Institut de chimie du Canada | ***Pour notre avenir***
Chemical Institute of Canada | ***For Our Future***

The 2024 National Crystal Growing Competition Handbook

Sponsored by:

BRUKER

PROTO
X-RAY DIFFRACTION

Mineralogical Association of Canada

Association Minéralogique du Canada

CCDC
advancing structural science

boreal science

SolidStatePharma®

Table of Content

A word about our sponsors

These scientific companies, and this association, have generously accepted to sponsor this competition. Without them, this competition would not be possible! They all share a common passion for science, and in most cases, specifically for crystals. Here are, in their words, their main interests.

SolidStatePharma®	Solid State Pharma is a Halifax based pharmaceutical research company with speciality in crystallization engineering and solid-state science. As a partner to global pharmaceutical companies, SSPI combines rigorous experimentation with insightful analysis to generate knowledge, not just data.
PROTO X-RAY DIFFRACTION	Proto is a leading provider of portable and laboratory-based x-ray diffraction (XRD) systems for the characterization of materials. Proto's product lines include powder diffractometers, residual stress and retained austenite measurement systems, Laue single-crystal orientation systems, x-ray tubes, and custom XRD systems. We are also pleased to offer measurement services through our American and Canadian laboratory locations, which are ISO/IEC 17025:2017 accredited.
BRUKER	Detailed insight into the relationship between structure, function, and reactivity is crucial for the success of modern science. Single Crystal X-ray Diffraction is one of the most powerful methods for generating this vital information and has thus become an essential tool for new discovery. Bruker is proud to develop state-of-the-art XRD instruments for the scientific community.
Mineralogical Association of Canada Association Minéralogique du Canada	The Mineralogical Association of Canada (MAC) was formed in 1955 as a non-profit scientific organization to promote and advance the knowledge of mineralogy and the allied disciplines of crystallography, petrology, geochemistry and mineral deposits. MAC has a commitment to further public awareness of mineral sciences, and is proud to sponsor the National Crystal Growing Competition.

CCDC advancing structural science	The Cambridge Crystallographic Data Centre (CCDC) are world-leading experts in structural chemistry data, software and knowledge for materials and life sciences research and development. The CCDC software suite allows for searching and structure or arrangement of elements, and seeing quickly if anyone has submitted a crystal with that structural feature before.
boreal science	For over 55 years, Boreal Science has proudly served educators throughout Canada with the best in science supplies and service. From microscopes and models to probeware and physics, Boreal Science offers high quality materials for teaching science in the classroom and lab. A reputation of dependability and a focus on meeting the unique needs of Canadians have earned Boreal Science the honour of being Canada's most trusted science education supplier. Striving to consistently bring you the best, Boreal Science offers you a variety of value added conveniences.

Information on the National Crystal Growing Competition

What is the Chemical Institute of Canada?

The Chemical Institute of Canada (CIC) is a Canadian, not-for-profit association of professionals involved in the field of chemistry, chemical engineering and chemical technology. The CIC association organizes outreach activities promoting chemistry to students and the public. The National Crystal Growing Competition, which has been going on for more than thirty years, is one of these.

How does this competition work?

The competition aims at growing the largest and highest quality crystal possible. It takes place in Canadian high schools during the winter semester. Winning crystals from each school are sent for evaluation, first to a regional coordinator, and regionally winning crystals are sent for judging at the national level.

Competition schedule

The 2024 competition schedule appears below. ***Please note that these dates are considerably different to the usual schedule. For the 2024-2025 competition, this change is being made to allow for more effective outreach.*** In case of abnormal delivery delay of the substance to be crystallized, please contact your regional coordinator, who will adjust dates if required.

September to December	Competition announcements and information packages shared with teachers, high schools, and school boards by regional coordinators
October to January	Schools register with their regional coordinator
October to January	Schools order/purchase their chemicals (Potassium Chloride for 2025)
February 3rd to April 3rd	Crystal growth
By April 24th	Schools send their best two student crystals (and the teachers crystal) to regional coordinator
By June 11th	Regional coordinators send their two winning crystals (student and teacher) to the national coordinator
June to July, results between July and August	National judging: results are sent to regional coordinators

<u>What can I win?</u>
Students and their teachers can win cash prizes for their school and will receive individual certificates for the national prizes. Prizes will be posted on the Competition web site.

In the coming years, efforts are being made to expand the scope and impact of the prizes, including more than just monetary prizes, ideally not exclusively at the National level. Discussions are underway with current and new sponsors relating to this intent, and updates will come with upcoming competition cycles.

<u>Who can participate?</u>
All Canadian high school students or homeschooled youth between the ages of 13 and 18 (included) can participate. Students can participate individually or as teams. There are no fixed limits to the number of participants per school.

The competition is also open, although in a separate division, to high school teachers and lab technicians.

<u>Whom am I up against?</u>
Participants are assigned to the following four divisions:

- Division 1: High school students within regions that have coordinators. Crystals are submitted to the regional coordinator for regional judging.
- Division 2: “Outlier” high school students are those living outside regions that have coordinators. These crystals will be submitted to the national coordinator for “regional” judging.
- Division 3: Home-schooled students. Please see coordinator list on the web site.

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

Winning crystals in each regional section of Division 1, and in Divisions 2 to 3 are pooled against one another for the final, national judging.

How do I sign up?

All you need to do is contact your regional coordinator to let them know that you are participating. If you are unsure of who your coordinator is, please reference the "Important Contacts for the Crystal Growing Competition" table below. The information is posted on the Cheminst.ca website at https://www.cheminst.ca/discover/national-crystal-growing-competition/ under the "Regional Coordinators" section of the website. Your regional coordinator will be the nearest regional coordinator to your location. If multiple coordinators are in your area, check which host institution is closer via using Google Maps. If you still cannot tell, please contact the national coordinator at Tanner.George@smu.ca. Parents of home-schooled students should register with Gayle Hanlon at info@learnfree.ca.Please do not overlook this step, as it allows regional coordinators to organize their event and contact participants if their crystals do not arrive.

Important Contacts for the Crystal Growing Competition

Role	Name	Province or Territory	Institution	Email
National Coordinator	Tanner George	Nova Scotia	Saint Mary's University	Tanner.George@smu.ca
Member Engagement Coordinator	Peter Glowacki	Ontario	The Chemical Institute of Canada	pglowacki@cheminst.ca
Regional Coordinator	Ian Phillips	Alberta - Edmonton	University of Alberta	driang.phillips@gmail.com
Regional Coordinator	Mike DiPietro	British Columbia - Vancouver	Southridge School	mdipietro@southridge.bc.ca
Regional Coordinator	Violeta Iosub	British Columbia - Vancouver Island	University of Victoria	viosub@uvic.ca
Regional Coordinator	Frank Schaper (Hein)	Quebec - Montreal	Universite de Montreal	Frank.Schaper@umontreal.ca
Regional Coordinator	Nicholas Ryan	Newfoundland	Memorial University of Newfoundland	nickryan@mun.ca
Regional Coordinator	Gayle Hanlon	Ontario - Niagara	AGATE Private School	info@learnfree.ca
Regional Coordinator	Barbara Blackwell	Ontario	Agriculture and Agri-Food Canada	Barbara.Blackwell@AGR.GC.CA
Regional Coordinator	Indira Thapa	Ontario	Agriculture and Agri-Food Canada	Indira.Thapa@agr.gc.ca
Regional Coordinator	Jordan Bentley	Ontario - Toronto	University of Western Ontario	jordan.bentley000@gmail.com
Regional Coordinator	Abdelaziz Nait Aijou	New Brunswick	Universite de Moncton	Abdelaziz.nait.ajjou@umoncton.ca
Regional Coordinator	Amitabh Jha	Nova Scotia	Acadia University	Amitabh.jha@acadiau.ca
Regional Coordinator	Nicholas Vukotic	Ontario - Windsor	University of Windsor	nvukotic@uwindsor.ca

To order your material:

In 2025, the crystal being grown is **Potassium Chloride, KCl** (Figure 1).

Figure 1 KCl crystals grown from slow evaporation of a saturated potassium chloride solution.

Item #	Description	Grade	Size	Chemical/Physical Specifications	Unit	Availability	Price	Quantity
470302-092	Potassium Chloride	Reagent	500 g	Granular	Each (500g)	In Stock at Supplier	$42.20	

Boreal Science is pleased to offer a discount on the chosen chemical, potassium chloride, items 470302-092 and 470302-088 (500 g and 2.5 kg sizes respectively). The regular prices for those two chemicals are $42.20 (item 470302-092) and $92.70 (item 470302-088) but with the discount the prices will be $35.87 (item 470302-092) and $78.80 (item 470302-088) each. Shipping and taxes are not included in the prices. The quote number (8602855528) must be mentioned at the time of ordering. Orders can be placed via phone at 1-800-387-9393, via fax at 1-800-668-9106, or via email at scied_boreal_main@avantorsciences.com.

The chemical must be shipped directly to a school, we do not ship to private residences, but the orders can be placed using personal credit cards if requested. Participants will pay the shipping charge for the chemical (unless the school has a contract already in place with Boreal Science). The shipping charges are calculated at the time of shipment. If the school already has a board discount contract with us, they will pay whichever price is lower. The quoted price cannot be combined with any other offers/discounts. Please allow 7-10 business days for delivery once an order has been processed.

- If you need more material, you can order one extra bottle at the same time or choose the larger 2.5 kg option. Quantity is limited due to the supply available. Of course, you may purchase supplies from alternative sources.
- Home schooled students must ask their parents to contact a school for ordering the chemical, as shipping can only be made to a school. Alternatively, parents can buy the chemical from a different supplier.

<u>How does the competition work?</u>

Crystal growing must occur between February 3rd and April 3rd. Two main rules apply

- RULE 1: Participating crystals must weigh between 0.5 g to 100.0 g. This corresponds to the use of a maximum of 100.0 g chemicals per student or team.
- RULE 2: So that all students across the country have an equal preparation time, crystal production must be maintained only within the growth period of February 3rd to April 3rd. We trust that participants will honor this request. If recrystallizing grocery store potassium chloride to use for the growing period, this may be done prior to the February 3rd growth period start date.

  As soon as the growth period is finished, teachers should select the two best crystals that will represent the school at the regional level and send these to the regional coordinator:

1) The best quality crystal, notwithstanding size (minimum mass must nevertheless be 0.5 g)

2) The best overall crystal, which combines a large size to a good quality (single crystal, well-formed, sharp edges, faces, good transparency, etc.), which must not have a mass higher than 100.0 g.

Each of these two crystals should be well dried and placed in a small plastic bag (Ziploc or similar) labelled with the **name of students having grown the crystal, the name of the participating school and the email of the teacher.**

We know that several crystals from a school may be of roughly equivalent overall quality, and it is sometimes difficult for the teacher to make a choice. In such a case, it may be necessary to submit several crystals. Of these crystals from a given school, only two will be the “official” crystals to be considered for all prize(s) awarded.

<u>How and when are the crystals judged?</u>

See schedule for judging timelines Regionally and Nationally. Prizes will be attributed to the students having submitted the best crystals. Results will be announced in late July or early August.

<u>National Judging Criteria</u>

One single crystal will be judged based only on quality, as outlined below. The other single crystal will be judged on mass and quality criteria, as also outlined below.

Experts will rank crystals on a scale of 0 to 10. A score of 10 will be given to a perfect gem quality, unique single crystal (no crystal cluster or ‘twinned’ crystals) that fits the ideal crystal form known for the chemical.

The crystal is weighed, and the mass M_o recorded. **Crystals must weigh between 0.5 and 100.0 g.**

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, clean and well-defined/broken, rounded 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)

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 do not swamp out smaller good quality crystals.

The value 1 is added to the mass so that crystals weighing less than 1.0 g get a positive score.

A 100 per cent yield crystal made from 100 g (M_{MAX}) that scores a perfect 10 on quality (Q_{MAX}) would get a theoretical maximum of:

$$[\log (100+1)] \times 10 = 20.01$$

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

$100 \times \{[\log (M_o+1)] \times Q_o\} / \{[\log (M_{MAX}+1)] \times Q_{MAX}\}$ = Overall Score %

A perfect crystal weighing 100 g would get a score if 100%.

Example: The best overall crystal in the 2001 competition with 150 g starting material (M_{MAX} = 150 g) weighed 46.53 g and had a quality of 8.65. Its overall score was:

$100 \times \{[\log (46.53+1)] \times 8.65\} / \{[\log (150+1)] \times 10\} = 66.6\%$.

Why Potassium Chloride?

The decision to use potassium chloride as the material during the 2025 competition was made for a few key reasons:

1. Potassium chloride is generally highly accessible to people through availability at grocery stores (Figure 2), albeit in a ~1% less pure form than is sold by chemical supply companies such as Boreal, who sell pure material. If grocery store potassium chloride is used, it may be purified through hot filtration of the dissolved salt (like making coffee). Use of a coffee filter will allow for the removal of the “Magnesium Carbonate” and “Calcium Silicate” used to prevent clumping of the potassium chloride. These are essentially insoluble in water.

Figure 2. Example of a grocery store available source of potassium chloride (left) and the insoluble anti-caking agents which can be removed via filtering hot solutions of the salt. Evaporation then gives potassium chloride crystals, which can be recovered from solution, or the solution can be dried thoroughly to afford purer potassium chloride. Ensure the ingredients contain no sodium chloride, and only potassium chloride (commonly alongside things like sugar, potassium ioddie, magnesium carbonate, and calcium silicate).

2. Potassium chloride is an exceptionally important mineral, as it is a significant source of the element potassium, which is vital to life in humans, animals, plants, and more.
3. Potassium chloride has significance as a component of the ocean. As an “evaporite” mineral, many significant mining operations for this material seek ancient salt deposits formed from evaporation of massive quantities of sea water over millions of years. Potassium chloride thus allows for teachers to provide tangential lessons to this competition cycle, tying in much of what is know of nature in some way.
4. Potassium chloride, unlike other compounds grown within this competition, is not a hazardous substance and does not feature adverse effects when working with it. Irritation may occur when exposed to concentrated warm salt solutions, so caution should still be taken (eye protection or gloves when handling warm solutions of potassium chloride).

Guide to crystal growth

First, what is a crystal?

A crystal is a solid that consists of the various atoms, ions, or molecules organized in a uniform repeating pattern. This results in the material having a specific shape, colour, hardness, lustre, and having characteristics such as magnetic, optical, electronic, mechanical, or other properties, based on what and how the elements are arranged in the crystal. 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 substances that can form crystals. In medicine, crystals can be engineered to be specific shapes, sizes, and mixtures of compounds which can greatly improve or impart desirable pharmaceutical properties like high or low solubility as needed, controlled dissolution rate, and synergistic effects. Crystals, and the many science disciplines reliant on their applied use, are made possible by understand what it means for a given material to be crystalline.

Crystals are also found within technology such as hardware components where they play key roles such as capacitors (lithium fluoride), resistors (ceramics), conductors (thinly plated gold crystals, polycrystalline copper wires), photo active layers in solar cells (silicon, lead iodide perovskites), light detectors (germanium telluride for X-ray detection), in light emitting materials (gallium nitride = blue light in LEDs, nickel chromium alloy used to generate infrared radiation (and cook toast)), and many more. To understand why these specific elements find their way into crystals whose shape and size imparts their properties and thus function is to be a chemist, physicist, geologist, structural biologist, and many more science careers. Industry is largely built on the understanding and utilization of crystals across every field of modernity, encompassing agricultural through fertilizers, technology through most hardware, health through vitamins and medicines, art through dyes and pigments, and contruction through many of the materials used.

Recrystallization

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:

Buffalo University videos used for the American crystal growing competition:

1) https://www.youtube.com/watch?v=gsC039jpOT0

2) https://www.youtube.com/watch?v=_0F0I3XKiOY

University of Otago, NZ:

https://www.otago.ac.nz/chemistry/outreach/crystals/growing/index.html

Web site of the international Union of Crystallography competition held in 2014:

https://www.iycr2014.org/participate/crystal-growing-competition-2014/info-for-newcomers/how-to-grow

Instructables workshop:

https://www.instructables.com/How-to-grow-great-crystals/

CrytalVerse Youtube channel for high quality growth tutorials:

https://www.youtube.com/channel/UCbLvU2Gj9bNG0kusKw-tbfQ

CrystalVerse website for more detailed instructions and demonstrations/tutorials (Figure 3):

https://crystalverse.com/

Figure 3. Example of some of the incredible tutorials available at crystalverse by Chase Lean. These crystals of sodium chloride (table salt, NaCl) are grown following a specific procedure which allows for isolation of these pyramid structured crystals.

Which substances crystallize well?

Many substances crystallize. At home, table salt (sodium chloride) is often used to grow crystals. For the competition, we change the chemical used each year. Thus far, the National Crystal Growing Competition has used three different substances:

- Cupric sulfate pentahydrate (copper (II) sulfate pentahydrate, or “bluestone”), which was used in 2022.
- Aluminum potassium sulfate (or “alum”). This substance seems to be a popular one with which to experiment, was used in 2021 and again in 2023.
- Potassium sodium tartrate (or “Rochelle Salt”).
- Potassium chloride, the crystal to be grown in 2024.
- An endless variety of novel crystalline solids being made in academic synthetic chemistry research labs (organometallic compounds, new types of salts, and novel organic compounds).

Choice was made based on relative safety, availability, and good crystal growth. The first two chemicals are available from most laboratory chemical supply houses. The third may be bought at a grocery store, but make sure to use real cream of tartar to do your experiment, as some sellers substitute a blend of two different chemicals. Potassium chloride can also be found as a sodium free salt substitute in grocery stores, however, this contains impurities such as anti-caking agents which may impact crystal growth.

Other chemicals that give good crystals include:

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

Precautions when manipulating chemical substances

Substances chosen for the competition are not very dangerous. Precautions are nevertheless needed. In high schools, crystal growth will probably be undertaken in a laboratory, and wearing a lab coat and safety glasses will be mandatory, as will be washing your hands after manipulating these substances.

If growing crystals at home, wearing an overall or an apron is advised, and wearing safety glasses, which are readily available in hardware shops, is strongly suggested. Again, you should wash your hands after using the substance.

In all cases, if you get some solid or solution in your eyes, thoroughly wash your eyes with room temperature tap water for 5 to 15 minutes. If your eye remains irritated, consult your doctor or local hospital immediately. In such an event, it is strongly advised to bring the Safety Datasheet supplied by Boreal (https://www.boreal.com/assetsvc/asset/en_CA/id/10607448/contents).

Chemicals used in this contest are listed in the Workplace Hazardous Materials Information System WHIMS-1985 system. Safety information is given in the Safety Data

Sheet that the chemical supplier normally includes with the product. According to the Répertoire toxicologique of the CNESST (https://reptox.cnesst.gouv.qc.ca/en/Pages/to-english-users.aspx), the following safety information for these follows in Table 1.

When manipulating chemicals, is it essential to always thoroughly wash your hands with soap and water afterwards. The key hazards for chemicals used in the National Crystal Growing Competition are listed below.

Table 1 : Safety information for most commonly used crystal growing substances.

Chemical	Pictogram and signal word	Classification	Hazard statements	Precautionary statements
$CuSO_4 \cdot 5H_2O$	 Warning	- Acute oral toxicity - cat. 4 - Serious eye damage eye irritation cat. 2	- Harmful if swallowed - Causes serious eye irritation	▪ Wash hands thoroughly after handling ▪ Do not eat, drink or smoke when using this product. ▪ IF SWALLOWED: Call a POISON CENTER or a doctor if you feel unwell ▪ Rinse mouth ▪ Dispose of contents/containers in accordance with local regulations ▪ Wear eye protection ▪ IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing ▪ If eye irritation persists: Get medical advice/attention.
Alum	 Warning	- Serious eye damage/eye irritation cat. 2	- Causes serious eye irritation	▪ Wash hands thoroughly after handling ▪ Wear eye protection ▪ IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing ▪ If eye irritation persists: Get medical attention.
Potassium Chloride	Potassium chloride is not a hazardous substance. Avoid contact with eyes, and ingestion of the material in large amounts.			

How to grow crystals

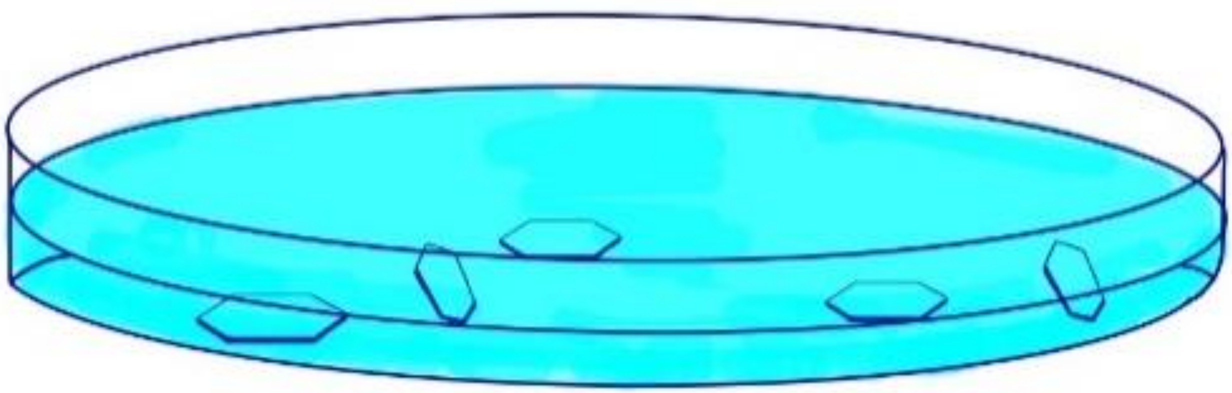
To obtain large single crystals, three steps are usually followed:

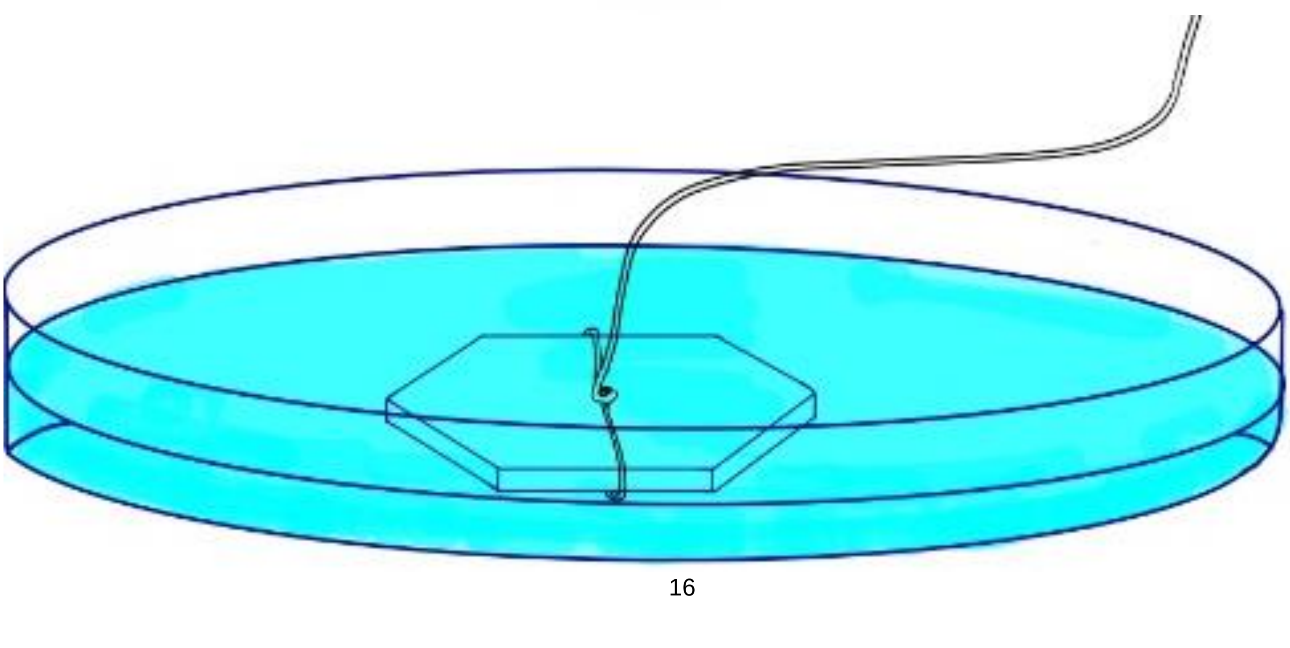
1) A small seed crystal is obtained
2) A supersaturated solution is prepared
3) Increasing the size of the seed crystal is performed by suspending this seed crystal into the supersaturated solution (more details later).

It is relatively easy to obtain nice small crystals. Obtaining larger, almost perfect crystals is almost an art, and requires constant attention to details. The rest of this guide will teach you the basics of this art.

What you need to know before starting

- 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 the Handbook of Chemistry and Physics, section Aqueous Solubility of Inorganic Compounds in Mass % as a Function of Temperature.*





First step: growing a seed crystal

The aim of the competition is to obtain a single crystal and not a bunch of crystals all stuck together and intergrown, no matter how nice this may look. In order to do this, you will need a small, well-formed crystal, which will serve a “seed” to start crystal growth. You will then let this small crystal slowly grow bigger, as a rapid crystallization often leads to multiple crystals instead of a single, well-formed crystal.

What you will need

- Substance to be crystallized;
- Distilled or demineralized water;
- A shallow dish (e.g., Petri);
- Heating plate or stove;
- Beaker or other small container, 100 to 250 mL capacity
- Fishing line (1 to 2 kg strength);
- Small stick (popsicle sticks work fine)
- A magnifying glass (optional).

What you should do

- Warm about 50 mL (1/4 cup) of water in a glass container.
- Dissolve enough of the substance to produce a saturated solution at 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 magnifying glass, select a regular, small transparent crystal. This will be your seed crystal.
- Tie the seed crystal with the fishing line by using a simple overhand knot. Make sure the line is long enough (approximately half of the height of the beaker used in Step 3).
- Suspend the seed crystal in a shallow dish (1 to 2 mm deep) containing a small amount of supersaturated solution (a few milliliters, see next section for how to prepare the solution) in a shallow container, for example a Petri dish for some time (1 to 2 days).
- Check with the magnifier that the seedling crystal is well attached to the line, and that the crystal grows over the line. 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 step: Preparation of a supersaturated solution

To grow a large crystal, you will need to suspend it in a supersaturated solution. This solution is not in an equilibrium state: you want it to contain more of the crystallizing substance (the solute) than normally presented. In order to do this; you will first prepare a saturated solution, which is at equilibrium and which contains the maximum of the substance that can dissolve in water. Afterwards, you will change the conditions in order for the substance to be too concentrated as compared to equilibrium conditions and the solute will need to crystallize out. This, however, takes time, and meanwhile, your solution is supersaturated!

Many methods exist to obtain a supersaturated solution. We have given below three different methods.

Please note: Quantities of the growing substance and of water depend on solubility at room temperature and at a slightly higher temperature. Handbook data will guide you, but you may also need to proceed by trial and error to determine the exact proportions, just like any scientist would do when beginning a new experiment.

What you will need

- Substance to be crystallized;
- Distilled or demineralized water;
- Thermometer;
- Scale;
- Heat-resistant glass or stainless steel container (1 L or more);
- Heating plate;

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 gently stirring the mixture while slowly heating it.
- Once all of the substance has gone into the solution, remove the container from the heat.
- Allow the solution to cool to room temperature.

You now have a supersaturated solution.

Note: The supersaturation method, as well as the second one, 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. Some substances are even more soluble at low than at high temperatures.

Method Two

- Select an appropriate volume of water.
- Warm this water to about 15–20° above room temperature.
- Add some of your substance to the warm water and stir the mixture to dissolve completely.
- Continue adding the substance and stirring until there is a slight amount of material that won't dissolve (the solution will be slightly cloudy).

- Warm the mixture a bit more until the remaining material goes into solution. The solution must be entirely transparent, with no haziness whatsoever.
- Once all of the substance has gone into the solution, remove the container from the heat.
- Allow the solution to cool to room temperature.

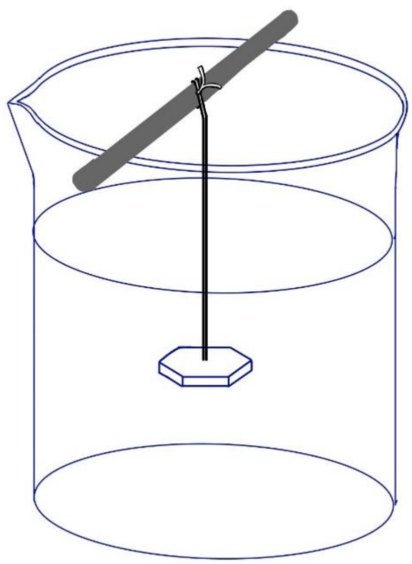
- You now have a supersaturated solution, one which should be clear. If slightly cloudy, **add a bit of water, reheat and let the solution cool again.**

Method Three

- Prepare a saturated solution, using the solubility value (mass of substance / volume of water) found in a chemistry handbook.
- Let the water evaporate (this can take a few hours up to a few days, depending on how well saturated the initial solution is).

This procedure is simple, but slower, and also works with substances which are more soluble at lower temperatures, contrary to the two previous methods.

Third step: Growth of a large crystal



You are now ready for the final growing step. You will suspend your seed crystal in the supersaturated solution prepared in Step 2. This solution contains more than the maximum solubility of the solute, it is not at equilibrium, and the solute will "want" to get out of the solution. It will crystallize onto any surface that can serve as a seed, including your seed crystal (and this is what you want) or any dust particle or solid impurity present (which you want to avoid, as it will give irregular, badly shaped crystals).

The speed at which crystallization occurs will greatly influence final crystal quality. The more supersaturated the solution (the higher the excess in solute as compared to equilibrium conditions), the faster the crystal will grow. However, the best crystals are always obtained with a slow growing speed.

One word of warning: as solubility varies with temperature, it is of utmost importance to avoid temperature fluctuations during crystal growth. Further, your solution must always remain saturated at the chosen growth temperature (usually room temperature), or else your crystal could dissolve partially or entirely.

A more symmetrical crystal can be obtained by slowly rotating the crystal in the supersaturated solution. Having such a setup can improve your crystal shape, but is not essential.

Unfortunately, many schools have had the disappointment of admiring a big crystal on a Friday, only to come back on Monday to an empty fishing line. The reason? A rise in room temperature in the school over the weekend, which caused the crystal to dissolve completely. The worst period for this is around October when schools turn on the heating systems. For this reason, if available, growing the crystals in a thermostated bath set to a few degrees above room temperature is highly recommended. If unavailable, placing the growth set up inside a cooler (Styrofoam or other) will limit temperature fluctuations, and can also save the day.

What you will need

- Substance to be crystallized;
- Seed crystal of the substance to be crystallized, tied to a fishing line;
- Small wood stick (e.g., Popsicle stick);
- Distilled or demineralized water;
- Thermometer;
- Scale;
- Heating plate or other heating device;
- Beaker of 2 to 4 liters volume;
- Styrofoam picnic cooler (optional);
- Magnifying glass or microscope (optional);
- Thermostated bath (optional);
- Slow revolution motor (1 to 4 rotations per day) (optional).

What you should do

1. Take the fishing line on which you have tied your seeding crystal. Attach to a wooden stick (popsicle stick) at the other end, making sure the crystal will be immersed approximately in the middle of your supersaturated solution in the growing vessel.
2. Carefully suspend your seed crystal from the stick into the supersaturated solution, taking care not to let the crystal touch the bottom of the container.
3. Cover the container in which the crystal is growing. This is to:
    - keep out dust, and

- reduce temperature fluctuations.

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

4. Observe the crystal growth. Depending upon the substance, the degree of supersaturation, and the temperature, it may take several days before the growth slows down and stops.

- WHY DOES THE CRYSTAL STOP GROWING?

A crystal will only grow when the surrounding solution is supersaturated with the 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 the 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 the 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?

You must re-supersaturate your solution. Refer to steps 5 and 6 for details.

5. Re-supersaturate 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 re-supersaturate 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. Alternatively, 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.) You can also supersaturate the solution by warming it somewhat, then adding and dissolving more solute, and finally cooling it.

   Removing the crystal, cleaning as below, and dissolution of the residual solid and filtering into a new vessel may also lead to a supersaturated solution, but losses may material may occur on the filter funnel and paper. Reducing the volume slightly with heat, filtering, and washing with 3 very small portions of water can help prevent losses.

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.

6. Resuspend the crystal back into the newly supersaturated solution.
7. Repeat steps 5 and 6 as needed.

8. To get improved symmetry and size, especially if the crystal gets very big, better results will be obtained if you slowly rotate the growing monocrystal (1 to 4 rotations per day) while it is immersed in the supersaturated solution. An electric motor with 1 to 4 daily rotations might be difficult to find (reusing one from an old humidity drum register or a similar apparatus is suggested).
9. Remove your crystal from the bath once the growth period is finished and wipe it thoroughly with absorbent paper. Do not touch your crystal with your fingers! Once well dried, put your crystal in a small plastic bag (such as a Ziploc bag), close it, and put a label on the bag stating your name and school name, and give the crystal to your teacher or lab technician. They will choose the best two crystals and will send them to the regional coordinator for judging. It is important to verify, before sending any crystal, if their mass falls between the 0.5 to 100 g thresholds for acceptable crystals: if not, the crystals are automatically disqualified.

The teacher or technician should consult sections “Competition schedule”, “How the competition works” and “Judging criteria” for more information on how the crystal are judged, and when and how to send your two selected crystals to the regional coordinator. Before sending your crystals, please do not forget to check that they weigh between 0.5 and 100.0 g. Crystals outside this range will be automatically disqualified.

At this stage, some people varnish their crystals. This ensures that the crystals do not dry out, and maintains their general shape longer. This may hide some defects present on the crystal faces, but on the other hand, edges appear rounder, less well-defined. Although we have decided not to disqualify these varnished crystals, these will invariably lose many points due to loss in perfection of the edges and will invariably fall down the ranking. We do not recommend that you varnish the crystals that will be submitted to the competition.

10. Finally, when manipulating chemicals, is it essential to always thoroughly wash your hands with soap and water afterwards.

11. In the event a crystal wins, ensuring the winner can be contacted and receive their prize is very important. Teachers must seek the approval of the parental guardian of participating students to provide necessary informed consent for participants sharing the contact information (email) that will be needed to reach out and award prizes.