How Crystals Are Made.

In other **CCDC Home Learning activities**, you can learn that crystals are solid materials with molecules well organised and close to each other; you can admire how beautiful crystals are and find crystals from our everyday life. The question that you might be asking now is:

how are crystals made?

To answer this question, in this activity we will observe the formation of crystals and solutions from daily or familiar situations, while learning about **crystallisation**. We will then watch a video of rapid crystallisation.

Before starting: This activity should be easy and safe to follow but it is carried out at your own risk. Please read the health and safety guidelines on the **activity webpage** to reduce risks.

This activity will take approximately one hour to complete.

Tip: Search for the words in **bold** in the glossary at page 7.

Crystallisation around us

1 **Crystallisation** is the process through which **crystals** are made.

You, scientists, or industrial producers may crystallise something because you want it as a solid product. For example, we use solid sugar, or a drug needs to be produced in tablets. Or maybe we just want an ice lolly!

Another reason you might need crystallisation is to separate a specific substance from others present in the liquid solution; in this case, crystallisation is used as a separation technique. An example of this is the purification of sea water by removing the salt crystals.

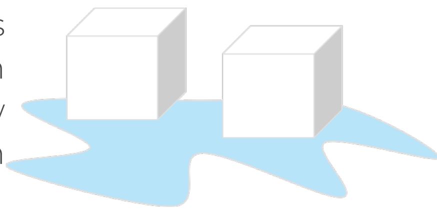
We cannot forget that crystallisation also happens spontaneously and beautifully in nature! As an example, we can think of snowflakes and the breath-taking stalactites and stalagmites found in caves.

2 The following are **examples of crystallisation** that you can observe or that you might cause in everyday life. Can you complete the descriptions with the correct words from the list below?

You can compare your answers with the descriptions on page 8.

* deposited * deposited * freezer * fridge * hard * jar * sea salt * structure * sugar * summer * winter *

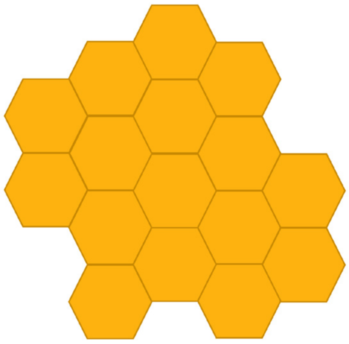
a) Water becoming ice. We see this happening in __________ with the formation of snow or ice sheets because of the low temperature, but also in __________ when we make ice or icicles in the __________ !



b) Limescale formation in sinks. __________ water contains the substances that form limescale and these are __________ in the sink.

c) When you put a melted chocolate bar in the __________ , you are re-crystallising chocolate! (Did you know the __________ of chocolate will not be the same as before melting? Read about it in the **“Lego, Chocolate and Polymorphs” activity**).

d) Honey crystallises! Has it ever happened to you to find honey crystallised in the __________? That is because the __________ in it has crystallised over time.



e) Salt on the skin after swimming in the sea. When sea water evaporates, salt is __________, so you can spot it on your skin. This is also the same principle of how __________ is collected.

Can you think of more examples? You can list them or draw them in this space.

3 If you consider the examples from the question before, you might notice that crystallisation takes place in different conditions and ways.

Sometimes you notice that all the liquid becomes a solid crystal, like in the case of ice formation.

Other times, instead, only a specific part (a specific substance) of the liquid **solution** forms crystals, as in the limescale example: this is called crystallisation from solution (and we will learn more about it in this activity!).

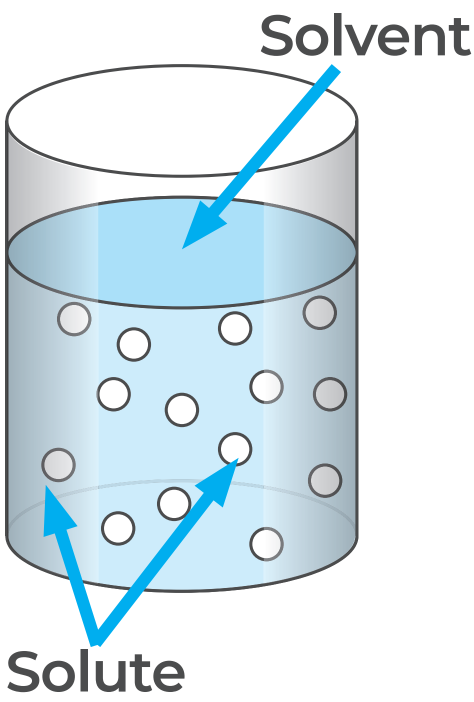
You probably also noticed that in some cases crystallisation takes place as a result of a decrease in temperature (the case of ice lollies), while other times it is quite the opposite and it happens after water evaporates (sea salt on the skin), and sometimes we cannot notice any difference in the environment (honey left at room temperature for long)!

Solution

4 In this activity, we will consider an example of crystallisation from solution.

To begin with, we need to learn what a solution is.

A **solution** is a liquid that contains different substances. The most abundant component is called the **solvent**, which means that in the solution there is much more of this component than of the others. The other component, present in smaller amount, is called **solute** and it is **dissolved** in the solvent.



For example, when salt is added to water to make pasta, the salt is dissolved in the water, creating a solution. Hence, salt is the solute, while water is the solvent.

Another example is when you add sugar to your tea or when sugar is added to coffee, you are dissolving the solid sugar into the solution. **Remember:** when crystals have dissolved you will no longer be able to see the solid.

5 An important property of the solute is its **solubility**.

The solubility is the capability of the solid to dissolve in a solvent. It is usually expressed in g/ml, which means how many **grams** of solute you can dissolve in a **millilitre** of solvent.

When the solid (solute) is added to the solvent until no more will dissolve, this makes the solution **saturated**.

If then you add more solid, the solution becomes **supersaturated**.

Nucleation from Solution

6 Now that we have learnt about **solutions**, **saturation**, and **supersaturation**, it is time to move on to crystallisation!

Crystallisation takes place in two steps:

1. The first one is called **nucleation** and it is the formation of a very very very very tiny crystal nucleus.
2. The second step is called **growth** and it is indeed the growth of these little crystal nuclei to become the final bigger crystals.

Nucleation is a change of phase, or **phase transition**, as we learnt in the **"Crystals Showcase" activity**. Indeed, solute molecules go from a liquid disperse phase to the solid state, where all the molecules are now aligned in a regular repeating pattern.

It's your turn!

7 In this (optional) activity, you become the director! Can you script and/or design a video showing something we have learnt today? For example, which steps would you take to make a brief movie of sugar dissolving into water?

Always make sure to ask an adult for help if you intend to record a video. Only heat or freeze substances under adult supervision.

8 What we have learnt today

After the "How Crystals Are Made" activity (tick all those that apply):

- ☐ I can recognise examples of crystallisation around me.
- ☐ I know what a solution is and I have learnt concepts like solute, solvent, solubility and saturation.
- ☐ I know what crystallisation is, and that it takes place via nucleation and growth.
- ☐ I have learnt about the nucleation of a supersaturated solution containing a salt.

To see crystallisation in action, and to tick the last box, head back to the activity webpage and watch the crystallisation video. A description of the experiment and an explanation of what is happening are available in the handout **"Crystallisation in Action!"**.

9 Congratulations on completing the activity!

We hope that you enjoyed this activity and that it will inspire you to connect with the world around you in the search for crystals and crystallisation.

It is now time for the learners to collect their badge! You can find a downloadable copy of the virtual badge following the directions in the activity webpage.

Do you have any picture or drawing of crystals, solutions and crystallisation, that you would like to show us? Did you draw something inspired to this activity? We would like to see it! You can post it on social media and tag us (Twitter @ccdc_cambridge, Facebook @ccdc.cambridge, Instagram @ccdc_cambridge), with the hashtag #CCDCHomeLearning.

10 Further Learning

Learners aged 14+ can continue the learning on the **"Crystallisation Activity handout"**.

For all learners, we recommend the **"Crystals Showcase"** and the **"Lego, Chocolate and Polymorphs"** activities, which present in more detail some of the concepts and definitions used in this activity (age 8+).

For learners aged 16+, a more comprehensive handout on crystals and crystallisation is available in our **teaching resources space**.

Glossary

Atoms are the basic building-block of all matter and are the smallest unit of a chemical element. Did you know the word atom comes from Greek and it means "*that cannot be cut*"?

Bonds are strong chemical connections formed between atoms.

A **molecule** is a group of two or more atoms that are held together by bonds.

The **formula** of a compound is a list of all the elements present in the molecule. Each element is followed by a subscript number to specify how many atoms of that element are present.
As an example, in a water molecule there are two hydrogen atoms (H) and one oxygen (O): its formula is thus H_2O.

An **ion** is an atom or molecule that is charged. The charge can be positive or negative. The formula of the substance indicates whether it is charged using a superscript: + for positively charged ions, or -, for negatively charged ones.

A **salt** is a substance composed by a positive ion and a negative ion. The overall charge of a salt is 0, which is said to be neutral. Pay attention: compounds with ions H^+ or OH^- are not salts, but are rather called acid or base.

A **solution** is a liquid that contains different compounds. The most abundant component is the **solvent**, which in our example was water. The other component, present in smaller amount, is the **solute** and in the video it was the sodium acetate.

Solubility is, in this context, the capability of a solid to dissolve into a liquid.

A solid **dissolving** into a liquid breaks down into its components (atoms, molecules or ions), which get separated from each other and become part of the solution.

A solution is **saturated** when it contained the maximum amount of solute that can be dissolved.

Supersaturation is a state of a solution that contains more of the dissolved material than could be dissolved by the solvent under normal circumstances.

A **crystal** is a solid material where molecules or atoms are packed in an ordered way. Crystals have specific geometries and shapes.

Crystallisation is the process that makes crystals! It has two steps. The first, called **nucleation**, is the formation of crystal nuclei, which are a very small version (microscopic!) of the final crystal. The second step is **growth**, which is the addition of other molecules to the nucleus to create a bigger crystal.

A **phase transition** is the transformation that a substance undergoes to change its state, for example from liquid to solid.

The term **macroscopic** refers to things you can observe with a naked eye. **Microscopic**, instead, is for things too small to be seen with a naked eye, for example molecules.

Grams and **millilitres** are units of measurement, which means that they help us understand and evaluate measures. Grams are used to measure the mass, so how heavy a thing is, while millilitres to measure the volume, so the space occupied by a substance, especially for liquids . A gram is one thousand times smaller than a kg, while a millilitre is a thousand times smaller than a litre.

Answers to question 2

a) Water becoming ice. We see this happening in **winter** with the formation of snow or ice sheets because of the low temperature, but also in **summer** when we make ice or icicles in the **freezer**!

b) Limescale formation in sinks. **Hard** water contains the substances that form limescale and these are **deposited** in the sink.

c) When you put a melted chocolate bar in the fridge, you are re-crystallising chocolate! (Did you know the **structure** of chocolate will not be the same as before melting? Read about it in the **"Lego, Chocolate and Polymorphs" activity**).

d) Honey crystallises! Has it ever happened to you to find honey crystallised in the **jar**? That is because the **sugar** in it has crystallised over time.

e) Salt on the skin after swimming in the sea. When sea water evaporates, sea salt is **deposited**, so you can spot it on your skin. This is also the same principle of how **sea salt** is collected.