SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Highly Commended

Crystal Investigation

Year 9-10

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Concordia College

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Oliphant Science Awards

Crystal Investigation Logbook

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Materials

- 90g Potash Alum
- 750ml distilled water
- 15L tap water
- 4x 250ml glass beaker
- electronic scale
- 6x pop stick
- 60cm cotton thread
- 3x 10cm diameter filter paper
- water bath
- thermometer
- stirring rod
- 3x 15cm squared paper
- 30cm ruler
- foam box
- plastic box
- kettle
- forceps
- teaspoon
- lamp
- magnifying glass
- whiteboard marker
- camera

Methodology

I used the RACI "Crystal Growing: Advice to Students" method (see below). This used the ratio of 30g Potash Alum to 200ml of distilled water.

https://raci.org.au/common/Uploaded%20files/Website%20files/School/crystal/SA%20Crystal%20Growing%20comp/Crystal%20Growing%20-%20Advice%20to%20students.pdf

Hypothesis

If the initial temperature to dissolve the Potash Alum is 56°C, then the crystal growth will be higher than the 32°C because the solution is more saturated.

The crystal growth will increase because the solution is more saturated, at a higher melting temperature range which is closer to the 92°C melting point of Potash Alum. The higher temperature, the more Potash Alum will dissolve in distilled water. Therefore, the solution will become more saturated. The crystals growth will increase, as there is more Potash Alum in the saturated solution.

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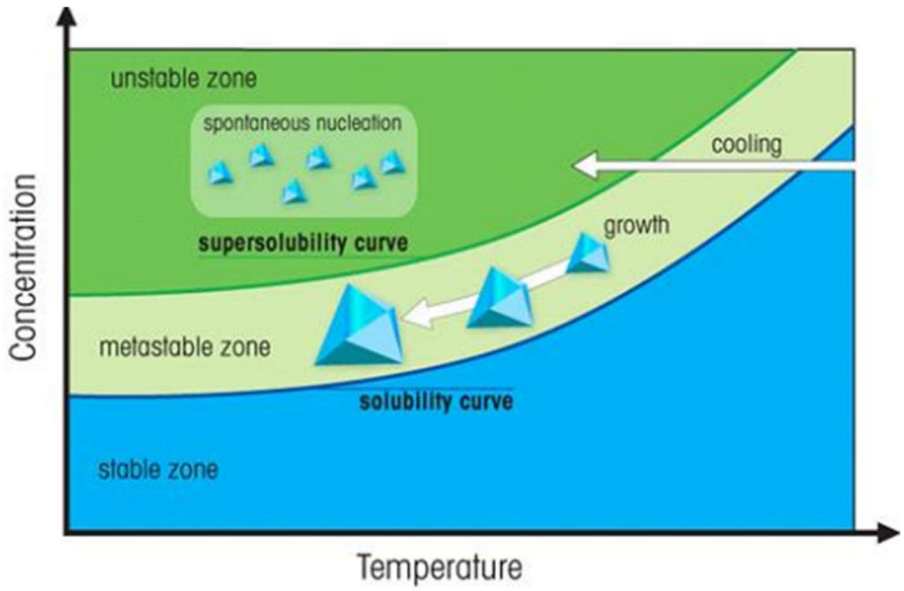
Background

The chart below shows the different stability zones. The three stability zones are unstable, metastable, and stable. The unstable zone (green) is when spontaneous nucleation occurs at low temperatures in a supersaturated solution. Crystals will grow too quickly as it cools down in a supersaturated solution. There will be lots of small seeds. The metastable zone (yellow) is in between the other zones as is the most ideal zone for growing crystals. A slower crystal growth rate from a lower initial temperature usually has better overall quality. The stable zone (blue) occurs in saturated solutions and produces small crystals, over a longer period.



Variables

INDEPENDENT VARIABLE

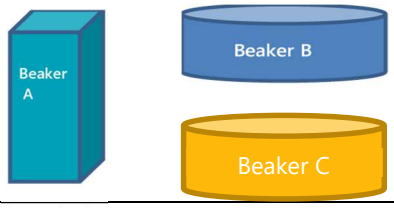
The initial temperature at which the Potash Alum is dissolved will change. The temperatures will be approximately 20°C, 40°C, 60°C. This will be measured with a thermometer in the unit of Celsius (°C). The water bath will be altered by changing the ratio of boiling water to room temperature tap water.

DEPENDENT VARIABLE

The crystal growth will be measured. It will be measured with a 30cm ruler in millimetres (mm). This will be measured every 3 days. The data collected will be quantitative.

CONTROLLED VARIABLE

Factor to be kept constant	**How may this factor affect the dependent variable?**	**How will it be kept constant**
Size and shape, of the beakers	The size, shape and material of the beakers must be kept constant as it would affect the dependent variable. If the beakers A, B, and C (shown below) were used in the experiment the experiment would not be fair. Having different shapes and sizes of beakers has an impact on the evaporation rate. Having a smaller surface area shown in beaker A, will have a slower evaporation rate compared	To prevent this factor from happening, the experiment will consist of three 250ml, for each experiment *(20°C, 40°C, 60°C).* All beakers will

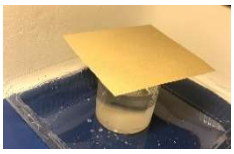
	to a larger surface area shown in beakers B & C. Beaker B & C have the same shape and size however, different materials. This would impact the solutions volume, temperature, and evaporation rate.  *Figure 1: Diagram of different beakers*	have the same volume, shape and size as they will be the same model.
Material of beakers and equipment.	All materials have different absorbability of the solution for example glass and cardboard. Cardboard would absorb the solution reducing the volume. Materials also have different heat conductivity for example metal and foam. A metal beaker would conduct more heat in the water bath and from the ambient, compared to a foam beaker. By increasing the solution's temperature, the evaporation rate is therefore increased, affecting the dependent variable. The material of the other equipment like stirring rod, water bath must be kept the same as well.	All beakers will be glass and the same model. The other equipment will be used for each test, and clean with distilled water and then wiped dry after contamination.
Type of water	There are many types of water (distilled, deionized, saline etc), which have different chemical properties. If different types of water were used for each test subject, the experiment would be invalid. Different waters have different effects on the crystals clarity as there can be impurities present in the water. Having impurities can also affect the crystals shape and therefore size.	This factor must and will be kept constant. The water used for all crystals will be distilled water. This will be sourced from Concordia College.
Potash Alum Particle size	The particle size of the solute must be kept constant. Potash Alum can be found in different particle sizes for example powder of 3mm solids as shown below in figures 2 and 3. Particle size affects the dissolving rate and how easily it dissolves. Smaller particle sizes Potash Alum will dissolve faster so the dissolution will occur more quickly. This does not affect the dependent variable to a large extent, but it should be kept constant.  *Figure 2: Potash Alum Powder (Newlife, n.d.)*  *Figure 2: Potash Alum solids (Havos, 2018)*	The Potash Alum used in the experiment will be the same for all tests. It will be the Potash Alum solids sourced from Concordia College.
Potash Alum Quality	Potash Alum can have different quality levels or grades. Changing this quality for each test would be invalid. The lower the quality of the Potash Alum the more impurities. Impurities impact the crystals shape, clarity, transparency, and size. Therefore, this factor must be kept the same.	The Potash Alum used in the experiment will be the same and all sourced from the same source. Therefore, each test will have the same quality as Potash Alum. Of course, the purer the Potash Alum the better however this is out of my control.

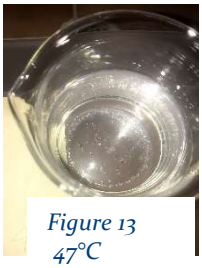
Concentration	The mass of Potash Alum added to the solvent must be kept the same. This will change the solute amount, which changes the concentration of the solution. By having more Potash Alum, to begin with, there is more Potash Alum that can be dissolved, increasing the concentration of the solution. The volume of water must be kept constant as well.	The mass of 30g Potash Alum will be added to the 200ml of distilled water. This will be measured by a sensitive scale that weighs at least 3 decimals. The water will be measured with a measuring cylinder.
Ambient Temperature	The ambient temperature impacts the crystals growth. The ambient temperature impacts the solutions temperature, which impacts the evaporation, clarity as well as crystal growth. Lower ambient temperatures allow for lower evaporation rates, good clarity but small crystal seeds. Higher ambient temperatures allow for higher evaporation rates, poor clarity but large crystal seeds.	The crystals will all be grown in the same room right next to each other. Therefore, the ambient temperature can be kept constant. The ambient temperature will be out of my control but will hopefully be cool and stay constant throughout the 10 weeks. The door and windows in and to the room where the crystals will grow will all be kept shut unless access is needed.
Agitation	Agitation throughout the experiment will impact the experiment dependent variable, possibly to a large extent. This agitation could be, stirring the alum solution in the water bath which would help dissolve it or repeatedly touching and interrupting the crystals growth. This would reduce clarity and impact the shape of the crystals.	This factor may be hard to keep constant and fair. As agitation may be needed, removing buds from the crystals would require me to touch the crystal. However, I will not purposely agitate the experiment.
Lighting	Lighting can impact crystal growth depending on the light source and how close from this source. Light sources produce heat which would impact the evaporation rate and therefore crystal growth rate. Therefore, crystals will grow faster in light than in a dark environment.	All crystals will have the same lighting conditions. They will be stored together in a room. No lights will be on however there are two small windows. Therefore, the crystals will experience both light and dark environments.
Evaporation	Evaporation is a big factor that must be kept constant. Evaporation has been mentioned in most of these factors. Evaporation will concentrate the solution and impact crystal growth. If one beaker was covered, another was half-covered and the last one was not covered the experiment would be invalid. The uncovered beaker would be at a disadvantage as its evaporation rate would be the highest.	All beakers will be fully covered. It will be covered with a piece of paper. This will slow down and prevent most of the evaporation. The paper may absorb some evaporated solvent.
Suspension	Another main factor is how the crystals will grow. The two methods are suspension or letting them grow at the bottom of the beaker. These two methods are very different and impact the crystals shape and therefore size. By growing the crystal on a flat surface, the crystal cannot grow symmetrically and octahedrally. By suspending the crystal, it allows for it to grow all 8 facets symmetrical. The crystal can be attaching to the string by superglue or tying a knot around it. However, using too much super	To control this factor all crystals will be suspended with string. The string will be tied around the

	glue can impact the shape and smoothness of the crystals.	crystal seed.
When and how I measure the crystal dimensions	The crystals dimensions/growth is my dependent variable. So, keeping when and how I measure it must be kept constant otherwise the results will be invalid. I must measure all my crystal dimensions at the same time. If I were to measure the crystals on different days, it would be hard to compare and unfair. The way the crystals are measured must be kept constant as well. If I were to measure one crystal in the air as it spins around and another as it rests stationary on a flat, clean surface. The stationary crystal's measurements would be more accurate. The face that I measure each time must be the same. Otherwise, the results may differ and will not be valid.	To keep this factor constant, I will try to measure all three crystals every 3 days. I will measure them straight after each other. I will measure them with a plastic 30cm ruler whilst they are stationary on a flat surface. This surface will be a desk and I will lay tissue papers on it to avoid impurities.
How long in the water bath	The time the solution is in the beaker when dissolving the Potash Alum must be the same. The longer the time in the water bath, the longer the Potash Alum must dissolve. If more Potash Alum is dissolved the solution is more saturation, creating larger crystals.	All solutions will be in the water bath for 30 mins, to make the experiment fair.

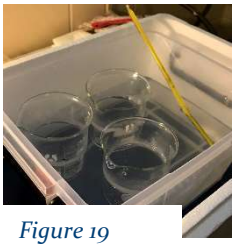
Weekly Log Entries

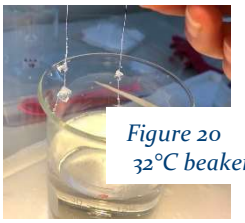
Date/Time	Descriptions of what the student(s) did, problems encountered and solved observations	Photos
Day 1 12th June	- Weighed 3x 30g Potash Alum in 250ml beakers.	 *Figure 4*
	32°C	
5:07pm	- Poured 200ml of distilled water into one beaker and placed in a water bath set at 24°C.	
5:28pm	- The Potash Alum did not dissolve at all. I then added boiling water making the water bath reach 32°C. This was a problem because the beaker was now floating. I then had to take the beaker out and pour approx. ¼ of water bath's water out. The temperature ranged from 31-32°C. The beaker then was placed back in.	 *Figure 5*
6:02pm	- Took the beaker out, at 31°C. Started to filter the solution.	
7:23pm	- Finished filtering the solution. 1 drop every 10secs. Covered with paper.	 *Figure 6* *32°C*
	47°C	
7:31pm	- Poured 200ml of distilled water to another 250ml beaker and placed in the water bath with temperatures ranging from 43°C - 48°C.	

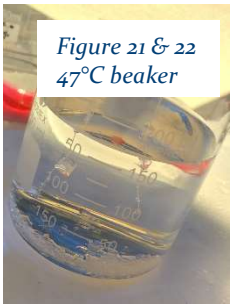
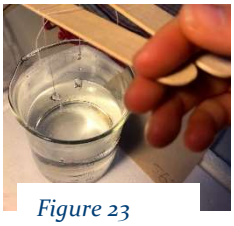
8:09pm 8:53pm 9:07pm 9:41pm 10:28pm	- Took beaker out of water bath and filtered. - Finished filtering and covered with paper. 56°C - Added 200ml of distilled, <u>room temperature</u> water to the beaker. Placed in the water bath with temperatures ranging between 52°C - 57°C. - Took out of the water bath and started filtering. - Finished filtering left covered. There is an aquarium heater (see figure 5) with a maximum temperature of 24°C.	 *Figure 7 32°C*  *Figure 8 32°C* Crystal seeds grew spontaneously after I took the beaker out of the water bath.
Day 2 13th June	- Decant the solution of all beakers, by pouring the solution into another beaker, leaving the seed crystals behind. (figure 9 & 10)	 *Figure 9*  *Figure 10*  *Figure 11*

Day 8 19th June	32°C - Crystal seeds are not octahedral. Has the least crystal seeds. - About 2mm 47°C - At least 100 crystal seeds, mostly around the edge, stuck together. Has the most crystal seeds. The crystal seeds are all unique and have different sizes. - About 2mm 56°C - Crystal seeds around the beaker and in the middle. None of them is octahedral. All unique. - About 2mm	 *Figure 12 32°C*  *Figure 13 47°C* *Figure 14 56°C* 

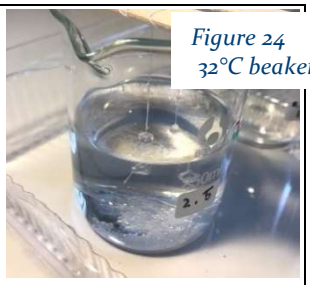
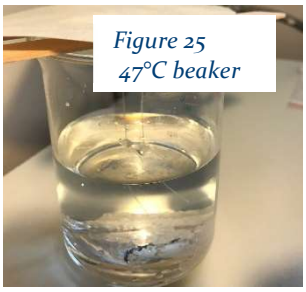
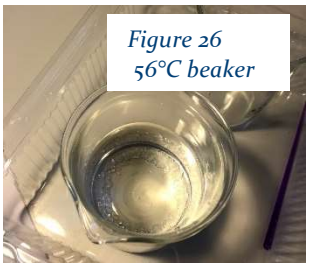
Day 10 21st June 6:21pm	32°C, 47°C, 56°C - Selected 2 crystal seeds from each beaker. Used forceps, magnifying glass and lamp. - Attached cotton string to a pop stick (see figure 15) and tied the other end around the crystal seed. This was extremely hard and took a good hour. The problem was the crystal seeds were wet and slippery. - I did have to touch the crystal seeds with my finger a lot. This might affect its clarity. - When placing the crystal seeds in the solution they were floating. To sink them I lightly touched them with the forceps. - I labelled the crystals on the pop sticks. (32A, 32B, 47A, 47B, 56A, 56B). I also drew a line on the beakers with a whiteboard marker to record the solution volume. - All crystal seeds are approximately 2mm. It was hard to measure as they are all so small and have a string. All crystal seeds were not octahedral, and were not found in a group.	 *Figure 15* *32°C*  *Figure 16* *47°C*  *Figure 17* *56°C*

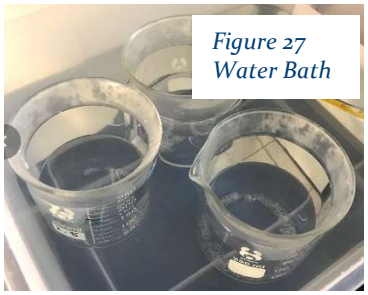
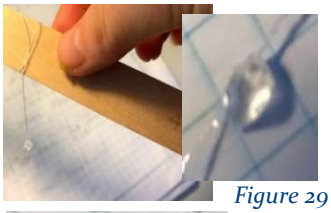
Day 16 27th June	Placed all 6 crystals in a spare beaker with no solution or distilled water. Whilst the three beakers were in a water bath. This water bath started at 31°C, reached 75°C at 3:31pm and ended at 58°C. The purpose was to dissolve all the Potash Alum crystal seed, making the solution supersaturated. 32°C, 47°C, 56°C - All crystals are clear and octahedral. Too small to describe and judge.	 *Figure 18* *32°C*  *Figure 19* *Water Bath*

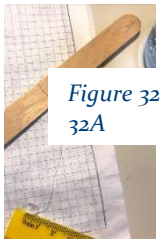
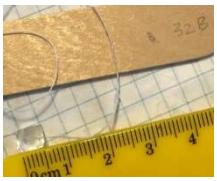
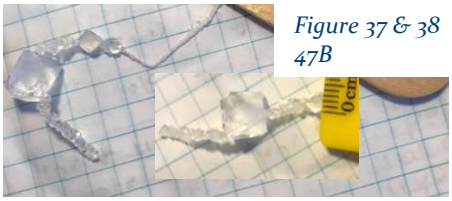
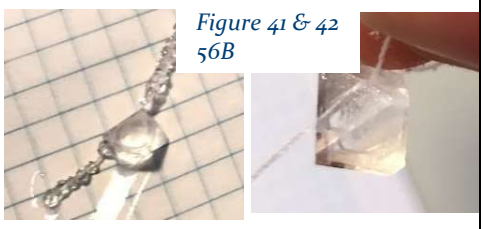
Day 19 30th June	32A - 4mm - Grew 1mm. The crystal is extremely transparent. I can see the thread very clearly. The regularity of edges is adequate. The thread is very long though. The shape is becoming octahedral. 32B - 5mm - Grew 2mm. The crystal is octahedral but not the most symmetrical. The crystal is transparent and has reasonably sharp edges. The crystal's thread has multiple crystals growing on it, which I removed with my fingers.	 *Figure 20* *32°C beaker* 

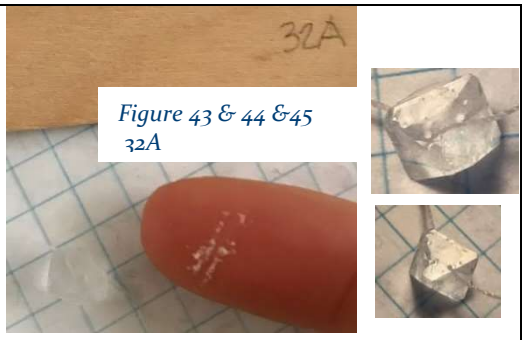
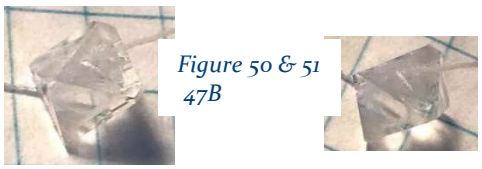
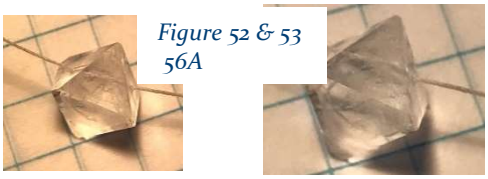
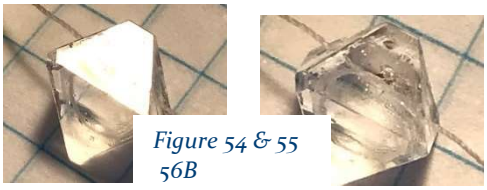
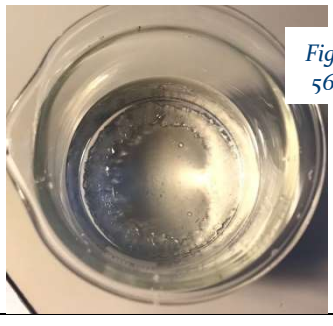
	47A - 4mm - Grew 1mm. The crystal doesn't have sharp edges. It has excellent clarity and smoothness. The crystal is octahedral. 47B - 5mm - Grew 1mm. Had many crystals attach to the bottom of its thread. Therefore, the thread must have been touching the bottom of the beaker I removed them with my fingers and placed them back in the solution. The crystal is extremely clear. The shape is coming together nicely, and it looks smooth. 56A - 6mm - Didn't grow. The crystal has a few growth lines but is transparent. The crystal is octahedral and symmetrical. The faces are smooth. 56B - 5mm - Didn't grow. The crystal is octahedral but not symmetrical. One side is larger than the other. The crystal is clear, but it has a few crystal buds in the thread beneath it.	 *Figure 21 & 22* *47°C beaker*  *Figure 23* *56°C beaker*
Day 25 6th July	32A - 5mm - Grew 1mm. Octahedral shape. Smooth faces. However, the edges aren't sharp but flat. Had many buds on the crystals thread., which I removed with fingers. 32B - 6mm - Grew 1mm. Excellent shape. Is an octahedron with smooth faces. Had lots of buds which I removed. The regularity of the crystal is good, and it is symmetrical. 47A - 5mm - Grew 1mm. Had a few crystal buds stuck on the crystal which was removed with a struggle. This would affect the crystal clarity as I had to touch it all around for a long period. The crystal was symmetrical and had sharp edges. 47B - 5mm - Didn't grow. The crystal was the same as last time. Octahedral, good smooth faces, but bad clarity and no sharp edges. 56A - 7mm - Grew 1mm. Excellent shape and transparency. Clarity is great and the surface is smooth. The edges are shaped and not rounded. The tips aren't pointed though.	No photos

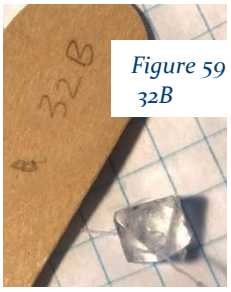
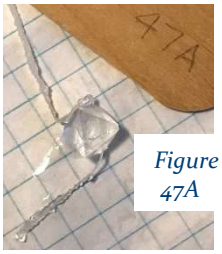
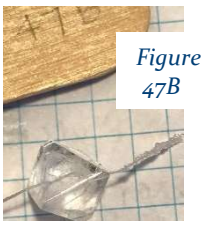
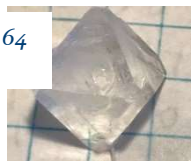
	56B - 7mm - Grew 2mm. this crystal has great clarity but is slightly octahedral. One of the sides is flat. I believe the crystal must have stuck to the side of the beaker during growth. - beaker 32°C solution volume = 173ml - beaker 47°C solution volume = 165ml - beaker 56°C solution volume = 175ml	

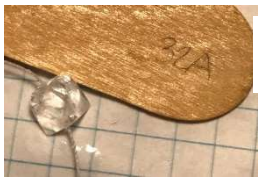
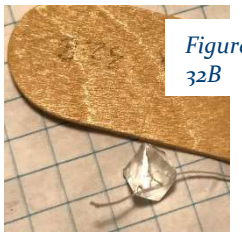
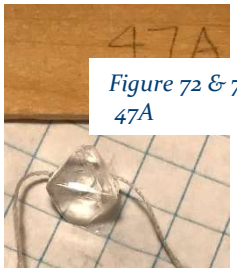
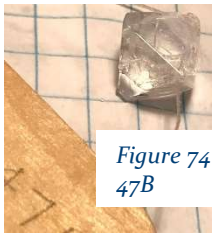
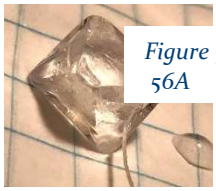
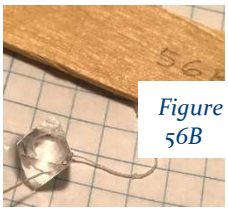
Day 28 9th July	32A - 5mm - Didn't grow. Perfect octahedral shape. Very clear and transparent sharp edges and vertices. Can still see the thread. Symmetrical as well. 32B - 6mm - Didn't grow. Slightly rounded edges and vertices. The vertices are not pointed but instead are flat. Very transparent. Can reflect light when held near a lamp. 47A - 5mm - Didn't grow. The crystal is the same. Smooth faces. No crystal bud on the thread or surface. The edges are sharp, and the vertices are pointed. The crystal isn't symmetrical, but it is octahedral. 47B - 6mm - Didn't grow. The crystal isn't the smoothest. The crystal also doesn't have the best clarity. The crystal is slightly cloudy. It has the worst clarity out of all the crystals. The crystal also doesn't have sharp points. 56A - 7mm - Grew 1mm. Has one flat surface. Not the best shape. The clarity however is adequate, but all faces are smooth. The regularity of edges is good. 56B - 7mm - Didn't grow. The crystal is smooth and clear, but it doesn't have the best shape. It's octahedral but it isn't symmetrical. The vertices are pointed but to a limited extent. - beaker 32°C solution volume = 172ml - beaker 47°C solution volume = 160ml - beaker 56°C solution volume = 170ml	 *Figure 24* *32°C beaker*  *Figure 25* *47°C beaker*   *Figure 26* *56°C beaker*

Day 34 15th July	- Placed all beakers in the same water bath. The water bath reached 80°C and lasted 68mins. When I placed the beakers there was immediate condensation on the outside of all the beakers. - The majority of crystals dissolved 1mm. This is because the solution wasn't saturated and went to the stable zone. 32A - 5mm - Didn't grow. The crystal is transparent with excellent clarity. The crystal is octahedral and symmetrical. I cannot tell if it is smooth or light reflective. 32B - 5mm - Dissolved 1mm. The crystal is octahedral. The edges are rounded and not sharp. This is the same for the vertices. The crystal is transparent and clear without any imperfections. 47A - 4mm - Dissolved 1mm. The crystal is octahedral and symmetrical. The edges are rounded and not sharp or pointed. The crystal is clear and there are no growth lines. 47B - 5mm - Dissolved 1mm. The crystal is octahedral, but the edges aren't sharp. The crystal is clear and transparent. The crystal isn't whiting and there are no growth lines. 56A - 6mm - Dissolved 1mm. The crystal's regularity of edges is excellent. The crystal is smooth and shows symmetrical growth. The crystal is light reflective and has good clarity. 56B - 5mm - Dissolved 1mm. The crystal has extremely poor edges. There are rounded and not sharp. The crystal is very transparent as I can see the blue line. The crystal is smooth but has a poor overall quality. - beaker 32°C solution volume = 160ml - beaker 47°C solution volume = 155ml - beaker 56°C solution volume = 165ml	 *Figure 27 Water Bath*  *Figure 28 32A*  *Figure 29 47A*  *Figure 30 56A*  *Figure 31 56B*

Day 37 18th July	32A - 6mm - Didn't grow. The crystal has sharp edges. The crystal is octahedral and symmetrical. The crystal is transparent. The crystal is also light reflective and smooth. 32B - 6mm - Didn't grow. The crystal is highly transparent and lights reflective. There a no signs of growth lines or whiting. The crystals show excellent regularity of edges and are symmetrical. 47A - 6mm - Grew 1mm. The crystal had a lot of crystals seeds and buds growing on the thread and the top and bottom of the crystal. The crystal is octahedral but not symmetrical. The crystal is light reflective and transparent. The vertices and edges are sharp and pointed. 47B - 7mm - Grew 2mm. There were many crystal buds and seeds on the thread. These reached up to 4mm big. These were the biggest I've seen. The crystal is transparent and had sharp edges. The crystal is octahedral and smooth. - 56A - 7mm - Grew 1mm. The crystal again had buds and seeds growing. The crystal is octahedral but not symmetrical. The crystal is not symmetrical, the edges are sharp but slightly chipped and not straight. The crystal has good clarity. - 56B - 6mm - Grew 1mm. The has excellently sharp edges and vertices. The crystal isn't smooth but has high clarity and is light reflective. The crystal has no whiting or growth lines. - beaker 32°C solution volume = 150ml - beaker 47°C solution volume = 148ml - beaker 56°C solution volume = 149ml	  *Figure 32 & 33 32A*  *Figure 34 32B*   *Figure 35 &36 47A*  *Figure 37 & 38 47B*  *Figure 39 & 40*  *Figure 41 & 42 56B*

Day 40 21st July	- Placed all beakers in the same water bath for an hour. Reached 75°C. **32A** - 6mm - Grew 1mm. Had crystal seeds growing on the thread. Removed with fingers. Also had a powdered alum on the thread too. The crystal is not smooth. There are evident imperfections on the surface. The edges also aren't highly sharp. There are slightly rounded. The vertices aren't pointed too. The crystal is octahedral and very light reflective. **32B** - 6mm - Grew 1mm. The crystal is symmetrical and light reflective. The surface is smooth and there aren't any crystal buds on the surface. The edges and vertices are sharp. The crystal is moderately transparent. You can only see the blue line up close. **47A** - 6mm - Grew 1mm. The crystals edges are rounded and not sharp. Its vertices are rounded and not pointy. The crystal is octahedral and symmetrical. The crystal Is light reflective and smooth. **47B** - 8mm - Grew 1mm. The crystal has extremely sharp edges. The crystal is octahedral but not symmetrical. It is on a slight slope. The crystal has poor clarity, there is evidence whiting. **56A** - 7mm - Didn't grow. The crystal has sharp edges and vertices. It is smooth and has no evident growth lines or marks. The crystal has poor clarity. **56B** - 7mm - Grew 1mm. The crystal is light reflective. The crystal is not smooth and has crystal buds on the surface. The crystal edges are sharp but the top vertices are extremely flat. The crystal has moderate clarity. It is not pure transparent. - beaker 32°C solution volume = 145ml - beaker 47°C solution volume = 140ml - beaker 56°C solution volume = 145ml	 *Figure 43 & 44 &45 32A*  *Figure 46 & 47 32B*  *Figure 48 & 49 47A*  *Figure 50 & 51 47B*  *Figure 52 & 53 56A*  *Figure 54 & 55 56B*  *Figure 56 56°C beaker*

Day 43 24th July	**32A** - 7mm - Grew 1mm. The crystal is clear and transparent. The edges aren't the sharpest. The vertices, are not sharp and are slightly rounded. The top and bottom vertices are flat. The crystal is still octahedral and symmetrical. **32B** - 7mm - Grew 1mm. The crystal is octahedral and smooth. The edges are sharp. The side vertices are pointed but the top and bottom are flat. The crystal shows mostly good regularity. The crystal is light reflective and there aren't any growth lines. **47A** - 7mm - Grew 1mm. The crystal has highly sharp and pointed edges and vertices. Lots of small crystal seeds on the thread. They were easily removed. Evident small crystal growth lines. Poor clarity, cannot see the graph lines. The surface is smooth. **47B** - 9mm - Grew 1mm. Has crystal seeds on the thread. The edges are sharp and pointed but bowed. The crystal is not symmetrical but is octahedral. The clarity is adequate. There are small imperfections evident. **56A** - 8mm - Grew 1mm. The crystal is octahedral and symmetrical. The crystal, however, has crystal buds and is not smooth. There are evident imperfections. Light reflective. **56B** - 8mm - Grew 1mm. Octahedral and symmetrical. Light reflective however the edges and vertices are slightly rounded. Excellent clarity, I can see the graph lines. - - beaker 32°C solution volume = 127ml - beaker 47°C solution volume = 125ml - beaker 56°C solution volume = 145ml	 *Figure 57 & 58* *32A*   *Figure 59 & 60* *32B*   *Figure 61 & 62* *47A*   *Figure 63 & 64* *47B*   *Figure 65 & 66* *56A*    *Figure 67 & 68* *56B*

Day 46 27th July	All crystals had dissolved at least 1mm. This was because the solution became undersaturated and it was in the stable zone, not the metastable zone. I then placed them all in hot water bath to re-saturate the solutions. Reached 85°C and lasted 1 hour. 32A - 5mm - Dissolved 2mm - The crystal is clear, but all edges and vertices are rounded and not sharp or pointed. The faces are smooth, and the shape is octahedral. - 32B - 6mm - Dissolved 1mm. The edges are still quite sharp, and the vertices are only slightly rounded. The surface has growth lines that reduce its overall quality. The crystal is octahedral. - 47A - 6mm - Dissolved 1mm. The vertices are dissolved and the shape of an octahedral is still there. The clarity is excellent and as well as the smoothness of the surface - 47B - 8mm - Dissolved 1mm. The crystal has dissolved and all of the vertices and edges. The clarity of the crystal is translucent. There are some crystal growth lines and some buds on the crystal. - 56A - 7mm - Dissolved 1mm. The crystal has rounded edges and vertices. The crystal has growth marks but is smooth. The crystal is reasonably clear. - 56B - 7mm - Dissolved 1mm. The crystal has a massive chip on the top vertex. All the other vertices and edges aren't pointed or sharp. - beaker 32°C solution volume = 125ml - beaker 47°C solution volume = 124ml - beaker 56°C solution volume = 130ml	 *Figure 69*  *Figure 70 & 71* *32B*   *Figure 72 & 73* *47A*   *Figure 74 & 75* *47B*   *Figure 76 & 77* *56A*   *Figure 78 & 79* *56B* 

Day 49
30th July

32A
- 8mm
- Grew 3mm. The top and bottom vertices are flat and not pointed. There are growth marks evident. However, you can still slightly see the blue graph lines. The shape is symmetrical however the faces surface is not smooth.

32B
- 9mm
- Grew 3mm. The crystal has extremely sharp edges and side vertices. The top and bottom vertices are flat. The crystal has enough clarity to be able to see the thread inside. The crystals surface is smooth.

47A
- 8mm
- Grew 3mm. Had a clump of crystal seeds attached to its thread. The thread most of been touch the beaker's bottom. The crystal's edge was sharp, but the vertices were slightly rounded compared to 32B. Not clear in the middle, looks like clouds.

47B
- 10mm
- Grew 2mm. The surface is very chipped and not smooth. The chip is large, and it also looks cracked. The crystal clarity is poor, but it is shaped like an octahedron.

56A
- 9mm
- Grew 2mm. The crystal is not the most symmetrical. The bottom half is longer than the top half. The top vertex is also flat, unlike the side. The crystal has lines in the middle and lots of crystal buds on the thread.

56B
- 10mm
- Grew 3mm. Super grainy and not transparent. However, you can still see the blue lines, unlike the other crystals. The crystal shape is not symmetrical however the surface is smooth to a moderate extent.

- beaker 32°C solution volume = 119ml
- beaker 47°C solution volume = 122ml
- beaker 56°C solution volume = 124ml
-
- All the Alum crystals seeds are all bonded together and are super flat. They are in the middle and are all different shapes.

Figure 80 & 81

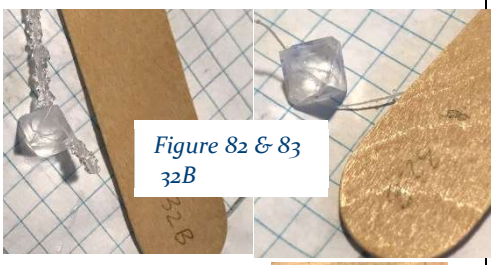
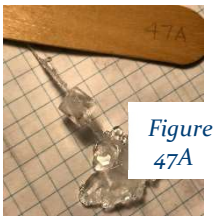


Figure 82 & 83 32B

Figure 84 32°C beaker



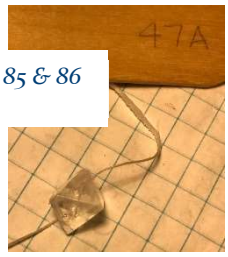


Figure 85 & 86 47A

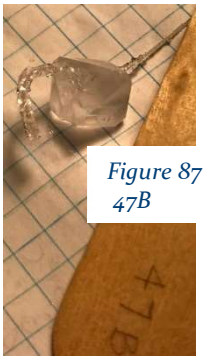


Figure 87 & 88 47B

Figure 89 47°C beaker

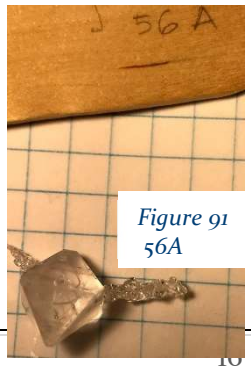
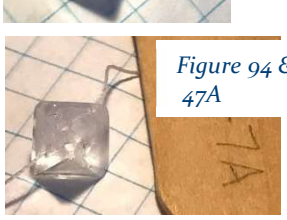
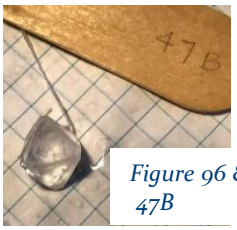
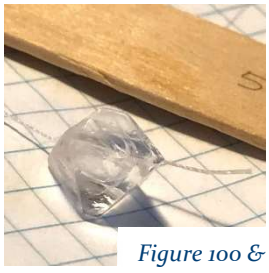


Figure 91 56A

Figure 90 56B

Day 50 31st July	- The crystals had dissolved 1-2mm. This is because the solution turned undersaturated and the Potash Alum dissolved in the solution. This is called an equilibrium condition. To resolve this and regrow the crystals I placed all the beakers in a water bath to re-supersaturate the solution. The water bath lasted 30mins which was half the time of every other water bath. Surprisingly all of the Potash Alum dissolved, which had never happened. What was different was that I replaced the water bath more frequently. 32A - 7mm - Lost 1mm. The top and bottom (in figure 92) vertices are rounded and not sharp. The edges are rounded but are defined. Not transparent. Cannot see the blue line behind the crystal. 32B - 7mm - Lost 2mm. All the crystals edges and vertices are rounded. The crystal is still octahedral and symmetrical. In figure 93 you can see how the top face is light reflective. Not transparent. 47A - 6mm - Lost 2mm. All vertices are rounded. The edges have dissolved but are still defined. The crystal isn't transparent but is translucent enough to see the thread. Is not symmetrical. 47B - 9mm - Lost 1mm. Edges aren't sharp but aren't too rounded. All vertices are either chipped and flat. Extremely grainy and not transparent. The surface isn't smooth too. 56A - 9mm - The vertices and edges are super rounded and not sharp. The clarity is grainy apart from one vertex. This vertex is more transparent than the whole crystal. Looking at figure 98 the upper-left edge is not straight. And slightly bowed in. 56B - 9mm - Lost 1mm. The edges are sharp but not the vertices. The top and bottom vertices are not sharp but are extremely flat. One of the edges is chipped (left edge of figure 100. - beaker 32°C solution volume = 119ml - beaker 47°C solution volume = 121ml - beaker 56°C solution volume = 124ml	  *Figure 90 & 91* *Beakers before and after water bath*  *Figure 92* *32A*  *Figure 93* *32B*   *Figure 94 & 95* *47A*   *Figure 96 & 97* *47B*   *Figure 98 & 99* *56A*   *Figure 100 & 101* *56B*

Day 51
1st August

32A
- 10mm
- Grew 3mm. Had a lot of crystal buds growing on the thread, which I removed. The crystal is symmetrical but not enough, so it doesn't matter which dimension you measure. The crystal is extremely cloudy and more translucent. The faces are also not the smoothest.

32B
- 11mm
- Grew 4mm. The crystal is slightly clearer than the 32A. The crystal is flat at the top and bottom vertices. It's also slightly chipped affecting its quality.

47A
- 9mm
- Grew 3mm. The crystal has poor clarity, but it is sharper than before. The vertices are pointed, and the edges are defined. There is a slight chip in the bottom right corner (referring to figure 105).

47B
- 11mm
- Grew 3mm. The crystal had lots of buds that were easily removed. This crystal has lots of chips and crystal growth marks. His chips make the crystal not smooth and more fragile. The edges are sharper and the shape is octahedral.

56A
- 12mm
- Grew 3mm. The crystal has extremely poor clarity. You cannot see the blue graph line behind it. The edges are chipped, and the top vertex is flat and not pointed. Growth lines are evidence however, the crystal is octahedral.

56B
- 12mm
- Grew 3mm. Spontaneous seeds on the thread and a nice octahedral shape. Chipped on one vertex and super cloudy.

- beaker 32°C solution volume = 105ml
- beaker 47°C solution volume = 101ml
- beaker 56°C solution volume = 110ml
- All beakers have many Potash Alum seeds that are all around the bottom and not just the edges.

Figure 102
32A

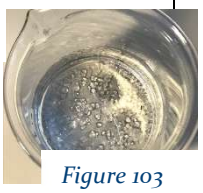


Figure 103
32°C beaker

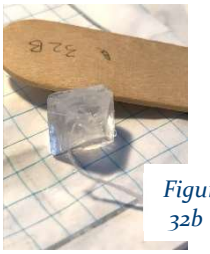



Figure 103 & 104
32b


Figure 105
47A

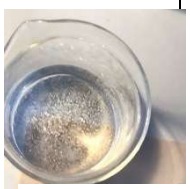


Figure 106
47°C beaker

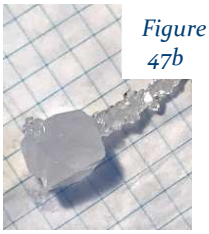
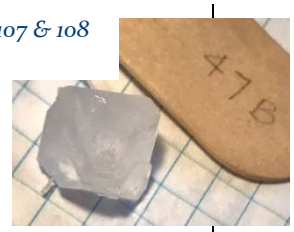



Figure 107 & 108
47b



Figure 109 & 110
56A

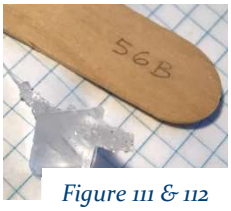


Figure 111 & 112
56B

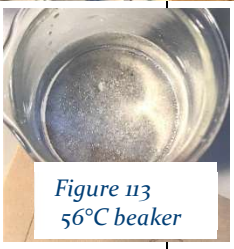
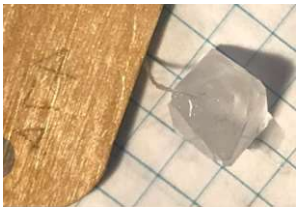
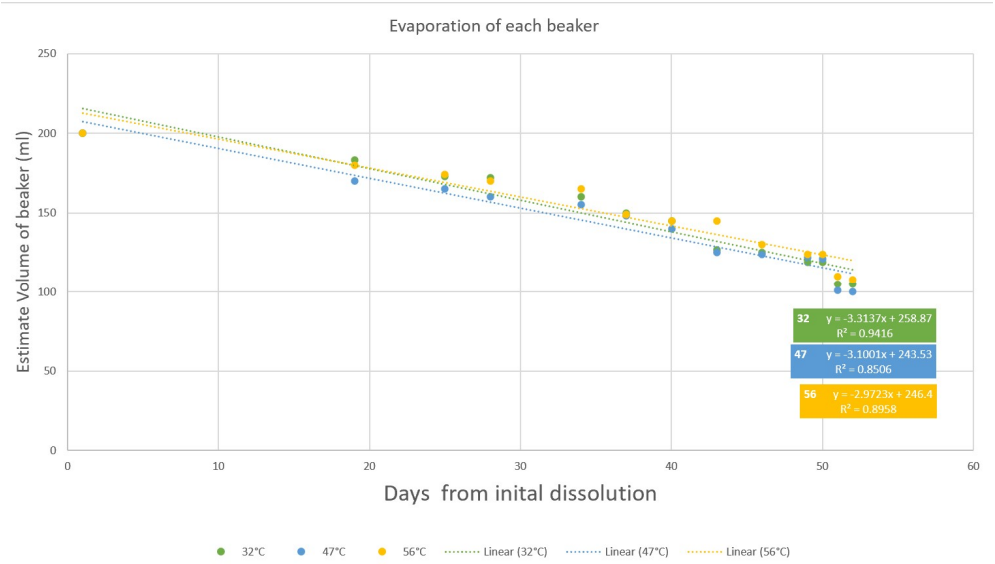


Figure 113
56°C beaker

Day 52 2nd August	- Terminated crystal growth for all crystals. Removed from solution and dunked it in a distilled water for a few seconds. This was to remove the layer of Potash Alum solution. If I left this on it would make the crystals cloudier. **32A** - 12mm - Grew 2mm. Had a lot of crystal buds growing on the thread, which I removed. The crystal is symmetrical but not enough, so it doesn't matter which dimension you measure. The crystal is extremely cloudy and more translucent. The faces are also not the smoothest. **32B** - 11mm - Grew 0mm. The crystal is slightly clearer than the 32A. The crystal is flat at the top and bottom vertices. It's also slightly chipped affecting its quality. **47A** - 10mm - Grew 1mm. The crystal has poor clarity, but it is sharper than before. The vertices are pointed, and the edges are defined. There is a slight chip in the bottom right corner (referring to figure 116). **47B** - 12mm - Grew 1mm. The crystal had lots of buds that were easily removed. This crystal has lots of chips and crystal growth marks. His chips make the crystal not smooth and more fragile. The edges are sharper, and the shape is octahedral. **56A** - 12mm - Grew 0mm. The crystal has extremely poor clarity. You cannot see the blue graph line behind it. The edges are chipped, and the top vertex is flat and not pointed. Growth lines are evidence however, the crystal is octahedral. **56B** - 12mm - Grew 0mm. Spontaneous seeds on the thread and a nice octahedral shape. Chipped on one vertex and super cloudy. - beaker 32°C solution volume = 105ml - beaker 47°C solution volume = 101ml - beaker 56°C solution volume = 110ml - - All beakers have many Potash Alum seeds that are all around the bottom and not just the edges. -	 *Figure 114* *32A*  *Figure 115* *32B*  *Figure 116* *47A*  *Figure 117* *47B*  *Figure 118* *56A*  *Figure 119* *56B*

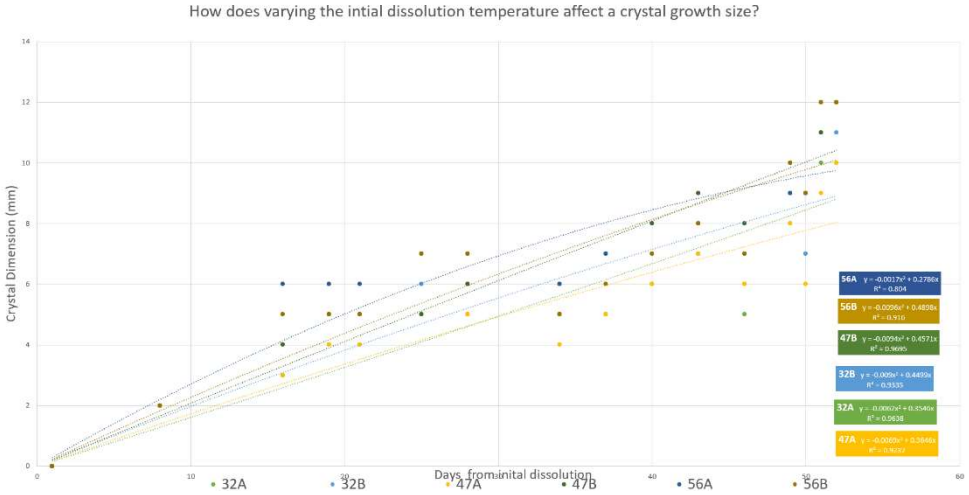
Results and Interpretation

Graph 1



Graph 1 shows the evaporation of the 32°C, 47°C and 56°C solutions. The graph shows that as the days from the initial dissolution increased the solution volume decreased. This is a proportional relationship. All three solution volumes evaporated relatively at the same rate. The trend line gradients have an approximately 0.1x difference. The different initial dissolution temperatures do not affect the evaporation rate. Beaker 56°C had the highest solution volume of 108ml. Beaker 47°C had the lowest volume of 100ml. All beakers started with an initial 200ml solution volume. Deriving from the graph, the volume would decrease the most, on the days, when the beaker was placed in a water bath. This is because the water bath heats the solution, so the molecules will move and vibrate more quickly. The molecules, then evaporate into the atmosphere as water vapour. When the beakers are not in the water bath solar and light energy can be the heat sources.

Graph 2



Graph 2 represents how varying the initial dissolution temperature affects the crystals growth size. Deriving from the graph, as the days from the initial dissolution increased, so does the dimension of the crystal. This is a proportional relationship. The graph's trendlines are polynomial. The crystal's dimensions are scattered above and below the trendlines. Crystals 56A and 56B have the highest gradient and therefore, growth rate. Crystal 47A followed by 32A has the lowest growth rate and dimensions.

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Hypothesis and Method validity and reliability

The hypothesis was supported based on the outcome of the experiment. The results show that the 56°C crystals (56A and 56B) had the greatest growth size and therefore growth rate.

The method is valid and reliable to a limited extent. The result patterns and overall outcome were expected. However, there are numerous problems or mistakes with the method.

Problem or mistake with Method	**Possible effect on data** Explain the improvement/extension to the method	**Possible improvement** Explain how the improvement reduces errors/extension benefits investigation
Time in the water bath	The time that the beakers were in the water bath for the initial dissolving was different. Each beaker had a separate water bath. The 32°C was in for 55mins, 47°C for 45mins and the 56°C for 64mins. The longer the beaker is in the water bath the longer the Potash Alum has to dissolve, saturating the solution more.	To improve this, a set time should be made before the experiment. A stopwatch should also be running. This would benefit the validity and reliability of the experiment.
Agitation	When the beakers were in the water bath and the Potash Alum wasn't dissolving, I would lift it ad slowly swirl it around. This agitation impacts the rate of dissolving. This increasing the rate of dissolving because it helps spread out the solute in the solvent. Agitating is only acceptable when all three beakers are treated the same.	In the future to prevent this from happening agitation of the beaker shall not happen. If it does all beakers should be agitated the same.
The volume of water in the water bath	The volume of the water bath's water wasn't kept constant. This is a problem as the more water, the slower it takes to cool down and the faster the beakers will heat up. This would affect the results as a solute will dissolve faster, the warmer the solvent is.	This can be kept constant sticking to the same amount each time. The kettle has a maximum limit of 1.7L. So, this is an easy limit to go by.
The beaker wasn't covered	When adding the beakers to the hot water bath there would be condensation on the outside immediately. This may have been a problem because it could have affected the clarity of the solution if any founds its way there.	To improve this, next time I shall glad wrap the beakers before placing them in the water bath.
The edge that was measured	There were multiple times where I measured a different crystal edge each time. Majority of the time I measured the largest dimension. However, sometimes I would forget or not double-check that it was the largest dimension. This is a problem as it affects the results.	Next time, all crystal edges will be measured. Therefore, the largest dimension can be found correctly.
The solution's volume	The solution's volume, reading each time was only an estimate. I had now the actual way of measuring the solution. Instead, I would estimate, using the	Next time I should find a beaker with clearer, graduated indications/measurements or measure the height of solution

reading	25ml, 50ml, 75ml etc indications.	and use the equation of $V=\pi r^2 h$ and work out the volume.
Human contact	Each time I measure the crystal I would have to use my hands to remove any buds or move them around to measure each edge. The number of times I touch the crystal, how long I touch it for or what is on my hands changed for each crystal. This is a problem that would have affected the crystals clarity.	I cannot make this factor even for each crystal. I can minimise the impact by washing my hands thoroughly before my hands and only touching them when I must.
The water that they were dipped in.	Used the same water at the end in which the crystals were dipped for a few seconds. The first crystal would have had pure water whereas the last crystal would have a tiny bit of Potash Alum	Next time I should dip the crystals in clean distilled water. I shouldn't keep the same water.

Conclusion

The crystal growth will increase because the solution is more saturated, at higher melting temperatures. At a higher temperature, more Potash Alum will dissolve. Therefore, the solution will become more saturated. The crystals growth will increase, as there is more Potash Alum in the solution. At lower temperatures, the solution is unstable so there will be smaller crystal seeds. In the metastable zone (56°C) it is the ideal condition for steady growth.

Acknowledgement

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