



Item #28929
Item #2891-08
Ages 10 AND UP

WARNING:

“Only for use by children over 8 years old. To be used solely under the strict supervision of adults that have studied the precautions given in the experimental set.”

WARNING:

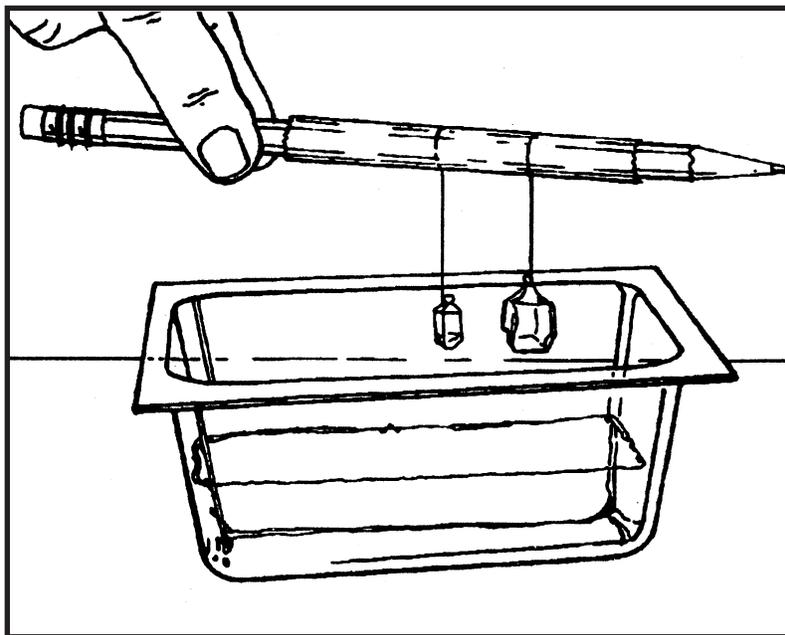
THIS KIT CONTAINS CHEMICALS THAT MAY BE HARMFUL IF MISUSED. READ ALL WARNING STATEMENTS ON INDIVIDUAL PACKETS AND INSTRUCTIONS BEFORE USING THIS KIT.

THIS CRYSTAL KIT MAY BE USED BY YOUNG CHILDREN ONLY WITH ADULT SUPERVISION. IF DRY POWDER OR MIXED LIQUID IS SPILLED, RINSE WITH WATER. DO NOT USE ANY BLEACHES OR CLEANERS CONTAINING CHLORINE.

SMITHSONIAN

CRYSTAL GROWING SET

CRYSTAL GROWING PROCEDURES



DEAR CUSTOMER,

NSI is the manufacturer of this kit. If we made an error and left something out of this set, or if something is damaged, we are sorry and wish to correct our error. Please do not return the set to the store where you purchased it, or to the Smithsonian, as they do not have replacement parts.

Instead, write us a letter giving us:

- | | |
|---------------------|---------------------------------|
| 1. Date of Purchase | 4. Name of Set |
| 2. Where Purchased | 5. Brief Description of Problem |
| 3. Model Number | 6. Sales Slip |

We will do our best to satisfy you.

Quality Control Department, NSI International, Inc.
105 Price Parkway, Farmingdale, NY 11735-1318
(888) 425-9113

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CRYSTALS AND CRYSTAL GROWING PROCEDURES

WARNING! READ ALL SAFETY PRECAUTIONS BEFORE STARTING. ALL CHEMICALS AND PROCEDURES HAVE THE POTENTIAL TO CAUSE HARM!

In this crystal growing set, the chemicals used and the procedures outlined have been made as safe as possible through careful testing and packaging. However, they are not without some hazard since ALL chemicals are potentially dangerous. Be sure you read the warnings and caution statements on the individual containers and follow the procedures and directions carefully.

NOTE: This crystal growing set may be used by young children only with adult supervision!

(1) NEVER put any chemicals, crystals or solutions into the mouth. Never swallow or eat any chemicals, crystals or solutions. Do not eat or drink when handling chemicals, crystals or solutions.

(2) AVOID contact of any chemicals, solutions or crystals with the skin, eyes and mouth. Be careful with stirring sticks and containers which have been used with the chemicals or solutions. Always wash your hands and arms after handling chemicals, crystals, or solutions. Keep your work area clean and dust-free!

(3) READ INSTRUCTIONS for each procedure before actually doing the procedure. Make sure you have all of the equipment and materials ready for the procedure before starting.

(4) If chemicals accidentally come in contact with skin, wash the area with soap and water. If eye contact occurs, carefully flush eyes with water for fifteen minutes. If irritation occurs, or if it persists, get medical attention. Some chemicals may form or contain DUST. If a chemical dust is inhaled, seek fresh air. If symptoms occur, seek medical attention. If any chemicals, crystals, or solutions are swallowed, immediately rinse your mouth with milk or water; drink several glasses of milk or water. Seek medical attention or call a Poison Control Center.

(5) Keep chemicals, solutions, and crystals out of the reach of small children and pets.

(6) Always work with the safety goggles that are supplied in your Smithsonian Giant Crystal set.

(7) Make sure your work area is covered with several sheets of newspaper or a waterproof plastic sheeting to reduce the problem of spills from chemicals and from the dyes which are used in the chemical solutions. If there is a spill, clean the area immediately with paper towels.

(8) It is important to cover clothing with a protective layer of cloth, plastic or rubber. You should obtain an apron (like a workshop apron) and wear it while you are doing the procedures.

(9) Dispose of USED chemicals in a manner which is environmentally safe. Talk to your parents or school science teacher about the best way to dispose of chemicals.

**NO MATTER WHAT THE EXPERIMENT, EQUIPMENT OR PROCEDURE, THE ONE THING TO CONSIDER AT ALL TIMES IS
S-A-F-E-T-Y.**

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE "BASE ROCKS" FOR YOUR CRYSTALS.

CONTENTS OF YOUR CRYSTAL GROWING KIT

Your crystal growing set contains the following materials and equipment for growing beautiful chemical crystals:

- Safety goggles
- 8 plastic crystal growing vessels and one plastic geode mold
- 8 poly bags of crystal growing chemicals
- One poly bag of geode shell plaster
- 2 wooden spatulas
- 12" of monofilament plastic thread
- Instruction booklet
- Graduated measuring cup marked in "ml" (milliliters), "cc" (cubic centimeters), as well as in "oz" (ounces)
- Magnifying glass
- Poly bag containing granite "base rocks"
- Granite Base Rocks

MATERIAL NEEDED TO BE SUPPLIED BY YOU

Gather together the following materials and containers to help your procedures run more smoothly and to insure that your crystal growing will be more successful.

You will need:

- A room or location in your home where the temperature remains relatively constant and where the crystals may grow and not be disturbed. Once you have prepared your crystals and they are ready to grow, try not to disturb them.
- A large (2 quart) size saucepan in which to heat water to boiling. Always use a stainless steel or a non-stick pan. **Never use an aluminum pan.** The boiling water will be used to dissolve chemicals. When using boiling water, always have parents or an adult help you.
- Plenty of newspaper or plastic sheeting to protect your work area from spills and from the dyes which are added to many of the chemicals. The powerful dyes may stain floors or table tops if the colored solutions are spilled onto these surfaces.
- A supply of paper towels or tissue paper for drying crystals and cleaning up any spills.
- Scissors
- Flashlight
- Several long pencils
- Two-part glue or model maker's white glue
- A selection of various rocks on which you will grow your own crystals. These rocks may be collected from the neighborhood or may be from your own rock collection. The prettier and more interesting the rocks you use, the more interesting will be the "bases" for your crystals to grow on. You may have to break the rocks with a hammer. When breaking rocks with a hammer, work outdoors, and **always wear your safety goggles.** Cover the rock you are trying to break with an old cloth or burlap sack to prevent rock shards from scattering or flying outward from the breaking area. Be careful of sharp edges from the broken rocks. You may also use the granite "base rocks" supplied in your kit.

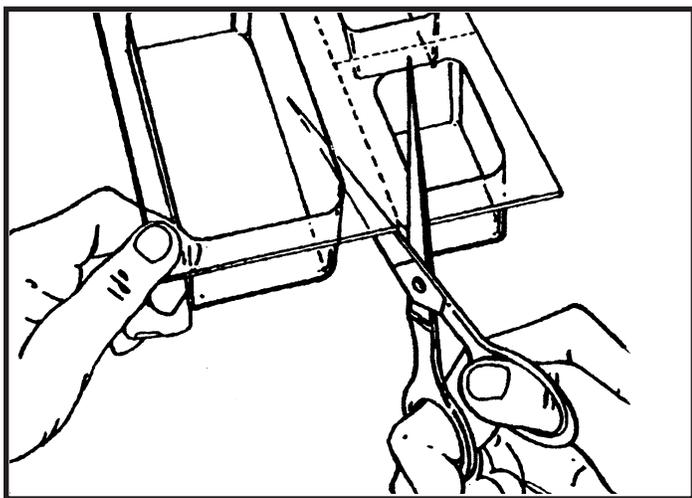
- Several small clean jars with tops (like used jelly, baby food or canning jars) in which to store some of your chemical solutions for use later on.
- A small plastic bucket (like a clean, empty peanut butter bucket or discarded quart Tupperware® container). Make sure that your containers and buckets are thoroughly cleaned and dried.
- Transparent tape on which you can write with a permanent ink marker. This will help you keep track of which chemical solutions you are saving and which crystals are growing in each container.

GETTING READY

Using scissors, cut apart the individual plastic crystal growing cups from the plastic sheet where they are all attached. Leave a rim around each individual plastic growing cup, but cut off sharp points from the corners of the rims. You will also use the flat plastic sheet to cut “lids” for various growing cups. You will need lids for size “D” growing cups and for size “B” growing cups. All other growing cups do not need lids.

Crystals which are found in nature may have taken thousands or even millions of years to grow into the final shape and size which we recognize. Some natural crystals form in hot solution soft chemicals deep within the earth. Crystals may also form as the result of minerals from molten rock or superheated vapors of minerals or elements.

The crystals which you will grow in this kit are chemical crystals. Your crystals grow very rapidly, needing only a few hours or days to complete their growth. Both the crystals found in nature and the ones you grow from your kit are actual crystals with internal structures much the same, except you do not have to wait thousands of years to see the result of your crystal growth!



Carefully cut all of the crystal growing cups apart from one another. Be sure to leave a rim around each growing cup. Also remove any sharp corners from the rims with your scissors.

KEEPING RECORDS - LABORATORY NOTES:

It is important to keep a record of each procedure you perform. Use a small notebook and pencil to record the important information about each operation OR you may use the record keeping log at the end of each procedure.

The information you should record is:

1. Time and date you start each crystal growing procedure.
2. Time and date you end each crystal growing procedure.
3. What size rock and what type rock used for the “base rock” for your crystal growing procedure.
4. The name of the chemical used, how much chemical used, and how much water used in each crystal growing procedure.
5. Record the room temperature and the solution temperature at the beginning of each crystal growing procedure.
6. Comments: Note also when you could first see crystals beginning to grow, what shape they are and how fast they appear to grow. Note if the “base rocks” you are using are light or dark colored and what kind of rock is used for “base rocks” (like limestone, granite, etc.) You may wish to use the “record keeping log” printed at the end of each procedure. The most important technique to develop is to measure all chemicals and all amounts of water VERY CAREFULLY. For each crystal growing experiment, the amount of water needed is given in grams and milliliters (ml) as well as in cups, teaspoons and tablespoons. You may use any system you like, but the metric measurement in milliliters (ml) or grams (g) will be used in this manual.
7. When you remove the crystals from their growing vessel and are ready to dry them, place the crystals on absorbent paper toweling or newspaper and let them dry for a day or so undisturbed. Letting the crystals dry this way will insure the crystals become firmly attached to the “base rocks” and will serve as a safe and stable method to display your new crystals.
8. If you make a display of all your crystals, it is important to keep them dry and free of dust, and away from too much heat. Some of the crystals you grow are very delicate and will break if handled roughly. If you can find some clear plastic boxes in which to display them, all the better. If your crystals get dusty, you may want to clean them off with a soft bristle brush, or the air from a hair dryer.

REMEMBER: All of your crystals will re-dissolve in water!! So do NOT get your crystals wet or try to wash them...the crystals will turn back into solution!!

“Golden Citrine” Crystals

Actual CITRINE crystals are a variety of quartz which show a light yellow color. The giant “Golden Citrine” crystals which you will grow in Procedure #1 use the chemical monoammonium phosphate and a yellow food dye to simulate actual CITRINE quartz. Both your chemical crystals and actual citrine crystals do, however, form in the hexagonal crystal system.

Crystals of the same chemical substance may exhibit a wide variety of shapes. However, it is possible to choose three reference axes (called crystallographic axes) that uniquely define the geometry of each crystal. These axes intersect at a common point at the center of the crystal. For highly regular shapes like cubes (high symmetry), the axes are the same length, and the angles between the axes are 90°. An example of this type of crystal is table salt (the mineral halite). There are seven different combinations of crystallographic axes. These are called crystal systems. The “Golden Citrine” crystals that you will grow in Procedure #1 crystallize in one of these systems.

The crystals which you will grow in a water (aqueous) solution are not actual citrine quartz crystals as seen in jewelry stores or museums, but are nonetheless beautiful golden crystal structures.

Procedure #1:

“GOLDEN CITRINE” CRYSTALS

In procedure #1 - “Golden Citrine” Crystals, you will grow crystal clusters of a golden amber color on a base rock. The crystal growing chemical contains Monoammonium Phosphate and a concentrated food dye colorant. After you have grown the “Golden Citrine” crystals, keep them as clean and dry as possible. If they become dusty, they may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer.

Protect your finished crystals from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #1 containing Giant "Golden Citrine" crystal growing chemical
- Size "C" plastic crystal growing cup
- Size "D" plastic crystal growing cup
- Size "D" plastic crystal growing cup lid
- Plastic graduated beaker (for measuring liquid & solid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) **Do not use an aluminum saucepan.** Use only a non-stick pan or a stainless steel saucepan.
- Base rock piece to place in the bottom of plastic crystal growing cup for your crystals to grow upon
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of this procedure OR you may use the record keeping log at the end of this procedure.
- Small storage jar with lid for storing the excess solution for later steps or follow up procedures.

(1) Open poly bag #1, the "Golden Citrine" crystal growing chemical and pour the contents into a size "C" plastic crystal growing cup.

(2) Using a clean dry wooden spatula and your magnifying glass, carefully look at the small grains and crystals of the chemical from the poly bag #1.

(3) After you have examined the crystals, put a few (about 1/8 teaspoon) of them back into poly bag #1 for use as seed crystals.

(4) Using your graduated measuring cup, measure out about 68 milliliters (ml) of water and pour this water into a small saucepan. Place the saucepan onto the stove and heat until water is boiling.

(5) Pour the boiling water from the small saucepan into the size "C" plastic growing cup which contains the contents from poly bag #1. Stir this mixture with one of your wooden spatulas until all of the chemical grains have dissolved completely.

(6) Place one or two broken rock fragments in the bottom of the size "D" plastic growing cup. These "base rocks" should only come up from the bottom of the growing cup about 3/4" (or about 2 cm.).

(7) Pour the chemical/water solution from the size "C" plastic cup INTO the size "D" crystal growing cup. Pour right over the base rocks. The liquid should be poured in the cup so as to allow about one-third of an inch (8 mm) of space between the top of the liquid and the rim of the cup. Let the solution cool until lukewarm.

(8) From the poly bag, take a few "seed" crystals which you saved back, and carefully deposit these at different places on the top of the rocks which are on the bottom of the size "D" plastic crystal growing cup. You may just let these "seed crystals" sink down through the liquid and land on the rocks.

(9) Place the lid which fits the top of the size "D" cup on top of your crystal solution cup.

(10) Set your "Golden Citrine" crystal growing cup in a place where it will not be disturbed by movement or changes in temperature.

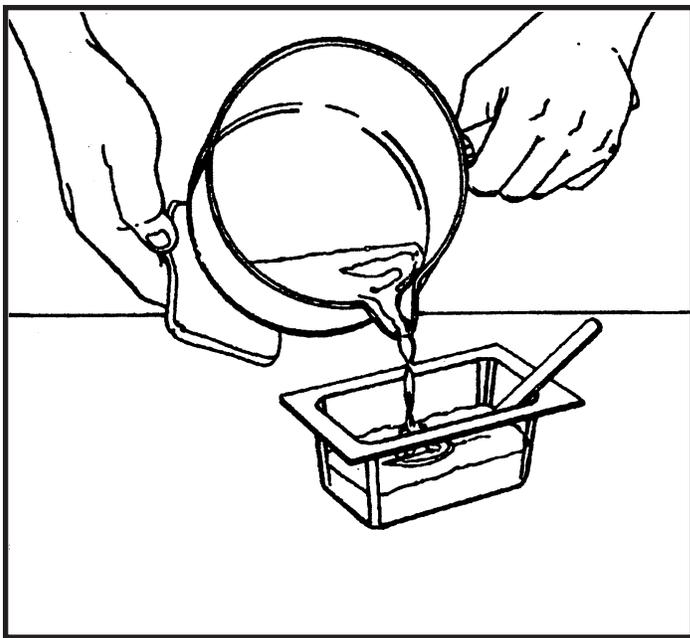
(11) Record in your notebook all of the steps which you have performed during this procedure, including time, date, and which crystal type you are growing. Make sure you also label the crystal growing cup with the type of crystal you are growing in it and when the crystal will be ready to be removed from the solution. You may use the RECORD KEEPING LOG at the end of this procedure as a handy place to record your data and results.

(12) Your crystals will start growing in just a few hours. You may use your flashlight to look through the sides of the cup and watch the process.

(13) Allow the crystals to grow without being disturbed for three or four days. At that time you may remove your crystals from the solution OR you may take off the lid and let the solution evaporate for a few more days (to make larger crystals). If you remove the lid and let the solution evaporate, a crust of crystals may form at the top of the solution or at the top rim of the crystal growing cup. In any case remove your grown crystals BEFORE the top of your crystals are exposed through the surface of the solution. If the crystal mass and the "base rock" have formed a square shape due to the shape of the growing cup, you may want to break off excess crystals which form a square shape in order to make your crystal mass display look more geologically natural.

(14) When you are satisfied with the shape and size of your crystal mass specimen, set it aside on a piece of newspaper or paper towel and allow to dry completely for one day.

(15) Pour the extra solution from the growing cup into a storage jar. Label the jar with transparent tape as to which solution the jar contains. Retain this jar of solution for later procedures. Make sure the jar has a tight fitting lid.



Carefully pour boiling water into the crystal growing cup. Stir boiling water and chemical until it is completely dissolved. Always have adult supervision when dealing with boiling water.

(16) The crystals which may have grown on the sides or bottom of the crystal growing cup can now be removed and dried on newspaper or paper toweling. After they are dry, return them to the “Golden Citrine” crystal poly bag #1, and save them for use in a later procedure or for follow-up experiments of your own design.

(17) If you prefer to grow even larger “Golden Citrine” crystals, you may wish to combine your excess solution and the “excess” crystals which have formed on the sides and bottom of the growing cup together with about 20 milliliters (20 ml) of water.

Heat this mixture of excess solution, excess crystals and water to boiling, and stir constantly with a wooden spatula until all of the solid crystal and powder is dissolved. Be sure to use a stainless steel or Teflon® coated saucepan (NOT ALUMINUM) for this procedure.

(18) While this solution is cooling, place your “Golden Citrine” cluster, previously grown, into a clean size “D” growing cup. Carefully pour the new solution over the “golden citrine” clusters. You do not need to add seed crystals this time. Cover growing cup with lid and allow your crystals to grow as before.

RECORD KEEPING LOG: Procedure #1: “GOLDEN CITRINE” CRYSTALS

- (1) Date this procedure started _____ Time started _____
- (2) Type of “base rock” used (limestone, granite, etc.) _____
- (3) Number of “base rocks” used _____ Total weight of “base rocks” _____
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.

“Pink Quartz” Crystals

The “Pink Quartz” crystals in Procedure #2 are not really quartz because they are not made of the same atoms (silicon and oxygen). Also, the quartz crystals you might find in nature belong to the Rhombohedral crystal system. Careful observation of the “Pink Quartz” crystals will show that they belong to a different crystal system. Natural quartz can occur in a variety of colors, including pink (rose quartz). The colors are due to a number of factors. In rose quartz, the coloring is due to small amounts of titanium. Quartz crystals may also contain foreign materials or inclusions, such as other minerals, liquids and gases.

**Procedure #2:
“PINK QUARTZ” CRYSTALS**

In procedure #2 - “Pink Quartz” Crystals, you will grow crystal clusters of a pink color on a base rock. The crystal growing chemical contains Monoammonium Phosphate and a concentrated food dye colorant. After you have grown the “Pink Quartz” crystals, keep them as clean and dry as possible. If they become dusty, they may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished crystals from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #2 containing “Pink Quartz” crystal growing chemical
- Size “C” plastic crystal growing cup

- Size “D” plastic crystal growing cup
- Size “D” plastic crystal growing cup lid
- Plastic graduated beaker (for measuring liquid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. DO NOT USE AN ALUMINUM saucepan. Use only a Teflon® coated or stainless steel saucepan.
- “Base rock” pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon.
- Small storage jar with lid for storing the excess solution for later procedures
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

- (1) Open poly bag #2, the “Pink Quartz” crystal growing chemical, and pour the contents into a size “C” plastic crystal growing cup.

(2) Using a clean dry wooden spatula and your magnifying glass, carefully look at the small grains and crystals of the chemical from the poly bag #2.

(3) After you have examined the crystals, put a few (about 1/8 teaspoon) of them back into poly bag #2 for use as seed crystals.

(4) Using your graduated measuring cup, measure out about 68 milliliters (ml) of water and pour this water into a small saucepan. Place the saucepan onto the stove and heat until water is boiling.

(5) Pour the boiling water from the small saucepan into the size "C" plastic growing cup which contains the contents from poly bag #2. Stir this mixture with one of your wooden spatulas until all of the chemical grains have dissolved completely.

(6) Place one or two broken rock fragments in the bottom of the size "D" plastic growing cup. These "base rocks" should only come up from the bottom of the growing cup about 3/4" (or about 2 cm).

(7) Pour the chemical/water solution from the size "C" plastic cup INTO the size "D" crystal growing cup. Pour it right over the base rocks. The liquid should be poured in the cup so as to allow about one-third of an inch (8 mm) of space between the top of the liquid and the rim of the cup.

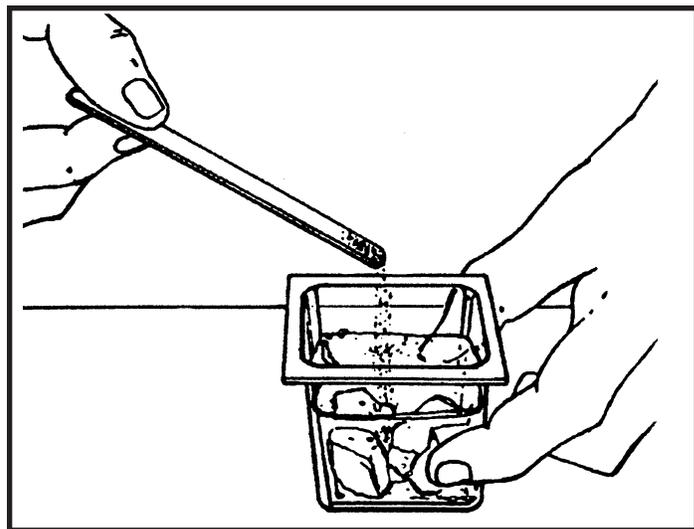
(8) From the poly bag, take a few crystals which you saved back, and carefully deposit these at different places on the top of the rocks which are on the bottom of the size "D" plastic crystal growing cup. You may just let these "seed crystals" sink down through the liquid and land on the rocks.

(9) Place the lid which fits the top of the size "D" cup on top of your crystal solution cup.

(10) Set your "Pink Quartz" crystal growing cup in a place where it will not be disturbed by movement or changes in temperature.

(11) Record in your notebook all of the steps which you have performed during this experiment, including time, date, and which crystal type you are growing. Make sure you also label the crystal growing cup with the type of crystal you are growing in it and when the crystal will be ready to be removed from the solution. You may use the RECORD KEEPING LOG at the end of this procedure as a handy place to record your data and results.

(12) Your crystals will start growing in just a few hours. You may use your flashlight to look through the sides of the cup and watch the process.



After you have carefully placed the broken "base rock" fragments in the bottom of a size "D" growing cup, make sure these rocks cover the bottom as completely as possible. Now pour the warm solution of dissolved chemical/water over the "base rocks". After allowing the solution to cool, take a few crystals from the poly bag which you have saved, and carefully deposit these "seed crystals" at different spots on the "base rocks". You may use a wooden spatula to just let these "seed crystals" sink down through the liquid and land on top of the "base rocks".

(13) Allow the crystals to grow without being disturbed for three or four days. At that time you may remove your crystals from the solution OR you may take off the lid and let the solution evaporate for a few more days (to make larger crystals). If you remove the lid and let the solution evaporate, a crust of crystals may form at the top of the solution or at the top rim of the crystal growing cup. In any case, remove your grown crystals BEFORE the top of your crystals are exposed through the surface of the solution. If the crystal mass and the "base rock" have formed a square shape due to the shape of the growing cup, you may want to break off excess crystals which form a square shape in order to make your crystal mass display look more geologically natural.

(14) When you are satisfied with the shape and size of your crystal mass specimen, set it aside on a piece of newspaper or paper towel and allow to dry completely for one day.

(15) Pour the extra solution from the growing cup to a storage jar. Label the jar with transparent tape as to which solution the jar contains. Retain this jar of solution for later procedures. Make sure the jar has a tight fitting lid.

(16) The crystals which may have grown on the sides or bottom of the crystal growing cup can now be removed and dried on newspaper or paper toweling. After they are dry, return them to the "Pink Quartz" crystal poly bag #2 and save them for use in a later procedure.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE "BASE ROCKS" FOR YOUR CRYSTALS.

RECORD KEEPING LOG: Procedure #2: "PINK QUARTZ" CRYSTALS

- (1) Date this procedure started _____ Time started _____
- (2) Type of "base rock" used (limestone, granite, etc.) _____
- (3) Number of "base rocks" used _____ Total weight of "base rocks" _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.

"Frosty Diamond" Crystals

The "Frosty Diamond" crystals in Procedure #3 belong to the same crystal system as natural diamond (cubic), which consists of pure carbon. Natural diamond is the hardest material known to man. Graphite (pencil "lead") is also made of carbon, but it is very soft. That is why your pencil leaves a mark on paper. Why is diamond so much harder than graphite when both crystals are made of the same atoms? The explanation must lie in the way the atoms are arranged. In diamond, the attraction between atoms (called a chemical bond) is very strong in all directions. The carbon atoms in graphite, however, are arranged in layers that are only weakly attracted to one another. This is why graphite is so soft. When you scratch graphite with your fingernail, you are literally breaking the chemical bonds that hold the layers together! The "Frosty Diamond" crystals you will grow in a water (aqueous) solution of aluminum potassium sulfate are not real DIAMONDS, of course, but large attractive chemical crystals.

Procedure #3: "FROSTY DIAMOND" CRYSTAL CLUSTER

In procedure #3 - "Frosty Diamond" Crystal Cluster, you will grow crystal clusters of a clear to frosty appearance on a base rock. The crystal growing chemical contains Aluminum Potassium Sulfate and no colorant. After you have grown the "Frosty Diamond" crystal cluster, keep them as clean and dry as possible. If they become dusty, they may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished crystals from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #3 containing "Frosty Diamond" crystal growing chemical
- Plastic bucket (like an empty peanut butter plastic pail - washed out, clean and dried - OR a quart sized Tupperware® container, clean and dry)
- Measuring beaker - supplied with your crystal growing kit
- Size "A" plastic crystal growing cup

- Two size "E" plastic crystal growing cups
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. DO NOT USE AN ALUMINUM saucepan. Use only a Teflon® coated or stainless steel saucepan.
- "Base rock" pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon. (A dark rock is best to use for this crystal)
- Quart size jar with tight fitting lid for storing the excess solution for later procedures
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

- (1) Open poly bag #3, the "Frosty Diamond" crystal growing chemical, and pour the contents into the clean, dry, plastic bucket or quart Tupperware® container.
- (2) Using your graduated measuring beaker, measure out 1 3/4 ounces (oz) or about 50 ml of the chemical crystals.
- (3) Put this 1 3/4 oz. (or 50 ml) BACK into poly bag #3 for later use in procedures 5 and 6.
- (4) Again using your graduated measuring cup, measure out about 680 milliliters (ml) of water and pour this water into the saucepan. You will have to use your graduated beaker multiple times to get up to 680 ml. (Four fillings of 140 ml each, and one filling of 120 ml, will total the

680 ml of water you require). Place the saucepan on the stove and heat the water to boiling.

(5) Carefully add the 680 ml of boiling water to the chemical in the plastic bucket. Stir the mixture with your wooden spatula until all of the chemical grains have dissolved.

You will grow "Frosty Diamond" crystal clusters from the materials in your crystal growing set. These are not real diamonds, of course, but are still beautiful, large crystals formed from the chemical Alum (Aluminum Potassium Sulfate).

(6) Now prepare your "base rock" for this crystal growing procedure by selecting a dark colored, flat, "base rock" which will nearly cover the bottom of a size "A" crystal growing cup. You may have to use a hammer and chisel to break and trim the rock to size. If so, be sure and wear your safety goggles while doing so. You may wish to place several small rocks, instead of one large one, to cover the bottom of the growing cup. Try to cover the bottom of the growing cup as completely as possible but make sure the rocks do not come up more than 1 1/2" (4 cm) from the bottom of the cup.

(7) Pour the chemical/water solution on the top of the rocks in the size "A" plastic crystal growing cup. The solution should fill the growing cup right up to the rim.

(8) Store the remaining solution in a storage jar with a tight fitting lid for use later on.

(9) Allow the crystals to grow on their own for several days and until the crystals start to grow toward the surface of the liquid in the growing cup. Since some of the solution will have evaporated, add more solution from the storage jar of excess solution to replenish the solution in the growing cup.

(10) Add more solution to the growing cup every few days until your "Frosty Diamond" crystals have grown to the height of the growing cup.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE "BASE ROCKS" FOR YOUR CRYSTALS.

(11) When you are satisfied that you have crystals as large as you desire, remove the "base rocks" with the crystal growth on them and set aside on a paper towel or newspaper to become completely dry.

(12) The crystals which may have grown on the sides or bottom of the plastic crystal growing cup may now also be removed and placed on a paper towel or newspaper to become dry. After they are completely dry, return these crystals to the "Frosty Diamond" poly bag #3. Save them for re-use in a later procedure.

(13) Pour the extra solution from the plastic growing cup into your storage jar. Label the jar with transparent tape as to which solution the jar contains. Retain this jar of solution in a quiet place and let it remain undisturbed for three days.

(14) After the solution in the storage jar has "cleared", pour the clear top portion of the solution into two small size "E" plastic growing cups. Keep the remainder of the solution in your storage jar for use in procedure #10.

(15) After a few days, single crystals will form in the two size "E" growing cups. Let these "seed crystals" grow undisturbed until they reach a size of 1/6" (4mm). When they are large enough, allow them to dry and save these "seed crystals" for use in procedure #10.

(16) Now clean out all of the growing cups and spatulas you have used in this procedure and dry them for later use.

RECORD KEEPING LOG: Procedure #3: "FROSTY DIAMOND" CRYSTAL CLUSTER

- (1) Date this procedure started _____ Time started _____
- (2) Type of "base rock" used (limestone, granite, etc.) _____
- (3) Number of "base rocks" used _____ Total weight of "base rocks" _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ 'C.
- (8) Temperature of solution at beginning of procedure _____ 'C.
- (9) Temperature of solution at end of procedure _____ 'C.
- (10) Temperature of room at end of procedure _____ 'C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.
- (17) Amount of dry "seed crystals" obtained _____ g.

“Rama Quartz”

“Rama Quartz” is the name which was chosen for the crystals you will grow in Procedure #4. There is no actual quartz called “Rama” although there is a quartz chert named Rama Chert which has been found in a deposit only in northeastern Canada. The crystals you will grow look similar to the Rama Chert, thus the name “Rama Quartz” was given to your chemically grown crystals in this procedure.

Quartz is but one form of natural silica, which is made of silicon and oxygen atoms. Some forms of silica crystallize in lavas at very high temperatures. One form, called coesite, is associated with diamonds, and crystallizes at very high pressures deep inside the Earth. Where pressures are even higher, for example, at the point of impact of a meteorite, a rare silica mineral called stishovite has sometimes been found. In some cases, where cooling has been very rapid, the atoms do not have time to order into crystals, and a silica glass forms. Some of the tools and weapons (arrowheads) used by early man are made of chert, a silica mineral with crystals too small to be seen without a microscope. All of these forms of silica are composed of only silicon and oxygen atoms. What makes them different is the way these atoms are arranged. Remember that the conditions under which crystals grow have a lot to do with how the atoms pack together! Your “Rama Quartz” crystals are grown from a water (aqueous) solution containing monoammonium phosphate, a chemical which contains nitrogen, oxygen, hydrogen and phosphorous atoms. Actual quartz is made from atoms of silicon and oxygen. Both your “Rama Quartz” and actual quartz have the same crystalline “habit” and are in the same crystal system (Hexagonal). Crystal “habit” is a characteristic.

Procedure #4: “RAMA QUARTZ” CRYSTALS

In procedure #4 - “Rama Quartz” Crystals, you will grow crystal clusters of a clear to frosty appearance on a base rock. The crystal growing chemical contains Monoammonium Phosphate and no colorant. After you have grown the “Rama Quartz” crystals, keep them as clean and dry as possible. If they become dusty, they may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished crystals from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #4 containing “Rama Quartz” crystal growing chemical
- Size “B” plastic crystal growing cup
- Size “B” plastic crystal growing cup lid
- Plastic graduated beaker (for measuring liquid & solid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. **DO NOT USE AN ALUMINUM** saucepan. Use only a Teflon® coated or stainless steel saucepan.
- “Base rock” pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon.
- Small storage jar with lid for storing the excess solution for later procedures
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

- (1) Open poly bag #4, the “Rama Quartz” crystal growing chemical, and pour the contents into a clean, dry plastic bucket or quart Tupperware® container.
- (2) Using a clean, dry wooden spatula and your magnifying glass, carefully look at the small grains and crystals of the chemical from poly bag #4.
- (3) After you have examined the crystals, put a few (about 1/8 teaspoon) of them back into poly bag #4 for later use as seed crystals.
- (4) Again using your graduated measuring cup, measure out about 325 milliliters (ml) of water and pour this water into the saucepan. You will have to use your graduated beaker multiple times to get up to 325 ml. (Two fillings of 140 ml each, and one filling of 45 ml will total the 325 ml of water you require). Place the saucepan on the stove and heat the water to boiling.
- (5) Carefully add the 325 ml of boiling water to the chemical in the plastic bucket. Stir the mixture with your wooden spatula until all of the chemical grains have dissolved.
- (6) Now prepare your “base rock” for this crystal growing procedure by selecting a dark colored, flat, “base rock” which will nearly cover the bottom of a size “B” crystal growing cup. You may have to use a hammer and chisel to break and trim the rock to size; if so, be sure and wear your safety goggles while doing so. You may wish to place several small rocks, instead of one large one, to cover the bottom of the growing cup. Try to cover the bottom of the growing cup as completely as possible but make sure the rocks do not come up more than 1” (2.5 cm) from the bottom of the cup.
- (7) Pour the chemical/water solution on the top of the rocks in the size “B” plastic crystal growing cup. The solution should fill the growing cup to within 1/4” (6mm) from the rim.
- (8) From the poly bag, take a few seed crystals which you saved back, and carefully deposit these at different places on the top of the rocks which are on the bottom of the size “B” plastic crystal growing cup. You may just let these “seed crystals” sink down through the liquid and land on the rocks.
- (9) Place the lid which fits the top of the size “B” cup on top of your crystal solution cup.
- (10) Set your “Rama Quartz” crystal growing cup in a place where it will not be disturbed by movement or changes in temperature. Let these crystals grow for about one week.
- (11) Record in your notebook all of the steps which you have performed during this experiment, including time, date, and which crystal type you are growing. Make sure you also label the crystal growing cup with the type of crystal you are growing in it and when the crystal will be ready to be removed from the solution. You may use the RECORD KEEPING LOG at the end of this procedure as a handy place to record your data and results.

Quartz crystals may also occur in many different colors owing to the various minerals in the solutions from which they form. Amethyst is a form of quartz that may vary from purple to green in color due to the amount of ferric iron present in the solutions as the crystal forms. Citrine is a quartz which is a beautiful amber yellow in color

(12) When you are satisfied that you have crystal specimens as large as they can get, remove the “base rocks” with the crystal growth on it, and set it aside on a paper towel or newspaper for it to become completely dry.

(13) Pour the extra solution from the growing cup into a storage jar. Label the jar with transparent tape as to which solution the jar contains. Retain this jar of solution for use in procedure #9.

(14) The crystals which may have grown on the sides or bottom of the crystal growing cup can now be removed and dried on newspaper or a paper towel. After they are dry, return them to the “Rama Quartz” crystal poly bag #4 and save them for use in a later procedure.

(15) Now clean out all of the growing cups and spatulas you have used in this procedure and dry them for later use.

RECORD KEEPING LOG: Procedure #4: “RAMA QUARTZ” CRYSTALS

- (1) Date this procedure started _____ Time started _____
- (2) Type of “base rock” used (limestone, granite, etc.) _____
- (3) Number of “base rocks” used _____ Total weight of “base rocks” _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ 'C.
- (8) Temperature of solution at beginning of procedure _____ 'C.
- (9) Temperature of solution at end of procedure _____ 'C.
- (10) Temperature of room at end of procedure _____ 'C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.

“Amethyst Geode”

Actual AMETHYST is a variety of quartz crystal which is tinted purple by the presence of small amounts of ferric iron present as the quartz crystal forms. Actual amethysts are often found in geodes.

The “Amethyst Geode” in procedure #5 will look very similar to a real geode that has been broken into two pieces. However, there are important differences. Geodes in nature are formed inside spherical cavities or holes in rocks. At first, they consist of a soft, jelly-like outer shell. This jelly-like shell is made of a rich mixture of minerals, sand and dissolved chemicals. After the outside of the geode has hardened due to heat and pressure it begins to crack, and chemical solutions enter the cavity. Crystals grow from these solutions by attaching their base to the walls of the cavity. Sometimes the crystals grow so large that the entire cavity is filled. More often, though, the center part of the geode is empty. The outer shell of the geode is made of chert, which is a very hard and resistant silica mineral. This is why geodes do not break apart easily, and must be cut with a special blade coated with diamond crystals. Once the geode has formed, the surrounding rock may be completely worn away but the geode is not destroyed because of its hard outer shell. If you find a geode lying on the ground, remember that it was once a small cavity inside a rock that has long since disappeared! A variety of minerals are found in geodes but the most common is quartz. Amethyst is a type of quartz that is purple in color.

Your chemically grown geode is made of the chemical aluminum potassium sulfate (alum) which is embedded in a plaster (calcium sulfate) shell. A water (aqueous) solution of alum and purple dye is then poured over the plaster “geode shell”. The amethyst “look-alike” crystals then begin to form on the surface of the plaster geode shell.

Your “amethyst” crystals will form in the hexagonal crystal system, similar to actual amethyst crystals.

Procedure #5: “PURPLE AMETHYST GEODE”

In procedure #5 - “Purple Amethyst Geode”, you will form a plaster geode in the geode mold. The plaster half-egg casting will contain the plaster of Paris (Calcium Sulfate) and seed crystals upon which your geode crystals will grow. The crystal growing solution contains Aluminum Potassium Sulfate and a concentrated food dye colorant. Your finished “Purple Amethyst Geode” will have crystals growing on all surfaces of the geode shell. After you have grown the “Purple Amethyst Geode” keep it as clean and dry as possible. If it becomes dusty, it may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished geode from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #5 containing “Purple Amethyst Geode” growing chemical
- Plastic bucket (like an empty peanut butter pail, washed out clean and dried) OR a quart sized Tupperware® container, clean and dry.

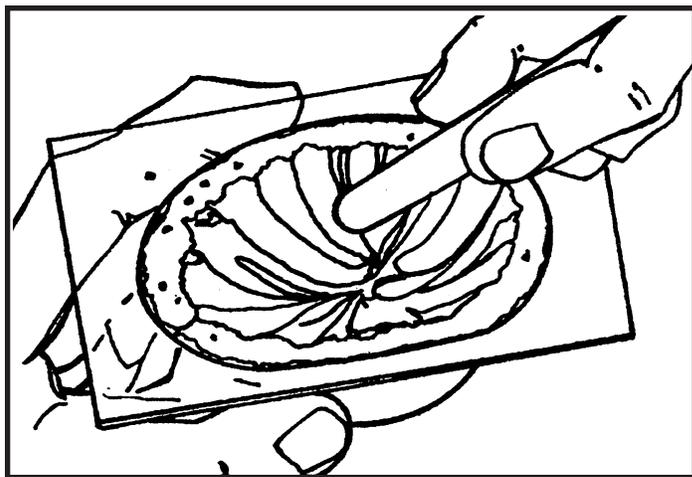
- Poly bag #9 containing Plaster of Paris “Geode Shell Material”
- Plastic geode mold (half-egg shaped mold)
- Size “B” plastic crystal growing cup
- Size “C” plastic crystal growing cup
- Plastic graduated beaker (for measuring liquid & solid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. **DO NOT USE AN ALUMINUM** saucepan. Use only a Teflon® coated or stainless steel saucepan.
- “Base rock” pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon and to support the geode shell
- Small storage jar with lid for storing the excess solution for a later procedure
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of this experiment, OR you may use the record keeping log at the end of this procedure.

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Procedure steps:

In this, and the following procedure you will not only “form” the geode shells (1/2 egg-shaped plaster castings), but you will grow colored crystals in and on the “geode casts” to produce a geode-like crystal specimen. Purple crystals will also be grown on some base rocks placed in the bottom of the size “B” plastic crystal growing cup. These “base rocks” will support the geode casting.

- (1) Open poly bag #9 labeled “Geode Shell Material” (plaster of Paris)
- (2) Pour this “Geode Shell Material” on to a large clean piece of paper
- (3) From your “Frosty Diamond” poly bag #3, measure out 50 ml (about 50g) of the crystals you saved back from that procedure
- (4) Add these 50 ml of “Frosty Diamond” crystals to the Plaster of Paris on the sheet of paper. Mix these two dry chemicals together. **Mix them thoroughly.**
- (5) Now divide the plaster and chemical mixture into two equal halves, using your wooden spatula as a divider tool.
- (6) Return one (half) mixture back to the geode shell poly bag for later use.
- (7) Pour the other (half) mixture into your geode shell mold. Support the round geode mold while you are working by placing it temporarily into the top of a size “C” plastic growing cup. This will give you a firm support for the geode mold while you mix and spread the plaster/chemical



Using your wooden spatula, coat the sides and bottom of the geode mold evenly with the plaster in order to form a concave shell of plaster. Allow plaster to dry for 30 minutes before removing plaster geode shell from the mold.

mixture in the round-bottomed geode mold.

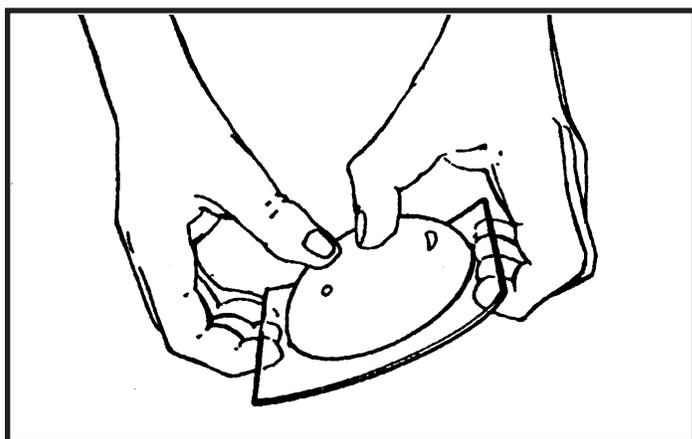
(8) Using your measuring beaker, add 13 ml of water to the plaster/chemical mixture in your geode mold.

(9) Working quickly, mix the water and chemicals together to form a paste, and spread this paste evenly. Using your wooden spatula, coat the sides and bottom of the geode mold with the paste, leaving a concave depression in the center of the geode. This paste will start to harden fairly rapidly. When you feel like the plaster mixture/paste is hardening, be sure you have completed all of the spreading and molding you are going to do.

(10) Using a clean wooden spatula as a scraper, scrape off the top of your geode mold so that your hardening geode casting is even with the rim of the geode mold.

(11) Let the geode shell casting harden for about 30 minutes. Turn the plastic geode mold cup upside down and press the bottom firmly with your thumbs in order to press the new plaster casting out of its mold.

(12) Place the plaster casting geode shell into a size “B” crystal growing cup with the concave (open) size facing upward. If you wish, you may place one or two “base rocks” beside the geode casting shell. The “base rocks” which you add should only be about an inch (2.5 cm) thick.



After the plaster dries, carefully remove the finished “geode shell”

These will serve to hold the casting in place as well as to promote crystal growth on the “base rocks” themselves.

(13) Open poly bag #5, “Purple Amethyst Geode” and pour the contents into your clean plastic bucket (peanut butter bucket, cleaned and dried) or quart Tupperware® container.

(14) Using your graduated beaker, measure out 380 ml of water into a small saucepan. You will have to use the graduated beaker multiple times to measure out the full 380 ml (two full measures of 140 ml each, and one partial measure of 100 ml). Boil this 380 ml of water in the saucepan on the stove.

(15) Pour the boiling 380 ml of water over the chemicals in the plastic bucket. (You may wish to have your parents or an adult help you with pouring the boiling water). Using your wooden spatula, stir the chemical/hot water mixture until all of the chemical grains have dissolved.

(16) Cool the chemical/water mixture for about five minutes

(17) Finally, pour the chemical/water solution over the geode casting in the size “B” crystal growing cup. The solution will be inside as well as outside of the geode casting and will fill up the size “B” container nearly to the rim

(18) Allow the crystals to grow for at least a week, or until crystal growth can be observed reaching the surface of the solution

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(19) When you are satisfied that you have crystal growth as large as you can get, remove the geode casting with the crystal growth on it, and place on a piece of newspaper or paper towel to dry for at least one day

(20) Pour the remaining solution into your storage jar and label it as to which solution it is. Save this solution for use in procedure #11

(21) Remove the remaining crystals which grew on the sides or bottom of the growing cup, dry them on newspaper or a paper towel, and keep for use later on. Save them in poly bag #5

(22) Clean thoroughly and dry the crystal growing cup and other containers you have used during this procedure

RECORD KEEPING LOG: Procedure #5: “PURPLE AMETHYST GEODE”

- (1) Date this procedure started _____ Time started _____
- (2) Type of “base rock” used (limestone, granite, etc.) _____
- (3) Number of “base rocks” used _____ Total weight of “base rocks” _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.

“Red Ruby” Geode

Natural ruby is a gem variety of the mineral corundum. Pure corundum consists of aluminum and oxygen atoms and is colorless. If some of the aluminum atoms in corundum are replaced by chromium during crystal growth, a deep red color results. In nature, rubies are not found in geodes. The rocks that contain ruby were formed millions of years ago. With time, they were broken apart, and the rubies have been carried by water and mixed with gravel at the bottom of streams. In some cases, several feet of mud must be removed before rubies can be found. Crystals large enough to yield gems are actually quite scarce. For this reason, ruby is a very expensive gem. Some types of lasers are made with synthetic ruby. Your “Red Ruby” Geode is, of course, not a real ruby. The crystals grown in Procedure #6 on a plaster “geode shell” are formed from a water (aqueous) solution of potassium aluminum sulfate (alum) and a red dye. The red crystals which you will grow have a red ruby-like color and will cluster on the surface of the plaster “geode shell” which has alum seed crystals embedded in it.

Procedure #6: “RED RUBY” CRYSTAL GEODE

In procedure #6 - “Red Ruby” Crystal Geode, you will form a plaster geode shell in a geode mold. The plaster half-egg casting will contain the plaster of Paris (Calcium Sulfate) and seed crystals upon which your geode crystals will grow. The crystal growing solution contains Aluminum Potassium Sulfate and a concentrated food dye colorant. Your finished “Red Ruby” Crystal Geode will have crystals growing on all surfaces of the geode shell as well as on the support “base rocks”. After you have grown the “Red Ruby” Crystal Geode, keep it as clean and dry as possible. If it becomes dusty, it may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished geode from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #6 containing “Red Ruby” Crystal Geode growing chemical
- Plastic bucket (like an empty peanut butter pail, washed out clean and dried) OR a quart sized Tupperware® container, clean and dry
- Poly bag #9 containing Plaster of Paris “Geode Shell Material”
- Size “B” plastic crystal growing cup
- Size “C” plastic crystal growing cup
- Plastic geode mold (half-egg shaped mold)
- Plastic graduated beaker (for measuring liquid & solid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. **DO NOT USE AN ALUMINUM saucepan.** Use only a Teflon® coated or stainless steel saucepan.
- “Base rock” pieces to place in the bottom of the plastic crystal growing cup for your crystals to grow upon and to support the geode shell
- Small storage jar with lid for storing the excess solution for a later procedure
- Newspaper or plastic sheeting to cover your working area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of this experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

In this procedure, as in the preceding one, you will again “form” a geode shell (1/2 egg shaped plaster casting), and will grow colored crystals in and on the “geode casts” to produce a geode-like crystal specimen. “Red Ruby” crystals will also be grown on some base rocks placed in the bottom of the plastic crystal growing cup size “B”, which will hold the base rocks and the geode casting.

(1) Open poly bag #9 labeled “Geode Shell Material” (Plaster of Paris). You have already prepared the plaster of Paris/chemical mix in procedure #5. Again, place this plaster of Paris/chemical mix into your plastic geode shell mold. Support your geode shell mold by placing it temporarily into the top of a size “C” plastic growing cup. This will give you a firm support for the geode mold while you mix and spread the plaster/chemical mixture in the round-bottomed geode mold.

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(2) Add 13 ml of water and stir this plaster/chemical mix to form a paste. Working quickly, spread the plaster mix onto the inside of the geode mold as evenly as you can. The paste will start to harden fairly rapidly, so work quickly. When the paste feels as if it is hardening, be sure you have spread and worked the plaster all that you are going to.

(3) Using a clean, wooden spatula as a scraper, scrape off the top of the geode mold so that your hardening casting is even with the rim of the geode mold.

(4) Let the geode shell casting harden for about 30 minutes. Turn the plastic geode mold cup upside down and press the bottom firmly with your thumbs in order to press the new plaster casting out of its mold.

(5) Place the plaster casting geode shell into a size “B” crystal growing cup with the concave (open) side facing upward. If you wish, you may place one or two “base rocks” beside the geode casting shell in order to support it. The base rocks should only be about an inch (2.5 cm) thick.

(6) Open the poly bag #6 “Red Ruby” Crystal Geode, and pour the contents into your clean plastic bucket (peanut butter bucket, cleaned and dried) or quart Tupperware® container.

(7) Using your graduated beaker, measure out 370 ml of water into a small saucepan. You will have to use the graduated beaker multiple times to measure out the full 370 ml (two full measures of 140 ml each and one partial measure of 90 ml). Boil this 370 ml of water in the saucepan on the stove.

(8) Pour the boiling 370 ml of water over the chemicals in the plastic bucket. (You may wish to have your parents or an adult help you with pouring the boiling water). Using your wooden spatula, stir the chemical/boiling water mixture until all of the chemical grains have dissolved.

(9) Cool the water/chemical mixture for about five minutes.

(10) Finally, pour the chemical/water solution over the geode casting in the size “B” crystal growing cup. The solution will be inside as well as outside of the geode casting and fill up the size “B” container nearly to its rim.

(11) Allow the crystals to grow for at least a week, or until crystal growth can be observed reaching the surface of the solution.

(12) When you are satisfied that you have crystal growth as large as you can get, remove the geode casting with the crystal growth on it, and place on a piece of newspaper or paper towel to dry for at least one day.

(13) Pour the remaining solution off into your storage jar and label it as to which solution it is. Save this solution for growing additional “red ruby” crystals on “base rocks” later on.

(14) Remove the crystals which you have grown on the sides and bottom of the crystal growing cup, dry them on newspaper or a paper towel, and save them in your poly bag #6 for later use.

(15) Clean thoroughly and dry the crystal growing cup and other containers which you have used during this procedure.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE “BASE ROCKS” FOR YOUR CRYSTALS.

RECORD KEEPING LOG: Procedure #6: “RED RUBY” CRYSTAL GEODE

(1) Date this procedure started _____ Time started _____

(2) Type of “base rock” used (limestone, granite, etc.) _____

(3) Number of “base rocks” used _____ Total weight of “base rocks” _____ g.

(4) Name of chemical used _____ Poly bag No. _____

(5) Weight of chemical used _____ g.

(6) Amount of water used _____ ml.

(7) Temperature of crystal growing room _____ °C.

(8) Temperature of solution at beginning of procedure _____ °C.

(9) Temperature of solution at end of procedure _____ °C.

(10) Temperature of room at end of procedure _____ °C.

(11) Date when first crystal growth observed _____ Time _____

(12) Estimated size of first crystals seen growing _____

(13) Estimated growth rate of crystals seen growing _____

(14) Date procedure ended _____ Time _____

(15) Amount of dry crystal residue saved after procedure _____ g.

(16) Amount of residue solution saved after procedure _____ ml.

“Aquamarine Blue” Crystals

The actual gem AQUAMARINE is a color variation of the mineral crystal beryl. Emeralds are also beryls. Both aquamarine and emeralds are classified in the hexagonal crystal system. In Procedure #7 you will grow a blue chemical crystal which only simulates actual aquamarine in color and crystalline appearance. Your blue crystal clusters are formed in a water (aqueous) solution of monoammonium phosphate which contains atoms of nitrogen, oxygen, hydrogen and phosphorous. Actual aquamarine is formed under extreme pressure and heat over long periods of time. Actual aquamarine beryl is made of atoms of beryllium, aluminum, silicon and oxygen. Both actual aquamarine and your chemically grown “Aquamarine Blue” crystals form in the hexagonal crystal system.

Sometimes you may obtain needle-like crystals from your crystal growing experiments. Other conditions may produce prismatic crystals. The difference may be due to conditions of temperature or humidity, or to the impurities given to the solution by the “base rocks” that you use.

Similar differences in crystal shape occur in nature because atoms in the solution surrounding the growing crystal are attracted more strongly to some surfaces (faces) than others. This means that different crystal faces grow at different rates - the slower the rate of growth, the larger the face. When an impurity atom attaches itself to a growing surface, it may alter the rate of growth of a particular face, and change the shape or “habit” of the crystal (needle-like to prismatic, for example).

**Procedure #7:
“AQUAMARINE BLUE” CRYSTALS**

In procedure #7 - “Aquamarine Blue” Crystals, you will grow crystal clusters of a deep blue color on a base rock. The crystal growing chemical contains Monoammonium Phosphate and a concentrated food dye colorant. After you have grown the “Aquamarine Blue” crystals, keep them as clean and dry as possible. If they become dusty, they may be

cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished geode from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag containing “Aquamarine Blue” crystal growing chemical
- Size “C” plastic crystal growing cup
- Size “D” plastic crystal growing cup
- Size “D” plastic crystal growing cup lid
- Plastic graduated beaker (for measuring liquid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. DO NOT USE AN ALUMINUM saucepan. Use only a Teflon® coated or stainless steel saucepan.
- “Base rock” pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon.
- Small storage jar with lid for storing the excess solution for a later procedure
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of this experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

(1) Open poly bag #7, the “Aquamarine Blue” crystal growing chemical and pour the contents into a size “C” plastic crystal growing cup.

(2) Using a clean, dry wooden spatula and your magnifying glass, carefully look at the small grains and crystals of the chemical from the poly bag #7.

(3) After you have examined the crystals, put a few (about 1/8 teaspoon) of them back into poly bag #7 for use as seed crystals.

(4) Using your graduated measuring cup, measure out about 68 milliliters (ml) of water and pour this water into a small saucepan. Place the saucepan onto the stove and heat until water is boiling.

(5) Pour the boiling water from the small saucepan into the size “C” plastic growing cup which contains the contents from poly bag #7. Stir this mixture with one of your wooden spatulas until all of the chemical grains have dissolved completely.

(6) Place one or two broken rock fragments in the bottom of the size “D” plastic growing cup. These “base rocks” should only come up from the bottom of the growing cup about 3/4” (or about 2 cm).

(7) Pour the chemical/water solution from the size “C” plastic cup INTO the size “D” crystal growing cup. Pour right over the base rocks. The liquid should be poured in the cup so as to allow about one-third of an inch (8 mm) of space between the top of the liquid and the rim of the cup.

(8) From the poly bag, take a few crystals which you saved back, and carefully deposit these at different places on the top of the rocks which are on the bottom of the size “D” plastic crystal growing cup. You may just let these “seed crystals” sink down through the liquid and land on the rocks.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE “BASE ROCKS” FOR YOUR CRYSTALS.

(9) Place the lid which fits the top of the size “D” cup on top of your crystal solution cup.

(10) Set your “Aquamarine Blue” crystal growing cup in a place where it will not be disturbed by movement or changes in temperature.

(11) Record in your notebook all of the steps which you have performed during this experiment, including time, date, and which crystal type you are growing. Make sure you also label the crystal growing cup with the type of crystal you are growing in it and when the crystal will be ready to be removed from the solution. You may use the RECORD KEEPING LOG at the end of this procedure as a handy place to record your data and results.

(12) Your crystals will start growing in just a few hours. You may use your flashlight to look through the sides of the cup and watch the process.

(13) Allow the crystals to grow without being disturbed for three or four days. At that time you may remove your crystals from the solution OR you may take off the lid and let the solution evaporate for a few more days (to make larger crystals). If you remove the lid and let the solution evaporate, a crust of crystals may form at the top of the solution or at the top rim of the crystal growing cup. In any case remove your grown crystals BEFORE the top of your crystals are exposed through the surface of the solution. If the crystal mass and the “base rock” have formed a square shape due to the shape of the growing cup, you may want to break off excess crystals which form a square shape in order to make your crystal mass display look more geologically natural.

(14) When you are satisfied with the shape and size of your crystal mass specimen, set it aside on a piece of newspaper or paper towel and allow to dry completely for one day.

(15) Pour the excess solution from the growing cup to a storage jar. Label the jar with transparent tape as to which solution the jar contains. Retain this jar of solution for later procedures. Make sure the jar has a tight fitting lid.

(16) The crystals which may have grown on the sides or bottom of the crystal growing cup can now be removed and dried on newspaper or a paper towel. After they are dry, return them to the “Aquamarine Blue” crystal poly bag #7 and save them for use in a later procedure.

RECORD KEEPING LOG: Procedure #7: "AQUAMARINE BLUE" CRYSTALS

- (1) Date this procedure started _____ Time started _____
- (2) Type of "base rock" used (limestone, granite, etc.) _____
- (3) Number of "base rocks" used _____ Total weight of "base rocks" _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.

"Emerald Green" Crystals

Natural emerald is a green variety of beryl. It is one of the most highly prized of all gems. Emeralds have been known from the time of the Greeks, and were mined in Egypt as early as 2000 B.C. Crystals of emerald are smaller than other beryl gems such as aquamarine (blue-green), which is one reason why large emeralds are so valuable. Emeralds do not crystallize from hot chemical solutions, as do the other beryls, but grow in solid rock as the temperature and pressure increases. All beryls belong to the hexagonal crystal system, and commonly show six-sided shapes called prisms. The deep green color in emerald is due to the replacement of aluminum by small amounts of chromium during crystal growth. Natural emerald contains inclusions of foreign materials that can be used to distinguish it from the synthetic gem. These inclusions, which are trapped inside the crystal as it grows, can sometimes be used to determine the exact place where the emerald was found. The "Emerald Green" crystal clusters which you will grow in Procedure #8 are, of course, not real emeralds. Your chemical crystals are grown from a water (aqueous) solution containing monoammonium phosphate and a green dye. Your chemically grown crystals only simulate the color of real emeralds. Nonetheless, you will enjoy the beautiful shape (hexagonal system) and color variations of your own "Emerald Green" crystals.

Procedure #8: "EMERALD GREEN" CRYSTALS

In procedure #8 - "Emerald Green" Crystals, you will grow crystal clusters of a green color on a base rock. The crystal growing chemical contains monoammonium phosphate and a concentrated food dye colorant. After you have grown the "Emerald Green" crystals, keep them as clean and dry as possible. If they become dusty, they may be cleaned with a soft brush or with air from a gentle blower such as a hair dryer. Protect your finished geode from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles

- Poly bag #8 containing "Emerald Green" crystal growing chemical
- Size "C" plastic crystal growing cup
- Size "D" plastic crystal growing cup
- Size "D" plastic crystal growing cup lid
- Plastic graduated beaker (for measuring liquid & solid amounts)
- Wooden spatula (for stirring)
- Sauce pan for boiling water (let your parents help you with boiling water) OR styrofoam cup if water is boiled in microwave. DO NOT USE AN ALUMINUM saucepan. Use only a Teflon® coated or stainless steel saucepan.
- "Base rock" pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon.
- Small storage jar with lid for storing the excess solution for a later procedure
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the procedure OR you may use the record keeping log at the end of this procedure.

Procedure steps:

- (1) Open poly bag #8, the "Emerald Green" crystal growing chemical and pour the contents into a size "C" plastic crystal growing cup.
- (2) Using a clean dry wooden spatula and your magnifying glass, carefully look at the small grains and crystals of the chemical from poly bag #8.
- (3) After you have examined the crystals, put a few (about 1/8 teaspoon) of them back into poly bag #8 for use as seed crystals.

(4) Using your graduated measuring cup, measure out about 68 milliliters (ml) of water and pour this water into a small saucepan. Place the saucepan onto the stove and heat until water is boiling. (You may wish to have your parents or an adult help you with the boiling water).

(5) Pour the boiling water from the small saucepan into the size "C" plastic growing cup which contains the contents from poly bag #8. Stir this mixture with one of your wooden spatulas until all of the chemical grains have dissolved completely.

(6) Place one or two broken rock fragments in the bottom of the size "D" plastic growing cup. These "base rocks" should only come up from the bottom of the growing cup about 3/4" (or about 2 cm).

(7) Pour the chemical/water solution from the size "C" plastic cup INTO the size "D" crystal growing cup. Pour the chemical solution right over the base rocks. The liquid should be poured in the cup so as to allow about one-third of an inch (8 mm) of space between the top of the liquid and the rim of the cup.

(8) From the poly bag, take a few crystals which you saved back, and carefully deposit these at different places on the top of the "base rocks" which are on the bottom of the size "D" plastic crystal growing cup. You may just let these "seed crystals" sink down through the liquid and land on the rocks.

(9) Place the lid which fits the top of the size "D" cup on top of your crystal solution cup.

(10) Set your "Emerald Green" crystal growing cup in a place where it will not be disturbed by movement or changes in temperature.

(11) Record in your notebook all of the steps which you have performed during this experiment, including time, date, and which crystal type you are growing. Make sure you also label the crystal growing cup with the type of crystal you are growing in it and when the crystal will be ready to be removed from the solution. You may use the RECORD KEEPING LOG at the end of this procedure as a handy place to record your data and results.

(12) Your crystals will start growing in just a few hours. You may use your flashlight to look through the sides of the cup and watch the process.

(13) Allow the crystals to grow without being disturbed for three or four days. At that time you may remove your crystals from the solution OR you may take off the lid and let the solution evaporate for a few more days (to make larger crystals). If you remove the lid and let the solution evaporate, a crust of crystals may form at the top of the solution or at the top rim of the crystal growing cup. In any case remove your grown crystals BEFORE the top of your crystals are exposed through the surface of the solution. If the crystal mass and the "base rock" have formed a square shape due to the shape of the growing cup, you may want to break off excess crystals which form a square shape in order to make your crystal mass display look more geologically natural.

(14) When you are satisfied with the shape and size of your crystal mass specimen, set it aside on a piece of newspaper or paper towel and allow to dry completely for one day.

(15) Pour the extra solution from the growing cup to a storage jar. Label the jar with transparent tape as to which solution the jar contains. Retain this jar of solution for later procedures. Make sure the jar has a tight fitting lid.

(16) The crystals which may have grown on the sides or bottom of the crystal growing cup can now be removed and dried on newspaper or a paper towel. After they are dry, return them to the "Emerald Green" crystal poly bag #8 and save them for use in a later procedure.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE "BASE ROCKS" FOR YOUR CRYSTALS.

RECORD KEEPING LOG: Procedure #8: "EMERALD GREEN" CRYSTALS

- (1) Date this procedure started _____ Time started _____
- (2) Type of "base rock" used (limestone, granite, etc.) _____
- (3) Number of "base rocks" used _____ Total weight of "base rocks" _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Amount of dry crystal residue saved after procedure _____ g.
- (16) Amount of residue solution saved after procedure _____ ml.

“White Calcite” (Fast Growth) Crystals

In your crystal growing experiments, you are trying to grow the perfect “gem-like” crystals, but did you know that scientists often grow crystals with defects on purpose? Small crystals are “doped” with several different types of impurities to create special electronic properties. This changes the atomic structure in subtle but important ways. Solar batteries, electronic circuits in video games, and transistors are all based on “doped” silicon crystals.

Actual calcite is a crystal composed of the chemical calcium carbonate and crystallizes in the rhombohedral crystal system. Your chemically grown “White Calcite” (fast growth) crystals may form in a number of unpredictable shapes due to the conditions in which you grow them. The crystals which you will grow in Procedure #9 were called “White Calcite” because of the white, sugar-like color which they may exhibit. Your “White Calcite” crystals will probably not have a rhombohedral habit as true calcite has, but be prepared for unusual variations which may occur.

Procedure #9:

“WHITE CALCITE” (FAST GROWTH) CRYSTALS

In procedure #9 - “White Calcite” (Fast Growth) Crystals, you will grow clusters of a very fast growing white crystal on a base rock. The crystal growing chemical contains monoammonium phosphate and some aluminum potassium sulfate. No colorant is used in this procedure. After you have grown these crystals, try to protect them from moisture and rough handling, as they are quite fragile. If they become dusty, you may clean them VERY GENTLY with air from a gentle source, such as a hair dryer or with a soft brush. Protect them from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Hammer (to crush crystals reclaimed from procedure #4 “Rama Quartz”)
- Solution retained from procedure #4 (“Rama Quartz”)
- Solution retained from procedure #3 (“Frosty Diamond”)
- Poly bag #4 containing reclaimed crystals from “Rama Quartz” crystal growing procedure
- Size “D” plastic crystal growing cup
- Size “D” plastic crystal growing cup lid
- Plastic graduated beaker (for measuring liquid & solid amounts)
- Wooden spatula (for stirring)
- “Base rock” pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon.
- Old sauce pan no longer used for cooking. (To heat the dissolving chemicals into solution) DO NOT USE AN ALUMINUM saucepan. Use only a Teflon® coated or stainless steel saucepan.
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

(1) Ask your parents or an adult for the use of a saucepan which is no longer used for cooking. You will use this saucepan for mixing and heating chemical solutions.

(2) Using your graduated plastic measuring beaker, measure out 100 ml of solution saved from procedure #4 (“Rama Quartz”).

Pour this solution into the saucepan which you have set aside for this procedure. DO NOT USE AN ALUMINUM saucepan. Use only a Teflon® coated or stainless steel saucepan.

(3) Add one teaspoon (4.8 ml) of solution retained from procedure #3 (“Frosty Diamond”) to the saucepan.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE “BASE ROCKS” FOR YOUR CRYSTALS.

(4) Using the poly bag #4 (“Rama Quartz”) and the crystals you saved over from this procedure, gently crush these crystals to a powder by hammering gently on the outside of the poly bag #4. The crystals will become crushed on the inside of the poly bag and will be easy to keep together as a powder.

(5) Measure out 1/2 oz. (20 ml) of these crushed crystal fragments and powder to the saucepan.

(6) Slowly heat the saucepan containing the two solutions and the fragments and stir with your wooden spatula until the solids are completely dissolved.

(7) Select a flat “base rock” to fit the bottom of a size “D” crystal growing cup. The “base rock” should be no more than 1/2” thick. Place one or more “base rocks” to cover the bottom of the crystal growing cup.

(8) With your solution still hot (but NOT boiling), pour the solution into the size “D” crystal growing cup over the top of the “base rocks”.

(9) The liquid should fill the crystal growing vessel to within 1/3” (8 mm) of the rim.

(10) Place a plastic lid on top of the size “D” crystal growing cup. Set this growing apparatus aside in a place where it will not be disturbed.

(11) Your crystals will start a fast growth and will be close to the surface of the solution in less than 12 hours.

(12) When you are satisfied that you have the greatest crystal growth possible, remove the “base rocks” with their crystal growth and set them on newspaper or a paper towel to dry completely.

(13) Discard the rest of the solid and solution from the growing cup and wash the cup for later use. Clean all other containers and spatulas used in this procedure.

RECORD KEEPING LOG: Procedure #9: "WHITE CALCITE" (FAST GROWTH) CRYSTALS

- (1) Date this procedure started _____ Time started _____
- (2) Type of "base rock" used (limestone, granite, etc.) _____
- (3) Number of "base rocks" used _____ Total weight of "base rocks" _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Weight of chemical used _____ g.
- (6) Amount of water used _____ ml.
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____

"Diamond" Single Crystals

Have you ever wondered what the Earth is like hundreds of kilometers (1 kilometer = 0.62 mile) below the surface? The occurrence of natural diamonds in certain types of rocks provides a clue. Diamond crystals are mined in South Africa from a rock called kimberlite. These rocks are now at the surface, but the presence of diamond crystals indicates that at one time, millions of years ago, they were deep beneath the surface where the temperature and pressure are high enough to change carbon into diamond. When we examine kimberlite, we are looking at rock that came from deep inside the Earth! Actual diamonds are found in single crystals in a granular rock called peridotite. The variety of peridotite containing diamonds is called kimberlite.

The single large chemical crystals which you will grow in procedure #10 are, of course, not real diamonds. Your crystals are made of the chemical aluminum potassium sulfate and are grown from seed crystals of the same chemical. The procedure, as outlined below, is different from growing crystal clusters since single large crystals grown on monofilament thread are allowed to grow on all of their faces at the same time. The result is a large perfectly formed crystal undisturbed by the growth of neighboring crystals.

Procedure #10: SINGLE LARGE CRYSTALS ("CLEAR DIAMOND")

In procedure #10 - Single Large Crystals ("Clear Diamond"), you will be growing four crystals on a monofilament thread. Seed crystals from procedure #3 will be glued onto the monofilament thread. These seed crystals will be suspended in a crystal growing solution containing Aluminum Potassium Sulfate. After several weeks of growth, the crystals may be removed from the growing solution and used as single example specimens, or glued to an attractive base rock. Protect your crystals from moisture and dust. If they become dusty, they may be cleaned with a soft brush.

You will need the following materials to complete this procedure:

- Safety goggles

- Poly bag #3 containing excess crystals from procedure #3 ("Frosty Diamond")
- Size "C" plastic crystal growing cup
- Monofilament plastic thread (included in your set)
- Long wooden pencil
- Transparent cellulose tape
- Solution saved from procedure #3 ("Frosty Diamond")
- Scissors
- White glue OR two-part epoxy glue
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the experiment, OR you may use the record keeping log at the end of this procedure.

Procedure steps:

- (1) Open poly bag #3 containing the crystals you saved from the "Frosty Diamond" procedure #3. Pour contents out on a clean sheet of paper for examination. Look at the crystals with a magnifying glass. Select the crystals which are the largest and are the best formed crystals.

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(2) Select four of the best and most well-formed crystals. If there are notable deformities to these crystals, it is due to their growth on a flat surface. In this procedure you will grow crystals on a monofilament thread which will allow the crystals to now grow to a large and more perfect shape.

(3) Cut your monofilament line with scissors to lengths of 4" (10 cm). You will need four lengths of a 4" (10 cm) long line.

(4) On a clean piece of paper, put a dab of white glue (or two-part glue if desired). Dip one end of the monofilament line into the dab of glue and then touch the glued end to one of your selected "seed crystals". Glue each of the selected "seed crystals" to one end of a piece of the monofilament line. Set these aside to let the glue dry completely.

(5) When the monofilament line has been glued securely to the crystals, either tie or tape the monofilament lines to a long wooden pencil. Each line should be distanced from its neighbor by about 3/4" (2 cm). Neither the lines nor the crystals should touch the sides or bottom of the growing cup. The crystals should be arranged so that they are suspended in the center of the size "C" growing cup halfway between the bottom and the top rim. The pencil will act as a support across the top of the growing vessel, upon which the lines and their crystals are suspended.

(6) After you have arranged the monofilament line and the crystals on the pencil to your satisfaction, tape the monofilament lines so that they do not slip on the pencil. Remove the set-up from the size "C" growing cup and put it aside momentarily.

(7) Fill the size "C" crystal growing vessel with the solution from the storage jar from procedure #3 ("Frosty Diamond" solution). Let the size "C" crystal growing cup with the solution in it stand quietly for three days, or until small crystals begin to grow on the bottom of the growing cup.

(8) Take your pencil with its attached seed crystals and dip the crystals briefly in luke warm water. Now hang the crystals in the size "C" growing cup filled with the solution. Again, make sure the seed crystals do not touch each other or the sides or bottom of the cup.

(9) Keep this crystal growing apparatus and the solution in a room or location where the temperature stays fairly constant and is undisturbed. As the solution starts to evaporate into the air, the crystals will begin to grow.

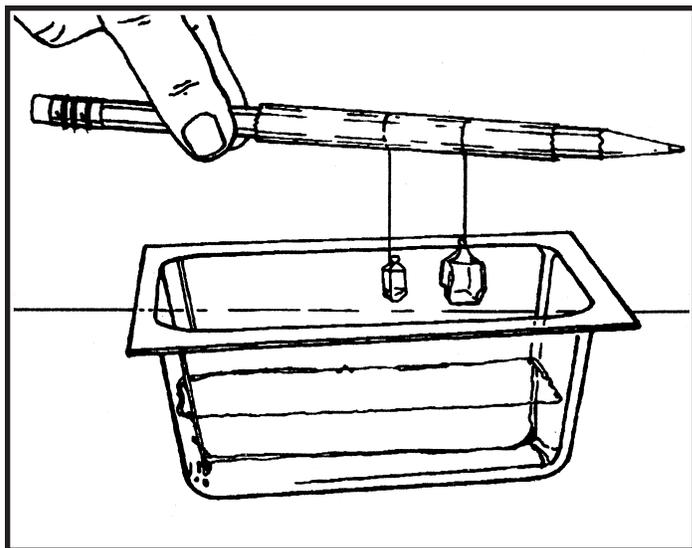
(10) You may add more solution from time to time to the crystal growing container, each time you observe the growth of the crystals. This procedure may take as long as three weeks, or until such time as you are satisfied with the size of your crystals.

(11) When the crystals have grown as large as you can get them, remove them from the solution, dry them on a paper towel or newspaper, and cut the monofilament threads off close to the crystals.

(12) You may display these crystals as examples of single large crystals, or you may wish to glue them on to base rocks for individual displaying.

(13) Pour the excess solution back into the storage jar.

(14) Clean your size "C" growing cup for later use.



Seed crystals, already glued onto the monofilament thread, are ready to be suspended in the solution in a size "C" growing cup.

The monofilament thread is tied loosely around a pencil, and when the length of the line and the spacing of the seed crystals is just right on the pencil, a small length of tape will secure the thread to the pencil.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE "BASE ROCKS" FOR YOUR CRYSTALS.

RECORD KEEPING LOG: Procedure #10: SINGLE LARGE CRYSTALS "CLEAR DIAMOND"

- (1) Date this procedure started _____ Time started _____
- (2) Type of "base rock" used (limestone, granite, etc.) _____
- (3) Number of "base rocks" used _____ Total weight of "base rocks" _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Size of seed crystals selected _____ mm
- (6) Number of seed crystals selected _____
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Size of finished crystals _____ mm
- (16) Weight of finished crystals _____ g.

"Fluorite" Single Crystal

Actual fluorite is composed of atoms of calcium and fluorine. In Procedure #11 you will be growing a simulated fluorite crystal. You simulated "Fluorite" single crystal is composed of atoms of aluminum, potassium sulfur and oxygen which are in the chemical aluminum potassium sulfate (alum). In growing your "fluorite" crystal you will start with an alum "seed crystal" on a monofilament thread and immerse this in a water (aqueous) solution containing aluminum potassium sulfate (alum) and a purple dye. Your crystal will grow on all of its faces when in contact with the growing solution, thus producing a large perfect crystal.

Fluorite usually occurs in nature as cubic crystals. If a small chisel is correctly aligned with respect to the cube faces, and gently tapped with a hammer, you can make the cube into an octahedron, an eight-sided ("octa") shape consisting of two four-sided pyramids that are joined together at the bases of the pyramids. This property - the ability to break or split along certain planes - is called cleavage. Diamond has the same cleavage as fluoride. This is why such a hard crystal like diamond can be shaped into an octahedron before it is cut, and placed in a gold ring. Cleavage planes form in directions where the chemical bonding is weak, or where there are a small number of bonds. When you cleave a crystal, you are breaking bonds between atoms!

Actual fluorite crystals have a cubic habit (shape). Your simulated "fluorite" crystal may have a hexagonal shape. If your alum "fluorite" crystal grows large enough you may wish to try and cleave it (split it along certain planes in the crystal) just as natural fluorite is able to be cleaved.

Procedure #11: SINGLE LARGE "FLUORITE CRYSTALS"

In procedure #11 - Single Large "Fluorite Crystals", you will be growing four large single crystals of a purplish color on a monofilament thread. Seed crystals from procedure #3 will be glued on to the monofilament thread. These seed crystals will be suspended in a crystal growing solution containing Aluminum Potassium Sulfate and a concentrated food dye colorant.

After several weeks of growth, the crystals may be removed from the growing solution and used as single example specimens, or glued on an attractive base rock. Protect your crystals from moisture and dust. If they become dusty, they may be cleaned with a soft brush.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #3 containing crystals from procedure #3 ("Frosty Diamond")
- Size "C" plastic crystal growing cup
- Monofilament plastic thread (included in your set)
- Long wooden pencil
- Transparent cellulose tape
- Solution saved from procedure #5 ("Purple Amethyst Geode")
- Scissors
- White glue OR two-part epoxy glue
- Newspaper or plastic sheeting to cover your work area to reduce the hazard of spills on table or floor
- Flashlight
- Magnifying glass
- Small notebook and pencil for recording the steps of the experiment, OR you may use the record keeping log at the end of this procedure.

ALWAYS WEAR YOUR SAFETY GOGGLES WHEN PERFORMING EXPERIMENTS WITH CHEMICALS OR DOING THE PROCEDURES OUTLINED FOR CRYSTAL GROWING AND SOLUTION MAKING! BE CAREFUL WHEN HANDLING HOT WATER! ALWAYS WEAR YOUR SAFETY GOGGLES WHEN BREAKING UP ROCKS FOR THE "BASE ROCKS" FOR YOUR CRYSTALS.

Procedure steps:

(1) Open poly bag #3 containing the crystals you saved from the “Frosty Diamond” procedure #3. Pour contents out on a clean sheet of paper for examination. Look at the crystals with a magnifying glass. Select the crystals which are the largest and are the best formed crystals.

(2) Select four of the best and most well-formed crystals. If there are notable deformities to these crystals, it is due to their growth on a flat surface. In this procedure you will grow them on a monofilament thread which will allow the crystals to now grow to a large and more perfect shape.

(3) Cut your monofilament line with scissors to lengths of 4” (10 cm). You will need four lengths of a 4” (10 cm) long line.

(4) On a clean piece of paper, put a dab of white glue (or two-part glue if desired). Dip one end of the monofilament line into the dab of glue and then touch the glued end to one of your selected “seed crystals”. Glue each of the selected “seed crystals” to one end of each piece of the monofilament line. Set these aside to let the glue dry completely.

(5) When the monofilament line has been glued securely to the crystals, either tie or tape the monofilament lines to a long wooden pencil. Each line should be distanced from its neighbor by about 3/4” (2 cm). Neither the lines nor the crystals should touch the sides or bottom of the growing cup. The crystals should be arranged so that they are suspended in the center of the size “C” growing cup . . . halfway between the bottom and the top rim. The pencil will act as a support across the top of the growing vessel upon which the lines and their crystals are suspended.

(6) After you have arranged the monofilament line and the crystals on the pencil to your satisfaction, tape the monofilament lines so that they do not slip on the pencil. Remove the set-up from the size “C” growing cup and put it aside momentarily.

(7) Fill the size “C” crystal growing vessel with the solution from the storage jar from procedure #5 (“Purple Amethyst Geode” solution).

Let this size “C” crystal growing cup with the solution in it stand quietly for three days, or until small crystals begin to grow on the bottom of the growing cup.

(8) Take your pencil with its attached seed crystals and dip the crystals briefly in luke warm water. Now hang the crystals in the size “C” growing cup filled with the solution. Again, make sure the seed crystals do not touch each other or the sides or bottom of the cup.

(9) Keep this crystal growing apparatus and the solution in a room or location where the temperature stays fairly constant and is undisturbed. As the solution starts to evaporate into the air, the crystals will begin to grow.

(10) You may add more solution from time to time to the crystal growing container, each time you observe the growth of the crystals. This procedure may take as long as three weeks, or until such time as you are satisfied with the size of your crystals.

(11) When the crystals have grown as large as you can get them, remove them from the solution, dry them on a paper towel or newspaper, and cut the monofilament threads off close to the crystals.

(12) You may display these crystals as examples of single large crystals, or you may wish to glue them on to base rocks for individual displaying.

(13) Pour the excess solution back into the storage jar.

(14) Clean your size “C” growing cup for later use.

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RECORD KEEPING LOG: Procedure #11: SINGLE LARGE “FLUORITE CRYSTALS”

- (1) Date this procedure started _____ Time started _____
- (2) Type of “base rock” used (limestone, granite, etc.) _____
- (3) Number of “base rocks” used _____ Total weight of “base rocks” _____ g.
- (4) Name of chemical used _____ Poly bag No. _____
- (5) Size of seed crystals selected _____ mm
- (6) Number of seed crystals selected _____
- (7) Temperature of crystal growing room _____ °C.
- (8) Temperature of solution at beginning of procedure _____ °C.
- (9) Temperature of solution at end of procedure _____ °C.
- (10) Temperature of room at end of procedure _____ °C.
- (11) Date when first crystal growth observed _____ Time _____
- (12) Estimated size of first crystals seen growing _____
- (13) Estimated growth rate of crystals seen growing _____
- (14) Date procedure ended _____ Time _____
- (15) Size of finished crystals _____ mm
- (16) Weight of finished crystals _____ g.

FOLLOW-UP EXPERIMENTS

After completing all of the procedures, you should now have a collection of various crystal specimens of different crystalline shapes and colors.

You will also have an assortment of “saved” residue chemical solutions and residue crystals. You may experiment with these to try and grow your own crystals. You may experiment with growing large single crystals or with growing clusters of crystals. You may also want to try to grow multi-colored crystals by first growing a crystal cluster of one color and then changing the solutions to have the final growth of those crystals in a different color.

For example: if you use the chemicals from “White Calcite” crystal procedure as well as colored chemicals from other procedures, what kind of results can you obtain?

You have seen that by evaporating solutions you can concentrate the growing solutions to make the crystal growths larger.

Remember, when evaporation happens in a solution, the chemicals remain in the solution and only the water evaporates.

Try experiments of your own design, evaporating small amounts of various saved solutions and describe the results.

On all of the experiments which you try on your own, be sure to keep detailed notes so that if you discover a new crystal you can reproduce your results again.

TROUBLE SHOOTING: WHAT IF MY CRYSTALS DON'T GROW?

If crystals do not grow properly there can be several reasons. If no growth is observed, you have probably used too much water. If this is the case, just remove the solution and re-boil it in a saucepan which is no longer used for cooking. Let the solution cool and pour it back into the crystal growing cup. If you use too little water, you may get many very small crystals. In this case, simply add a bit more water to your growing solution, reheat it, cool it, and add it back to your crystal growing cup.

Sometimes the type of “base rocks” which are used will hinder the growth of crystals. Some “base rocks” seem not to accept crystals growing on them. You will have to experiment with what type of “base rock” works best with your different procedures.

Always try to keep good records, and carefully measure all chemicals and water to make your solutions.

The temperature in the room which you select for your crystal growing is an important factor. The temperature should remain fairly constant and unchanging. Humidity in the air also will cause changes in crystal growth. Humidity affects how fast the solutions will evaporate and therefore how long it will take for some crystals to grow.

While crystals are growing, try not to disturb them. You may use your flashlight to observe their growth, but try to do so without disturbing the crystal growing cup.

LIST OF SET CONTENTS

1 Packet	“Golden Citrine” crystal growing chemical (monoammonium phosphate and food dye colorant)
1 Packet	“Pink Quartz” crystal growing chemical (monoammonium phosphate and food dye colorant)
1 Packet	“Frosty Diamond” crystal growing chemical (aluminum potassium sulfate)
1 Packet	“Rama Quartz” crystal growing chemical (monoammonium phosphate)
1 Packet	“Amethyst Geode” crystal growing chemical (aluminum potassium sulfate and food dye colorant)
1 Packet	“Red Ruby Geode” crystal growing chemical (aluminum potassium sulfate and food dye colorant)
1 Packet	“Aquamarine Blue” crystal growing chemical (monoammonium phosphate and food dye colorant)
1 Packet	“Emerald Green” crystal growing chemical (monoammonium phosphate and food dye colorant)
1 Packet	Geode shell plaster (calcium sulfate)
One Pair	Safety Goggles
Eight	Plastic crystal growing vessels
One	Plastic Geode Mold
Two	Wooden Spatulas
12”	Monofilament Plastic Thread
One	Instruction Booklet
One	Graduated Measuring Cup marked in “ml” (milliliters), “cc” (cubic centimeters), as well as in “oz” (ounces)
One	Magnifying Glass
One	Poly bag containing granite “base rocks”