



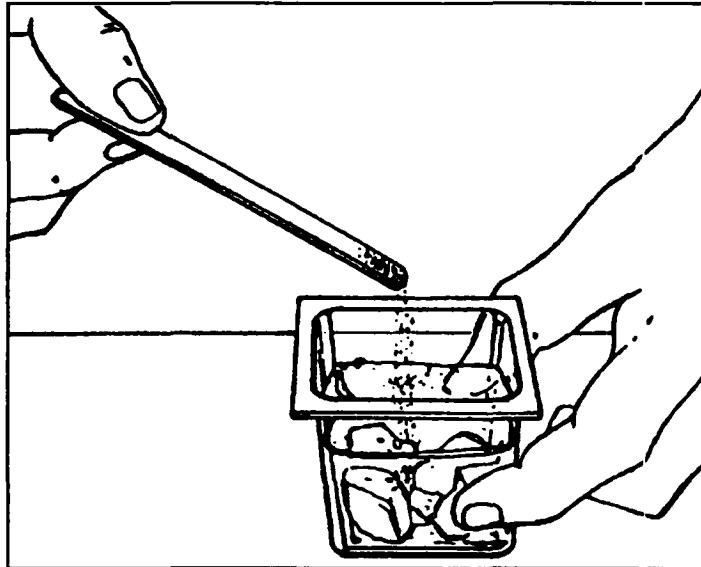
Item #3260  
Ages 10 AND UP

# 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 - SERIES 1 CRYSTAL GROWING PROCEDURES



**“GOLDEN CITRINE” CRYSTAL CLUSTER**  
**“AQUAMARINE BLUE” CRYSTAL CLUSTER**  
**“EMERALD GREEN” CRYSTAL CLUSTER**

**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, Natural Science Industries, Ltd.**  
910 Orlando Avenue, West Hempstead, NY 11552-3942  
(888) 425-9113

PRINTED IN U.S.A.

©2002 Smithsonian Institution - Natural Science Industries, Ltd  
910 ORLANDO AVENUE • WEST HEMPSTEAD, NY 11552-3942 • (888) 425-9113

ITEM #3260

## 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 crystal growing kit.

(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
- 2 poly bags of crystal growing chemicals
- 1 size "C" crystal growing cup
- 3 size "D" crystal growing cups
- 3 size "D" lids
- 2 wooden spatulas
- Instruction booklet
- Magnifying glass
- Poly bag containing 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 medium 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.
- 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.
- A supply of paper towels or tissue paper for drying crystals and cleaning up any spills.
- Scissors
- Flashlight
- 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.

□ 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.

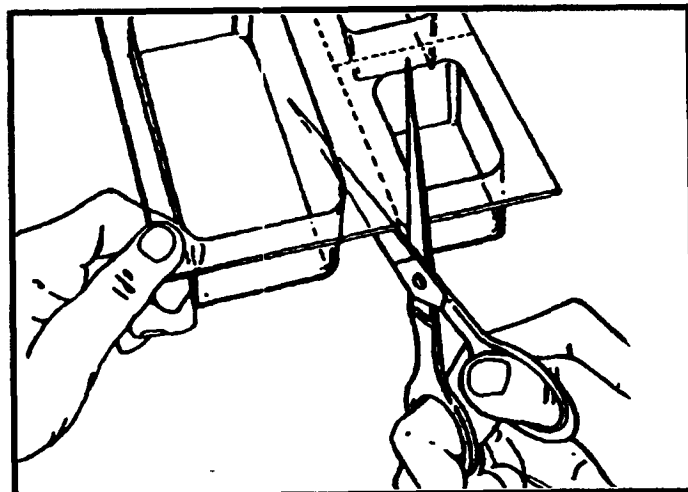
## KEEPING RECORDS - LABORATORY NOTES:

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!!

**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.**



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.

**NOTE:** The measuring cup included in this kit is marked with CC's. This instruction manual uses milliliters. One CC equals one milliliter.

*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!*

## "Golden Citrine" Crystals

Actual CITRINE crystals are a variety of quartz which show a light yellow color. The "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  $90^\circ$ . 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. Can you determine which one?

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.

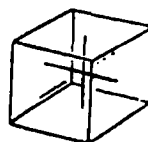
You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #1 containing "Golden Citrine" crystal growing chemical
- Size "C" plastic crystal growing cup
- Size "D" plastic crystal growing cup
- Size "D" plastic crystal growing cup lid
- Wooden spatula (for stirring)
- Sauce pan for boiling water OR styrofoam cup if water is boiled in microwave (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" pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon  
**Retain your poly bag #1 for use in a later experiment.**
- Small storage jar with lid for storing the excess solution for later steps or follow up 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 this procedure OR you may use the record keeping log at the end of this procedure.

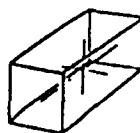
#### Procedure Steps:

(1) Open poly bag #1, the "Golden Citrine" crystal growing chemical and pour  $\frac{2}{3}$  (two thirds) of the contents into a size "C" plastic growing cup. The remaining  $\frac{1}{3}$  (one third) of the chemical should be kept in the poly bag #1 for use in procedure #3 later in this booklet. You should simply fold the top of the poly bag over and crease it to seal chemical in the poly bag. Set this aside in a safe dry place for later use.

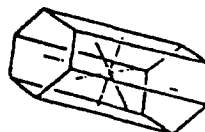
## THE SEVEN CRYSTAL SYSTEMS (shapes)



CUBIC



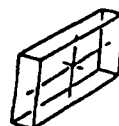
TETRAGONAL



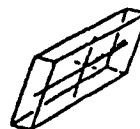
HEXAGONAL



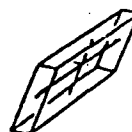
RHOMBOHEDRAL



ORTHORHOMBIC



MONOCLINIC



TRICLINIC

*All crystals which are known have been classified into one of the seven categories called CRYSTAL SYSTEMS. All natural crystals can be identified as belonging to one of these seven CRYSTAL SYSTEMS. The crystals that you grow with your crystal growing set may also be classified under one or the other of these categories (shapes).*

(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  $\frac{1}{8}$  teaspoon) of them back into poly bag #1 for use as seed crystals.

(4) Using the size "D" growing cup, fill with water to the upper mark and place this water into a saucepan. Place the saucepan onto the stove and heat until the 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.

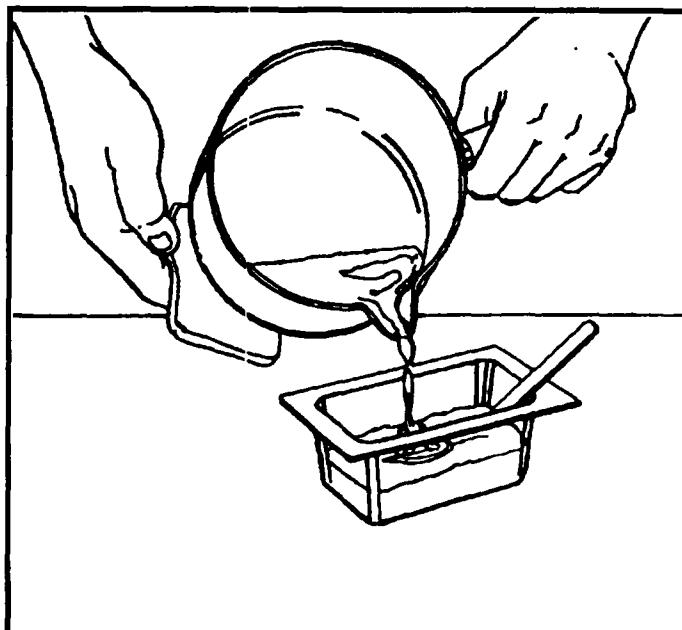
(12) Your crystals will start growing in just a few hours. You may use your flashlight to look through the sides of the cup and watch the process.

(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.

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.



*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. Fill the size "D" growing cup to the lower 20 milliliter (ml) line to get the measurement 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.

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 #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.

## “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 #2 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 solutions 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 #2: “AQUAMARINE BLUE” CRYSTALS

In procedure #2 - “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 crystals from harsh light and moisture.

You will need the following materials to complete this procedure:

- Safety goggles
- Poly bag #7 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
- Wooden spatula (for stirring)
- Sauce pan for boiling water OR styrofoam cup if water is boiled in microwave (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” pieces to place in the bottom of plastic crystal growing cup for your crystals to grow upon **Retain your poly bag #7 for use in a later experiment.**
- Small storage jar with lid for storing the excess solution for later steps or follow up 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 this procedure 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 #7, the “Aquamarine Blue” crystal growing chemical and pour 2/3 (two thirds) of the contents into a size “C” plastic growing cup. The remaining 1/3 (one third) of the chemical should be kept in the poly bag #7 for use in procedure #3 later in this booklet. You should simply fold the top of the poly bag over and crease it to seal chemical in the poly bag. Set this aside in a safe dry place for later use.
- (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 the size “D” growing cup, fill with water to the upper mark and place this water into a saucepan. Place the saucepan onto the stove and heat until the 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. Let the solution cool until lukewarm.

(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 "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 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.

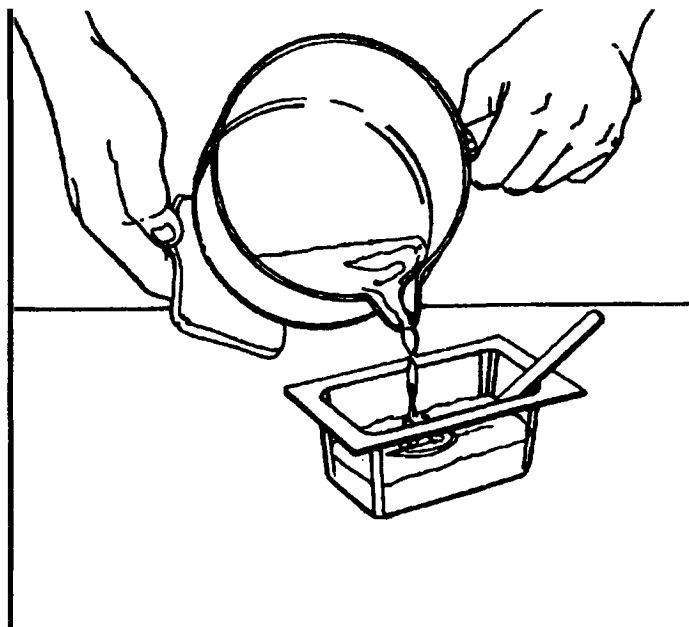
(12) Your crystals will start growing in just a few hours. You may use your flashlight to look through the sides of the cup and watch the process.

(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 excess 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.

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.



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 "Aquamarine Blue" crystal poly bag #7, 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 "Aquamarine Blue" 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. Fill the size "D" growing cup to the lower 20 milliliter (ml) line to get the measurement 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 "Aquamarine Blue" cluster, previously grown, into a clean size "D" growing cup. Carefully pour the new solution over the "Aquamarine Blue" clusters. You do not need to add seed crystals this time. Cover growing cup with lid and allow your crystals to grow as before.

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: "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" \_\_\_\_\_

(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 #3 are, of course, not real emeralds. Your chemical crystals are grown from a water (aqueous) solution containing monoammonium phosphate and a mixture of blue and yellow dyes, which create a green dye color. 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 #3: "EMERALD GREEN" CRYSTALS

In procedure #3 - "Emerald Green" Crystals, you will grow crystal clusters of a green color on a base rock. The crystal growing chemicals contains monoammonium phosphate from poly bag #1 ("Golden Citrine") and poly bag #7 ("Aquamarine Blue"). The combinations of these two poly bags and their respective yellow and blue concentrated dyes will provide the "Emerald Green" crystal growing chemical mixture. 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
- The two bags of chemicals which you saved from Procedure #1 (poly bag #1) "Golden Citrine" and from Procedure #2 (poly bag #7) "Aquamarine Blue".
- Size "C" plastic crystal growing cup
- Size "D" plastic crystal growing cup
- Size "D" plastic crystal growing cup lid
- 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) Re-open poly bag #1, the "Golden Citrine" crystal growing chemical and poly bag #7, the "Aquamarine Blue" crystal growing chemical which you saved from Procedures #1 and #2 earlier, and pour their 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 from poly bags #1 and #7, which you have now combined together.
- (3) After you have examined the crystals, put a few (about 1/8 teaspoon) of the mixed crystals back into one of the poly bags and save for later 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 two poly bags #1 and #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 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.

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 "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, save them for use in a later procedure.

(17) If you prefer to grow even larger "Emerald Green" crystals, you may wish to combine your excess solution, and the excess crystals which have formed on the bottom and sides of the growing cup together with about 20 milliliters (ml) of water. Fill the size "D" growing cup to the lower 20 milliliter (ml) line to get the measurement 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 has dissolved. Be sure to use a stainless steel or Teflon® coated saucepan (NOT ALUMINUM!) for this procedure.

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

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 #3: "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.

## 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 the "Aquamarine Blue" crystal procedure as well as colored chemicals from the "Golden Citrine" and "Emerald Green" 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 stainless steel or Teflon® coated saucepan or in a non-aluminum 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	.....	"Aquamarine Blue" crystal growing chemical (monoammonium phosphate and food dye colorant)
One Pair	.....	Safety Goggles
One	.....	Size "C" plastic crystal growing cup
Three	.....	Size "D" plastic crystal growing cups
Three	.....	Size "D" lids
Two	.....	Wooden spatulas
One	.....	Instruction Booklet
One	.....	Magnifying Glass
One	.....	Poly bag containing granite "base rocks"