Some information which may be helpful for growing crystals – e.g. crystals of alum (potassium aluminium sulphate).

(The sample of alum you purchase/have already purchased will be in the form of crystals but these will be small and not necessarily of a regular shape. The aim will be to grow some larger samples of individual crystals). Alum is graded for use K-12 in schools.

- **Crystals** are defined as pure solids with a regular shape and sharp, straight edges. They tend to be clear and shiny. All crystals of one chemical substance (e.g. alum) will tend to have the same shape which differs from the crystalline shape of other chemicals (e.g. salt, sugar). Solids such as flour which are not crystalline are called powders.

- **In order for crystals of one substance to grow** to their own particular shape they must be allowed to grow very slowly and each crystal needs to be ‘unencumbered’ by other crystals growing around it. If the crystals grow too quickly they are likely to be small, misshapen or aggregates of crystals growing on top of one another.
What do we mean by saying crystals need to grow? The pure chemical from which we are going to make crystals is made up from very, very, very, very ....... tiny particles (or ‘bits’) which are impossible to see with the naked eye or school microscopes. These ‘bits’ may be atoms, or ions, or molecules though it is not necessary for you to use these terms with students – if the wrong term is used it sets up problems in understanding later on in science – ‘bits’ or ‘particles’ is best. In fact, in the case of alum the ‘bits’ are ions (which are charged atoms or groups of atoms – potassium ions, aluminium ions and sulphate ions). These bits have to be arranged in a very specific pattern if a crystal is to be able to grow to the correct shape and so we must start from a situation in which all the bits are able to be separate from each other and are able to move around. This means starting off with our chemical (e.g. alum) in the form of a solution and letting crystals form or grow slowly from this solution.

A solution is formed when we dissolve the solid chemical (e.g. alum) in water. To do this you simply take e.g. a teaspoon of alum and place it in a container – preferably a glass jar or drinking glass or beaker but if necessary a plastic container will do. Add a little water and stir around until the solid disappears from view – it has not however disappeared completely however! You may need to add more water. When the solid can no longer be seen it means it has dissolved i.e. it has broken down into individual bits and each bit is surrounded by particles of water so that it can no longer be seen. The alum is now separated into tiny individual bits which can move around, so they have a chance of forming crystals.

A saturated solution For the alum bits to come out of the solution and form solid crystals the solution needs to be saturated (or supersaturated) with the alum. This means that the volume of water we have used to make the solution must have as much (or more) alum dissolved in it as it can possibly hold. You can get it to this stage by continuing to add alum and stir until there is some undissolved solid alum in the bottom of the container. If you now decant the clear solution carefully into a clean container you will have a saturated solution of alum from which to grow crystals (and which is free from the extra undissolved alum which would interfere). If you prefer, you can separate out the undissolved alum by pouring the mixture through a coffee filter or filter paper into a clean container – a process called filtering.

Solubility The amount of alum which will dissolve in a 100g (i.e.100ml volume) of water is called the solubility of alum and is dependent on temperature. At 20°C 14g of alum will dissolve in 100g water, while at 50°C about 37g will dissolve. This will give you some idea of about how much alum to add to get a saturated solution and how far your alum will go.
If your clear saturated solution is left undisturbed and covered over, crystals of alum will begin to form—a process called crystallization. This happens because as the solution stands, some of the liquid water will slowly evaporate from the surface i.e. move into the air as particles of water vapour (a gas). This means that there is too little liquid water to hold all the dissolved alum and some of the alum particles must come out of the solution as solid. The more slowly this happens, the more chance of the bits of alum arranging themselves in the correct pattern to grow well shaped crystals which are larger than those we started with.

The water will evaporate more slowly if the temperature remains about constant but the crystals will take longer to form. You may choose to dissolve alum at a higher temperature by warming the water (microwave, kettle, Bunsen burner) first in which case more alum will dissolve and as the saturated solution cools towards room temperature it becomes supersaturated and crystals will form more quickly.

This first crop of crystals will be used for you to select a seed crystal which you will then try to grow on into a larger and well shaped alum crystal. Decant the solution into another clean container and save. Using tweezers pick out the crystal which you deem to be of a good size and shape to use as the seed on which your larger crystal will grow and place it onto a clean surface (glass, china). The remaining crystals can go back into the saved solution to which you will also add more alum until it is saturated—decant the clear, saturated solution into a clean container and save any undissolved solid alum to use later. This is the solution into which you will place the seed crystal to grow.

Alternatives for growing the larger crystal from the seed crystal:

- The seed crystal may be carefully placed on to the bottom of the container of the growing solution. In this case the crystal will tend to grow as a flat crystal. The crystal can be carefully turned over from time to time, but must not be touched with your fingers.
- The seed crystal may be suspended from a ‘thread’ held in place by tying the thread around a pencil for example which is laid across the container holding the growing solution. This is not easy as it means tying the thread around the seed crystal or gluing thread to crystal with a tiny blob of water insoluble glue. The thread should ideally be very fine fishing line or a human hair rather than cotton as the latter will probably cause numerous crystals to grow on it rather than just the one you want to grow. In either case, thread or glue may become incorporated into the crystal but this cannot be helped.
- A third alternative is to suspend a thread into the seed crystal solution and try to grow a seed crystal directly onto the thread. Remove any extra crystals until you have the one you wish to grow further.
- Once the seed crystal is placed back into the saturated solution of alum the container needs to remain undisturbed and covered to allow the crystal to grow. You may wish to place it in a polystyrene container or the fridge to help keep the temperature constant.
**Things to think about**

- Crystals tend to form initially around a nucleus which may be a speck of dust, an irregularity on the surface of the container the solution is in, the lumps and bumps on the piece of cotton thread hanging into the saturated solution, oil from your skin left if you touch a crystal etc. Hence some of the suggestions above and others you will come up with so that only the one crystal grows as we want it to!
- If you knock the container in which your crystal is growing, or move it about it is likely to disturb the growing process and may impede the growth of a well shaped crystal, or initiate the growing of more crystals.
- If you move your seed crystal into a newly saturated solution which is at a higher temperature, or if for example you put your crystallizing solution in the sun to speed up the evaporation you are likely to lose your crystal. This is because if the temperature of the solution is higher, more alum can be dissolved in it and your precious crystal will also be dissolved!
- If your crystal seems to have stopped growing, then there might be a need to re-saturate the growing solution with solid alum. Carefully remove the growing crystal and suspend over a clean, empty container. Add more solid alum to the growing solution and stir – continue until no more alum will dissolve and then decant. Replace the crystal in the now re-saturated growing solution.

**HAVE fun**!

Most importantly – **have fun** with your crystal growing. Even if you do not feel like fiddling around with the conditions to get the ‘best’ crystals you will still be able to grow crystals and students will be thrilled by this. The comments above are a simple explanation of how crystals grow and include some hints as to how this may be achieved, aimed at a level your students can understand. This is not specifically a ‘crystal growing recipe’ or ‘worksheets’.

You may well be surprised with what your students come up with when you let them loose on finding the best way to grow crystals, especially if they have a simple understanding about what is going on at the particle level. All the trials and ideas are building skills for the ‘science inquiry approach’.
If you ‘Google’ growing alum crystals you will find many web sites offering information – not all of which are useful! A few are listed below. It is not suggested these as examples of excellent sites – but they contain bits which may be helpful. There are many other sites.

https://www.youtube.com/watch?v=cNyQ_pMGxWs&list=PL6UK2yPUlpzp0fAA59_Fsp_JLBKdhXpp&feature=c4-overview-vl  (done by a crystallographer so useful)

http://chemistry.about.com/cs/howtos/ht/alumcrystal.htm

www.youtube.com/watch?v=RnjiEdoSEvA

http://rockhoundingar.com/pebblepups/growcryst.html

http://www.seawhy.com/xl.html