Chemical Institute of Canada | *For Our Future*

The National Crystal Growing Competition Handbook

When does the competition take place?

The material is usually available for distribution the beginning of September. For 2017 the crystal growing period is from October 10 to November 13. The deadline for submitting your crystals to your regional coordinator is November 17 (see list of coordinators).

National Prizes

Students win cash prizes for their school and will receive individual certificates for the national prizes.

- Best Overall Crystal – 1st prize ($300), 2nd prize ($200), 3rd prize ($100)
- Best Quality Crystal – 1st prize ($200)
- Best Teacher's Crystal – 1st prize ($200)

Who Can Participate?

- All Canadian high school students or homeschooled youth ages 13-18.
- Individuals or teams of up to three students. There is no limit on the number of teams per school;
- High school science teachers.

Four divisions compete regionally as described below. The top one or two crystals in each region are sent to be judged nationally.

- Division 1: High school students within the regions that have coordinators. Crystals are submitted to the regional coordinator for regional judging.

- Division 2: 'Outlier' high school students are those living outside the regions that have coordinators. These crystals will be submitted to the national coordinator for 'regional' judging.

- Division 3: Home schooled students. These crystals will be submitted to the national coordinator for 'regional' judging.

- Division 4: High school teachers. High school teacher crystals are judged for overall quality on a national basis only, separate from the students' crystals. Crystals are submitted directly to the national coordinator for judging.

How do I Sign Up

All you need to do is contact your regional coordinator to let him/her know that you are participating. If you are unsure of who your coordinator is, contact Denis Bussières, national coordinator at: dbussier@uqac.ca .

If you do not 'fit' into one of the established regions, you will be placed in the 'Outliers" group and should sign up with the national coordinator.

Once you are registered, you may order your material (see below).

Coordinators

Register in advance with one of the National Crystal Growing Competition regional coordinators so that they are aware of your participation and can make preparations for getting your crystal(s) judged.

If you do not live in an area that has a coordinator listed in the pdf, then contact the national coordinator below.

National Coordinator

Denis Bussières, MCIC
Université de Québec à Chicoutimi
Département des sciences fondamentales

Chicoutimi, Que.
T: 418-545-5011, ext. 5074 F:
418-545-5012
denis_bussieres@uqac.ca

CIC National Office Contact

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What is a Crystal?

A crystal is a solid that consists of the various atoms, ions, or molecules being arranged in a uniform repeating pattern. This results in the material having a specific shape and colour, and having other characteristic properties. Diamond (used in jewelry and cutting tools) is an example of a crystal. It is made of pure carbon. Graphite (used in pencils and lubricants) is also a crystal made from carbon. Salt and sugar are also examples of crystals.

Recrystallization is a process that has been used to purify solid material by dissolving the solid (called a solute) in an appropriate liquid (called a solvent) and then having the material come out of solution in crystalline form. Depending upon conditions, one may obtain a mass of many small crystals or one large crystal. Click on these links for more detailed information:

- crystal types
- shapes and sizes
- light and colour
- how crystals form
- Frequently asked crystal questions

Which Materials to Get, and How to Get Them

For the sake of variety, we alternate the chemicals used each year. Thus far, the National Crystal Growing Competition has used three different substances:

- Cupric sulfate pentahydrate (copper (II) sulfate pentahydrate, or ‘bluestone’);
- Aluminum potassium sulfate (or ‘alum’). This substance seems to be a popular one with which to experiment;
- Potassium sodium tartrate (or ‘Rochelle Salt’).

The choices were made on the basis of relative safety, availability, and good crystal growth. The first two are available from most laboratory chemical supply houses. The third may be made from materials found in a grocery store but be sure to use real cream of tartar to do your experiment. Others that are known to give good crystals include:

- Potassium ferricyanide,
- Copper acetate monohydrate, and
- Calcium copper acetate hexahydrate.

The 2017 crystal is Aluminum potassium sulfate (alum)

To order your material:

- **Contact Boreal Science at 1-800-387-9393** or by fax at 1-800-668-9106 or e-mail at borealcs@vwr.com from September 11 to October 2.
- Promo Code **NCGC2017 – National Crystal Growing Competition – item no. 470300-154**. They will ship one 500g bottle of the material directly to you. The cost is $11.53 (15% of $13.25) – taxes and shipping are

not included. Provide a Purchase Order Number from your school. Home schools need to identify themselves accordingly. Their purchase will be processed as a cash sale. Payment: via credit card.

- NOTE: Only teachers may order material, which must be shipped directly to a school along with your invoice.
- If you need more material, order it at the same time. NOTE: Due to a limited supply available, schools will be limited to one extra bottle. You may purchase additional supplies from your own sources.

How to Grow Crystals

The crystal growing period is from October 10 to November 13

RULE 1: The maximum amount of starting material that may be used for each given crystal is limited to 100 g. The 500 g supplied is sufficient for preparation of five crystals.

RULE 2: So that all students across the country have an equal preparation time, crystal production must conclude within five weeks after receipt of starting material.

First Stage: Grow a Seed Crystal

The idea is to grow a single crystal, not a bunch of crystals. You will first need to grow a small perfect crystal, your seed crystal, around which you will later grow a large crystal. It is therefore essential to avoid excessive rapid growth, which encourages the formation of multiple crystals instead of a single crystal.

What You Need

- Substance to be crystallized;
- Distilled or demineralised water;
- A shallow dish (e.g., Petri);
- Heating plate or stove;
- Fishing line (1 to 2 kg strength);
- A small wood rod (e.g., popsicle stick);
- A magnifying glass (optional).

Important Things to Know

- How much substance you have to work with, which you can determine by weighing it on a balance.
- The solubility of the substance in water at room temperature, which you can obtain from a chemistry reference book.
- It would also be useful to know the solubility of the substance at elevated temperatures, which is information that may also be available in a reference book such as Handbook of Chemistry and Physics, 45th Ed (19645)]

What to Do

- Warm about 50 mL (1/4 cup) of water in a glass con2tainer.
- Dissolve a quantity of the substance to produce a saturated solution at the elevated temperature.
- Pour the warm solution into a shallow dish.
- Allow the solution to cool to room temperature.
- After a day or so, small crystals should begin to form.
- Remove some of the crystals.
- With a magnifier select a beautiful and transparent small crystal. This will be your seed crystal.
- Tie the seed crystal with the fishing line by using a simple overhand knot.
- Suspend the seed crystal in a shallow (1 to 2 mm deep) small volume (about 1 to 2 mL) saturated solution (for example, in a cover or a Petri dish) for some time (1 to 2 days).
- Check with the magnifier that the seedling crystal is well-fixed to the line by its beginning growth. This step is very important because one can lose several days of growth if the 'beginning growth' is not regular or not along the structure of the seedling crystal. It is worth checking properly before going on with the regular crystal growth.

Second Stage: Grow a Large, Single Crystal

Now you are ready to proceed with the preparation of a large single crystal.

Once you have mastered this step, you may be interested in trying to grow single crystals in the presence of introduced ‘impurities" that may give different crystal colours or shapes.

In recrystallization, one tries to prepare a solution that is supersaturated with respect to the solute (the material you want to crystallize). There are several ways to do this.

One is to heat the solvent, dissolve as much solute as you can (said to be a "saturated" solution at that temperature), and then let it cool. At this point, all the solute remains in solution, which now contains more solute at that temperature than it normally would (and is said to be "supersaturated").

This situation is somewhat unstable. If you now suspend a solid material in the solution, the "extra" solute will tend to come out of solution and grow around the solid. Particles of dust can cause this to occur. However this growth will be uncontrolled and should be avoided (thus the recrystallization beaker should be covered). To get controlled growth, a "seed crystal", prepared from the solute should be suspended into the solution.

The supersaturation method works when the solute is more soluble in hot solvent than cold. This is usually the case, but there are exceptions. For example, the solubility of table salt (sodium chloride) is about the same whether the water is hot or cold.

The rate at which crystallization occurs will affect crystal quality. The more supersaturated a solution is, the faster growth may be. Usually, the best crystals are the ones that grow SLOWLY.

Thus, if you heated the solvent to near the boiling point to get a highly supersaturated solution on cooling back to room temperature, crystals may start to form before the solution had completely cooled.

This is where the "art" of science comes into play. One has to experiment a bit to get the right conditions.

A second way to get supersaturation is to start with a saturated solution and let the solvent evaporate. This will be a slower process.

The above will apply to most situations. It is necessary to match the proper solvent with a given solute.

WARNING: the solubility of some salts is quite sensitive to temperature, so the temperature of recrystallization should be controlled as best you can. There have been reports in the past of students having a nice big crystal growing in a beaker on a Friday, the room temperature rising in a school over the weekend, and by Monday morning the crystal had totally gone back into solution.

What You Need

- Substance to be crystallized;
- A seed crystal of the substance to be crystallized on a fishing line;
- Distilled or demineralized water;
- A small wood rod or popsicle stick;
- Thermometer;
- Balance;
- Plastic or glass container;
- Heating plate;
- Beaker of 2 to 4 litres volume;
- Thermostated bath (optional);
- Slow revolution motor (1 to 4 rotations per day) (optional).

Important Things to Know

- How much substance you have to work with, which you can determine by weighing it on a balance.
- The solubility of the substance in water at room temperature, which you can obtain from a chemistry reference book.
- It would also be useful to know the solubility of the substance at elevated temperatures, which is information that may also be available in a reference book.

How to Prepare a Supersaturated Solution

To grow your large, single crystal, you will need a supersaturated solution.

The amounts of substance and water to be used will depend upon the solubility at room and elevated temperatures. You may have to determine the proper proportions by trial and error (just like the first scientists did).

Method One

- Place about double the amount of substance that would normally dissolve in a certain volume of water at room temperature into that volume of water. (e.g. If 30 g (about 1 oz) of X dissolves in 100 g (mL) of water at room temperature, place 60 g of X in 100 mL of water.) Adjust the proportions depending upon how much material you have. Use clean glassware.
- Stir the mixture until it appears that no more will go into solution.
- Continue stirring the mixture while gently warming the solution.
- Once all of the substance has gone into solution, remove the container from the heat.
- Allow the solution to cool to room temperature.
- You now have a supersaturated solution.

Method Two

- Select an appropriate volume of water.
- Warm this water to about 15–20 deg above room temperature.
- Add some of your substance to the warm water and stir the mixture to dissolve completely.
- Continue adding substance and stirring until there is a little material that won't dissolve.
- Warm the mixture a bit more until the remaining material goes into solution.
- Once all of the substance has gone into solution, remove the container from the heat.
- Allow the solution to cool to room temperature.
- You now have a supersaturated solution.

Now you Can Grow your Wonderful Crystal

Since the solubility of a substance varies a lot with temperature, it is very important to control the temperature carefully.

If the room temperature is stable then you might be able to leave your apparatus out in the open. If it can vary by even only a degree or two, then it may be necessary to place the apparatus into a thermostated bath set to a few degrees above room temperature (if available, but this is not mandatory). You could also place the growing apparatus inside a Styrofoam or picnic cooler.

Also, for the seed crystal to grow, it is absolutely necessary that the solution never be unsaturated at the temperature of the experiment (usually the room temperature).

Getting Started

1. Carefully suspend your seed crystal from the stick into the supersaturated solution, being careful not to let the crystal touch the bottom of the container.

2. Cover the container in which the crystal is growing. This is to:
   - keep out dust, and
   - reduce temperature fluctuations.

This can be done with plastic wrap or aluminum foil. If you want to allow the solvent (typically water) to evaporate (see step #4a below), then use porous paper (e.g., filter paper).

3. Observe the crystal growth. Depending upon the substance, the degree of supersaturation and the temperature, this may take several days before the growth slows down and stops. A couple of different things can happen at this stage. The questions and answers below can help you.

   - Why does the crystal stop growing?
     A crystal will only grow when the surrounding solution is supersaturated with solute. When the solution is exactly saturated, no more material will be deposited on the crystal. (This may not be entirely true. Some

may be deposited, however an equal amount will leave the crystal surface to go back into solution. We call this an equilibrium condition.)

- Why did my crystal shrink/disappear?
  If your crystal shrank or disappeared, it was because the surrounding solution became unsaturated and the crystal material went back into solution. Unsaturation may occur when the temperature of a saturated solution increases, even by only a few degrees, depending upon the solute. (This is why temperature control is so important.)
- How do I get crystal growth restarted?
  Step 4 below will give you the details.

4. Resupersaturate the solution. This may need to be done on a daily basis, especially when the crystal gets larger. But first, remove the crystal.

One way to resupersaturate the solution is to reduce the amount of solvent. This may be done by heating the solution for a while and then cool it to the original temperature. Or, you can just let the solvent evaporate from the solution (this may be a slow process, but has the advantage of getting a better quality crystal.)

One can also supersaturate the solution by warming it somewhat, then adding and dissolving more solute, and finally cooling it.

5. Each time the solution is saturated, it is a good idea to 'clean' the monocrystal surface, by

- making sure the crystal is dry;
- not touching the crystal with your fingers (hold only by the suspending line if possible);
- removing any 'bumps' on the surface due to extra growth;
- removing any small crystals from the line.

It is a good habit to clean your hands after each manipulation.

6. Resuspend the crystal back into the newly supersaturated solution.
7. Repeat steps 4-6 as needed.
8. To get improved symmetry and size, slowly rotate the growing monocrystal (1 to 4 rotations per day). An electric motor with 1 to 4 daily rotations might be difficult to find (consider one from an old humidity drum-register or other apparatus). This option becomes useful only when a monocrystal gets rather big.

How Are the Crystals Judged?

Regional judging will take place starting November 21.

Each school is encouraged to submit two crystals to the regional coordinator; one for best quality and one for best overall. It is recognized that where several crystals from a school may be of roughly equivalent overall quality, and it is difficult to make a choice, it may be necessary to submit several crystals. Of these several crystals from a particular school, only one may be the 'official' crystal to be considered for all prize(s) awarded locally.

The best crystal from each region will be sent for judging at the national level by December 16. Results will be announced in January.

Judging Criteria

One single crystal will be judged only on the basis of quality as outlined below. The other single crystal will be judged on the basis of combining mass and quality factors as outlined below.

The quality is judged by experts who will rank the crystals on a scale of 0 to 10. A score of 10 will be given to a perfect gem-quality crystal that fits the ideal crystal structure known for the chemical.

1. The crystal is weighed, and the mass M recorded. The crystal must be a minimum of 0.5 g to be eligible for judging.

2. The quality of the crystal is judged on a scale of 1 to 10, with 10 representing a perfect crystal. The following factors will be considered in judging quality:
   - match/mismatch with crystal type (out of 2)
   - presence/absence of occlusions (out of 2)
   - intact/broken edges (out of 2)
   - well-formed/misformed faces (out of 2)
   - clarity/muddiness (out of 2)

Total Observed Quality Qo = x.xx (out of 10)

3. The Total Score is then determined as follows:

Total Score = [log (Mo+1)] x Qo

The logarithm of the mass is chosen so that large poor quality crystals don't swamp out smaller good quality crystals.

The value 1 is added to the mass so that crystals weighing less than 1 g get a positive score.

A 100 per cent yield crystal made from 100 g (Mt) that scores a perfect 10 on quality (Qt) would get a theoretical maximum of:

The actual score is expressed as a percentage of the maximum. The crystal with the highest Overall Score is the winning crystal.

100 x {[log (Mo+1)] x Qo} / {[log (Mt+1)] x Qt} = Overall Score %

For example, the best overall crystal in the 2001 contest with 150 g starting material weighed 46.53 g and had a quality of 8.65. Its overall score was:

100 x {[log (46.53+1)] x 8.65} / {[log (150+1)] x 10} = 66.6%

This score is nearly an absolute score that could be used to judge different types of crystals grown from differing amounts of starting material.