EVVIVA SCIENCES

The Amazing Science Of Crystals

Welcome and Thank You

Thank you for supporting us here at Evviva Sciences. Our mission is to make science fun and enjoyable, and we hope to encourage a passion and love for this field. We hope you love this complimentary Crystal eBook, which includes several amazing crystal facts and even some experiments you can try out at home. We truly appreciate your support! Please let us know what you think by emailing support@evvivasciences.com, or contact us if you have any questions whatsoever!

Disclaimer and Warnings

We recommend adult supervision when performing any experiment in this eBook. Always be careful when handling chemicals. In case of skin contact, make sure to wash the affected area with plenty of water for at least 10 minutes. In addition, be very careful when handling boiling water. If you get a burn, make sure to also wash the affected area for at least 10 minutes with cold water, and cover the burn with a bandage. Never apply oil, powder, or flour to the wound. For larger burns, seek immediate medical help. Lastly, we try to verify all crystal facts in this eBook, but not all have yet been verified, so please take some of these with a grain of salt!

What is a crystal?

Crystals are amazing natural wonders. They are bright, glittering and often colorful and form a variety of very intricate and beautiful shapes.

A crystal is a solid and highly organized material. Crystals are made up of individual atoms or molecules that are arranged in an extremely organized structure. They are everywhere and include snowflakes, diamonds, and even table salt. In contrast, an "amorphous" solid has almost no organized structure. Amorphous solids include glass, wax, and many plastics. Polycrystals are in between crystals and amorphous solids in terms of the organization of their molecular structures. They include metals, rocks, and ice. Below is a cartoon showing the differences.

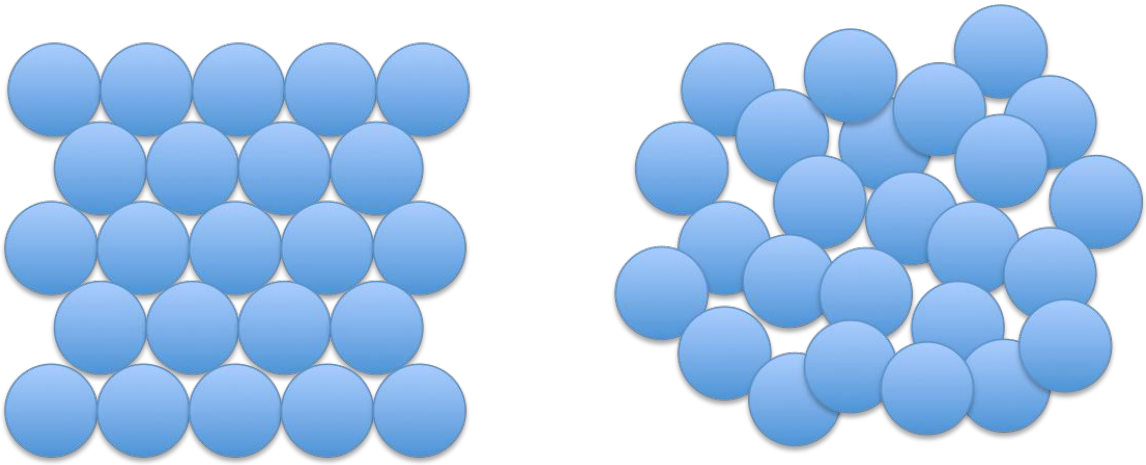

Figure 1. The picture on the left is an example of a crystal if we could see the individual atoms. You can see that the atoms in a crystal have a very organized arrangement. The picture on the right is an example of an amorphous solid (like glass or plastic), where the atoms are not organized at all.

Is ice a crystal?

Ice looks like a crystal but what is it exactly? When we freeze water, the water molecules actually do form very very small crystals called "crystallites". These crystallites then join together to form the ice cube. The little crystallites are real crystals because the water molecules (H2O) are lined up in a very organized arrangement like in Figure 1. But, the entire ice cube itself is not as organized and is actually a polycrystal.

What exactly is a diamond?

Diamonds are a very special (and VALUABLE) type of crystal made up of carbon. Carbon actually forms many less valuable materials such as graphite, but the difference between these things and diamonds lies in the structure. Diamonds have a very organized atomic crystal structure, where each carbon atom is bound to 4 other carbon atoms. Check out Figure 2 below. This structure is incredibly strong, which makes diamonds one of the strongest and hardest natural materials on the planet. But this structure is not easily created. It takes years of pressure and extremely high temperatures to cause carbons to take on a diamond crystal structure. This is why many diamonds are formed in the magma layer of the planet, which is nearly 100 miles below the surface. Over the years, eruptions of lava has pushed diamonds closer to earth's surface for us to find. Because diamonds are just made out of carbon, people can actually make them artificially, but it takes extremely intense conditions (750degF and over 400,000 psi to be exact). These artificial diamonds are indistinguishable from real diamonds to the naked eye, but are less valuable.

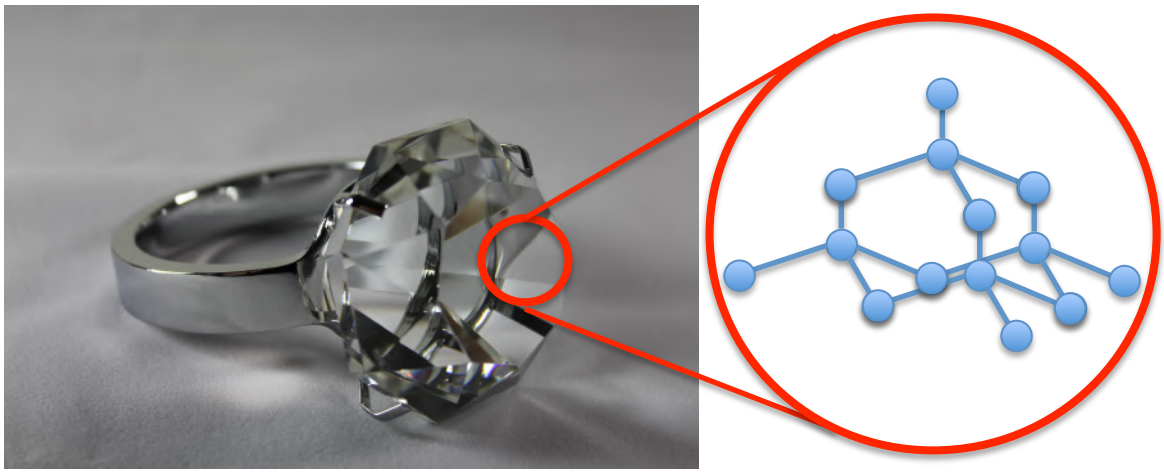

Figure 2. The left image shows a picture of a diamond ring. The right image is just a small portion of the atomic crystal structure of a diamond. The blue circles are carbon atoms and the lines are bonds between them. Each carbon molecule is bound to four other carbon molecules. This crystal atomic structure is extremely strong and makes diamond one of the hardest materials on earth!

Solubility, Temperature, and Saturation

Solubility refers to how much of a substance can dissolve in a certain amount of liquid. The substance being dissolved is called the solute and the liquid is called the solvent. For example, the solubility of sugar (the solute) in water (the solvent) is 210 grams per 100ml. This means that

if we had 100 milliliters of water, we could dissolve a maximum of 210 grams of sugar at room temperature. At this level, we say that the solution is **saturated**. This means that if we tried to add more sugar at this point, it would just sink to bottom of the water and not dissolve no matter how much we stirred. But if we heated the water up, the solubility increases, which means we can dissolve even more sugar. Here's an example. Let's say we boiled 100 milliliters of water, which means that the water reaches a temperature of 212°F. At this temperature, we could dissolve 420 grams of sugar, which is double the amount that we could dissolve at room temperature. Once again, the solution is saturated. If we let the boiling water cool down, the solution becomes "supersaturated" because it now has more dissolved sugar than it should at that temperature. When this happens the sugar will precipitate out forming crystals. This is actually how rock candy is made. See page XXX for more information about making rock candy

How Does Crystal Growing Work?

There are actually two ways that you can grow crystals: the "evaporation" method and the "cooling" method. In the evaporation method, you take a saturated solution and let the liquid evaporate off. For example, let's say we dissolve the maximum amount of sugar, which is 210 grams, in 100ml of water. If we waited and let the water evaporate, there would be less than 100ml of water but still 210 grams of sugar. This is more sugar than there should be in the smaller volume of water, so the sugar would have to come out of solution or precipitate.

In the cooling method, we heat the water up first, so that we can dissolve more sugar and then we let it cool down. As we let the solution cool, the solubility goes down and the solute precipitates out forming crystals.

Our Amazing Crystal Growing Kit uses a little bit of both the cooling method and the evaporation method. In the Amazing Crystal Growing Kit, you will boil water and dissolve a chemical powder. Then we let the solution cool down and we leave it undisturbed over several days. Cooling the solution down causes crystal formation by the "cooling method". In addition, leaving the solution undisturbed for several days allows water to evaporate, which forms crystals by the "evaporation method".

Crystal Rocks

The largest concentrations of crystals on earth are rocks. Crystal rocks can be very small in size, but they can sometimes be huge. For example, in 1999, the world's largest natural crystal was discovered in Malakialina, Madagascar. It is a crystal made of beryl (Be3Al2(SiO3)6), and it is 59 feet long and weighs 840,000lbs. Crystal rocks are often made under conditions of intense heat and pressure, and often involve exposure to lava. Rocks such as granite have cooled very slowly and under great pressures and are said to be completely crystallized. However, it is often the case that lava cools down fairly rapidly (for example at the earth's surface), and this results in the formation of amorphous or glassy rocks. Other crystal rocks, such as marble and quartzites, are formed by a process called recrystallization. In recrystallization, rocks such as limestone and sandstone are first exposed to very high temperatures and pressures. However, the conditions are not strong enough to melt these rocks. Instead, the rocks undergo a metamorphosis, where their original structure is erased and they develop the structure of a new crystal. Crystals can actually form inside rocks, and these types of crystals are known as geodes. The purple amethyst geodes from Brazil are especially valuable and extremely beautiful (see Figure 3).

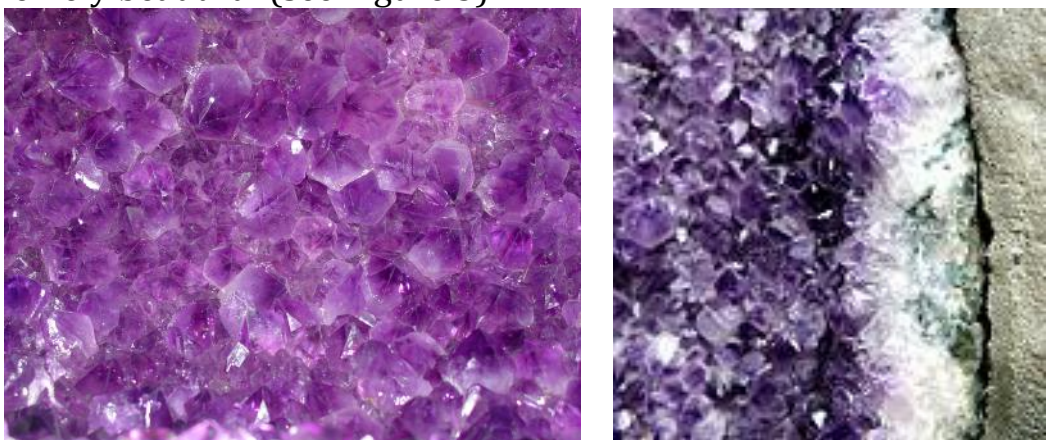

Figure 3: Purple amethyst crystals. The right image shows an amethyst geode. Amethyst is a form of quartz.

X-ray Crystallography

Scientists use an advanced technology called X-ray crystallography to determine the atomic structure of crystals. In this method, a crystal is exposed to actual x-rays, and the atoms cause the x rays to diffract into many different directions. The equipment can measure the angle of these x-rays as they pass through the crystal and can make a 3-dimensional picture of the crystal. Scientists also use x-ray

crystallography to determine the structure of other important substances, including vitamins, proteins, DNA, and pharmaceuticals. The method also revealed the structure and function of many biological molecules, including vitamins, drugs, proteins and nucleic acids such as DNA.

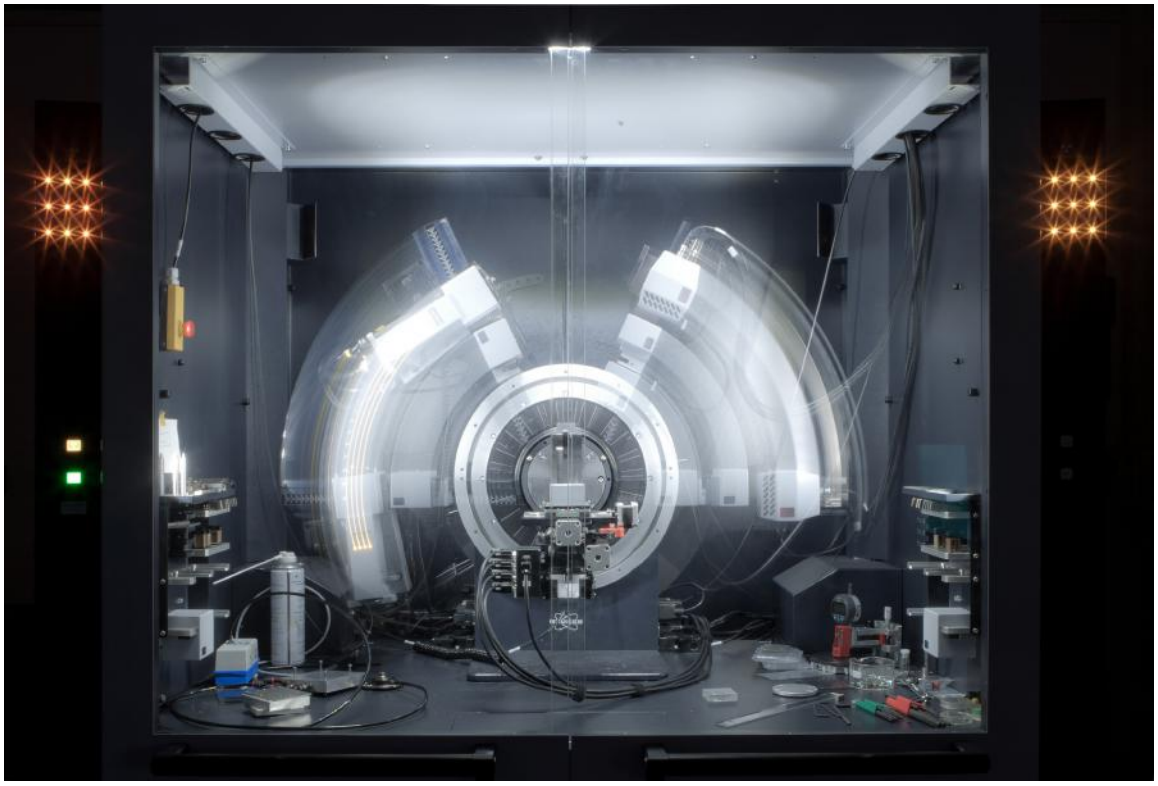

Figure 4: X-ray crystallograph in motion. This device is used to determine the molecular structure of crystals and other materials.

Two Crystal Experiments!

Experiment 1: Creating a Sugar Star

Materials Needed

1. Small cup
2. Small plate
3. Large shallow plate
4. Food coloring
5. Plastic pipette or eye dropper
6. Spoon to stir
7. Sugar cube
8. Large shallow plate
9. Tap water
10. Paper towel

Steps

1. Dissolve some food coloring in some tap water in the small cup
2. Place a sugar cube on a small plate and use a pipette or eye dropper to carefully add 5-6 drops of the colored solution to it
3. Wait for the sugar cube to dry
4. Fill a large shallow plate with some water and set the colored sugar cube in its center
5. Watch as an amazing colored star takes shape on the plate
6. Clean everything thoroughly with water

When the sugar dissolves, it takes the colored solution with it. The sugar particles move out to the edge of the plate and the colored solution flows outward as well. When this happens, a beautiful star is formed.

Experiment 2: Making rock candy

Making rock candy is similar to making crystals in your Amazing Crystal Growing Kit, except instead of using crystal chemicals, you use sugar. Here is a basic recipe to make rock candy at home:

1. Get several mason jars and put them in the bottom of a large Dutch oven. Fill the dutch oven with a small layer of water, just enough to cover the bottoms of the jars by 1 inch. Let the water boil for 2 minutes to sterilize the jars. Remove them with kitchen tongs and place them on a wire rack. Allow them to cool completely and dry.
2. Tie strings around the centers of several wooden skewers or pencils, and place these over the rims of the sterilized jars so that the ends of the string dangle into the jar without touching the bottom.
3. Boil two cups of water and add 4 ½ cups of sugar in a large saucepan for approximately 5 minutes stirring occasionally.
4. Remove from heat and add 10 drops of red food coloring and 1/8 teaspoon of cinnamon oil and 2 teaspoons of vanilla extract.
5. Let the mixture stand for 5 minutes, then add about 1 cup of the mix into each mason jar. Be careful not to let the mixture touch the skewers while pouring. Loosely cover the jar (including the skewer) with aluminum foil and make several holes in the foil.
6. Let the jars stand for 10-14 days undisturbed and rock crystal candy will form on the strings. After this time, remove the strings, which should be coated with crystals and let them dry for about 1 hour (it is best to suspend the strings between the jars to dry off).

7. Enjoy

Rock candy crystals form by the same principles used in your Crystal Growing Kit. You basically create a supersaturated solution of sugar water and as it cools and evaporates over several days, the sugar will precipitate out on the string forming crystals. Let us know how this works at support@evvivasciences.com.

Images

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Xray crystallography
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