EXPERIMENT MANUAL

CRYSTAL GROWING

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

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.

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First Aid Information

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

››› **In case of eye contact:** Wash out eye with plenty of water, holding eye open if necessary. Seek immediate medical advice.
››› **If swallowed:** Wash out mouth with water, drink some fresh water. Do not induce vomiting. Seek immediate medical advice.
››› **In case of inhalation:** Remove person to fresh air. For example, move person into another room with open windows or outside.
››› **In case of skin contact and burns:** Wash affected area with plenty of water for at least 10 minutes. Cover burns with a bandage. Never apply oil, powder, or flour to the wound. Do not lance blisters. For larger burns, seek immediate medical help.
››› **In case of cuts:** Do not touch or rinse with water. Do not apply any ointments, powders, or the like. Dress the wound with a germ-free, dry first-aid bandage. Foreign objects such as glass splinters should only be removed from the wound by a doctor. Seek medical advice if you feel a sharp or throbbing pain.
››› In case of doubt, seek medical advice without delay. Take the chemical and/or product and its container with you.
››› In case of injury always seek medical advice.

Poison Control Centers (United States)

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

1-800-222-1222

Local Hospital or Poison Centre (Europe)

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

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

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

An experiment to hit the ground running

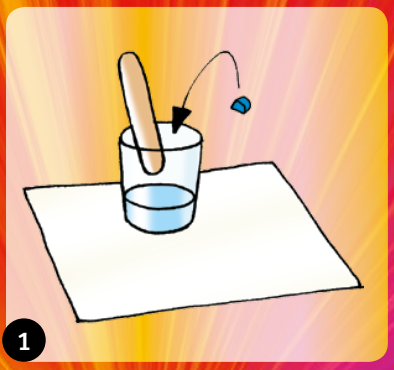
What happens when you place a colored piece of sugar in water? Try it and prepare to be surprised!

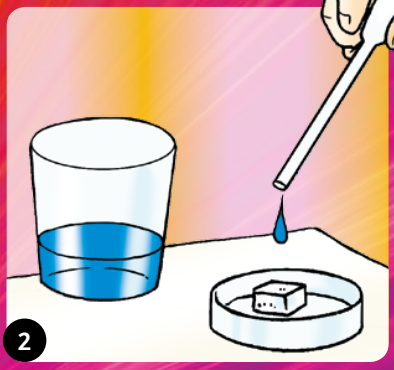
A colorful sugar star

YOU WILL NEED

- **2 small measuring cups**
- **Lid for one small measuring cup**
- **Dye tablet**
- **Pipette**
- **Wooden spatula**
- *Sugar cube*
- *Large shadow plate*
- *Tap water*
- *Paper towel*

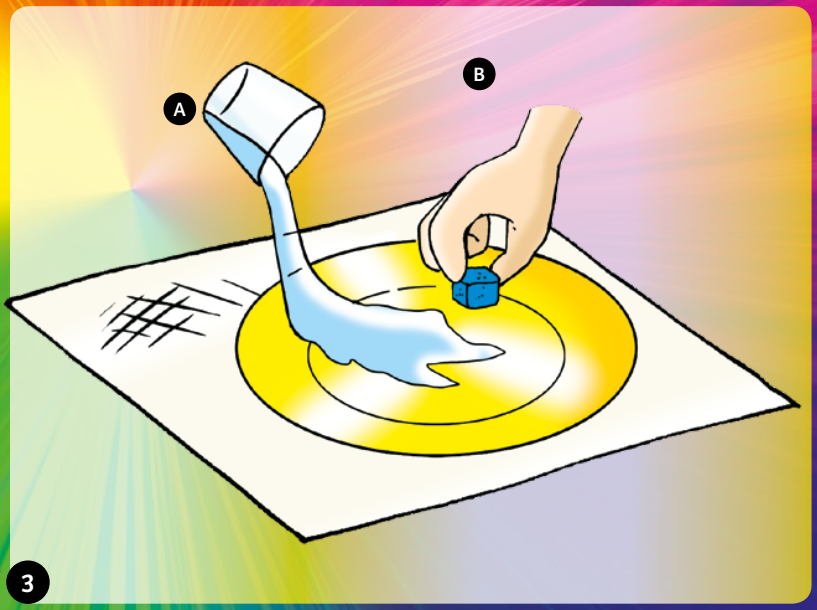
EAGER FOR MORE?
Then come along into the glittering world of crystals...





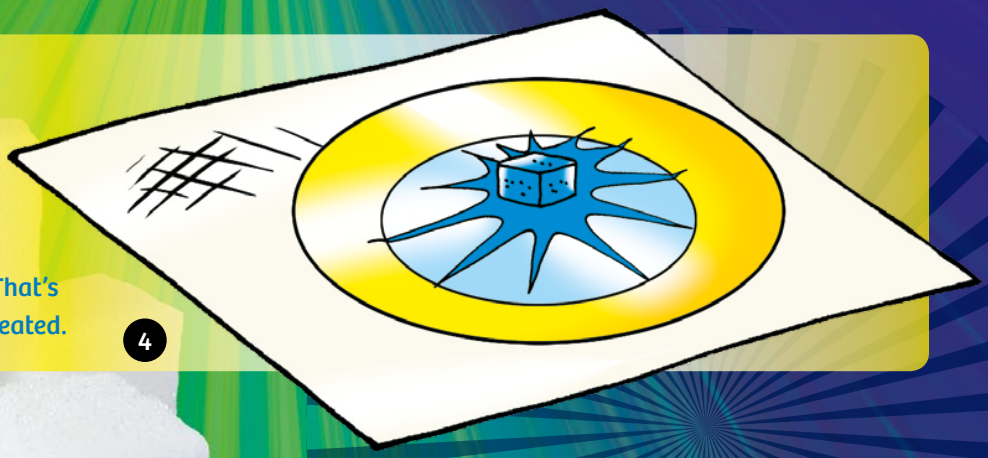
HERE'S HOW:

1. Dissolve a small crumb of dye tablet 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 colored sugar cube in its center.
4. A star takes shape.
5. Pour the colored sugar solution down the drain after the experiment and rinse the sink with water.



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.



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.

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

What's in your experiment kit:

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

Checklist: Find – Inspect – Check off

✔	No.	Description	Quantity	Item No.
❍	1	Geode mold and basin	1	703 028
❍	2	Mold for figures and shapes	1	703 029
❍	3	Plaster (calcium sulfate) bag	1	770 800
		Potassium aluminium sulfate (potassium alum):		
❍	4a	50 g packet	1	771 061
❍	4b	20 g packet	4	772 060
❍	5	Sodium acetate	1	771 062
❍	6	Sodium sulfate	1	771 063
❍	7	Lid remover	1	070 177
❍	8	Pipette	1	232 134
❍	9	Wooden spatula	3	000 239
❍	10	Packet of dye tablets	1	039 051

✔	No.	Description	Quantity	Item No.
❍	11	Measuring cup, 200 ml	1	702 810
❍	12	Lid for measuring cup	1	087 087
❍	13	Measuring cup, red, 30 ml	1	065 099
❍	14	Measuring cup, blue, 30 ml	1	065 100
❍	15	Measuring cup, yellow, 30 ml	1	065 101
❍	16	Lid for measuring cup, small	3	061 160
❍	17	Treasure chest	1	700 739

You will also need: *distilled water (about 1 liter), adhesive labels, pencil, transparent tape, thermometer, paper towels, pot holders, small, worn-out cooking pot (20 cm diameter), electric hot plate or electric kettle, at least 6 empty jelly or honey jars with lids (about 200 ml capacity), yarn or nylon string, scissors, all-purpose glue, old newspapers, empty yogurt container (250 ml), small pebbles, sandpaper, cloth handkerchief, knife, rubber band*

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TIP!
You will find supplemental information in the "Check it out" sections on pages 21, 26, 27, and 32.

So nothing goes wrong: A word to parents

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

Advice for supervising adults

Dear Parents,

With this crystal growing set, you will be accompanying 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.

A. 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.

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

C. This 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.

D. 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.

E. 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.

F. The area surrounding the experiment should be kept clear of any obstructions and away from the storage of food. It should be well lit and ventilated and close to a water supply. A solid table with a heat resistant top should be provided.

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

H. The working area should be cleaned immediately after carrying out the activity.

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

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

While experimenting, please be careful not to let the crystal salts (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 tablets will color things very intensely and may cause stains that can't be washed out of clothing. Keep all tablecloths, curtains, and carpets away from the experiment area. The child should wear old clothes when working.

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

Always get any required equipment and chemicals ready before beginning an experiment.

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

Basic rules for safe experimentation (safety rules)

Stop! Read this first, before you begin!

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

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

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

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

4. Clean all equipment after use.

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

6. Wash hands after carrying out experiments.

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

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

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

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

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

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

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

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

15. 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.

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

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

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

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

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

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

22. With additionally required products (such as all-purpose glue) also take note of the warnings on their packaging.

Practical tips for growing crystals

Safety...

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

Be particularly careful with hot burners, and don't forget to turn them off after use!

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

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

When handling plaster, follow these safety rules:
› **Do not place the materials in the mouth.**
› **Do not inhale dust or powder.**
› **Do not apply to the body.**

Information on handling chemicals

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

Calcium sulfate (gypsum or plaster powder):
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.

Sodium acetate: (No specific warnings)

Sodium sulfate: (No specific warnings)

Your experiment area...

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

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

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

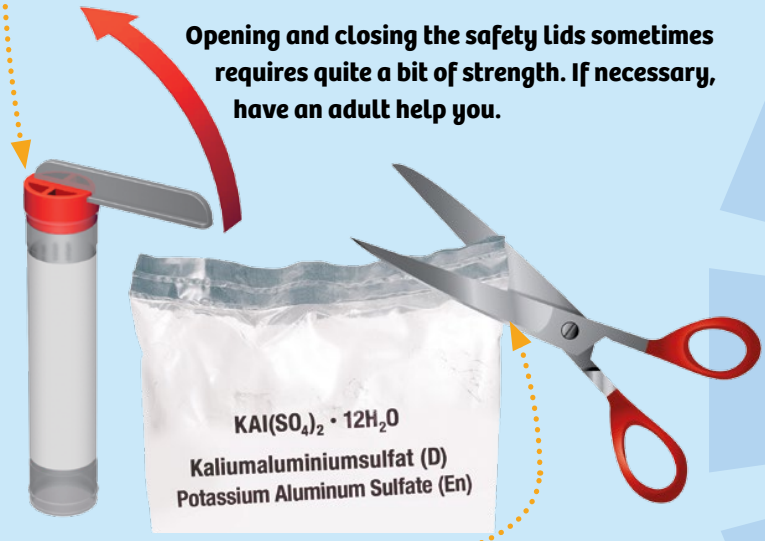
››› WARNING! The following applies to all chemicals: Store locked up. Keep out of reach of children. This primarily applies to young children, but also to older children who — unlike the experimenter — have not been appropriately instructed by adults.

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

The **chemical vials** have two chambers, a large one for larger quantities and a small one for chemicals that you only need to use in small amounts. The quantities inside them correspond to what you will need as well as requirements that apply to chemistry sets.

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

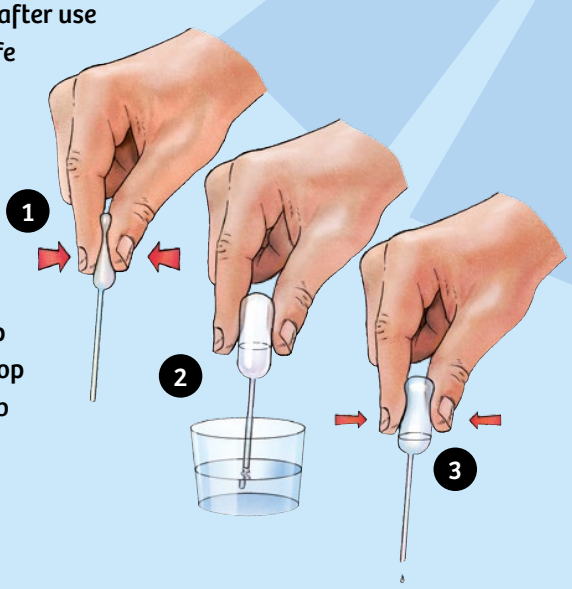
Opening and closing the safety lids sometimes requires quite a bit of strength. If necessary, have an adult help you.



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

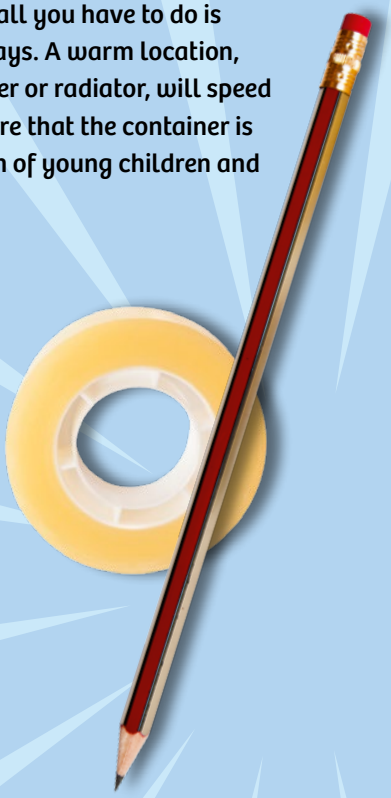
The alum packet should be completely used up during the experiment. Close the plaster bag immediately after use with a clip or a piece of tape, and keep it in a safe place.

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



For growing the crystals...

...you will need some additional containers. 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. You have to be sure to label the jars clearly. Self-adhesive labels are ideal, marked with a pencil (ink would get smeared by water), and then covered over with transparent tape to protect them from water. If you want to dry the contents, all you have to do is remove the lid for a few days. A warm location, such as a spot near a heater or radiator, will speed up evaporation. Just be sure that the container is stable and out of the reach of young children and pets!



Various chemicals...

...are included in the kit.

› **Potassium aluminium sulfate** (potassium alum, or simply alum) crystallizes particularly easily and well.
› **Sodium acetate** forms pretty, colorless crystalline needles.
› **Sodium sulfate** forms a white powder or colorless crystals, and displays a very unusual effect when it crystallizes. (More about that later.)
› **Plaster** (calcium sulfate) will be used to form "geodes" to grow crystals in, as well as other small shapes that you can make crystals grow on.
› **Various dye tablets** 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's 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 their function. The age of your crystal salts will likewise make no difference.

Water

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

When heating the solutions...

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

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

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

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

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

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

The quantity of water ...

...that you will need for your experiments is indicated in milliliters, or ml for short. Use the large measuring cup to measure precise quantities of water. It has a scale on its side with ml marks on it. Its total capacity is 200 ml. To measure the amount of crystal salt required for each experiment, use the small measuring cups.

While experimenting...

...with a substance, you will have a solution-filled jelly jar, and possibly a second jar with moist crystals to be re-dissolved, at your work place.

Note: All filled jars should have a label marked with the jar's contents.

If you have concluded all the experiments with a chemical and you are pleased with your crystals, you should only save the leftover substance in a solid state. To do that, let the jars stand open for a few weeks in a warm, out-of-the-way location. Cover them with a thin piece of cloth (a cloth handkerchief, for example) fastened over the top of the jar with a rubber band. This will prevent dust and insects from falling in.

Make absolutely sure that young children and pets cannot get to the chemicals!

Every couple days, check the jars and push any crystals back down into the jar. Once the contents are finally dry, you can return them to their containers in the experiment kit.

You can save your alum crystals and other trinkets in the treasure chest, which you can then lock with the screw.

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.

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 out of the way, and eventually throw away in the household garbage. These leftover chemicals can be mixed together without any danger.

Crystals: Miracles of Nature

Crystals are fascinating natural marvels. They can form cubes, sharp needles, twisted squares or octahedra, or other complex shapes with smooth, glittering surfaces. This emergence of order seemingly out of nowhere is something you will experience yourself when using the chemicals in this experiment kit. In addition, you can learn something about the processes taking place as the crystals grow, and the best methods for growing large crystals.

BASIC CONCEPTS

Basic concepts for crystal growers

[Solubility], *noun;*
Solubility means how many grams of a substance can dissolve in 100 g (100 ml) of liquid. The material in which something is dissolved is called a solvent by chemists. In our case, the solvent will be water.

[Temperature], *noun;*
Solubility normally increases as the temperature increases. Warm or hot water will dissolve a lot more of most chemicals than cold water. Table salt is an exception, though. Its solubility hardly changes at different temperatures.

[Saturated solution], *noun;*
A solution is said to be saturated when it contains as much of a substance as can possibly dissolve in it at a given temperature. A saturated sodium sulfate solution, for example, holds 16 g of sodium sulfate per 100 g of solution at 20 °C (68 °F). But if a saturated solution is heated, it will no longer be saturated, and it becomes capable of dissolving more of the substance. If, on the other hand, you cool a saturated solution, it becomes supersaturated: Now it contains more sodium sulfate (to use the same example) than it can hold at the lower temperature. Solid sodium sulfate will separate out on the bottom of the container and along the container's walls, in the form of crystals. Crystals always grow only from supersaturated solutions.

There are various ways to produce a supersaturated solution. We will use two of them when we grow crystals:

1. EVAPORATION METHOD

Using the evaporation of a saturated solution to form crystals is known as the evaporation method. In this method, only the water evaporates, reducing the quantity of water, while the amount of substance contained in it remains the same. This means that the solution gradually becomes supersaturated.

2. COOLING METHOD

Using the cooling of a saturated solution to form crystals is known as the cooling method. The cooling method works very quickly. An alum solution that is saturated at 60 °C (140 °F) deposits most of its alum in the form of crystals when it is cooled to 20 °C (68 °F).

But even if you let the solution cool as slowly as possible by pouring it into an insulated basin, the crystals will not look very pretty. You will get masses of crowded crystals forming along the walls and on the bottom of the container, keeping one another from developing the crystal shapes that are otherwise typical of that substance. A strongly supersaturated solution, in other words, will not produce very nice crystals. It is better to use a solution that is just barely supersaturated.

The cooling method is good, though, for quickly creating lots of small individual crystals, which you can then coax along to form larger, prettier crystals by using the evaporation method. Due to the slow evaporation of water from the container, the solution is always just barely supersaturated. This method does require a few weeks of time however.

Growing Crystals

Crystals need to be left in peace and given enough time to grow, if you want them to grow big and acquire the shapes that are characteristic of their particular substances. In this chapter, you will get to know some of the special qualities of the substances alum, sodium sulfate, and sodium acetate, and you will use them to create crystals to put inside your treasure chest.

EXPERIMENT 1

Your first crystals

YOU WILL NEED

- **20 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)*
- *Paper towels*
- *Pot holder*
- *2 labels*
- *Pencil*

HERE'S HOW:

1. Place a small packet's worth of alum in the jelly jar and add 80 ml 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!), put the lid on, and affix a label. Let it sit in a quiet place to cool. Soon, colorless crystals will form on the bottom. If no crystals have formed after a few days, add a few grains of alum salt.
4. The following day, carefully pour off the solution into a second jar. Affix a label marked "alum solution" and save it for the next experiment.
5. Use a wooden spatula to push the crystals onto a paper towel and let them dry. Sort out about 10 nice-looking crystals and save them in your treasure chest. You will need them later when you make your artificial crystal geodes.
6. Return the rest to the jar of alum solution.

WHAT'S HAPPENING?

A lot more alum will dissolve in hot water than at room temperature. As the liquid cools, the excess alum will crystallize out again. If the crystals aren't big enough, you can pour them back into the solution, heat it again, and wrap the jar tightly in a hand towel so it cools more slowly. Then the crystals will be bigger.

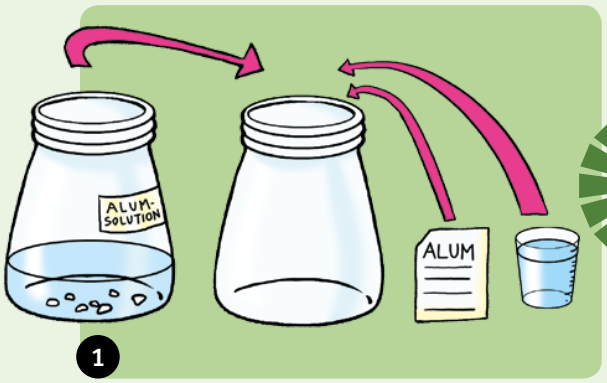
Signs of dissolution

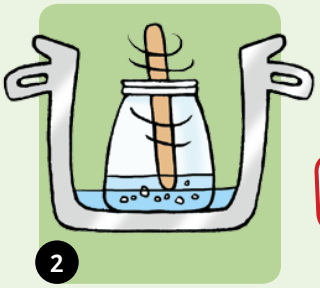
YOU WILL NEED

- **Alum solution from Experiment 1**
- **20 g alum packet**
- **Small measuring cup**
- **Wooden spatula**
- *Distilled water*
- *Empty jelly jar*
- *Pot holder*
- *Pot with hot water*

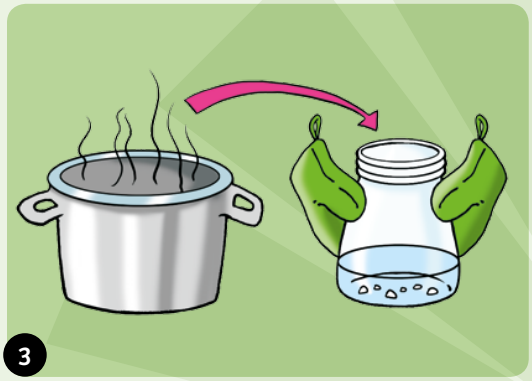
HERE'S HOW:

1. Pour the alum solution and the smaller, less-pretty crystals from Experiment 1 into an empty jelly jar, along with one small packet of alum and a small measuring cup of distilled water.
2. Set the open jar in the pot of hot water and stir repeatedly.
3. Remove the jar with the pot holder every 1 or 2 minutes (caution, it is hot!) and take a look to see what has dissolved. You will notice that the 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!



FACT SHEET: POTASSIUM ALUMINIUM SULFATE

Potassium aluminium sulfate, 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.

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.

EXPERIMENT 3

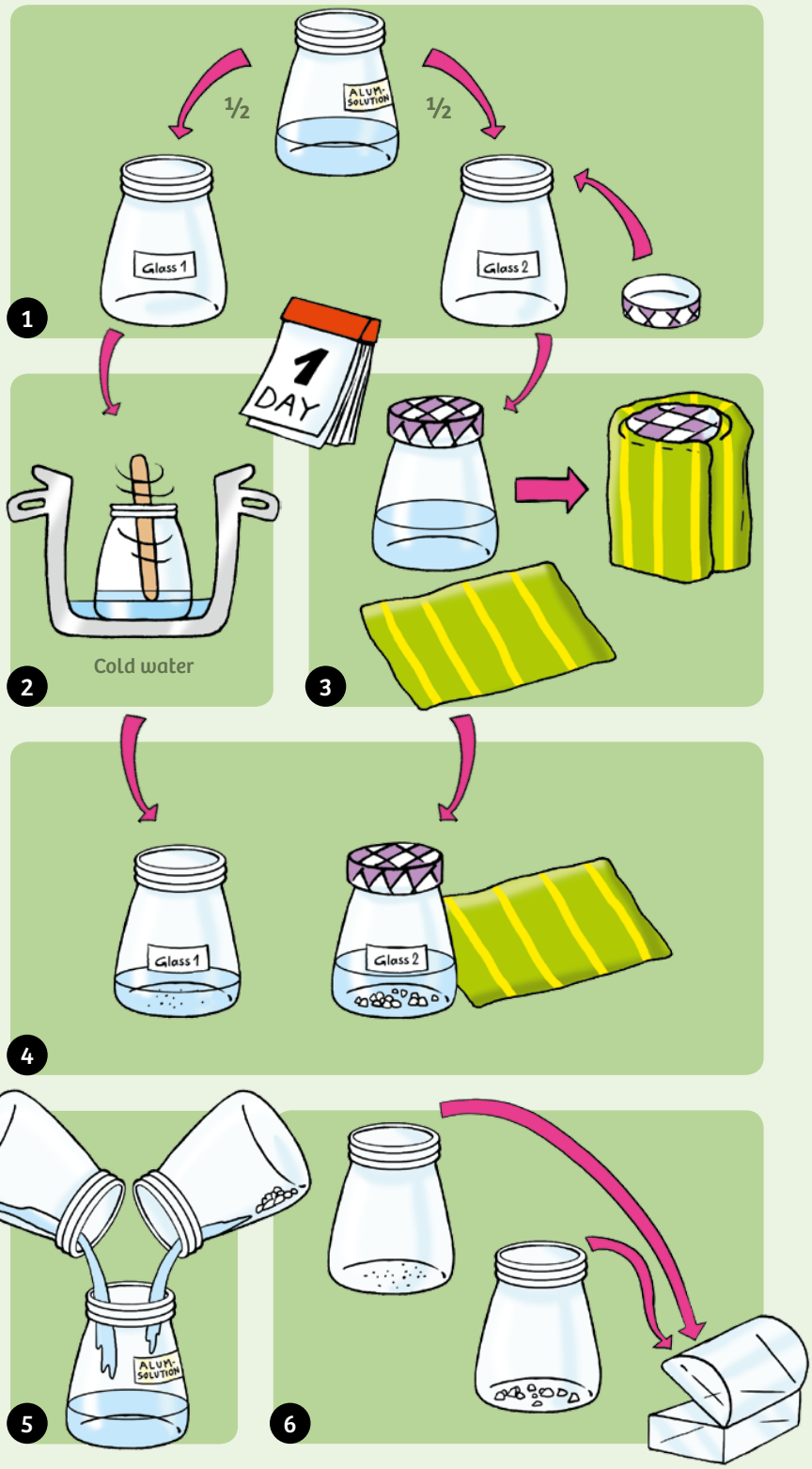
Fast and slow growth

YOU WILL NEED

- **Warm alum solution from Experiment 2**
- **Wooden spatula**
- **Treasure chest**
- *2 empty jelly jars*
- *Hand towel*
- *Pot with cold water*

HERE'S HOW:

1. Divide the warm alum solution evenly between the two labeled 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. You can store the crystals in the treasure chest.



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.

Larger crystals

In the first three experiments, you worked with the cooling method. If you want to create large individual crystals, the evaporation method works better.

YOU WILL NEED

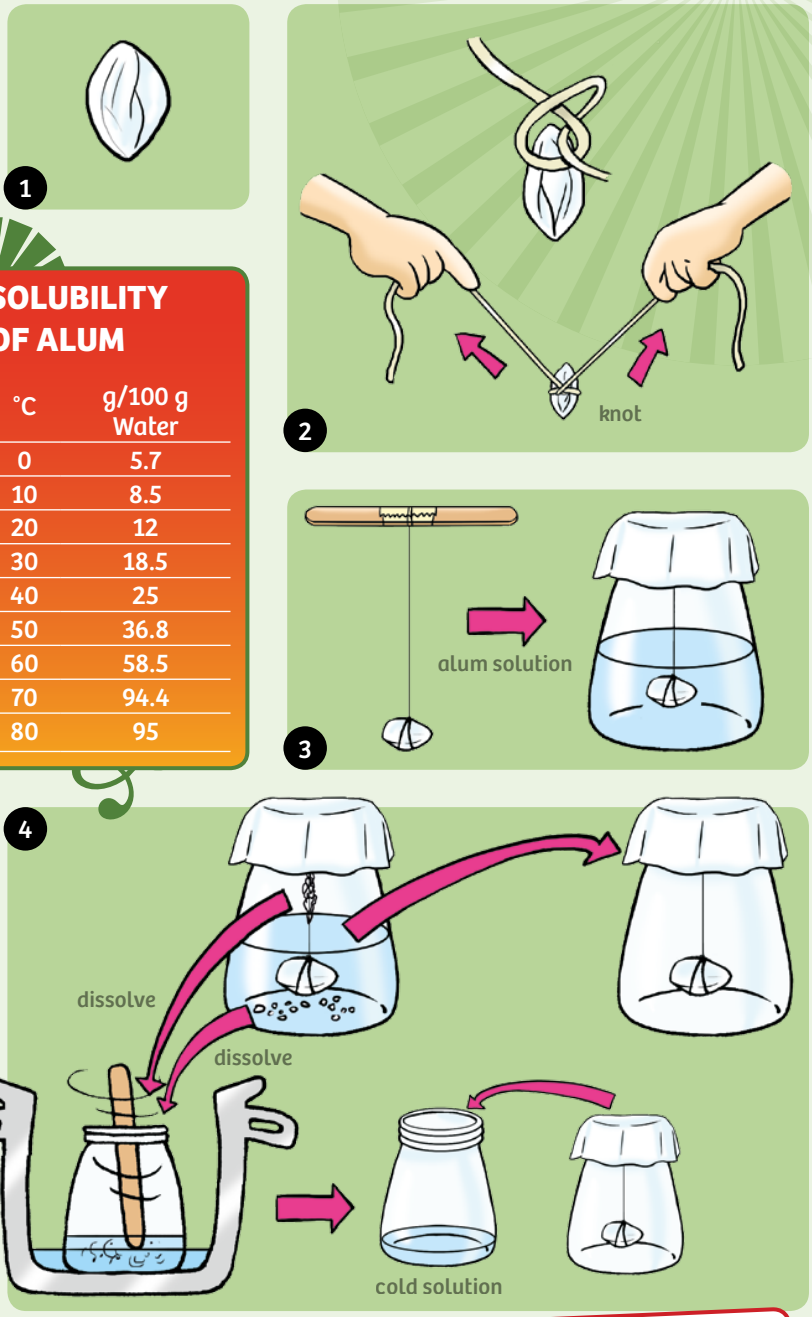
- **Warm alum solution from Experiment 3**
- **Large alum crystal from your treasure chest**
- **Wooden spatula**
- **Treasure chest**
- *Empty jelly jar, as tall as possible*
- *Yarn or nylon string*
- *Scissors, tape*
- *Paper towel, facial tissue*
- *Pot with warm water, pot holder*

HERE'S HOW:

1. Select one large alum crystal. This will serve as your seed crystal.
2. Cut a 10-cm length of yarn or nylon string. Tie a small loop at one end and fasten it to the seed crystal.
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.

SOLUBILITY OF ALUM

°C	g/100 g 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

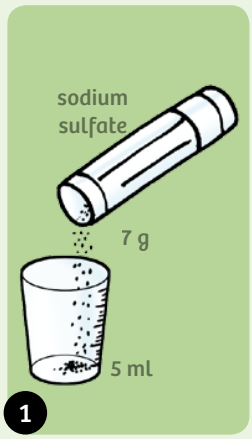


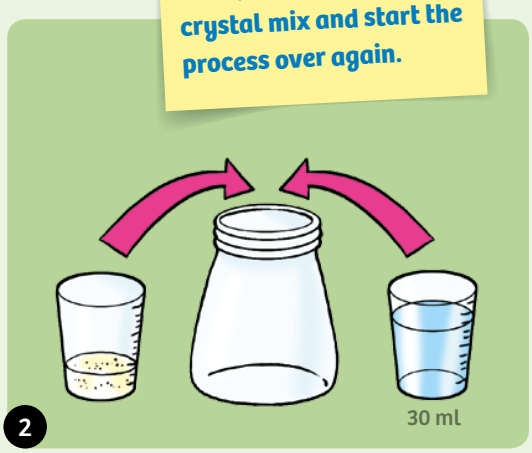
WHAT'S HAPPENING?

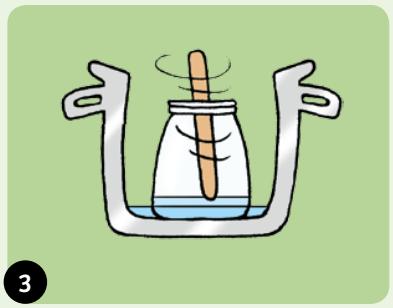
As the water evaporates, the solution is constantly kept slightly supersaturated. If you do your work properly, most of the excess alum will become deposited on the seed crystal dangling down into the solution, which will therefore grow bigger and bigger.

EXPERIMENT 5

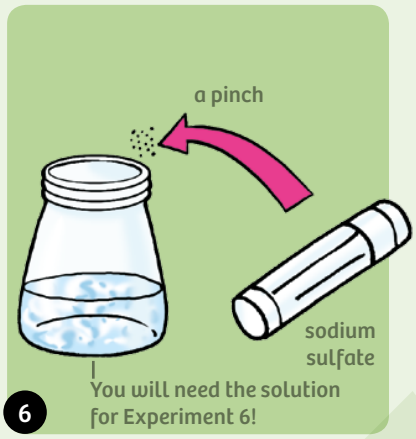
TIP!
To repeat the experiment, simply reheat the crystal mix and start the process over again.







Be careful when handling hot water!



WHAT'S HAPPENING?

In order to crystallize, the sodium sulfate needs a "push." That's what our seed crystal provides. Sometimes, dust particles or friction from the wooden spatula can have the same effect. As it hardens, the sodium sulfate gives off a portion of the heat energy that it took from the hot water. And because it crystallizes so rapidly, this heat is quickly released, and you can actually feel the temperature increasing.

Astounding sodium sulfate

A substance will usually crystallize out quite quickly if its solution is supersaturated. Sodium sulfate, though, is one of those salts that "forget" that and need to be reminded of it.

YOU WILL NEED

- **Sodium sulfate**
- **Lid opener**
- **2 small measuring cups, wooden spatula**
- *Distilled water*
- *2 empty, labeled jelly jars*
- *Paper towel*
- *Pot with hot water*
- *Pot holder*

HERE'S HOW:

1. Use the small measuring cup to measure 7 g of sodium sulfate (up to the 5 ml mark). Tap the cup gently on the table to make the powder settle evenly.
2. Transfer it to the jelly jar along with 30 ml of distilled water.
3. Heat the solution in a pot of hot water while stirring with the wooden spatula, until all the salt is completely dissolved. Make sure every last granule is dissolved!
4. Pour the solution into a clean jelly jar and let it sit in a cool, quiet place.
5. After one day, the solution will still be completely clear and liquid, even though it has cooled to room temperature. At 20 °C, 16 g of sodium sulfate will dissolve in 100 ml of water. So your solution is definitely supersaturated. And yet, no crystals have formed.
6. Now add a pinch of sodium sulfate to the jar. In just a short time, crystal needles will grow out from these granules and bind everything together into an ice-like mass. Not only that, but the jar will get noticeably warmer.

Crystals decomposing into powder

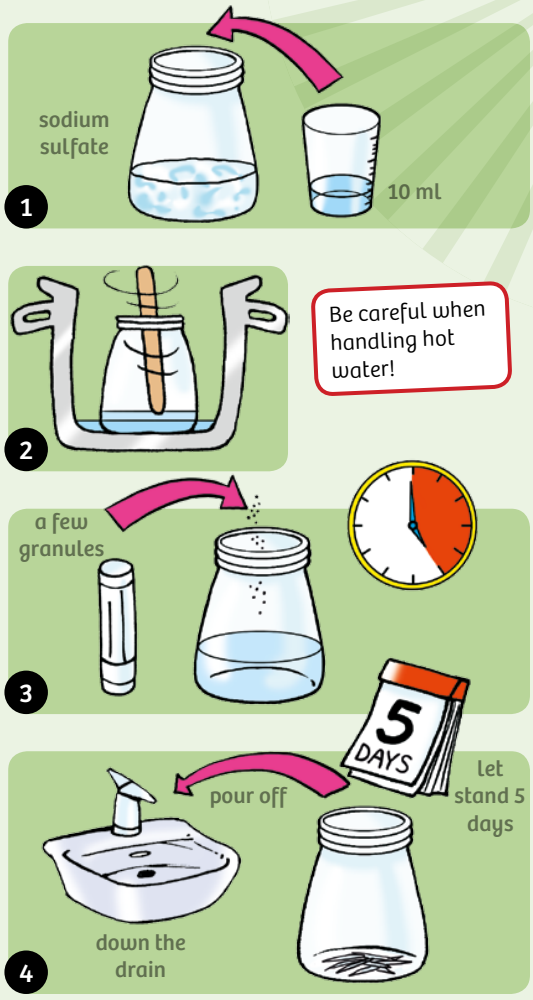
A lot of crystals are long-lived and won't change over the course of many years. But that doesn't apply to all substances.

YOU WILL NEED

- **Sodium sulfate mixture from Experiment 5**
- **Small measuring cup, wooden spatula**
- *Distilled water*
- *Empty jelly jar*
- *Paper towels*
- *Pot with hot water*
- *Pot holder*
- *Label and pencil*

HERE'S HOW:

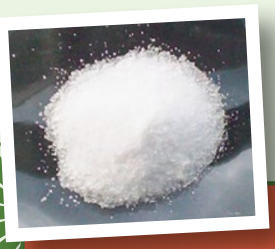
1. Add 10 ml of distilled water to the sodium sulfate mixture.
2. Set the jar in the hot water bath and stir until everything is dissolved.
3. Set the labeled jar in a cool, quiet spot. Optionally, add a few more granules of sodium sulfate to it. Within a few hours, pretty, clear, needle-shaped crystals will form.
4. Pour the remaining solution down the drain, rinsing it down with plenty of water. You can let the jar with the crystals stand open for a few days. The crystals will change into a white powder.



WHAT'S HAPPENING?

A lot of crystal salts contain water. This kind of water is known as **water of crystallization**. Individual water molecules are integrated firmly into certain locations of the crystal's structure. Alum contains twelve water molecules per alum molecule, sodium sulfate bonds ten water molecules to each of its own molecules, and sodium acetate bonds three.

Water of crystallization is normally bonded very tightly. It can only be pushed out of the crystal by heating, and what you then get is a water-free salt. But with sodium sulfate, the water will gradually start leaving the crystal structure at room temperature. The structure collapses — the crystal breaks down — leaving a white powder behind.



FACT SHEET: SODIUM SULFATE

Sodium sulfate is a sulfuric acid salt containing the chemical elements sulfur and oxygen. There is also some sodium in it, which you find in table salt (chemically, "sodium chloride"). It is also sometimes known as Glauber's salt after a 17th-century chemist.

In nature, sodium sulfate can be found in many types of mineral water and in some salt seas.

In small quantities, Glauber's salt works as a laxative, and it is sometimes sold for that purpose in drug stores. Much larger quantities are used in the production of washing detergents, for example, as well as for making paper and glass.

EXPERIMENT 7

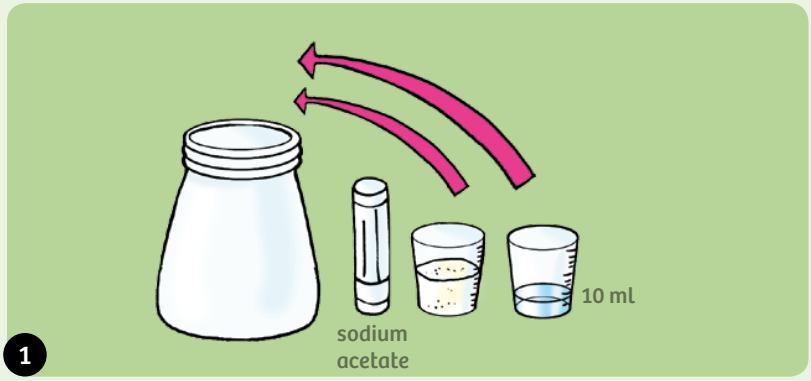
Needles of sodium acetate

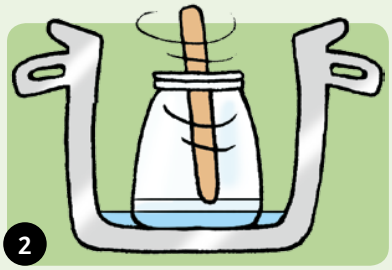
YOU WILL NEED

- **Sodium acetate**
- **Lid remover**
- **2 small measuring cups, wooden spatula**
- *Distilled water*
- *2 empty jelly jars*
- *Paper towels*
- *Pot with hot water*
- *Pot holder*
- *Label*
- *Pencil*

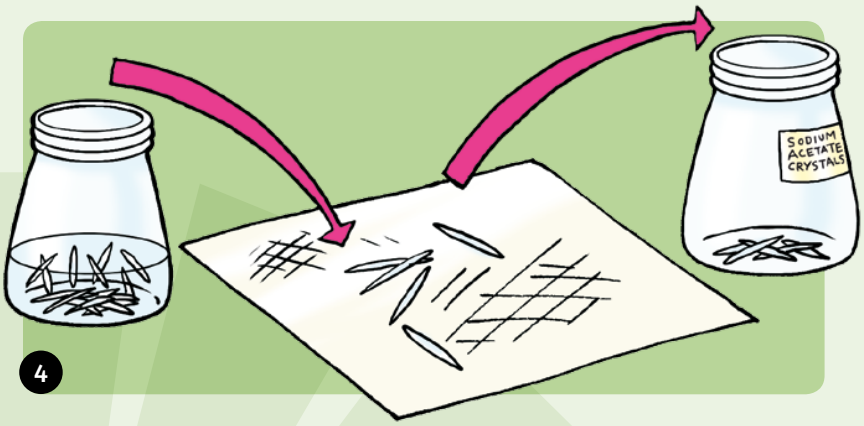
HERE'S HOW:

1. Place 5 g of sodium acetate (up to the 15 mark) in a jelly jar and add 10 ml of distilled water.
2. Heat the solution in a pot of hot water while stirring with a wooden spatula until everything is dissolved.
3. Let the solution sit in a quiet, cool place without moving it. It will form pretty, clear, needle-shaped crystals.
4. On the next day, pour the remaining solution off the crystals (down the drain), and shake the crystals onto a double layer of paper towels to dry. Save them in a labeled jar for the next experiment.





Be careful when handling hot water!



WHAT'S HAPPENING?

Sodium acetate crystallizes into needles when it is able to integrate water of crystallization into its crystal structure.

EXPERIMENT 8

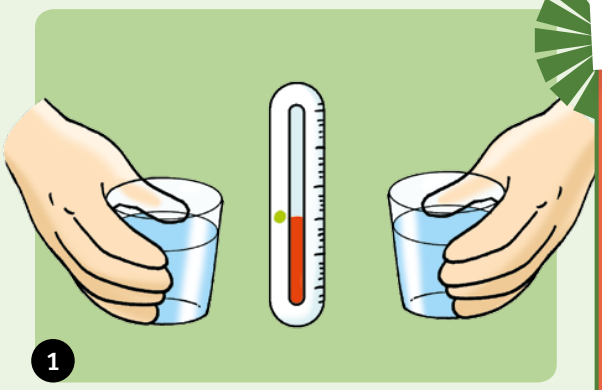
Cooling while dissolving

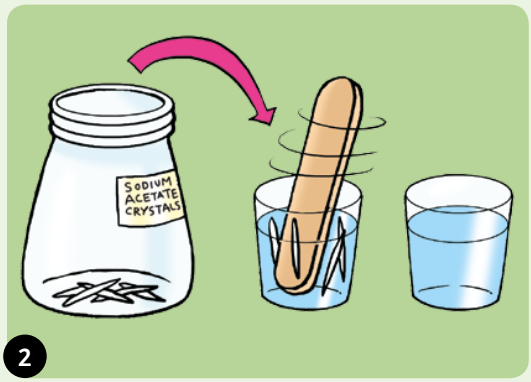
YOU WILL NEED

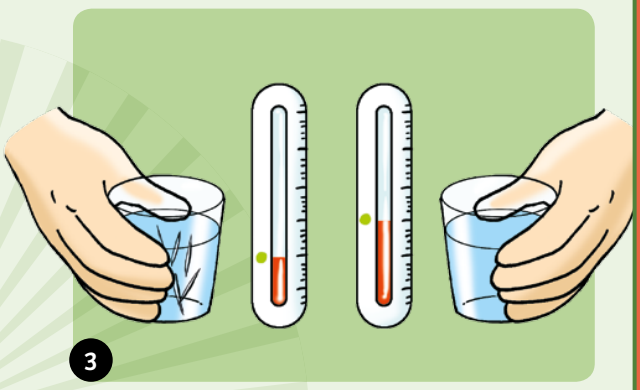
› **Sodium acetate crystals from Experiment 7**
› **2 small measuring cups, wooden spatula**
› *Distilled water*

HERE'S HOW:

1. Fill the two measuring cups with equal quantities of distilled water (room temperature). Touch the outside of both cups and note how warm or cool they feel.
2. Now dump the sodium acetate crystals into one of the cups and stir well with the spatula.
3. After 1 to 2 minutes, compare the temperatures of the two cups again. The one with the crystals will have become somewhat cooler.







WHAT'S HAPPENING?

In Experiment 5, you saw how a substance's change in state is always associated with an exchange of energy (usually heat energy). When the crystals dissolve in water, water molecules push their way into the crystal structure and dissolve the bonding forces between the molecules of the crystal. That takes energy. If you heat a salt solution to make the salt dissolve more quickly, you are specifically adding this energy as heat. With the sodium acetate though, you can easily feel how it takes the heat energy all by itself from its surroundings (the water) — and the solution gets noticeably cooler in the process.

FACT SHEET: SODIUM ACETATE

Sodium acetate is the sodium salt of acetic acid, which is the acid that makes vinegar taste sour. A solution of this white crystal powder in water wouldn't taste sour, though, but rather soapy.

Sodium acetate is used in the production of a lot of chemical substances, and it is also used as a food additive. It serves, among other things, to adjust the acidity of canned fruits and vegetables, as well as to season preserved fish products and salt and vinegar-flavored potato chips. Most of all, though, it is found in the heating pads sold in pharmacies or sporting goods stores, which are used as pocket warmers in winter or for medical heat therapy.

CHECK IT OUT

CRYSTALS & ENGINEERING

Natural and artificial crystals have found their way into new technologies. Silicon crystals, for example, serve to help generate electricity in solar cells. Pocket calculators and other electronic gadgets contain microchips made of silicon too. Quartz crystals, on the other hand, have a special quality: They can be nudged into performing electrical oscillations so they can be used as a clock or timer, much like a clock's pendulum. This comes in handy in quartz watches.

HOW LONG HAVE MINERALS EXISTED?

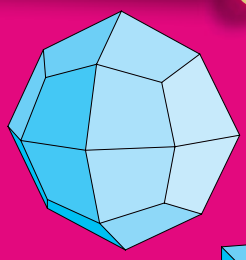
About 4.6 billion years ago, Earth was formed out of a giant cloud of dust in space. As it became more and more compressed, it heated up and turned into a glowing ball of fire orbiting the Sun. When that happened, the materials inside it separated according to their weight. The heavy, liquid iron sank to the bottom to form Earth's core, while the lighter materials made of oxygen, silicon, aluminium, and other chemical elements that were likewise still liquid floated to the top and formed Earth's mantle.
Earth cooled off, the surface hardened, and the liquid rock began to crystallize. That's how the first minerals were formed.

SALT FROM THE SEA

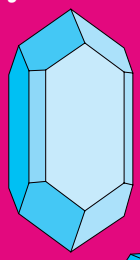
Seawater contains about 35 g of salt per liter. In warm countries, people fill large basins along the coasts with water, let it evaporate over a period of months under the hot sun, and then shovel together mounds of the resulting salt crystals. This kind of facility for obtaining salt is called a salt evaporation pond.

7 DIFFERENT CRYSTAL TYPES

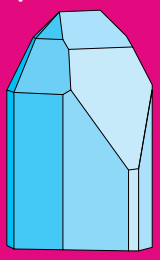
Crystals are divided into these 7 categories according to the regular arrangement of their surfaces:



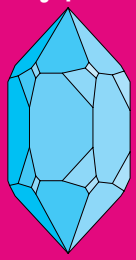
1. Cubic
e.g. garnet



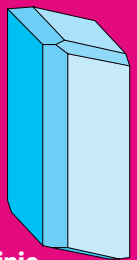
2. Tetragonal
e.g. rutile



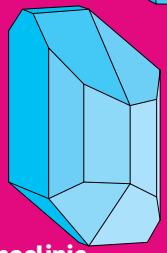
3. Orthorhombic
e.g. topaz



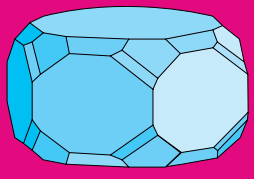
4. Trigonal
e.g. quartz



5. Triclinic
e.g. rhodonite



6. Monoclinic
e.g. azurite



7. Hexagonal
e.g. apatite

Crystal Decorations

Not only are crystals interesting, they are beautiful and decorative too. On the following pages, you will learn how to make beautiful decorations from plaster, food coloring, and alum crystal salt. The little plaster shapes in this kit are excellent for making crystal-studded ornaments.

EXPERIMENT 9

Crystal-adorned figures

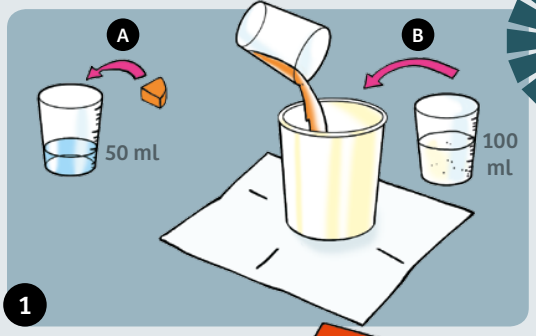
YOU WILL NEED

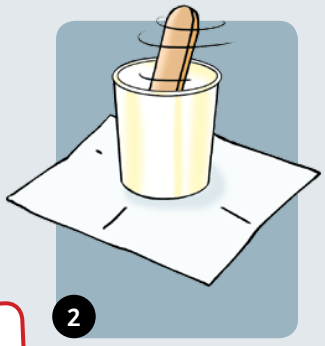
- **Plaster powder**
- **Dye tablets**
- **Large measuring cup, wooden spatula**
- **Plastic mold and basin**
- **50 g Alum packet**
- *Large, empty yogurt container (about 250 ml)*
- *Old newspapers*
- *Distilled water or tap water*
- *Empty jelly jar*
- *Pot with hot water (no longer boiling)*
- *Paper towels*
- *Pot holders*

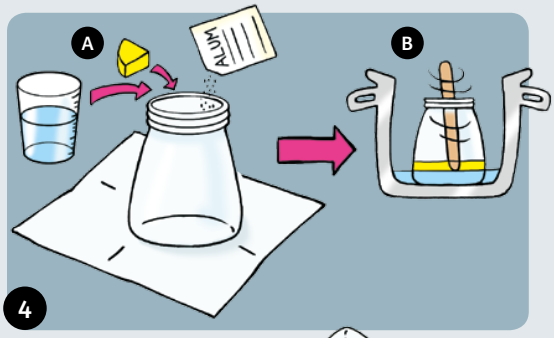
Be careful when handling hot water!

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 a quarter of a dye tablet in water. Mix the water together with 80 g of plaster powder (up to the 100-ml mark) in a yogurt container, trying not to produce a lot of dust.
2. Carefully stir the mixture with a wooden spatula until it is free of lumps.
3. Pour the mixture into the four small depressions in the plastic mold. Let the plaster dry for at least one day.
4. Make a new solution out of 50 g of alum and 100 ml distilled water. You can color your crystals by adding a quarter of a dye tablet to the solution.
5. 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. Let it cool off in a quiet place.
6. Fish out the crystal-coated figures with a wooden spatula. Note: The crystals are not waterproof.







TIP!
Clean the yogurt container under running water right away, so the plaster doesn't harden in it.

FACT SHEET: PLASTER

Plaster is made from gypsum, a sulfuric acid salt combined with the chemical element calcium. In its pure state, it is a white powder that is hard to dissolve in water.

In nature, however, gypsum also occurs in pretty crystals that can be as clear as glass.

Plaster is made by heating gypsum to about 110 °C. When mixed with some water and stirred into a paste, it will harden in just a few minutes.

The ancient Romans used this material as stucco on their walls. Today, gypsum plaster is used as a raw material, as a building material, to make models, and to make molds in dentistry.

EXPERIMENT 10

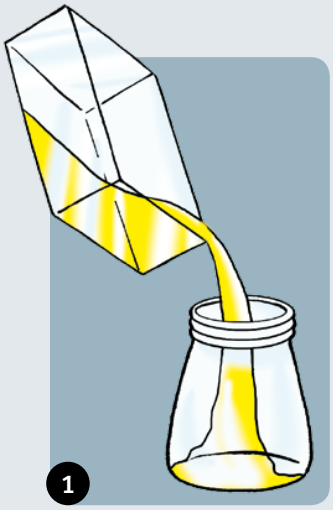
Artificial crystal layer

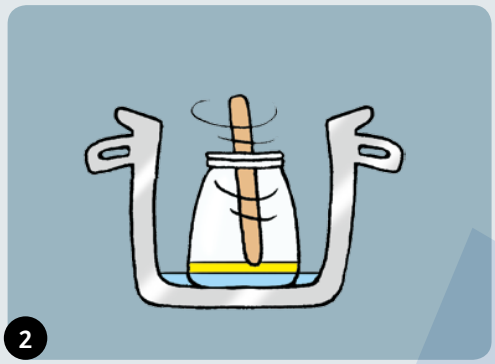
YOU WILL NEED

- **The rest of the alum solution from Experiment 9**
- **2 Wooden spatulas**
- *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)*

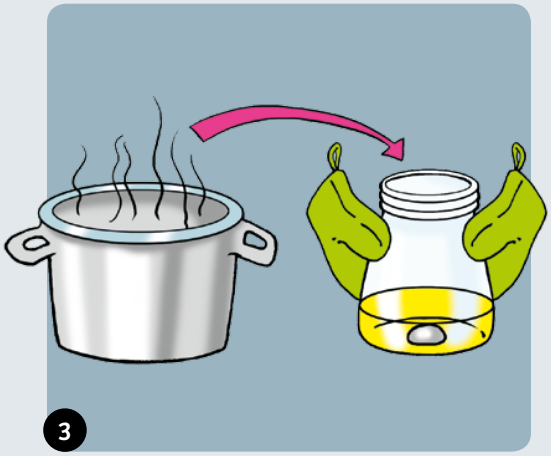
HERE'S HOW:

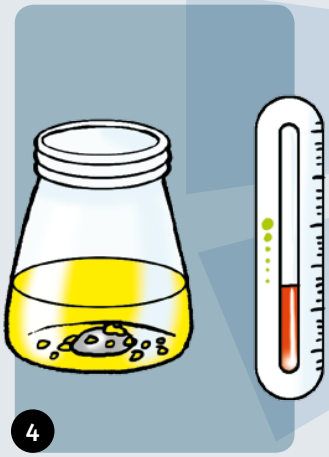
1. Pour the rest of the solution with the crystal sediment from Experiment 9 into a jelly jar.
2. Set the open jelly jar in a pot of hot water and stir with the wooden spatula until everything is dissolved.
3. Carefully take the jar with the solution out of the pot (caution, it is hot!) and place a stone 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. Fish out the stone with one or two wooden spatulas before it has a chance to get too firmly embedded in the crystals growing on the bottom of the jar. Optionally, heat the solution again and repeat the entire process to make the crystals grow even larger.
6. 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.

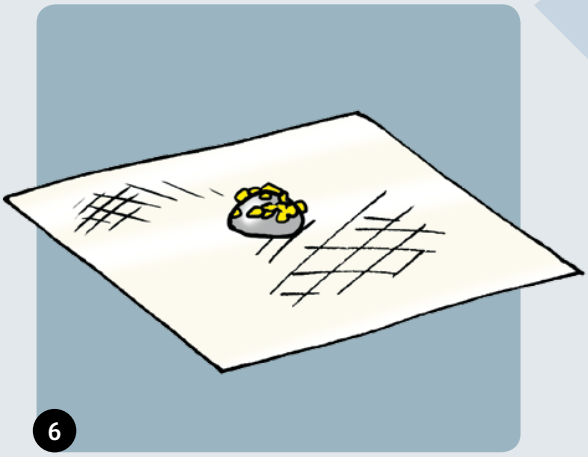




Be careful when handling hot water!





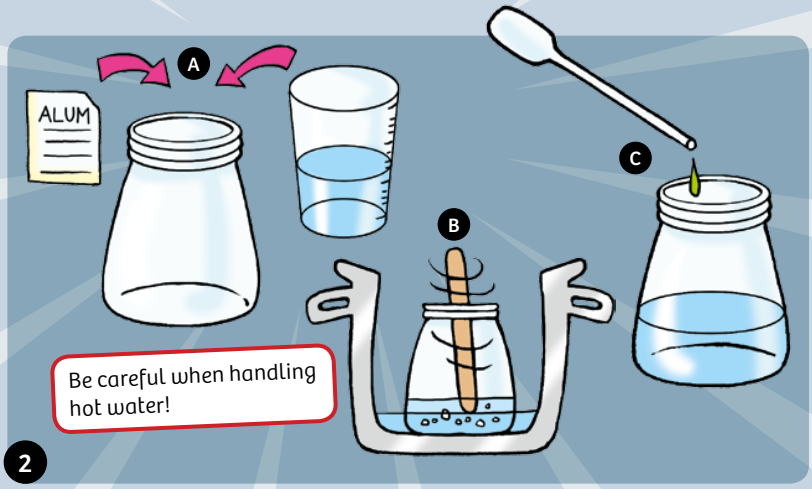


WHAT'S HAPPENING?

Crystals separate out of the supersaturated solution, especially on the rough surface of the stone. In nature, you can often find crystals on chunks of rock. In this experiment, you made your own artificial version.

EXPERIMENTS 11, 12, AND 13

1



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Colorful crystals

YOU WILL NEED

- **20 g alum packet**
- **Dye tablets**
- **Small measuring cup**
- **Large measuring cup**
- **Pipette**
- **Wooden spatula**
- *Distilled water*
- *Empty jelly jar*
- *Pot with hot water (no longer boiling)*
- *Paper towels*
- *Old newspapers*
- *Pot holders*

HERE'S HOW:

1. Spread out sheets of old newspaper across your work surface and prepare the dye solution. Break off about a quarter of a dye tablet and dissolve it in some distilled water in a small measuring cup.
2. Prepare a hot, saturated alum solution in a jelly jar out of 20 g of alum and 80 ml of distilled water, as you did in Experiment 1, and add the dye solution to it using the pipette.
3. Let the jar sit in a quiet place for a few hours or days, until the alum crystallizes. Finally, shake out the crystals onto a paper towel and let them dry. Save them in your treasure chest.

EXPERIMENT 12:

1. Repeat Experiment 4 by redissolving the alum crystals, but this time use a dye tablet to color the large crystal.

EXPERIMENT 13:

1. You should have enough alum solution or undesirable alum crystals laying around to make one final colored crystal. Try blending two dyes! Don't use the final 20 g alum packet — you'll need it for Experiment 15.

WHAT'S HAPPENING?

Even though all the chemicals in this kit form colorless crystals, you have now made colored alum crystals by using the dye tablets. As the crystals grow, small quantities of dye become integrated into the crystal structure — exactly how much depends on how much dye you use and also on chance.

TIP!
You can adjust the color intensity by adding more or less dye solution to the crystals, or change the color by blending different dyes together.

CHECK IT OUT

Mysterious forces at work?

For a long time, people puzzled over what hidden forces might have been capable of creating the organized structures of crystals. They assumed them to be beneficial forces, since they created order, regularity in form, and beauty. Today we know better: It isn't supernatural forces that guide the growth of crystals, but rather the forces of attraction between their smallest building blocks of matter.

[Crystal], *noun;* derives from the Greek word *krystallos.*

THE BUSINESS OF CRYSTALS

Swarovski, one of the world's most famous brands of cut crystal, has constructed an exhibition full of crystals in Austria called the Swarovski Crystal Worlds. For their 100th anniversary, they created 14 magical rooms of crystal designed by famous international artists and designers — a fairy-tale winter landscape made of thousands of crystals, the world's largest kaleidoscope, a mysterious alley of ice, and a dome resembling the inner surface of a crystal broken into 590 facets. You will also find the world's largest cut crystal, weighing 150 kg or 300,000 carats. If that's too much for you to absorb, you might want to take a look at the world's smallest cut crystal, which is displayed along with a magnifying glass so you can see it.

GEMSTONES TO BRING LUCK

Some crystals glow green red, or blue, while others are as colorless as ice and just as clear. The most beautiful of them carry famous names like diamond, sapphire, or emerald, and have long served as valuable decorations and good-luck charms. They adorned the crowns of emperors and kings, and filled the treasure chambers of powerful rulers.

The ancient Egyptians used jewel-encrusted amulets to keep evil away. Some precious and semiprecious stones were ascribed special magical powers. The beetle-shaped stone below, known as a scarab (after a type of beetle) was worn as a pectoral amulet.

WHAT IS A CARAT?

The **carat** is the unit used to indicate the mass of a gemstone. One carat is the equivalent of 0.2 grams. With gold, on the other hand, the carat indicates purity rather than weight.

MYSTERIOUS CRYSTALLINE GROWTH

The Great Pyramid of Giza in Egypt, a 4,000-year-old wonder of the world, provides a good illustration of the structure of a crystal. It is built out of over 2 million rectangular blocks stacked on top of one another in such a way that they form the pyramid's shape. This is exactly how crystals are formed, except in their case the building blocks are much tinier — not much bigger than atoms. They are known as elementary cells.

Elementary cells can be assembled in various ways depending on the type of material involved. Some consist of molecules, or atoms connected to each other in a certain way (one example being rock candy).

With other substances, they can consist of nothing but identical atoms (this applies, to diamond crystals, for example, which are composed of carbon atoms).

In addition, elementary cells can be made of ions, which are electrically charged atoms or groups of atoms. Substances made of ions are known as salts, and include table salt as well as the chemicals contained in this kit.

A crystal in solution is like a highly active construction site. This is where the forces of attraction are at work between atoms, ions, and molecules. The elementary particles constantly collect on all parts of the growing crystal, stay a while, and then zoom away again. That happens mostly on the edges and corners, and a little less on the flat surfaces. Usually, the arriving particle doesn't fit well into its landing spot, so it quickly flits off. Sometimes, though, the right particle joins just the right place on a growing elementary cell, and it is held tight there. That is how a crystal grows, layer by layer.

Crystal Geodes

Crystals can form inside small or large bubbles of rock. Crystal-filled rocks or hollow structures of this sort are known as "geodes" — from a Greek word meaning "earth-like." Particularly valued are the purple amethyst geodes from Brazil. You can make your own geodes too. If you work skillfully, your artificial geode will look a lot like a real one made of amethyst.

EXPERIMENT 14

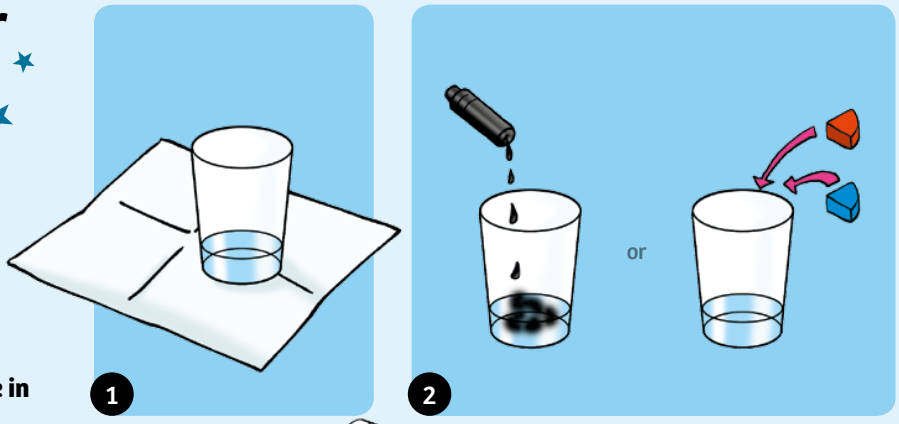
Creating the plaster mold

YOU WILL NEED

- **Plaster powder**
- **Large and small measuring cup**
- **Dye tablets, wooden spatula**
- **Hollow mold for geode**
- **The larger alum crystals that you made in 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.
2. To color the plaster, add black ink to the water or a quarter tablet each of red and blue dye.
3. 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.
4. Pour the plaster mixture into the geode mold. It won't even fill it halfway. 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. It will harden within a few minutes.
5. You have to work fast. Be sure not to make the walls too thin (or your geode will break!). The wall surface should be rough.
6. Before the plaster has hardened, sprinkle the alum crystals 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. Leave it inside the mold!



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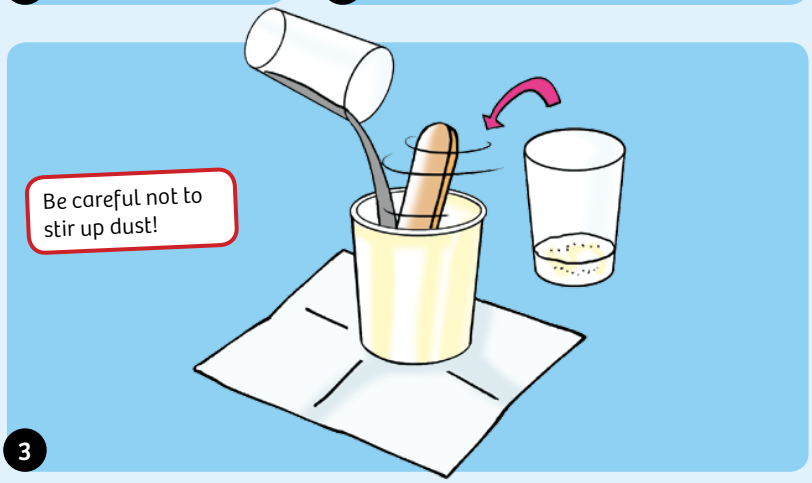

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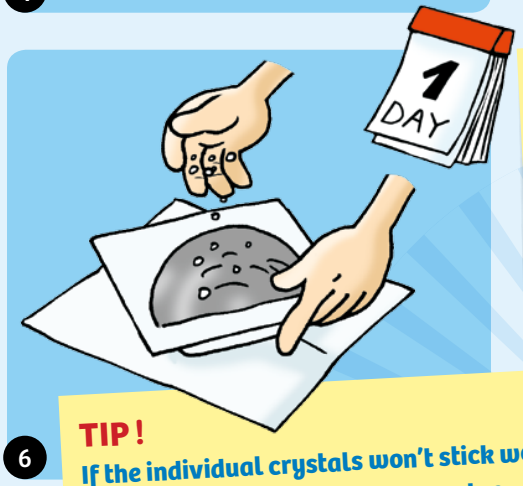

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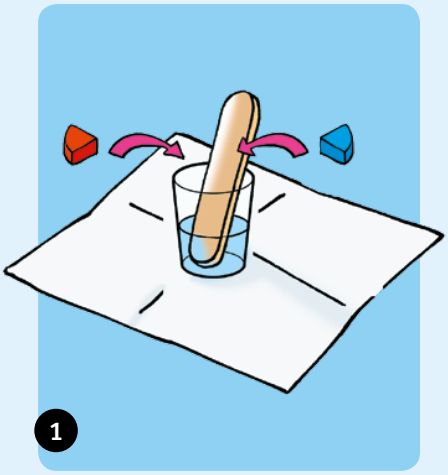
TIP !
Ideally, clean the yogurt container right away under running water. Or let the plaster harden and discard the container in the trash.

TIP !
If the individual crystals won't stick well to the plaster, you can use all-purpose glue.

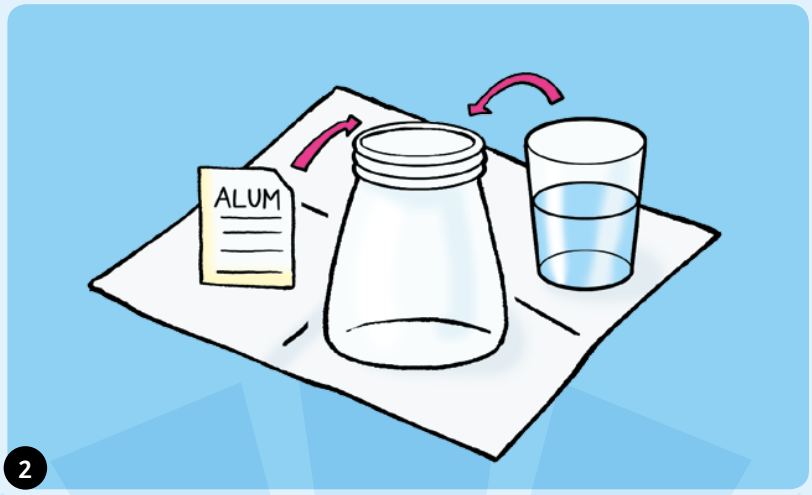
Crystal growth

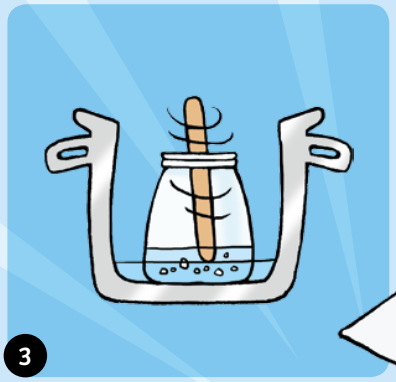


Now you will make another supersaturated alum solution, which you will pour into the plaster geode.

YOU WILL NEED

- **Plaster geode**
- **Small measuring cup**
- **Large measuring cup**
- **Dye tablets**
- **Pipette, wooden spatula**
- **20 g alum packet**
- *Distilled water*
- *Empty jelly jar*
- *Pot with hot water (no longer boiling)*
- *Paper towels*
- *Pot holders*
- *Old newspapers*





Be careful when handling hot water!

HERE'S HOW:

1. Cover your work surface with sheets of old newspaper. In the small measuring cup, dissolve one quarter of a tablet each of red and blue dye in some distilled water (of course, you can grow colorless crystals if you prefer).
2. Use the large cup to measure 90 ml of distilled water into the jelly jar, and add a 20-g packet of alum. You can also add a couple leftover 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.
4. Add the dye solution. Now you have to let the solution cool.

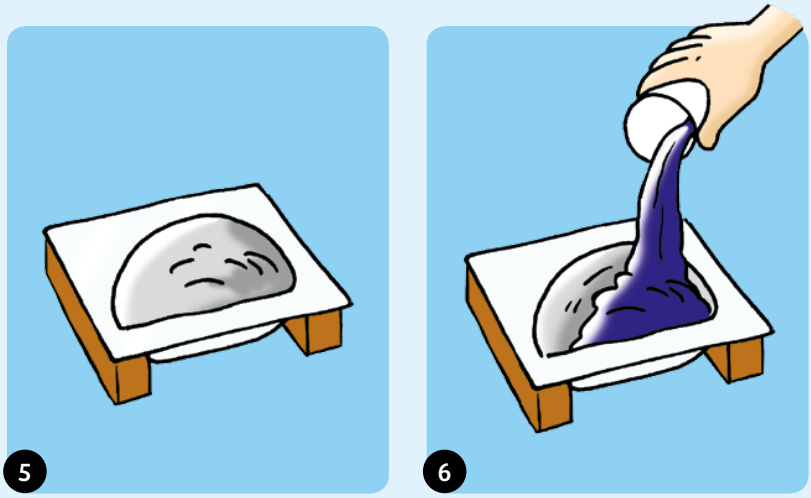
EXPERIMENT 15

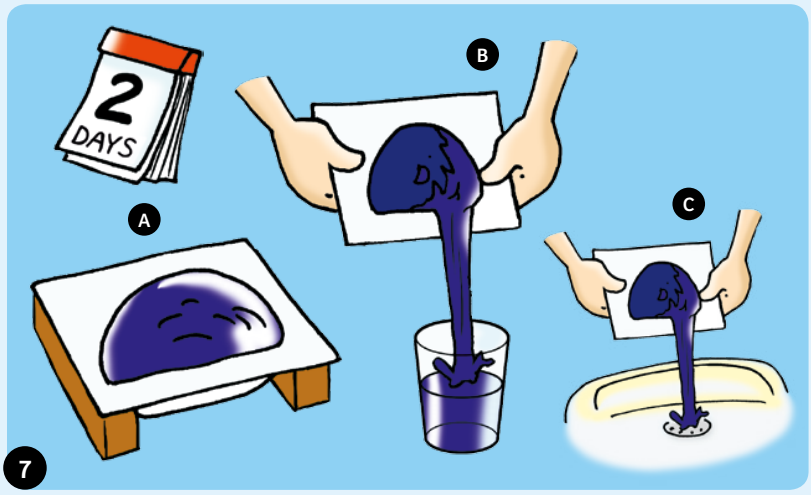
5. Meanwhile, set the plaster mold in a quiet place and support its sides so it can't tip over. You can use the polystyrene tray from the kit if you like.

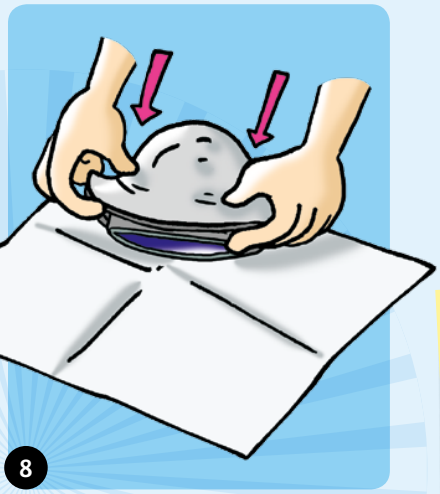
6. Once the solution has cooled sufficiently, pour it into the plaster geode up to the brim. It will be hard to prevent some from seeping between the plaster and the plastic mold, but it won't really matter. Be careful not to let any of the dye solution spill outside of the mold.

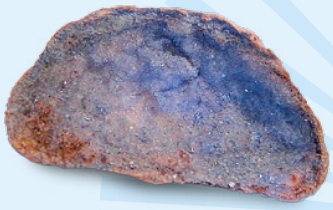
7. Let the geode sit quietly for two days. Then, carefully pour off the dye solution into the measuring cup and take a look at your geode. Be careful: it's still dripping! If you want bigger crystals, pour the dye solution back in and let it sit a few more days. Otherwise, pour the dye solution down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

8. 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.





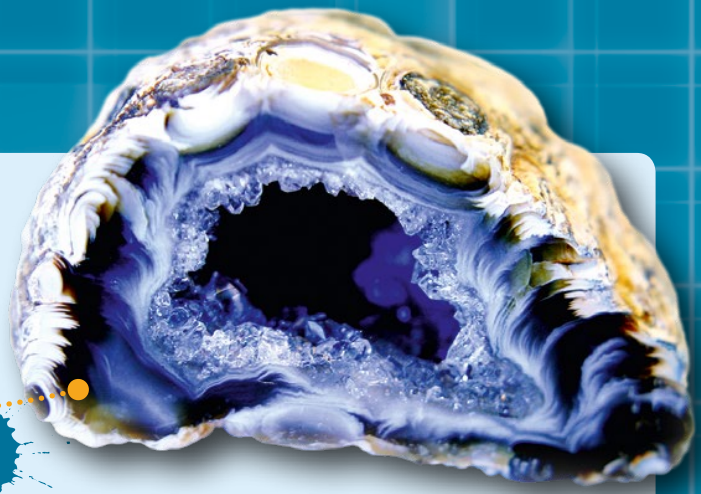




TIP!
If you want to make the edges of your geode more attractive, carefully smooth them with a sheet of sandpaper.

CHECK IT OUT

How do geodes form?



A **rock geode** forms when hollow spaces in volcanic rock, for example, become filled with hot water. Since this process takes place inside the Earth, pressure and temperature are often very high — ideal conditions for minerals to be dissolved in the water. If the mineral-containing water cools off in shallower layers of the Earth, the minerals will crystallize out on the geode's walls — just as the alum in your experiments turned to crystals when the temperature in the jar dropped.


Amygdaloid agate

If the hollow space is completely filled with crystals, it is called an **amygdaloid agate.**

The growth of crystals inside geodes can take years or decades. They look quite ordinary on the outside, but if you find a geode and break it open, you will discover the gorgeous crystals within.


Amethyst geode from Uruguay

GEODES IN NATURE

One of the most famous sources for amethyst geodes is the Brazilian state of Rio Grande do Sul, where geodes up to two meters in size have been and continue to be discovered.

Geodes are also fairly common in the United States, especially in Indiana, Iowa, Missouri, Utah, and Kentucky, along with similar volcanic rock formations known as thunder eggs.

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