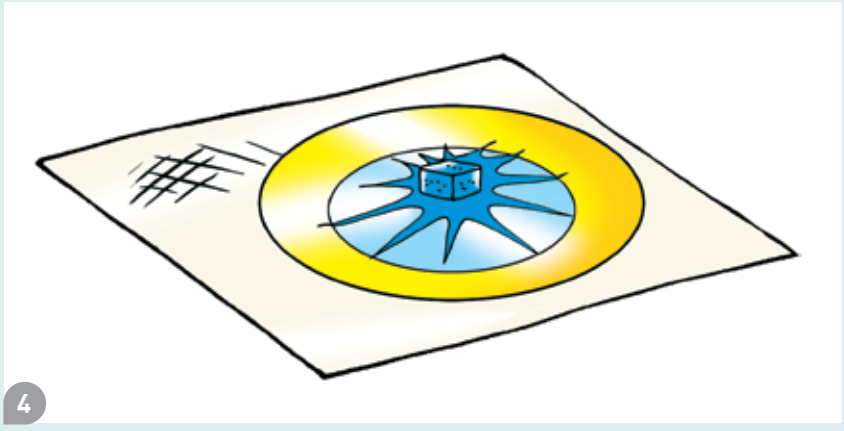
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WHAT'S HAPPENING?

The sugar dissolves and takes the colored solution with it. The sugar particles move out to the edge of the plate and the colored solution flows outward as well. That's how the beautiful sugar star is created.

Crystals
MIRACLES OF NATURE!

Crystals are fascinating natural marvels. They can form cubes, sharp needles, twisted squares, octahedra, or other complex shapes with smooth, glittering surfaces. You will learn what crystals are and about the special shapes they can take. In addition, you will learn about the processes taking place as the crystals grow and the best methods for growing large crystals. Welcome to the world of crystals!

EXPERIMENT 1

Your first crystals

You will need

– 50 g potassium aluminium sulfate (alum packet)
– Large measuring cup
– Wooden spatula
– Treasure chest
– Distilled water
– 2 empty jelly jars
– Pot with hot water (no longer boiling)
– Potholders or oven mitts
– Paper towels
– 2 labels, a pencil, and tape

Here's how

1. Place a packet of alum (50g) in the jelly jar and add 250ml of distilled water.

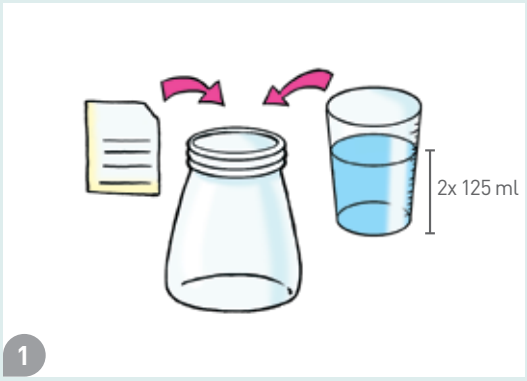
2. Set the open jar in the pot of hot water, and stir with the wooden spatula until everything is dissolved.

3. Carefully remove the jar with the clear liquid (caution, it is hot!) and affix a label to it marked "alum solution 1". Let it sit in a safe place to cool. After one day, colorless crystals will form on the bottom. If the crystals are not big enough, you can wait another day.

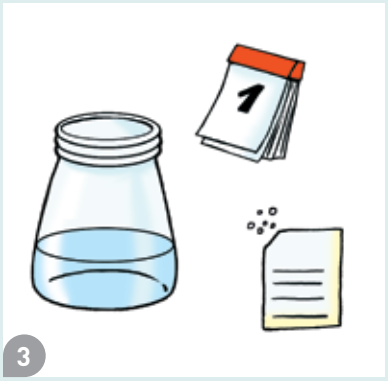
4. The following day, carefully pour the solution into a second jar. Affix a label marked "alum solution 2" to it and save it for the next experiment.

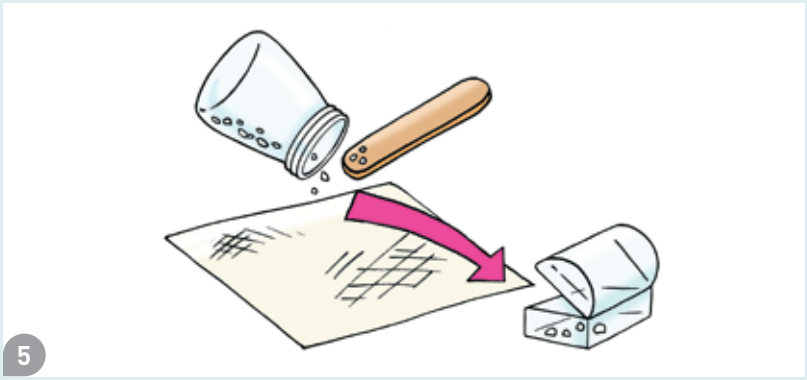
5. Use a wooden spatula to push the crystals out of the first jar onto a paper towel and let them dry. Sort out the most beautiful crystals and save them in your treasure chest. You will need them later.

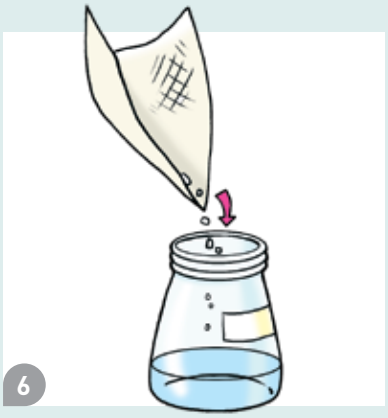
6. Return the remaining crystals to the jar marked "alum solution 2".



Be careful when handling hot water!







TIP

BE PATIENT WITH YOUR CRYSTALS. IT CAN SOMETIMES TAKE 3-4 DAYS FOR THEM TO DEVELOP. DO NOT MOVE THE JAR OF ALUM SOLUTION WHILE YOU WAIT.

EXPERIMENT 2

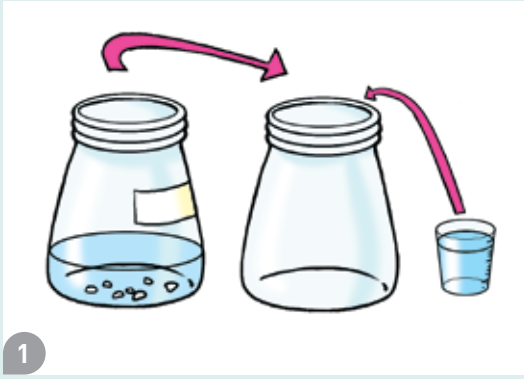
Signs of dissolution

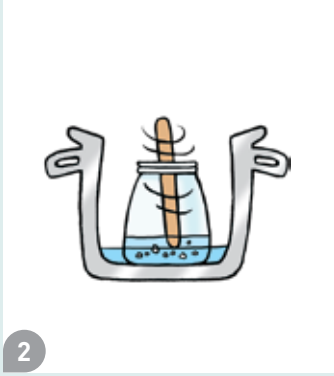
You will need

– "Alum solution 2" from Experiment 1
– Small measuring cup
– Wooden spatula
– Distilled water
– Empty jelly jar
– Pot holders
– Pot of hot water (no longer boiling)

Here's how

1. Pour the alum solution along with the smaller, less beautiful crystals from experiment 1 into an empty jelly jar. Add one small measuring cup of distilled water.
2. Set the open jar in the pot of hot water and stir repeatedly.
3. Using pot holders, remove the jar every one or two minutes (caution, it is hot!) and look to see what has dissolved. You will notice that the small granules of crystal dissolve much faster than the crystal pieces. Also, they will dissolve more quickly if the liquid is hotter.
4. Heat and stir until everything is dissolved. You can use this solution for Experiment 3.





Be careful when handling hot water!

WHAT'S HAPPENING?

When a solid substance dissolves, water pushes between its individual building blocks (its molecules) and releases them from the compound. These building blocks then float around individually in the water. The salt from the packet consists of large-grained crystals, although they are still a lot smaller than the ones you are growing. That's how the water can get at them from all sides at once and quickly dissolve them. The warmer the water, the harder it works, and the stronger its assault on the crystals. In most cases, warm water dissolves substances more quickly than cold water.

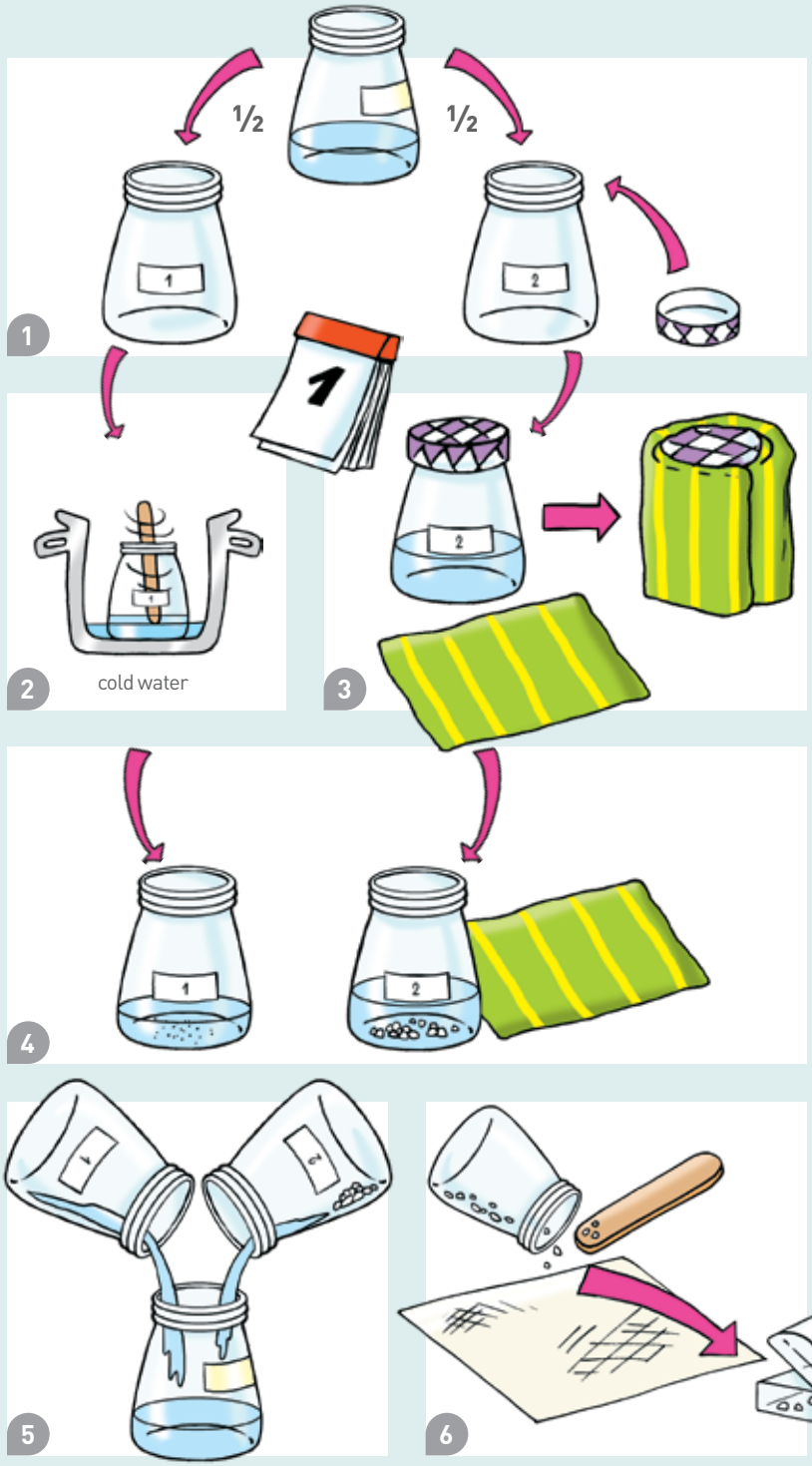
Fast and slow growth

You will need

– Warm alum solution from Experiment 2
– Wooden spatula
– Treasure chest
– 2 empty jelly jars (and 1 lid)
– Hand towel
– Pot with cold water
– 2 labels, pencil, and tape
– Paper towel

Here's how

1. Label the two empty jars "1" and "2." Divide the warm alum solution evenly between the two jars.
2. Set the first jar in the pot of cold water, which will rapidly cool the alum solution inside it. Stir it constantly as it cools. When the jar has cooled to room temperature, you can take it out of the pot. Let it stand overnight in a quiet spot.
3. Screw the lid onto the other jar and wrap it completely in a hand towel. Be careful not to tip the jar over or to spill any of the contents. Set the wrapped jar in a quiet spot and let it sit for one whole day.
4. On the next day, carefully unwrap the jar. Compare the size and shape of the crystals in the two jars.
5. Pour the leftover solution into the "alum solution" jar (you will need it for the next experiment).
6. Let the crystals dry out on the paper towel. You can store the larger, more impressive crystals in the treasure chest. Put the others back into the jar of "alum solution." You will need this jar for Experiment 4.



WHAT'S HAPPENING?

The crystals that formed more slowly are noticeably larger and show their characteristic shape more clearly. The small building blocks had more time to find their correct positions and fit themselves together properly. The other jar contains many little crystals. A lot of seed crystals were created when you stirred, and some of the building blocks collected on them, but the formation of crystals was disturbed again and again by the stirring action.

EXPERIMENT 4

Larger crystals

You will need

– Warm alum solution from Experiment 3
– Large alum crystal from your treasure chest
– Wooden spatula
– Treasure chest
– Empty jelly jar, as tall as possible
– Yarn or nylon string
– Scissors, tape
– Paper towel, facial tissue
– Pot with warm water, pot holder

Here's how

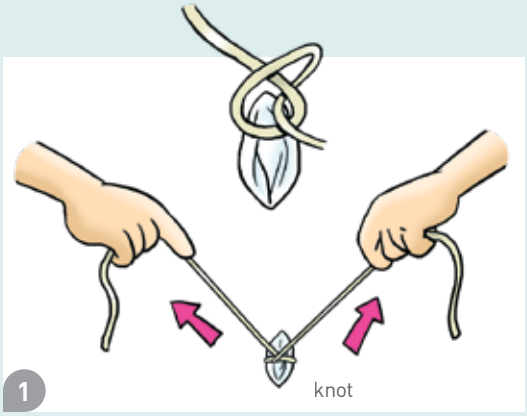
1. Select one large alum crystal. This will serve as your seed crystal. Cut a ten-centimeter (approx. four-inch) length of yarn or nylon string. Tie a small loop at one end and fasten it to the seed crystal.

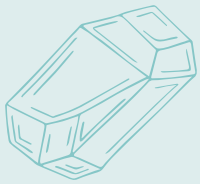
2. Take the jar of alum solution from Experiment 3 and redissolve the crystals it contains as described in Experiment 2. Let the solution cool down.

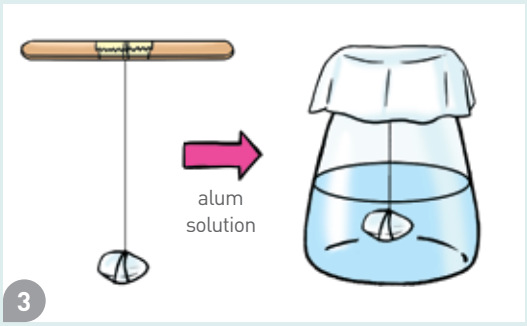
3. Attach the string to the middle of the wooden spatula with tape. Lay the spatula across the mouth of the jar, but don't let the crystal suspended in the alum solution hang too close to the wall of the jar. Cover the jar with a paper towel or tissue, and label it. Now let the jar sit quietly.

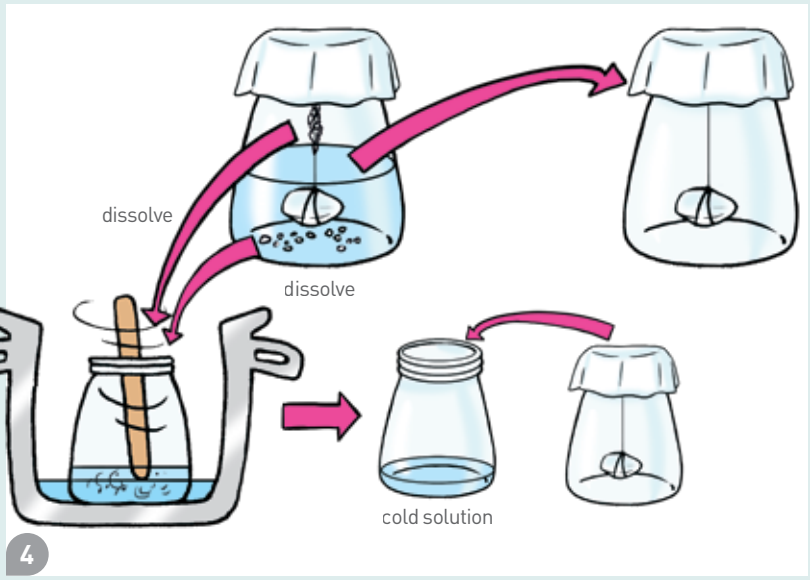
4. Every couple of days, check to see how the crystals are forming. If any are forming on the bottom of the jar, remove the seed crystal (temporarily hang it in an empty jar) and dissolve the other crystals by heating the jar in a water bath. Wait until the solution has cooled before hanging the seed crystal in it again, or it will dissolve. Over the course of several weeks, it will grow bigger and bigger and will clearly show the octahedral (eight-faceted) shape typical of alum.

5. Pull out the crystal, dry it, remove the string, and place it in your treasure chest.









Be careful when handling the hot water!

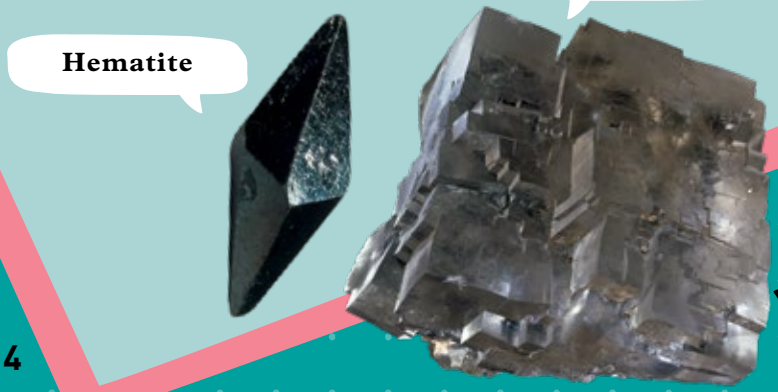
WHAT'S HAPPENING?

As the water evaporates, the solution is constantly kept slightly supersaturated. If you do your work properly, most of the excess alum will become deposited on the seed crystal dangling down into the solution, which will therefore grow bigger and bigger.

CHECK IT OUT!

One Crystal, Many Forms

Nature can do some really crazy things! A mineral can not only develop a crystal form, but can also look very different depending on the conditions during crystallization. The temperature and pressure of a substance, and the ambient temperature of the atmosphere and the surrounding material all impact the crystallization process. A good example of this is pyrite, also called fool's gold. Look at the variety of different crystal shapes it can develop:



KEYWORD
Crystal

What is a crystal?
A crystal is a solid material with fixed atomic building blocks. The individual components of the crystal (e.g. atoms, ions, or molecules) are arranged in a regular, highly ordered structure. Each material follows its own laws. For example, **table salt** forms completely different crystal structures than alum, hematite, and pyrite.

The word **crystal** derives from the Ancient Greek word "krustallos," which means both "ice" and "rock crystal."

Studying Crystals?

The science that deals with the study of stones (a naturally occurring solid mass of minerals) is called **geology.** The branch of geology that deals with the structure and properties of crystals is called **crystallography.**

Crystallographers try to determine how crystals are structured by analyzing the arrangement and bonding of their atoms. They also research what the different types of crystals can be used for. The most important instrument for this is the microscope, specifically an **electron microscope.**

KEYWORD

Alum

Potassium aluminium sulphate, or alum for short, is a sulfuric acid salt containing the chemical elements potassium, aluminium, sulfur, and oxygen.

For thousands of years, it has been obtained from alum shale and used as a teeth-cleaning agent, as a deodorant, and to stanch the bleeding of minor cuts. Above all, however, it has been used in making fine leather goods and as a dye.

Solubility of Alum

°C	g/100g Water
0	5.7
10	8.5
20	12
30	18.5
40	25
50	36.8
60	58.5
70	94.4
80	95

Solutions

A solution is a mixture of one or more **solutes** dissolved in a **solvent** (in our case, the solvent is water). Because solubility typically increases as the temperature increases, more alum dissolves in warm water than at room temperature. If the solution cools down, the solution becomes **supersaturated.** As a result, crystals form along the walls and on the bottom of the container. This is called the **cooling method.** The longer the solution cools down, the larger the crystals can become. By wrapping the jar in a thick towel, the heat is contained and escapes from the solution more slowly. As a result, the solution cools down more slowly, resulting in prettier crystals.

Colorful Crystal Creations

Color me fascinated! As beautiful as the colorless crystals sparkle, colorful crystals can be even more exciting. For a long time, people puzzled over the hidden meaning behind the different hues, and ascribed special magical powers to each color. In this section, you will learn how to color your crystals using the colorful dye paper.

Grow Colorful Crystals with Dye Paper

THE MORE PAPER YOU USE, THE MORE INTENSE THE COLOR OF YOUR CRYSTALS WILL BE. IN THE FOLLOWING EXPERIMENTS, BY USING DIFFERENT SIZES OF DYE PAPER, YOU WILL BE ABLE TO ACHIEVE DEEPER COLORS AND DIFFERENT COLOR COMBINATIONS.

There are four meters of dye paper in each color (red, blue, and green) for a total of 12 meters of dye paper.

For a deeply colored crystal, it's best to use half (two meters) of the four-meter roll.

For a lightly colored crystal, try using only one meter of dye paper.

To grow a soft, pastel-colored crystal, use a piece of dye paper that is about 50 cm long.

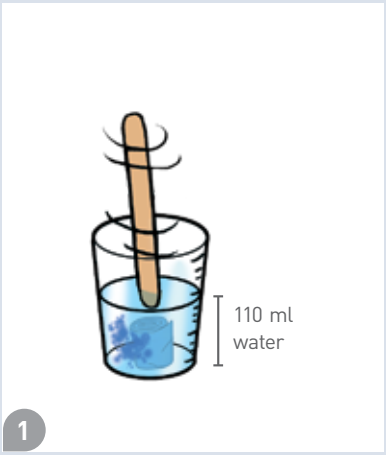
Keep in mind, you can combine colors, and you will also need some dye paper for experiments later on in the manual, so do not use all of the dye paper up in this section.

EXPERIMENT 5

Blue crystals

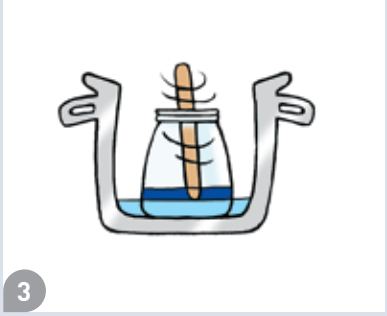
You will need

– 20 g alum packet
– A piece of blue dye paper
– Tweezers
– Wooden spatula, possibly pipette
– Large measuring cup
– Distilled water
– Empty jelly jar
– Potholders or oven mitts
– Pot of hot water (no longer boiling)

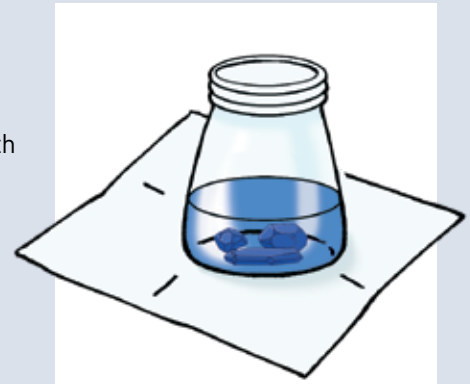


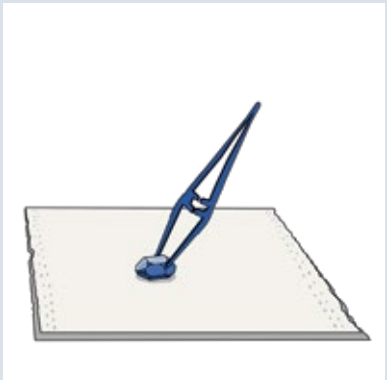
Here's how

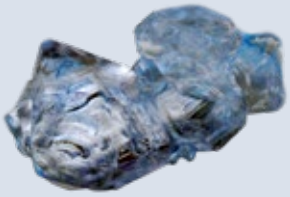
1. Pour about 110 ml of water into the measuring cup and add the blue dye paper. Stir gently with the spatula. The blue color will come off of the paper.
2. Take the paper out of the water with the tweezers, let it drain and dispose of it in the garbage. Also remove small bits of paper that may have become detached. The measuring cup should now be filled with about 90 ml of blue water. If there is not enough colored water in the cup, refill it with water. If it's too much, pour some off. You can also use the pipette to measure the exact amount.
3. Put the colored water into a clean jelly jar and pour in the entire contents of the alum packet (20 g). Stir the mixture with the spatula. Dissolve the crystal salt as described in Experiment 1.
4. Leave the solution in a quiet place for 1-2 days and see what happens. Large single crystals form on the bottom.
5. Use the tweezers to take the most beautiful crystals out of the jar. Place the crystals on paper towels to dry, then place in your treasure chest.
6. Store the remaining crystals and the solution in the jelly jar. You will need them for Experiment 7.



Be careful when handling the hot water!







EXPERIMENT 6

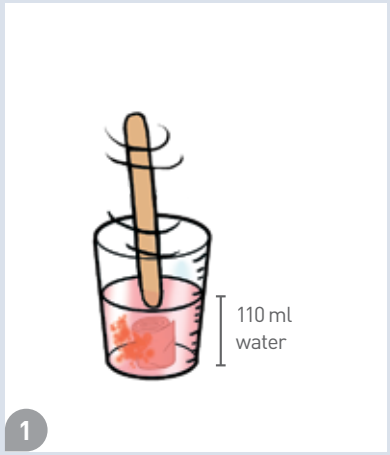
Red crystals

You will need

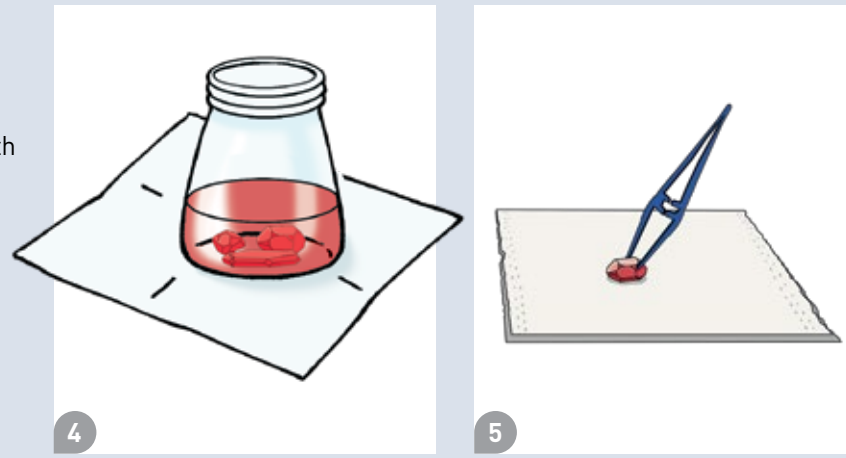
– 20 g alum packet
– A piece of red dye paper
– Tweezers
– Wooden spatula, possibly pipette
– Large measuring cup
– Distilled water
– Empty jelly jar
– Potholders or oven mitts
– Pot of hot water (no longer boiling)

Here's how

1. Pour about 110 ml of water into the measuring cup and add the red dye paper. Stir gently with the spatula. The red color comes off the paper.
2. Take the paper out of the water with the tweezers, let it drain and dispose of it in the garbage. Also remove small bits of paper that may have become detached. The measuring cup should now be filled with about 90 ml of red water. If there is not enough colored water in the cup, refill it with water. If it's too much, pour some off. You can also use the pipette to measure the exact amount.
3. Put the colored water into a clean jelly jar and pour in the entire contents of the alum packet (20 g). Stir the mixture with the spatula. Dissolve the crystal salt as described in Experiment 1.
4. Leave the solution in a quiet place for 1-2 days and see what happens. Large single crystals form on the bottom.
5. Use the tweezers to take the most beautiful crystals out of the jar. Place the crystals on paper towels to dry, then place in your chest.
6. Store the remaining crystals and the solution in the jelly jar. You will need them for Experiment 7.



Be careful when handling the hot water!



WHAT'S HAPPENING?

You may have noticed that the colored crystals sometimes grow larger than the colorless ones. This is because tiny paper particles from the dyed paper have dissolved in the water. Crystals can grow particularly well on these particles!

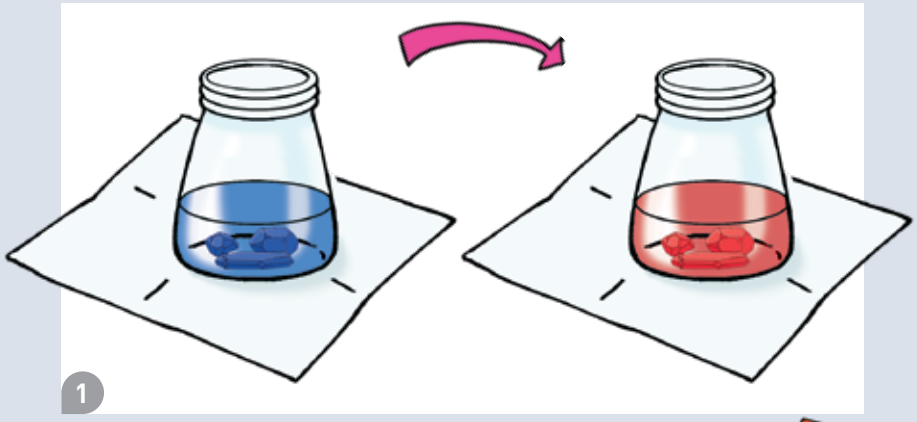
Mixed Colors

You will need

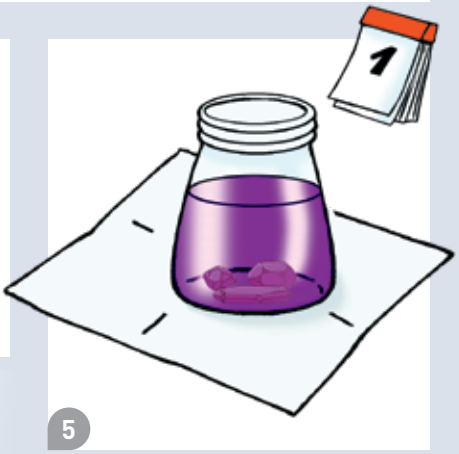
– Solutions from Experiments 5 and 6
– Wooden spatula
– Potholders or oven mitts
– Pot of hot water (no longer boiling)
– Paper towel

Here's how

1. Take the blue solution and remaining crystals from Experiment 5 and carefully pour them into the red solution from Experiment 6.
2. Place the open jar in the pot of hot water and stir with the spatula.
3. Heat and stir until everything is dissolved.
4. Remove the jar using the oven mitts (caution, it is hot!).
5. Leave the jar in a quiet place overnight.
6. The crystals that have now grown have a different color than those from Experiments 5 and 6.
7. Take out the crystals, place them on a paper towel to dry, then store them in your treasure chest. Run the water as you pour the rest of the solution down the drain. Be careful: the solution can stain the sink!

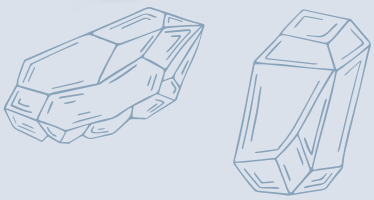


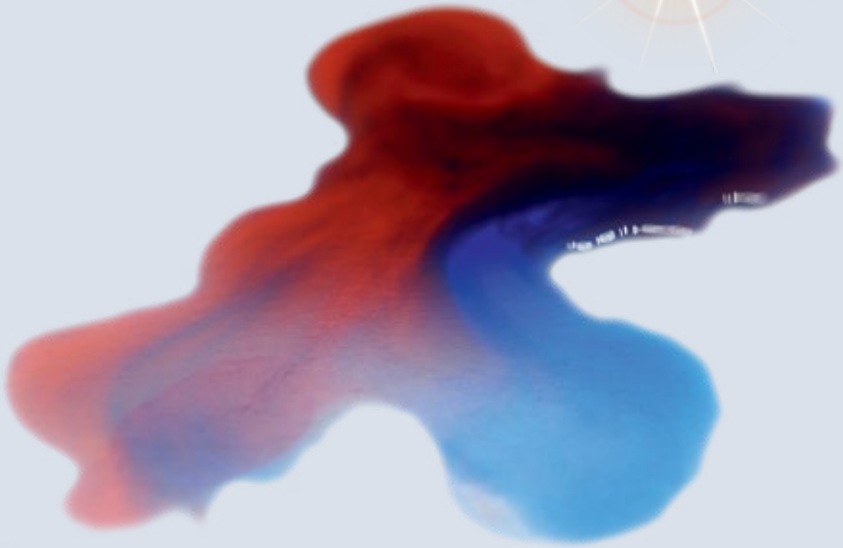
Be careful when handling the hot water!



WHAT'S HAPPENING?

If you mix two colors, a new one is created. For example, mixing red and blue creates purple, and mixing green and blue creates teal. Since the colors are dissolved in the water with the alum, the new color gets stored in the crystal that forms.





CHECK IT OUT!

Ice crystal under a microscope

Snow crystal

How Big Can Crystals Become?

How large a crystal can grow depends on how much time it is given to develop and whether or not there is enough supersaturated solution for permanent crystal growth. As the **solvent** evaporates, the excess **solute** gets deposited onto a seed crystal, growing bigger and bigger.

Gypsum crystals

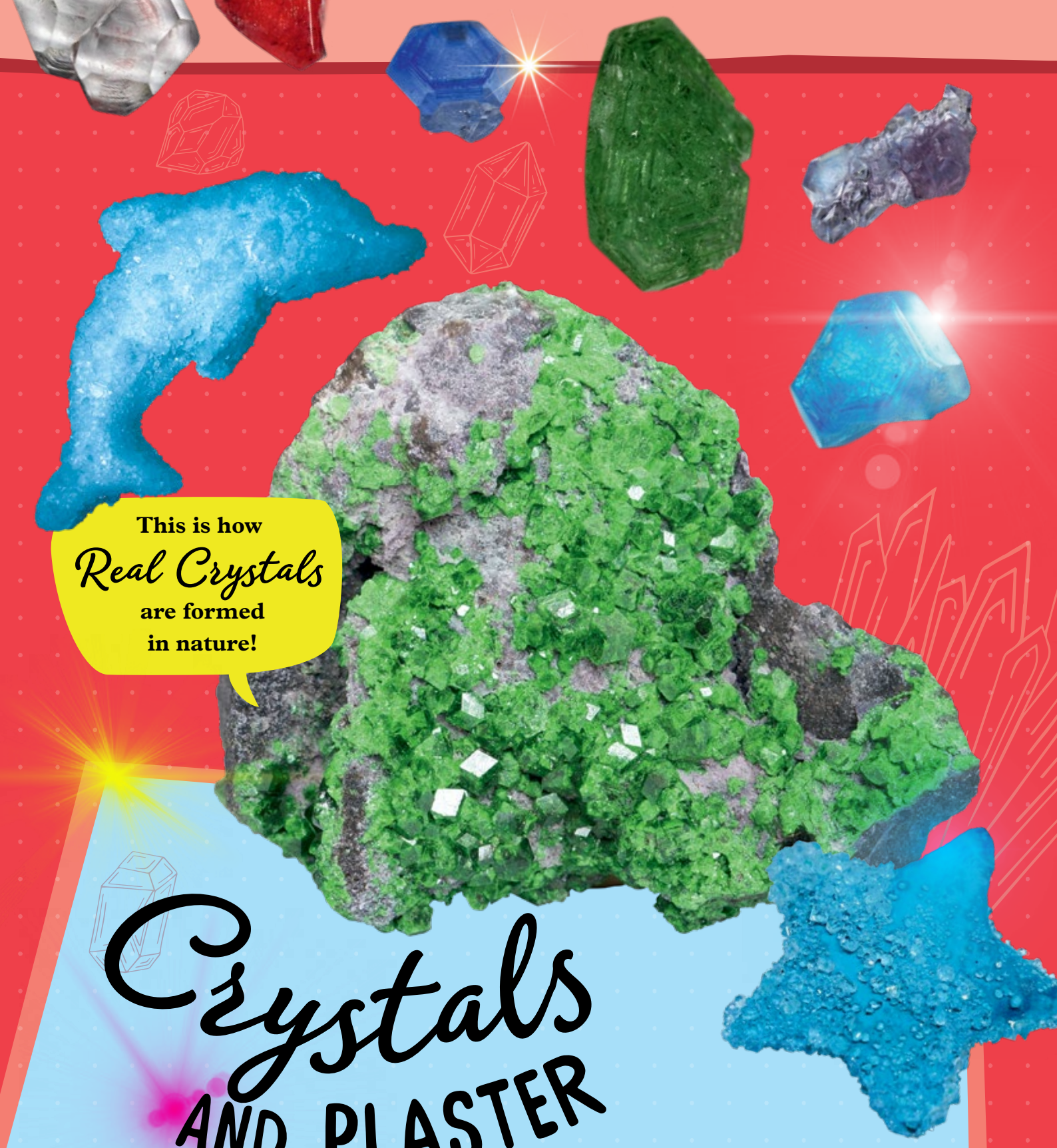
The world's largest crystals were discovered in 2000 at the Naica mine in northern Mexico, where **gypsum crystals** were found that are even larger than people! But crystals can also be tiny. For example, **snowflakes** are tiny crystals of frozen water.

KEYWORD

Colorful Crystals

Alum naturally forms colorless crystals, but if the crystal solution is dyed with the colored paper, the color particles are stored in the crystal structure, resulting in the formation of a colorful crystal.

Crystallization can also be used to separate commingled (blended) matter from each other. In this case, both substances are dissolved together and then allowed to cool. As this happens, one of the two substances will crystallize in it's pure form, while the other remains in the saturated solution or crystallizes separately. They can be distinguished from each other by their different crystal forms.

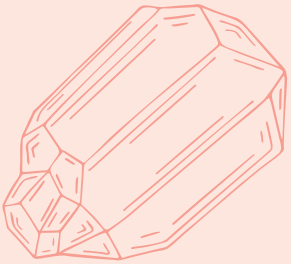


Crystals AND PLASTER

Not only can alum crystals grow in jars, but they can also grow on other materials. On the following pages, you will learn how to make beautiful decorations from plaster, dye, and alum crystal salt. The little plaster shapes in this kit are excellent for making crystal-studded ornaments. Not only are crystals interesting, they can be beautiful and decorative too!

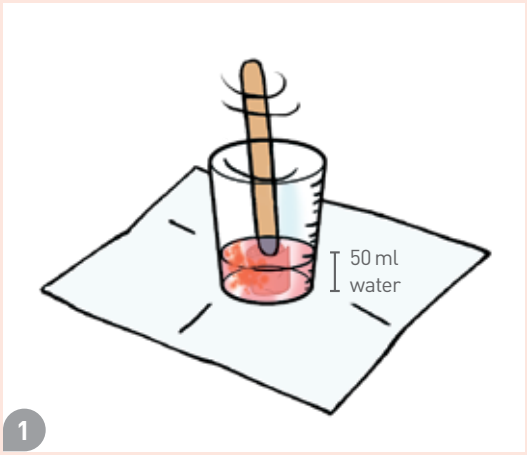
EXPERIMENT 8

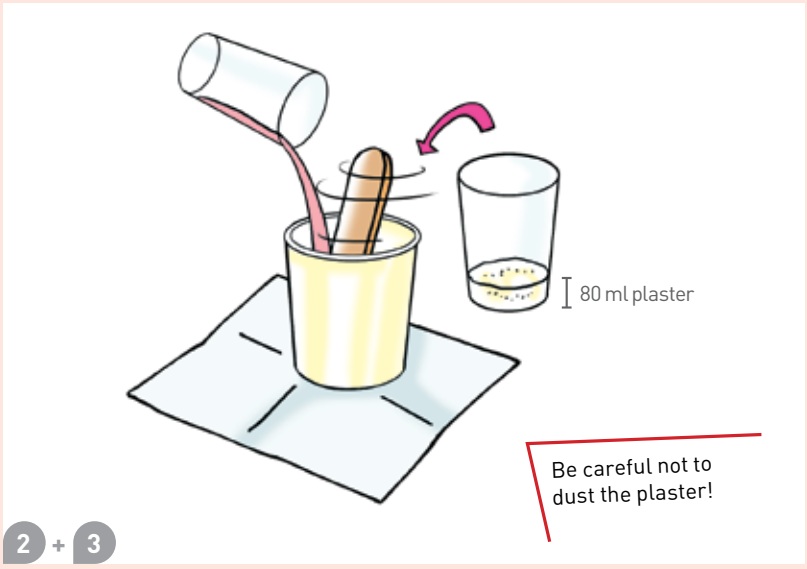
Crystal-adorned figures



You will need

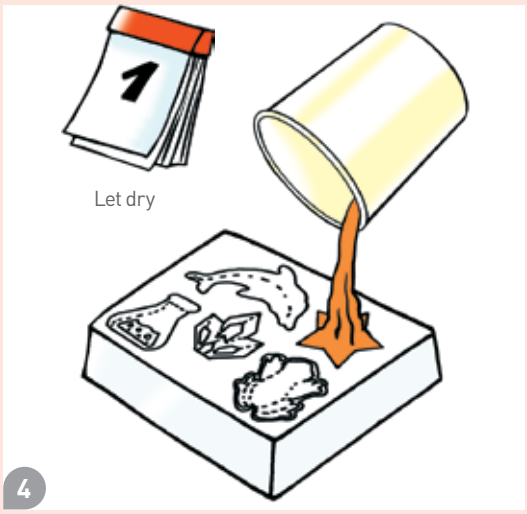
- **Plaster powder**
- **Dye paper**
- **Large measuring cup**
- **Wooden spatula**
- **Mold for plaster figures**
- **Alum packet**
- **Tweezers**
- *Large, empty yogurt container*
- *Old newspapers*
- *Distilled water or tap water*
- *Empty jelly jar*
- *Pot with hot water (no longer boiling)*
- *Paper towels*
- *Pot holders*



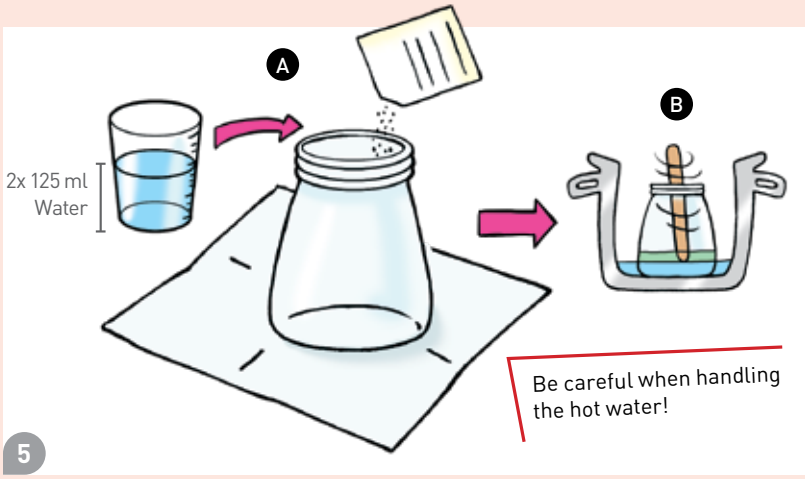


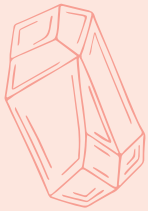
Here's how

1. Cover your work surface with old newspaper. Fill the measuring cup with 50 ml of warm tap water. If you want to make colorful figures, dissolve some of the dye paper in the water.
2. Pour the water into the yogurt container. Use a paper towel to dry the measuring cup, then use it to measure 80 g of plaster powder (up to the 100-ml mark on the measuring cup), trying not to produce a lot of dust. Add the plaster powder to the yogurt container.
3. Carefully stir the mixture with a wooden spatula until it is free of lumps.
4. Pour the mixture into the four small depressions in the plastic mold. Let the plaster dry for at least one day.



5. After the plaster has dried, carefully remove the figures from the mold. With scissors, separate the basin from the geode mold. Make a new solution out of 50 g of alum and 250 ml distilled water. You can color your crystals by adding a some of the dye paper to the solution.
6. Carefully take the jar with the hot solution out of the pot (caution, it is hot!) and empty it into the basin with two of the plaster figures. Be careful not to splash any of the hot solution.
7. Let it cool off in a quiet place for 1 to 2 days.
8. Remove the crystal-coated figures with a wooden spatula. Note: The crystals are not waterproof. Keep the rest of the alum solution, as you will need it for Experiment 9.





TIP

THE PLASTER LEFTOVERS IN THE YOGURT CUP CAN BE SCOOPED OUT AND DISCARDED IN THE HOUSEHOLD TRASH SO THAT YOU CAN USE THE YOGURT CUP FOR FURTHER EXPERIMENTS. ONCE ALL OF THE PLASTER IS DISCARDED, YOU CAN RINSE THE YOGURT CUP UNDER RUNNING WATER.

EXPERIMENT 9

Artificial crystal layer

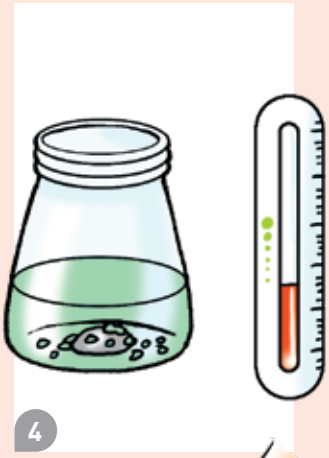
You will need

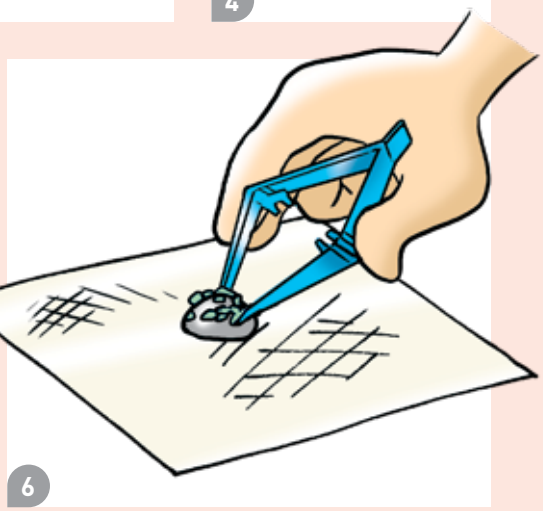
- **Alum solution from Experiment 9**
- **2 Wooden spatulas**
- **Tweezers**
- *Empty, labeled jelly jar*
- *Pot with hot water (no longer boiling)*
- *Paper towels*
- *Pot holders*
- *Distilled water*
- *Stone (about 3 cm, with a rough but flat surface)*

Here's how

1. Pour the rest of the solution with the crystal sediment from Experiment 8 into a jelly jar.
2. Set the open jelly jar in a pot of hot water and stir with the wooden spatula until everything is dissolved.
3. Carefully take the jar with the solution out of the pot (caution, it is hot!) and place a stone in it. Be careful not to splash any of the hot solution.
4. As the solution cools in a quiet spot, crystals will quickly form on the bottom of the jar and on the stone itself.
5. Remove the stone with one or two wooden spatulas. You can heat the solution again and repeat the entire process to make the crystals grow even larger. Finally, let the stone dry on a paper towel. It works just as well with the evaporation method (as in Experiment 4). That method takes longer, but the crystals grow larger.

Be careful when handling the hot water!





WHAT'S HAPPENING?

Crystals can also be found growing on the outside of rocks, just like the one you just created. This type of crystal growth, in which a coating of fine crystals forms on a rock's fractured surface is called **druse**.

CHECK IT OUT!

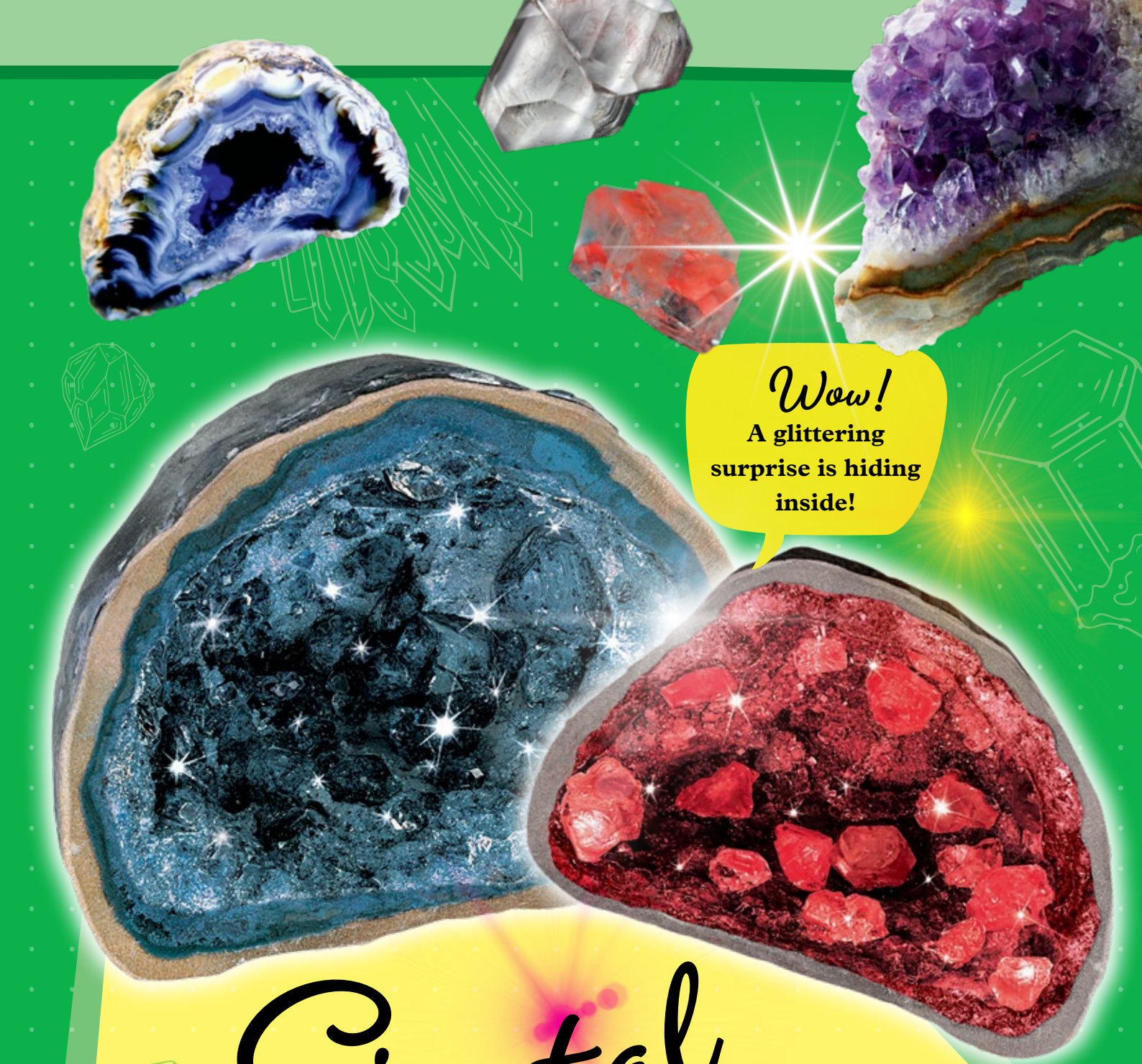
Crystals for Good Luck

Some crystals are blue, green, or red, while others are as colorless as ice. The most beautiful among them, with names like diamond, sapphire, and emerald, are considered precious, and are used to make valuable jewelry, even adorning the crowns of kings and queens. Crystals have also been considered magical lucky charms, with records showing that the ancient Egyptians used them to ward off harm. Today, crystals are used to practice a type of alternative medicine, called crystal healing. Because there is no scientific basis for the healing properties of crystals, it is considered a pseudoscience.

Special gems

Famous Gems

A crystal, particularly a gemstone, can be extremely valuable based on its size, rarity, or if it has an exciting story behind it. The world's largest diamond, the Cullinan Diamond, was found in South Africa in 1905. Prior to being split to create 105 stones, this diamond weighed 3,106.75 carats. (A **carat** is the unit used to indicate the mass of a gemstone. One carat equals 0.2 grams, so the Cullinan Diamond weighed a total of 621.35 grams!) Today, the largest cut of the diamond alone (called the Great Star of Africa) is worth an estimated $400 million. As of 2022, the most expensive sale of a diamond is the Pink Star Diamond, which sold for $71.2 million. It is the largest known diamond with a color rated Fancy Vivid Pink, which makes it exceptionally rare. The Hope Diamond, a 45.52-carat dark greyish-blue diamond, was worn by Marie Antoinette, among other French and English nobility, giving it an estimated worth of up to $350 million.



Crystal GEODE

Were you ever told you shouldn't judge something based on its outward appearance? The same thing can be said for rocks, as some contain spectacular crystals that can be revealed using a geologist's rock pick. This is called a **geode,** which is a cavity in a rock that becomes lined with crystals or other mineral matter. In this chapter, you will create a geode of your own!

Creating the plaster mold

You will need

– Plaster powder
– Large and small measuring cup
– Dye paper
– Spatula
– Hollow mold for geode
– Larger crystals from previous experiments
– Large empty yogurt container (about 250 ml)
– Tap water
– Black ink cartridge (optional)
– Old newspapers

Here's how

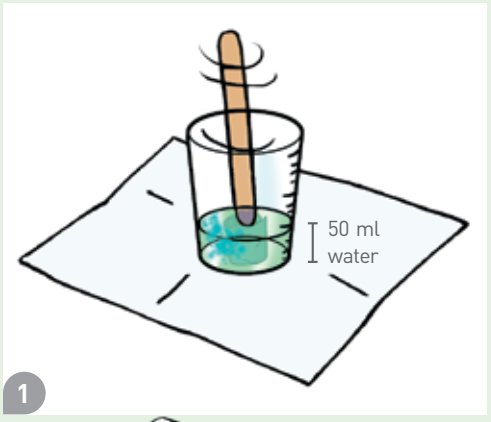
1. Cover your work surface with sheets of old newspaper. Fill the large measuring cup to just under the 50 ml mark with warm tap water. Add the dye paper to tint the water. After removing the paper, there should still be about 45 ml of water in the cup.

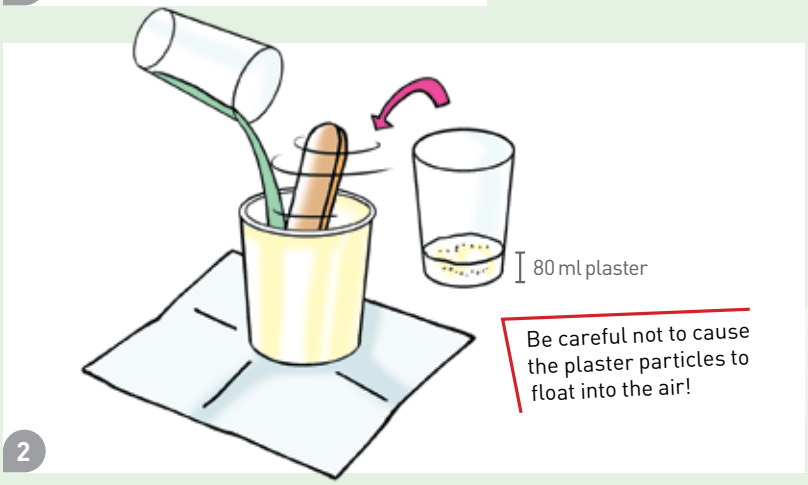
2. Add this solution to the yogurt container and shake 80 g of the plaster powder into it (up to the 100-ml mark). Stir the mixture with a wooden spatula until it is free of lumps.

3. Pour the plaster mixture into the geode mold. It won't even fill it halfway.

4. To create the hollow shape for the geode, spread the mixture against the walls of the mold with the wooden spatula, making a cavity in the middle. You have to work fast — the mixture will harden within a few minutes, and you need to complete step 5 before it does. Be sure not to make the walls too thin (or your geode will break!). The wall surface should be rough.

5. Before the plaster has hardened, sprinkle the alum crystals from earlier experiments evenly over the inner walls of the geode, and press them lightly into the plaster. These will help to hold the crystals to the plaster foundation as they form later on. Let your geode dry for one day, and make sure to leave it inside the mold.





EXPERIMENT 11

Crystal Growth

You will need

– Plaster geode from Experiment 10
– Small measuring cup
– Large measuring cup
– Dye paper
– Pipette
– Wooden spatula
– Alum packet
– Distilled water
– Empty jelly jar
– Pot with hot water (no longer boiling)
– Paper towels
– Pot holders
– Old newspapers

Here's how

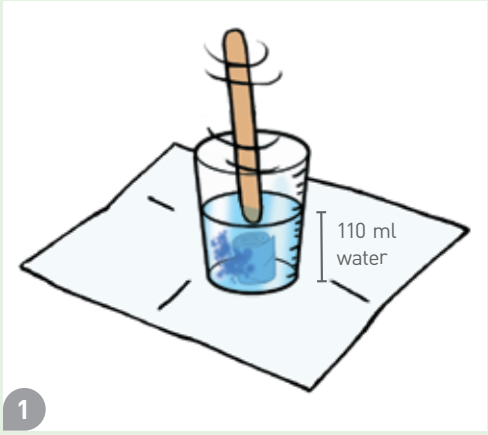
1. Cover your work surface with sheets of old newspaper. In the small measuring cup, dissolve some dye paper in 110 ml of distilled water (of course, you can grow colorless crystals if you prefer). After removing the paper, you should be left with 90 ml of liquid.

2. Pour the 90 ml of liquid into the jelly jar. Add a 20 g packet of alum. You can also add a couple of the crystals from your treasure chest.

3. Set the jelly jar in the pot of hot water, and stir with the wooden spatula until everything is dissolved. Once the alum has dissolved, remove the jar from the hot water bath and set it somewhere where it will be allowed to cool without being disturbed.

4. Meanwhile, set the plaster mold in a quiet place and support its sides so it can't tip over. You can use blocks or books, for example.

5. Once the solution has cooled sufficiently, pour it into the plaster geode up to the brim. It will be hard to prevent some from seeping between the plaster and the plastic mold, but it won't really matter. Be careful not to let any of the dye solution spill outside of the mold.



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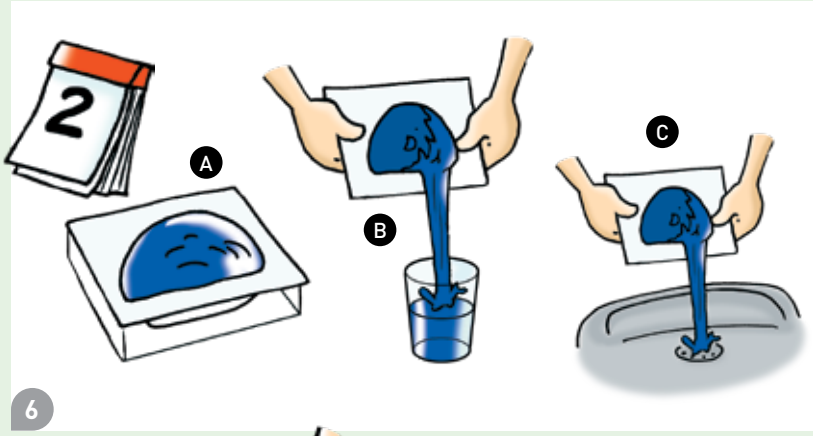
Be careful when handling the hot water!


4


5

6. Let the geode sit quietly for two days. Then, carefully pour off the dye solution into the measuring cup and take a look at your geode. Be careful: it's still dripping! If you want bigger crystals, pour the dye solution back in and let it sit a few more days. Otherwise, pour the dye solution down the drain along with a lot of water. Be careful: the solution can stain the sink!

7. Let the crystal geode dry for a day. Then you can carefully release it from the plastic mold by loosening the edges of the mold a little and then pushing firmly from the bottom. It's best to do this over an old sheet of newspaper. The crumbs of colored plaster that fall out in the process can be thrown away in the trash along with the newspaper.



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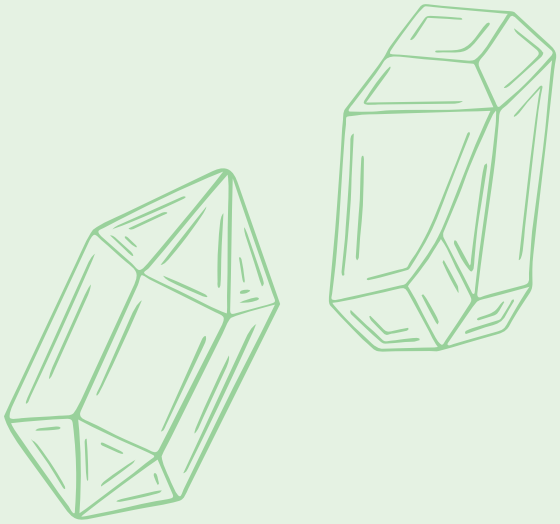


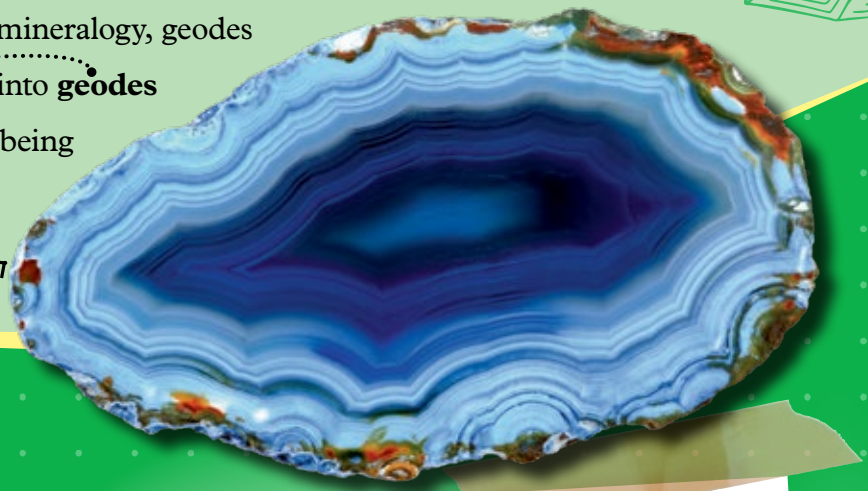
TIP

IF YOU WANT TO MAKE YOUR GEODE MORE BEAUTIFUL, YOU CAN SMOOTH THE OUTSIDE OF IT DOWN BY GENTLY RUBBING IT WITH A PIECE OF SANDPAPER.

What Is a Geode?

Geodes are usually formed in **volcanic rock.** As the lava flow cools, gas bubbles form, which can create cavities with diameters ranging from a few centimeters to several meters. Water containing lots of minerals then seeps into these cavities and crystallizes over time. The crystal-filled bubbles are called **geodes**.

In mineralogy, geodes are further divided into **geodes** and agates. **Agates** are characterized by being completely filled with crystals, while geodes have a cavity inside.



KEYWORD Gypsum

Gypsum is a salt of sulfuric acid with the chemical element calcium. In its pure state, it is a white powder that is poorly soluble in water. In nature, however, gypsum also occurs in beautiful, sometimes crystal-clear crystals. Plaster of Paris is produced by heating gypsum to around 110 °C. If you stir it into a paste with a little water, it solidifies within a few minutes. Even the Romans used this hardening substance as plaster when building houses. Today, gypsum is used as a raw material, building material as well as model and mold plaster, e.g. in dental technology.

Where can we find GEODES?

Geodes can be found wherever the geology is suitable for them to grow. Many of the geodes that are sold commercially come from South America. Brazil, in particular, is known for amethyst geodes that are several meters tall, found in the large igneous province (an accumulation of igneous rocks) called the Paraná-Etendeka traps. Geodes are also found in North America. Fun fact: In Oregon, geodes are colloquially referred to as "thundereggs."

EXPERIMENT 12

Scientists keep lab notebooks to keep track of their findings. Create a crystal growing notebook. For example: I started growing my crystals on _____ at _____ o'clock. After _____ days, I discovered the first crystal. On _____ at _____ o'clock, I took out the crystals. The temperature is _____ . _____ crystals have grown. The tallest is _____ cm tall, What do you notice? What conclusions can you draw? What other variables can you change to design a new experiment?

EXPERIMENT 13

Compare the crystals from the two jelly jars. How do they differ?

	JAR WITHOUT LID AND TOWEL	JAR WITH LID AND TOWEL
NUMBER OF CRYSTALS		
SIZE		
SHAPE		
FIRST CRYSTAL DISCOVERED ON		

EXPERIMENT 14

Log the progress of your crystal growth in the table. (For example: when you suspend the crystal in the solution with the cord, enter the date in the first column, what you did in the second column, and your findings in the third.)

DATE	WHAT HAVE I DONE?	HOW BIG IS THE CRYSTAL?
	CRYSTAL SOLUTION PRODUCED AND CRYSTAL SUSPENDED IN SOLUTION.	THE CRYSTAL IS ___ CM IN SIZE.

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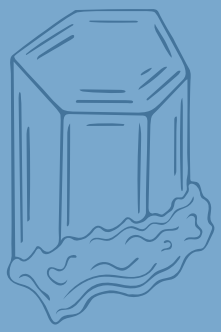

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