

晶体生长的最佳
条件是什么？

Global
Experiment
2014

2014 全球实验

The Art of Crystallisation
结晶的艺术

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What are the best conditions for growing the biggest crystals?

什么条件下才能培植出最大的晶体？

Introduction

操作说明

There are four simple parts to the Global Experiment. These instructions will guide you through them.

我们的全球实验只有四个简单部分。你可以轻松地遵照说明步骤完成该实验。

- **Part A:** Dissolving and saturating your samples (Practical)
- A 部分：将样本溶解、饱和（实践）
- **Part B:** Growing crystals of your samples (Practical)
- B 部分：培植晶体（实践）
- **Part C:** Sharing your data – post your results to our global interactive map (Results)
- C 部分：分享你的数据 - 将结果发布至我们的全球地图（结果）
- **Part D:** Analysing the website to discover the best conditions (Conclusions)
- D 部分：分析网站数据，找出晶体生长的最佳条件（结论）

We have included some background information on the importance of crystals in everyday life and teacher/technician notes for further advice at the end of these instructions.

在此我们给出了一些背景知识，你可以从中了解晶体在我们日常生活中的重要性，更多信息请参见操作说明最后部分的教师/技术员须知。



Chemicals

化学制品

Samples 样本	Health and Safety 健康与安全	Availability 可获得性
Table Salt 食盐 (sodium chloride, halite) (氯化钠、石盐)	LOW HAZARD 低危害 (do not consume, risk of contamination) (不要进食、可能变质)	Readily available in supermarkets 超市有售
Granulated Sugar 砂糖 (sucrose) (蔗糖)	LOW HAZARD 低危害 (do not consume, risk of contamination) (不要进食、可能变质)	Readily available in supermarkets 超市有售
Epsom Salts 泻盐 (magnesium sulfate, can be used as bath salts) (硫酸镁, 可用作浴盐)	LOW HAZARD 低危害 (不能进食)	Readily available in supermarkets, pharmacies, chemical supply companies and online retailers (eg Amazon) 超市、药店、化学药品供应公司及在线零 售商处(如亚马逊)有售
Potassium Nitrate 硝酸钾 (saltpetre, nitre) (硝酸钠、硝石)	OXIDISING 具有氧化性 (contact with combustible material may cause fire) (与易燃物接触可引起燃烧。 不能进食)	Readily available from chemical supply companies and online retailers (eg Amazon) 化学物药品供应公司及在线零售商处(如亚 马逊)有售
Alum 明矾 (Aluminium potassium sulfate, potash alum) (硫酸铝钾、钾矾)	LOW HAZARD 低危害 (不能进食)	Readily available in supermarkets, pharmacies, chemical supply companies and online retailers (eg Amazon) 超市、药店、化学药品供应公司及在线零 售商处(如亚马逊)有售

If you are planning on taking part in this experiment, we advise you to acquire all these samples.

如果你想参加这项实验, 建议你预先购买所有样本。



It is advisable to wear safety glasses with side shields for this experiment.

我们建议你在实验过程中戴上有护罩的安全防护眼镜。

Eyes: Wear eye protection.

眼睛: 佩戴防护镜。

For more information, please refer to the general guidance on health and safety at the end of these instructions.

如需了解更多信息, 请参考本说明结尾有关健康与安全的通用指南。



Background on crystals and their importance in everyday life

晶体知识及其在日常生活中的重要性

Crystals are all around us in everyday life. They range from common and inexpensive items such as salt and sugar through to expensive items such as diamonds and other jewels.

日常生活中，晶体随处可见。范围从普通便宜的糖和盐到价值昂贵的钻石和珠宝。

Almost anything can be made into a crystal through the process of crystallisation. Most commonly, crystallisation is the (natural or artificial) process for the formation of solid crystals from a solution. It is possible to grow crystals in other ways too, such as allowing metals to solidify from their melted states. The electronics industry relies on growing single crystals of silicon in this way.

结晶过程几乎可以将任何东西变成晶体。最常见的是通过结晶（天然或人工）将溶液转变为固态晶体。晶体也可以经由其它途径培植，比如铁从液态固化成形。电子业就是使用这种方法制成硅单晶。

Crystallisation is also a useful chemical technique to separate or purify a solid. This is done by dissolving the sample in a hot liquid, making a saturated solution. Anything that does not dissolve in the hot liquid can be removed by filtration and what remains can then be used to grow pure crystals which can be collected and dried (figure 1).

结晶还是一种有用的化学技术，可用于分离或净化固体。将样本溶于热的液体中，使溶液呈饱和状态。过滤掉那些不溶的物质，剩下就可用来生成纯净的晶体，然后收集并使其干燥。（图 1）

Definition

定义

A crystalline solid is made up of atoms or molecules which are arranged in a repeating pattern and stacked over and over again, very much like a three-dimensional brick wall (or several layers of stacked marbles on top of one another). In many ways, looking at a crystal is the closest the human eye will ever get to observing the order of atoms and molecules.

结晶固体由原子或分子按一定规律重复排列、层层堆积，类似一堵三维的砖墙（或多层堆积的大理石）。由此可见，晶体是最接近肉眼可以直接观察到的原子与分子排列顺序的物质。



History

历史

Just over a hundred years ago, father-and-son team William Henry and William Lawrence Bragg first showed that X-rays can be used to map the positions of atoms within a crystalline solid and determine its three-dimensional structure. This process is called crystallography and, to help celebrate this discovery, 2014 is the International Year of Crystallography.

一百多年前，威廉·亨利和威廉·劳伦斯·布拉格父子俩首先证明了可以用 X 射线来绘制结晶固体内部原子的位置，确定其三维结构。此过程即为结晶学，为庆祝这一发现，2014 年被宣布为国际晶体学年。

The two Braggs were awarded the Nobel Prize for this discovery in 1915 and, at the age of 25, Lawrence Bragg is still the youngest ever winner. Since this discovery, nearly 30 Nobel Prizes have been awarded which have used crystallography.

1915 年，布拉格父子因为该发现而获得诺贝尔奖，劳伦斯·布拉格时年 25 岁，成为历史上最年轻的诺贝尔奖得主。此后，有将近 30 位诺贝尔奖得主都得益于晶体学研究。

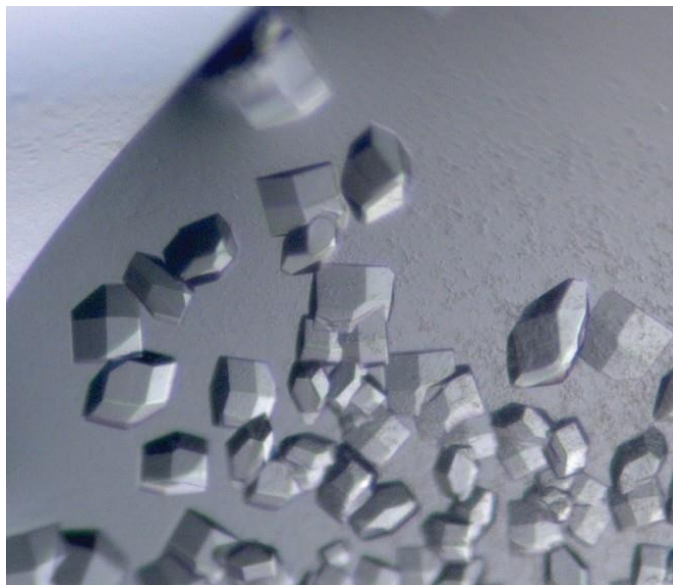


Figure 1

图 1

Single crystals of lysozyme, a protein found in hen egg whites

溶菌酶单晶，一种在鸡蛋白中发现的蛋白质



Examples

举例

Some of the largest crystals ever discovered can be found in the Cueva de los Cristales in Mexico; some are taller than three human adults! The conditions in which a crystal is grown can affect its size and shape and this can affect the sample's overall properties. The same atoms or molecules can be arranged in different ways within a sample (known as allotropes or polymorphs) and these also affect the sample's properties. One of the best known examples of this is diamond and graphite - both of which are made from carbon (**figure 2**). The structure of carbon in diamond prevents it from conducting electricity but it is well known for its hardness; this is determined by the chemical bonds between the carbon atoms. Graphite, on the other hand, has a different carbon atom arrangement which does allow it to conduct electricity and also means that it is much softer than diamond. In fact, because of its softness, graphite is often used in pencils for drawing as the layers of its atoms can easily slide over each other.

迄今为止，人类发现世界上最大的水晶是生长在墨西哥奈卡水晶洞；其中一些比三个成年人叠加起来还要高！晶体的生长环境会影响其大小与形状，也因此影响样本的总体特性。一个样本中相同的原子或分子排列方式也可以不同（称为同素异形体或同质多晶），其特性也因此受到影响。最著名的例子就是钻石和石墨，二者均由碳组成（图 2）。钻石中的碳结构使其不能导电，但硬度很强；这是由碳原子间的化学键决定的。另一方面，石墨有着不同的碳原子排列，其不仅能导电，而且比钻石要软的多。事实上，石墨也因为其柔软性，常用来制作铅笔，因为其原子层之间极易滑动。

Crystals are important in society today because they are used in many everyday products including washing powders, medicines and electronics to name but a few.

现代社会中晶体起着非常重要的作用，因为日常生活中很多东西都会用到晶体，比如洗衣粉、药物、电子产品。

The industries that produce crystalline materials and ingredients must ensure a consistent behaviour from their products. All of the variables in the process of crystallisation must be carefully monitored and controlled so that it can be reproduced.

生产结晶物质和原料的行业必须确保产品的一致性。结晶过程中的所有变量均需仔细监测、控制以便可以重制。

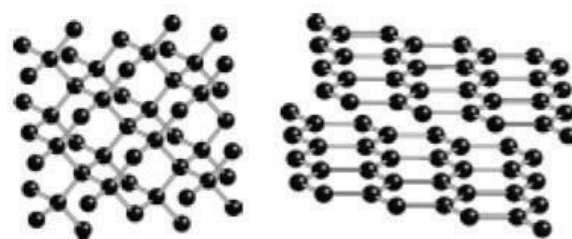


Figure 2

图 2

Two of the allotropes of carbon; diamond (left) and graphite (right)

碳的两种同素异形体；钻石（左）和石墨（右）





For example:

比如:

- Aspirin is absorbed differently by our bodies in its different crystal forms
阿司匹林晶形的不同会使人体对它的吸收也不尽相同。

- Ice cream has to have a consistent crystal size and shape to ensure the right texture, flavour and shelf life. Small crystals make a smoother ice cream. If you leave ice cream in your freezer for a long time, the crystals grow large and it doesn't taste as good!

冰淇淋必须要有大小和形状一致的晶体，才能保证合适的质地、口味和保质期。很小的晶体能让冰淇淋口感润滑，但如果在冰箱里放置时间过长，晶体长大，味道就不那么好了。

- The electrical properties of single silicon crystals are useful for semiconductors and computer chips in our phones, televisions and computers

手机、电视及电脑中使用的半导体及芯片就是使

用了单晶硅的电子特性。

- The pearl-like sheen of many cosmetics is dependent on the right crystal form
很多化妆品呈现的珍珠般的光泽也是依赖于适当的晶体形状。

In the Global Experiment 2014, you will be performing the process of crystallisation on many readily available samples at home or in schools. You will see that the samples behave very differently and will be able to compare your results with students around the world to see the global picture.

在 2014 全球实验中，你可以使用很多在家里或是学校唾手可得的样本完成结晶实验。你可以观察样本的不同表现，并将你的结果与全球各地学生进行比较。



Part A: Dissolving and saturating your samples

A 部分：溶解与饱和样本

In this experiment, you will find out that each sample has its own unique properties. You have a choice of five different samples (table salt, sugar, Epsom salts, alum and potassium nitrate) to make into a saturated solution. Once you have chosen your sample, you will need to carry out the experiment three times to obtain an average and record your observations.

本实验中，你会发现每个样本都有其独特性。你可以从五个不同样本中任选其一（食盐、糖、泻盐、明矾、硝酸钾），用于制作饱和溶液。确定了样本之后，你需要做三次实验，得出平均值，记录观察数据。

A saturated solution is one which will not allow any more of the sample to dissolve at a particular temperature.

饱和溶液是指在一定温度下不再继续溶解样本的溶液。

- If you are taking part in the experiment on your own you will need to test all five samples

如果你只是个人参与实验，这 5 种样本你都需要进行测试

- Within a class, working in pairs you can experiment with one sample and report your observations back to the class. Collaborate to find out other people's results

如果是在班级上，可两人一组，测试一种样本，将观察结果反馈给班级。通过合作查看其他人的实验结果。

Please post your data to our website.

请将你的结果发布至我们的网站。

Materials

材料

- Clear plastic disposable cups (or similar, eg glass beakers)
一次性透明塑料杯（或类似，如玻璃烧杯）
- The five samples: Table salt, sugar, Epsom salts, alum and potassium nitrate ($\frac{1}{2}$ a cup of each sample is plenty)
- 5 种样本：食盐、糖、泻盐、明矾、硝酸钾（每个样本有 $\frac{1}{2}$ 杯即可）
- Teaspoon (or spatula)
茶匙（或小铲）
- Cold tap water
凉的自来水
- Small measure (measuring 40 cm³ is required, eg. a measuring cylinder, beaker or clean medicine syringe)
1 只小量具（需能量 40cm³，如量筒、烧杯或洁净医用注射器）
- Balance or kitchen scales
1 个天平或电子秤
- Thermometer
温度计



Procedure

步骤

1. Accurately measure 40 cm³ of cold tap water into a clear plastic disposable cup and record its mass (record this in the student worksheet provided **[A]**).
精确量出 40cm³ 自来水，盛入一次性清洁塑料杯，记录质量（填写在我们提供的学生记录表 **[A]**）。
2. Carefully add ¼ of a teaspoon of your sample (table salt, sugar, Epsom salts, alum or potassium nitrate) to the cup of water and stir for 30 seconds. Once dissolved, continue adding ¼ teaspoon measures followed by stirring until no more of the sample will dissolve. 往塑料杯中小心加入¼茶匙样本（食盐、糖、泻盐、明矾或硝酸钾-只需选择一种样本加入），搅拌 30 秒。待溶解后，继续加入¼茶匙相同样本并搅拌，直至样本不再继续溶解。
3. Measure the temperature of this saturated solution (record in the table **[B]**).
测量该饱和溶液的温度（记录在表格**[B]**上）
4. Record the mass of the cup and saturated solution which should clearly have approx. ¼ of a teaspoon quantity of solid sample sitting at the bottom (record in the table **[C]**).
记录杯子与饱和溶液的质量，溶液底部应该有¼ 匙左右固体样本（记录于表格**[C]**）
5. Calculate the mass of the sample required to saturate 40 cm³ of your local tap water (record in the table **[D]**).
计算出使 40cm³ 自来水饱和所需样本的质量（记录于表格**[D]**）。
6. To ensure your data are consistent, repeat steps 1 to 5 twice more or compare with class colleagues.
为确保数据一致，重复操作两次步骤 1—5，或将数据与班上同学进行比较。
7. Using the student worksheet, calculate the average temperature of the saturated solution during the experiment **[E]** and record this for posting to the website.
使用学生记录表，计算实验过程中饱和溶液的平均温度**[E]**并记录，以便发布至网站。
8. Calculate the average mass of your sample needed to saturate 40 cm³ of your local tap water **[F]** and record this for posting to the website.
计算出使 40cm³ 自来水饱和所需样本的平均质量**[F]**并记录，以便上传至网站。
9. Gather the data for all five samples and record this in the overall conclusion.
采集全部 5 种样本的数据并记录于总体结论。



Part A: Dissolving and saturating your samples

A 部分：溶解与饱和样本

Student worksheet

Name

学生记录表

姓名

What is the definition of a crystal? 晶体的定义是什么?

.....
.....
.....

The sample I am testing is: 我测试的样品是:

.....

	Result 1 结果 1	Result 2 结果 2	Result 3 结果 3
Mass of disposable cup and 40 cm ³ of cold local tap water (g) [A] 一次性杯子和 40cm ³ 自来水的总质量(g)[A]			
Temperature of the saturated solution (°C) [B] 饱和溶液的温度(°C) [B]			
Mass of saturated solution and cup (g) [C] 饱和溶液及杯子的总质量 (g) [C]			
Mass of my sample needed to saturate 40 cm ³ of cold local tap water (g) [C - A = D] 使 40cm ³ 自来水饱和所需样本的质量 [C - A = D]			
Average Data 平均值			
Average temperature of the saturated solution (°C) [(B1+B2+B3) / 3 = E] 饱和溶液的平均温度(°C) [(B1+B2+B3) / 3 = E]			
Average mass of my sample needed to saturate 40 cm ³ of cold local tap water (g) [(D1+D2+D3) / 3 = F] 使 40cm ³ 自来水饱和所需样本的平均质量(g) [(D1+D2+D3) / 3 = F]			



Overall conclusion for posting to the website

上上传至网站的总体结论

	Table Salt 食盐	Sugar 糖	Epsom Salts 泻盐	Alum 明矾	Potassium Nitrate 硝酸钾
The average temperature of the saturated solution during the experiment for each sample (°C) [E] 各样本在实验过程中所形成的饱和溶液的平均温度(°C)[E]					
The average mass to saturate 40 cm ³ of local tap water for each sample (g) [F] 使 40cm ³ 自来水饱和的各样本的平均质量(g) [F]					

Could you tell the difference between the samples if they were not labelled?

如果样本没有贴标签，你能看出其中的区别吗？

.....

.....

.....

If an unknown sample was used to prepare a saturated solution with average properties [E] 8 °C and [F] 9.5 g, which of the five samples do you think it could be?

如果使用某种未知样本得到的饱和溶液，其平均温度为[E] 8°C，平均质量为[F]9.5g，你认为该未知样本可能是 5 种样本中的哪一个？

.....

.....



Part B: Growing crystals of your samples

B 部分：培植晶体

You have completed 'Part A: Dissolving and saturating your samples' and will have seen that the five samples have very different properties. In this experiment you will be making a saturated solution at a higher temperature and then cooling it down so that some of the dissolved material comes out of solution in a crystalline form.

在完成“A 部分：溶解与饱和样本”后，你会发现 5 种样本的特性迥异。在 B 部分的实验中，你将制作高温饱和溶液，经冷却后，一些之前溶解的物质会以晶体的形态从溶液中分离出来。

All five samples should be tested by the class (or individuals).

全班（或个人）应该完成全部 5 种样本的实验。

- Do you think the amount of sample that dissolves in hot water will be different from cold? Why?
你认为热水溶解与冷水溶解的样本量是否会不同吗？为什么？
- Can you predict which sample will grow the biggest crystal?
你能预测哪种样本可能生成最大的晶体吗？

After a week of crystal growth you should post your most successful result from each sample to our website (in the unlikely event that you get no crystals, please post this data also).

经过 1 周的晶体生长，你需从每个样本中选择最成功的结果上传至我们的网站（应该不会出现长不出晶体的情况，不过如果出现这种情况，也请你上传相关数据）。

Materials

材料

- Kettle (hot water required, needs adult supervision) [Potential burns/spill/slip hazards]
水壶（用来盛热水。需有成人监护）[有烫伤、溢出、滑跤的潜在危险]
- Thermometer
温度计
- Container/cup (eg glass beakers, styrofoam cup or clear plastic disposable cup)
容器/杯子（如玻璃烧杯、保丽龙杯、一次性透明塑料杯）
- The five samples: Table salt, sugar, Epsom salts, alum or potassium nitrate ($\frac{1}{2}$ a cup of each sample is plenty)
5 种样本：食盐、糖、泻盐、明矾、硝酸钾（每种样本有 $\frac{1}{2}$ 杯即可）
- Teaspoon (or spatula)
茶匙（或小铲）
- Small measure (measuring 40 cm³ is required, eg. a measuring cylinder, beaker or clean medicine syringe)
小量具（需能量 40cm³，如量筒、烧杯或洁净医用注射器）
- Filter paper (or paper towel/kitchen roll/coffee filters)
滤纸（或纸巾/厨房纸巾/咖啡滤纸）
- A thin wooden food skewer (contamination: do not re-use)[Potential sharp stick injury]
细的木质食物扦（不能重复使用，避免污染）[潜在被尖头刺伤危险]
- Clothes pegs (or alternative way to suspend the skewer in the saturated solution)
衣夹（或其它能将木扦悬于饱和溶液的方法）
- A magnifying glass to see your crystals more clearly
一个放大镜，以便清楚观察晶体



Procedure

步骤

1. Ask an adult to boil tap water.
请成人帮忙将自来水烧开。
2. Into a clean container/cup add four full teaspoon measures of your sample (table salt, sugar, Epsom salts, alum or potassium nitrate).
在洁净容器内加入 4 满匙样本（食盐、糖、泻盐、明矾或硝酸钾—只需选择一种样品）。
3. Ask an adult to measure 40 cm³ of the hot water (the temperature needs to be at 70 °C or above) and transfer this to your container/cup with your sample inside. [Potential burns/spill/cup melting hazards]
请成人帮忙量出 40cm³ 的热水（70°C 以上），并倒进装有样本的容器/杯中。[有烫伤/溢出/杯体熔化的潜在危险]。
– [Safety Tip: you could use secondary containment to prevent burns or spills].
– [安全贴士：使用辅助性容器防止烫伤或溢出]。
4. Stir for 30 seconds and – if required – add more sample repeatedly until your sample will no longer dissolve (larger amounts than in Part A can be added to get to saturation).
搅拌 30 秒，如需要，继续往里添加样本，直到样本不再溶化（加入的样本量要比 A 部分多）
5. Fold a square filter paper into a triangle making two folds and open it making a cone shape (see figure 3).
将一张正方形滤纸折成三角形，折两折，打开后成锥形（见图 3）。
6. Pour your warm saturated sample through the cone-shaped filter paper into a clean, empty plastic disposable cup (this process removes undissolved material).
将温热的饱和样本溶液经锥形滤纸，倒入洁净的一次性空塑料杯中（此过程过滤掉未溶解的物质）。
7. Using a wooden skewer and clothes pegs, suspend the tip of the skewer just below the surface of the solution (see figure 4).
使用木扦与衣夹，将木扦尖端正好悬在溶液表面下（见图 4）。
8. Leave the cup for a week for crystal growth. After a few hours, crystals can often be seen in the bottom of the cup but the slower-growing crystals will grow on the stick. [Tip: if after one day you do not get any crystals add a few grains of solid sample to encourage crystal growth].
杯子放置一周待晶体生长。几个小时后，通常就会在杯底看到晶体了，但是缓慢生长的晶体会长在木扦上。[贴士：如果过了一天你还没有看到晶体，就再加入几粒固体样本，促进晶体生长]。
9. After a week, record the temperature of the remaining liquid on your results table [G].
一周后，在结果表[G]中记录剩余液体的温度。
10. Remove the stick and identify the best (biggest) single crystal from your cup (see figure 5).
拿开木扦，找出杯中最好（最大）的单晶（见图 5）。
11. Match your crystal to our 'size and shape charts' below and record your data in the results table [H] and [I]. Collaborate with others to get results for all the samples.
将你的晶体与下面的“大小与形状表”相比配，在结果表[H]和[I]中记录你的数据。与他人协作，取得所有样本的结果。



Part B: Growing crystals of your samples

B 部分：培植样本晶体

Experiment Setup

实验准备



Figure 3

图 3

The folded cone-shaped paper towel which can be used to filter the solution

纸巾折成锥形用于过滤溶液



Figure 4

图 4

Suspend the stick so that the tip sits just below the surface of the solution

将木杆尖端正好悬于溶液表面之下



Figure 5

图 5

An example of a crystal (end point): take a photo and post your data to us

生长在木杆末端的晶体：拍张照片并将你的数据上传给我们



Crystal observations

晶体观察

The stick may have grown one large crystal (**figure 5**) or grown multiple smaller crystals. You will also have crystals in the bottom of the cup; please choose the biggest.

木杆上可能会长出一块大晶体（图 5），也可能长出几个较小的晶体。另外，杯底也会有晶体；请挑选出最大的晶体。

The samples you have crystallised typically fit the following crystal systems: table salt (cubic, **X**), sugar (monoclinic, **U**), Epsom salts (orthorhombic, **V**), alum (cubic, **X**) and potassium nitrate (orthorhombic, **V**).

用于结晶的样本通常符合下列晶系：食盐（立方晶，X）、糖（单斜晶，U）、泻盐（正交晶，V）、明矾（立方晶，X）、硝酸钾（正交晶，V）。

Look at your crystals and see if you agree with this classification, make your own choice and record your observations on your student worksheet.

看看你的晶体是否符合以上分类，作出决定后在学生记录表上记录你的观察结果。

Now collaborate with your class (if working alone compare all your results) to obtain the best result for each sample and post this data to our website.

现在和班上同学合作（如果你单独实验，比较你的全部结果），每种样本取最好的结果，将该数据发布至我们的网站。

- The temperature of the remaining solution for each sample (°C) [**G**]
每种样本剩余溶液的温度（°C） [**G**]
- The biggest single crystal from each sample (range from 8-28) [**H**]
每种样本生成的最大单晶（8-28） [**H**]
- The most likely crystal shape for each sample (range from T-Z) [**I**]
每种样本最像的晶形(T-Z) [**I**]

Tip: A magnifying glass will help you see your crystal system more clearly.

小贴士： 使用放大镜可以帮助你更清楚地观察晶体系统。



Part B: The crystal size and shape charts

B 部分：晶体大小和形状图表

Please print and share for class use

请打印并与全班分享

Crystal size chart

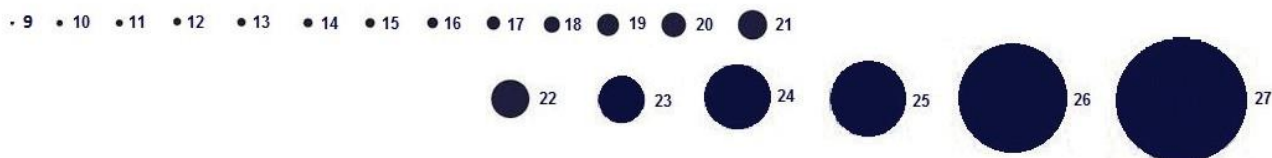
晶体大小表

Choose a number closest to your sample (8 = smaller, 28 = bigger) [H].

选择与你的样本最接近的数字 (8 = 更小, 28 = 更大) [H].

If you have needle-shaped crystals, fit the length to the circle's diameter.

如果是针形晶体，用其长度与各圆的直径匹配。





Crystal shape chart

晶体形状表

Choose a letter of the system closest to your sample [1].

选择最接近你的样本晶系字母[1]。

Triclinic (T) 三斜晶 (T)	Monoclinic (U) 单斜晶 (U)	Orthorhombic (V) 正交晶 (V)	Tetragonal (W) 正方晶 (W)	Cubic (X) 立方晶 (X)	Trigonal (Y) 三方晶 (Y)	Hexagonal (Z) 六方晶 (Z)
Like a packet of cereal squashed in two directions 像一包麦片，被双向挤压	Like a packet of cereal squashed on one side (it can be hard to tell T and U apart – U is a thin crystal) 像一包麦片，从一边挤压（要区别 T 和 U 很难，但 U 是较薄的晶体）	Like a packet of cereal (or matchbox) crystals can also be very long and 'needle-like' (fairly common) 像一包麦片（或火柴），晶体也可以很长，呈“针形”（常见）	Like two cubes stuck together 像两个立方体堆在一起	Like a cube (fairly common) sometimes the crystals do not have pointed corners so can appear 'diamond-like' 像一个立方体（常见）有时晶体没有尖角，形状像钻石	Like a 'Toblerone™' crystals can be needle-like in appearance (quite rare but distinctive) 像“三角”牌巧克力。晶体有可能呈针形（很少见但也有）	Like an unsharpened pencil, crystals can be 'needle-like' (quite rare but distinctive) 像未削过的铅笔，晶体可能呈针形（很少见但也有）
Crystal has six faces 晶体有 6 面	Crystal has six faces 晶体有 6 面	Crystal has six faces 晶体有 6 面	Crystal has six faces 晶体有 6 面	Crystal has six faces 晶体有 6 面	Crystal has five faces 晶体有 5 面	Crystal has eight faces 晶体有 8 面
Lengths: from one corner the three sides are different lengths 长度：任一角的三条边长度不同	Lengths: from one corner the three sides are different lengths 长度：任一角的三条边长度不同	Lengths: from one corner the three sides are different lengths 长度：任一角三条边的长度不同	Lengths: from one corner two sides are of the same length and the other is approx. Double 长度：任一角两条边长度相同，另一条近似于这两条边的和	Lengths: from one corner all the sides are of the same length 长度：任一角三条边的长度相同	Lengths: from one corner two sides are of the same length and the other is longer 长度：任一角两条边长度相等，另一边稍长	Lengths: from one corner two sides are of the same length and the other is longer 长度：任一角两条边长度相等，另一边稍长
Corners: none are at 90° 角：所有角均非 90°	Corners: some are 90° but not all 角：有些角是 90°，有些不是	Corners: all are at 90° (often a thin crystal) 角：所有的角均为 90°（晶体较薄）	Corners: all are at 90° 角：所有的角均为 90°	Corners: all are at 90° 角：所有的角均为 90°	Corners: some are at 90° and others are not 角：有些角是 90°，有些不是	Corners: some are at 90° and others are not 角：有些角是 90°，有些不是



Part B: Growing crystals of your samples

B 部分：培植样本晶体

Student worksheet

学生记录表

Name.....

姓名.....

Do you think the amount of sample that dissolves in hot water will be different from cold? Why?

你认为热水与冷水中溶解的样本量会相同吗？为什么？

.....

.....

.....

Can you predict which sample will grow the biggest crystal? Why?

你能预测哪种样本可以长出最大的晶体吗？为什么？

.....

.....

.....

The sample I am using to grow crystals is.

我培植晶体所使用的样本是.

.....

Temperature of the remaining solution (your local room temperature) (°C) [G] 剩余溶液的温度（室温环境下）（°C） [G]	The size of the biggest single crystal (range from 8-28) [H] 最大的单晶尺寸（8-28）[H]	The shape of the biggest single crystal (range from T-Z) [I] 最大的单晶形状（T-Z） [I]

Global Experiment 2014

The Art of Crystallisation

2014 全球实验

结晶的艺术



The collaborative best results for each sample for posting to the website

班里各种样本的最好结果（用于发布至网站）

	Table Salt 食盐	Sugar 糖	Epsom Salts 泻盐	Alum 明矾	Potassium Nitrate 硝酸钾
Temperature of the remaining solution (your local room temperature) (C) [G] 剩余溶液的温度（室温环境下）°C[G]					
The size of the biggest single crystal (range from 8-28) [H] 最大的单晶尺寸（8-28）[H]					
The shape of the biggest single crystal (range from T-Z) [I] 最大的单晶形状（T-Z）[I]					



Part C: Sharing your data

C 部分：分享你的数据

– Post your results to our global interactive map

– 将你的结果发布至我们的全球地图

Post all your data and pictures to our Global Experiment website: <http://rsc.li/ge2014>

将你的所有数据与照片发布至我们的全球实验网站: <http://rsc.li/ge2014>

- 1) Follow the link to post your data and click 'Submit your experiment data'

打开链接后发布你的数据，点击“提交你的实验数据”

Submit your experiment data

- 2) **Location Specifics:** Enter a Name, valid Email address and 'class or team name'

地点情况：输入姓名、有效 Email 地址及“班级或小组名称”

- 3) **Location Details:** Enter a country and post/zip code and click 'search'

地址详情：输入国家名称，邮政编码，然后点击“搜索”

Search

Use the interactive map to find your location. Once found, click on the map to 'pin the location'

用互动地图找到你的位置，一旦找到，点击地图上你的位置来“定位”



Then click on the blue text 'Pin the location where you completed the experiment'. This will add a 'red marker' to your location

然后点击蓝色文字“定位你完成实验的位置”。这会在你的位置加上“红色标记”

- 4) **Experiment Data:** You can now enter all your experiment data on the table provided (If you have not completed all of the samples just enter what you have)

实验数据：现在你可以在提供的表格中输入所有的实验数据（如果你没有做完所有样本，就输入已经完成的样本数据）

- 5) Finally, upload your experiment images to feature on our website

最后，将你的照片也发布到我们的网站上

Submit



Part D: Analysing the website to discover the best conditions

D 部分：分析网站数据，找出最佳条件

Analysis on the website

在网站上分析数据

After completing the experiment and posting your data why not analyse the data available to identify trends?
实验完成了，数据也发布了，为什么不来分析一下所得的数据，找出点其中规律呢？

The Global Experiment website offers an interactive map so you can search and find specific data, just by clicking on the pins. You can also access all of the data by using the 'Export data' button, which provides a spreadsheet.

全球实验网站上提供了互动地图，方便你搜索并找到特定数据。你也可以通过“导出数据”功能键访问所有数据，这些数据将列在一张表格上。

The graphs on the website provide the weighted average data.

网站上的图表提供了加权平均数据。

- Where was the biggest crystal grown?
哪儿生长出了最大的晶体？
- What were the conditions? (Temperature)
其生长环境是什么？（温度）

Other useful research

其它有用的研究

There are many websites which provide local data on tap water - (below are some examples)
有许多网站提供当地自来水水质的数据 — （以下略举几例）

<http://www.ecowater.co.uk/why-a-water-softener/test-your-water-water-in-the-uk/post-code-checker/>
(UK) <http://www.ewg.org/tap-water/whats-in-yourwater.php> (US)

A UK example would be to compare the results between London and Edinburgh. In London the tap water is 'hard' (the water contains a high concentration of calcium and magnesium mineral salts) but in Edinburgh the water is 'soft'. Are the results between London and Edinburgh very different?

英国的一个例子可以对比伦敦与爱丁堡的实验结果。伦敦的自来水质较“硬”（钙与镁矿物盐的浓度高），而爱丁堡的自来水质较“软”。伦敦和爱丁堡出来的结果是不是相差很大？



Extension activities

扩展活动

Try conducting your own research.

尝试做一些自己的研究

The hardness/softness, pH, salinity (saltiness) and additives (fluoride) in tap water varies around the world.

Can you find out anything about the local water at the location of the biggest crystal data?

世界各地自来水水质的硬/软度、pH 值、含盐度（咸度）、添加剂（氟化物）含量千差万别。那些生长出最大晶体的地方，你能发现那个地方的当地水有何不同吗？

What are the environmental considerations for this location?

该地的环境如何？

- Humidity (could high levels of humidity affect the growth of crystals?)
湿度（高湿度会影响晶体生长吗？）
- Dustiness of the air quality (could a dusty room grow bigger crystals?)
空气中的含尘量（充满灰尘的房间里能长出较大的晶体吗？）



Teacher/Technician notes

教师/技术员须知

The experiment has been designed as a class practical for age range 7-14. You will need to assess the timings of this experiment to fit the experience of your students.

本实验适于 7-14 岁年纪的班级。你需要根据学生的情况设定实验时间。

You can use the data on the Global Experiment website to compare data from students around the world to discover something new (errors should be discussed as part of this).

你可以利用全球实验网站，对世界各地学生的数据进行比较，看看是否有新的发现（讨论错误也是其中一部分）。

It is recommended that you use all five samples when taking part in the experiment but you can take part and submit data on less.

我们建议使用所有 5 种样本进行实验，但是学生也可以只用其中几种做实验，并提交数据。

Also, it is best to post data from Part A and B at the same time (after a week of crystal growth) but it is possible to submit Part A and B separately if you would like.

另外，最好同时上传 A 和 B 部分的数据（待 1 周后晶体长出），不过，你也可以分开上传。

The experiments

实验

500 g-1 kg bags of each sample will be plenty for a class experiment.

每种样本准备 500 g-1 kg 足够 1 个班级做实验了。

You do not need to be very accurate for this experiment; it can be done using kitchen scales and has been designed so you can take part at home or in school.

本实验不要求十分精准；可以使用电子秤，不管在家还是学校都能完成实验。

Part A: additional ideas

A 部分：其他做法

Dissolving and saturating your samples: With your class you could number half a cup of each of the samples and – in pairs – the students could try to identify their unknown sample by comparing their results to the Global Experiment results page (<http://rsc.li/ge2014>).

溶解和饱和样本：在班上，你可将 5 种样本分别装在 5 个小杯中，半杯量即可，并给与编号。让学生们两人一组作实验，然后把他们的结果与全球实验结果作比较，以识别他们的样本是什么。
(<http://rsc.li/ge2014>)。

If you run the experiment this way, please ensure you know what the samples really are so you can post your data onto our website.

如果你准备这样进行实验，请确保你知道些样本是什么，然后将数据上传到我们的网站。

Part A: Questions and Answers

A 部分：问题与答案

Q: What is the definition of a crystal?
问：什么是晶体？

A: A crystalline solid is made up of atoms or molecules which are arranged in a repeating pattern and stacked over and over again.
答：晶体是由原子或分子按一定规律重复排列、一层层堆积而成。

Q: In future, could you tell the difference between the samples if they were not labelled?

Q: 今后，如果这些样本没有标签，你能看出它们的不同吗？

A: Yes, they all have different properties.

答：能。因为他们各自有不同的特性。



Q: If an unknown sample was used to prepare a saturated solution with average properties [E] 8 °C and [F] 9.5 g which of the five samples do you think it could be?

问：如果制作饱和溶液时使用了某未知样本，溶液的平均特性为[E] 8 °C 和 [F] 9.5 g，你认为该样本可能是 5 种样本中的哪一个？

A: Potassium nitrate.

答：硝酸钾。

Part B: additional help with crystal growing

B 部分：晶体生长的协助方法

Not all of the samples grow crystals equally well so here are some tips to help.

不是所有样本生长出的晶体都如你所愿。这里有一些小窍门：

- 1) Run a few in parallel
同时多做几个
- 2) Sugar crystals are the most difficult to grow
糖晶体是最难生长的
- 3) If after a day no crystals appear, add a few grains of the same solid sample to encourage crystal growth (when we tried this for sugar it worked well – this is called ‘seeding’)
如果一天之后还没有长出晶体，再加入几粒固体样本，促进晶体生长（称作“播种”，我们对糖这样试过，效果很好。）

Part B: coloured crystals

B 部分：有色晶体

At the end of step 6 you could add a few drops of food colouring (or the ink from a highlighter pen) to grow coloured crystals. We don't know what effect this will have on the crystal growth for this experiment but it certainly makes it more fun!
步骤 6 结束后，你可加入几滴食用色素（或记号笔墨水），就能生长出有色晶体。我们不知道在本实验中这么做对晶体生长有什么影响，但肯定会使实验更有乐趣。

Part B: instant crystals

B 部分：快速生长晶体

At the end of step 7 you can rapidly cool the disposable cups containing the solutions in icy water which – for some of the samples – causes instant crystals. This fast crystallisation will not give very big crystals but this difference in crystal size can be discussed with the class once the bigger crystals have developed after a week.

步骤 7 完成后，你可以将盛有溶液的一次性杯子放入冰水中，快速降温，某些样本的晶体就能瞬间长出。这种快速结晶术不能产生较大的晶体，待一周后，当其它样本长出较大晶体时，可以在班上讨论晶体大小的产生原因。

Part B: Questions and Answers

B 部分：问题与答案

Q: Do you think the amount of sample that dissolves in hot water will be different from cold? Why?

问：你认为热水与冷水溶解的样本量会有区别吗？

A: Yes, because in hot water the particles move about more and so more can dissolve.

答：是的，热水中粒子活动更多，所以溶解得也多。

Q: Can you predict which sample will grow the biggest crystal?

问：你能预测哪种样本长出的晶体最大吗？

A: Just a prediction – but students might feel that sugar and Epsom salts might grow the biggest crystals because these dissolve the most in water (the experiment will reveal the real answer).

答：只是预测。同学们可能会觉得糖和泻盐长出的晶体最大，因为它们溶解的量最多。（实验后会揭晓正确答案）

Make full use of Part D: Analysing the website to discover the best conditions.

利用 D 部分：分析网站数据，找出最佳生长条件



Standard health and safety guidance for schools

学校的标准健康和安全管理指导

Health and safety in practical chemistry in schools and colleges affects all concerned: teachers, lecturers and technicians, employers and students, parents or guardians, as well as authors and publishers.

各院校里有关应用化学的健康与安全事宜应受到各方人员重视：教师、讲师、技术员、员工、学生、家长或监护人、作者以及出版商。

These guidelines refer to procedures in the United Kingdom. If you are working in another country you may need to make alternative provisions.

这里的指南参考了英国的规程。如果你在其它国家工作，你可能需要另外制定规则。

As part of the reviewing process, the Global Experiment has been checked for health and safety. 作为评估的一部分，全球实验已得到健康和安全管理检查。

We have attempted to ensure that: 我们试图确保：

- All common recognised hazards have been identified
所有常见的危害已得到识别
- Suitable precautions are suggested
已经建议采取适当的防范措施

It is assumed that: 本实验基于以下条件：

- Safe work practices are followed when chemicals are handled
处理化学制品的时候已遵照相关安全措施
- Eye protection is worn whenever risk assessments require it
必要时需佩戴防护镜
- Great care and adult supervision is required when transferring hot water

倒热水时需要小心谨慎并由成人监督

- When carried out in schools - practical work is conducted with teacher supervision and in a properly equipped area
如果是在学校完成实验，应由老师监督，实验区域有完备的安全设施。
- When carried out in schools - mains-operated equipment is regularly inspected, properly maintained and appropriate records are kept
如果是在学校完成实验，电网供电的设备需定期检查，妥善维护，并保存相关记录。
- When carried out in schools - first aid facilities and a trained first aider are available
如果是在学校完成实验，需有急救设施和受过训练的急救人员。

Teachers' and their employers' responsibilities 教师和雇主的责任

Under the COSHH Regulations, the Management of Health and Safety at Work Regulations, and other regulations, UK employers are responsible for making a risk assessment before hazardous procedures are undertaken or hazardous chemicals and materials are used. Teachers are required to co-operate with their employers by complying with such risk assessments. However, teachers should be aware that mistakes can be made and, in any case, different employers adopt different standards. 根据《危害健康物质控制》、《职业健康与安全管理条例》以及其它条例规定，英国雇主在实施有危险的动作、使用有害化学品或物质前有义务进行危险评估。老师需要遵守制定的相关规定。但是教师也应知道，错误有时在所难免，而且很多情况下，不同的雇主采用的标准不同。



Reference material

参考资料

Model risk assessments have been taken from, or are compatible with:

风险评估模型来自或兼容于:

CLEAPSS Hazards (see [CLEAPSS website](#))

CLEAPSS 危害 (参见 [CLEAPSS 网站](#))

CLEAPSS Laboratory handbook (see [CLEAPSS website](#))
CLEAPSS Recipe cards (see [CLEAPSS website](#))

CLEAPSS 实验室手册 (参见 [CLEAPSS 网站](#))
CLEAPSS 配方卡片 (参见 [CLEAPSS 网站](#))

ASE Revised Topics in Safety: key updated revisions are in the website (see [ASE website](#))

ASE 最新安全议题: 网站的修订版有重要更新 ([参见 ASE 网站](#))