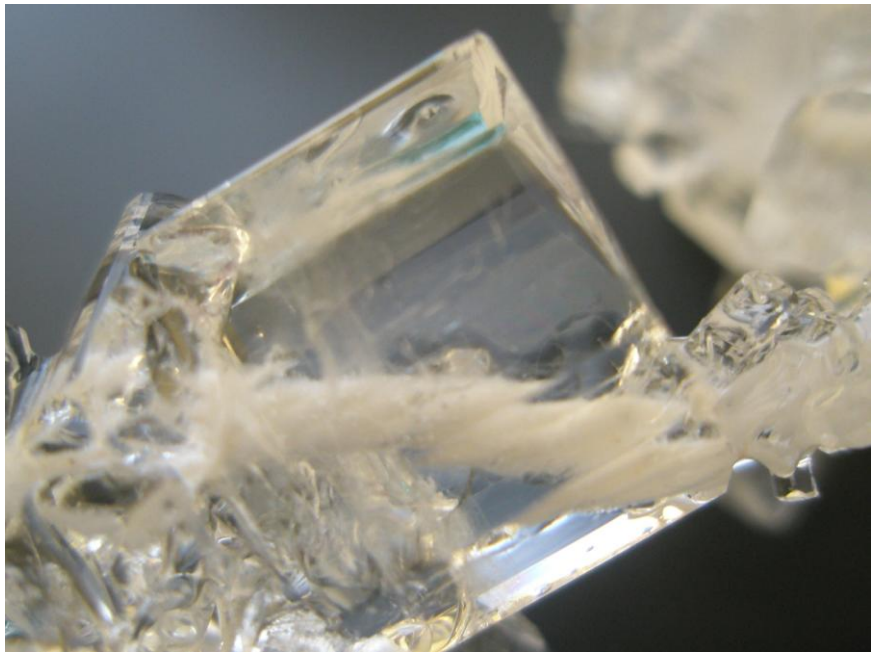
Crystals!



A Booklet for Elementary Students

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Crystal Vocabulary

Atom – the smallest particle of an element that can exist. An **ion** is a charged atom. A **molecule** is the smallest particle of a compound that can exist.

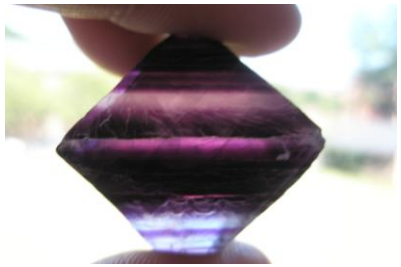
Bonds – the forces that hold atoms together

Crystal – a solid material with a defined geometric shape, straight edges, and smooth faces. Crystals are made up of atoms, ions or molecules arranged in a regular, orderly way.

Crystallography – the study of crystals

Evaporation – the process through which a liquid such as water changes into a gas, such as water vapor (steam).

Optical property – the ability of matter to interact with light to give visible color, **interference** (rainbows), **birefringence** (double vision) and/or **fluorescence** (glows-in-the-dark)



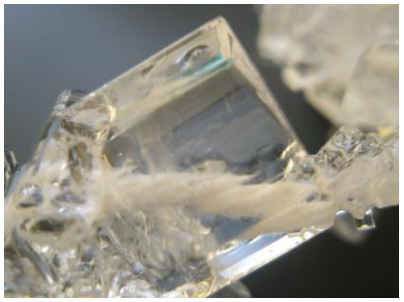
Saturated solution – a solution containing the maximum amount of solute dissolved in a certain amount (volume) of solvent at a given temperature.

Solute – the substance that is dissolved in a solution

Solution – a uniform liquid mixture of two substances, a solute and solvent

Solvent – the liquid that is used to dissolve a solute to form a solution

A crystal of Rochelle salt made from a supersaturated solution of Rochelle salt (potassium sodium tartrate) and water.



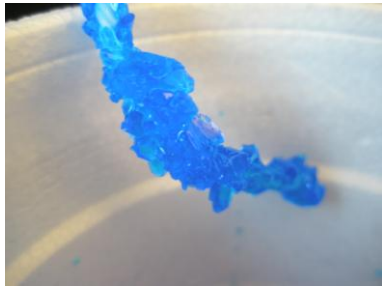
Supersaturated solution – a solution where more than the maximum amount of solute is temporarily dissolved in a certain amount of solvent at a given temperature

Symmetry – when a shape looks the same if you flip, slide, invert or turn it. For example, a square looks the same after you rotate it by a quarter turn.

Unit cell – the smallest building block of a crystal whose atoms, ions, or molecules form a geometric pattern that is repeated throughout the substance. This repetition forms the **crystal lattice**.

X-ray crystallography – the visualization of the molecular structure of crystals using X-rays.

Chrome Alum



Copper(II) sulfate

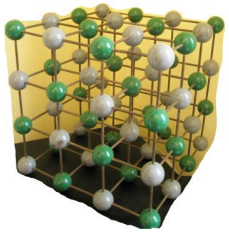
Fluorite

Mica

Vocabulary Word Search

c	r	y	s	t	a	l	q	w	e	t	y	u	i	k	o	g	h	i	s
s	e	b	a	t	o	m	y	r	c	s	i	u	t	l	u	b	g	f	c
c	y	r	t	a	s	s	l	v	c	d	s	s	o	l	u	t	i	o	n
u	t	r	u	c	r	o	d	f	e	v	a	o	r	a	g	s	o	l	s
e	n	s	r	k	y	g	l	e	b	c	v	l	v	r	e	c	a	u	a
d	e	i	a	l	t	d	s	v	s	c	a	u	a	m	n	a	p	r	w
c	f	s	t	i	d	d	v	d	e	a	r	t	m	e	i	e	c	e	o
y	c	y	e	c	v	e	v	c	f	n	u	e	v	y	r	r	e	y	g
b	s	a	d	i	e	c	a	s	s	a	t	d	v	s	r	e	k	j	c
r	g	s	s	m	v	l	g	h	d	r	a	s	a	k	e	y	i	e	m
c	e	x	o	y	a	c	l	e	y	g	s	t	v	a	h	k	m	a	k
r	v	h	l	y	p	c	s	y	f	s	d	c	e	t	t	o	y	n	n
s	g	r	u	u	o	p	t	i	c	a	l	p	r	o	p	e	r	t	y
a	h	e	t	n	r	r	t	c	r	a	m	c	c	e	a	r	e	y	a
y	s	d	i	f	a	r	s	y	d	s	e	a	n	s	k	i	r	e	r
l	s	f	o	s	t	d	c	e	y	c	n	c	i	l	y	s	a	t	f
s	b	o	n	d	i	s	e	c	h	d	t	e	b	y	e	e	c	t	d
e	t	f	d	s	o	s	r	u	s	e	d	c	o	n	r	t	f	e	n
m	r	b	b	s	n	c	r	w	r	e	v	a	r	c	a	e	n	e	a
x	r	a	y	c	r	y	s	t	a	l	l	o	g	r	a	p	h	y	s

atom, bond, crystal, crystallography, evaporation, optical property, solution, saturated solution, solvent, solute, symmetry, unit cell, x-ray crystallography

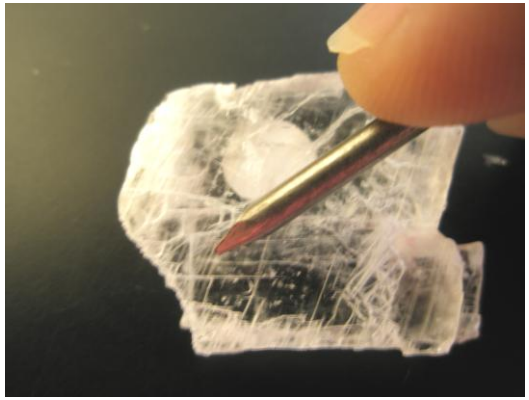


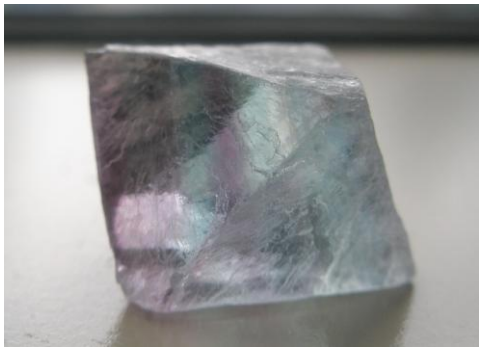
What is a Crystal?

If you were asked to name a crystal, what would you choose? Would it be the "crystal" chandelier in a fancy hotel or your grandmother's good glassware that she calls her good "crystal"? In fact neither of those things is crystal. They are made of cut glass. A **crystal** is a solid substance made of **atoms**, **molecules** or **ions** that form regular repeating patterns called a **crystal lattice**. The regular patterns of atoms in

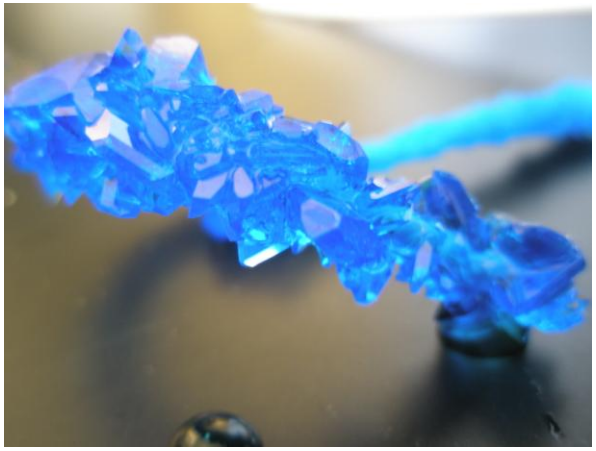
Glass must be cut or molded into regular shapes,

but crystals form these shapes naturally. The atoms or ions in crystals are held together by attractive forces often referred to as **bonds**. The **hardness** of a crystal results from the strength of the bonds. When mineralogists study rocks and minerals, they often test for the hardness of these materials. Scientists also study **optical properties** of crystals. An optical property involves the way a crystal interacts with light. Four common optical interactions with light are color, interference, birefringence, and fluorescence.





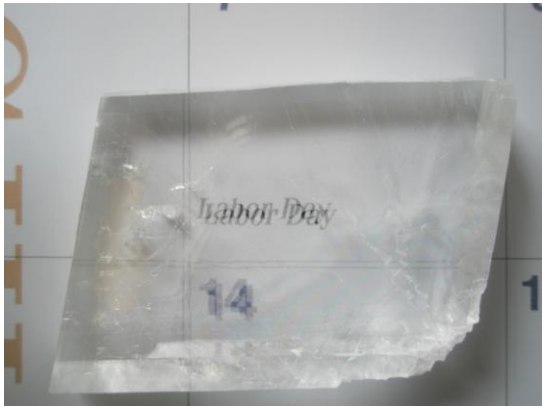
Crystals often have a characteristic **color** due to absorption of light, for example hydrated copper(II) sulfate crystals are a characteristic royal blue color.



Color may also be caused by interference.

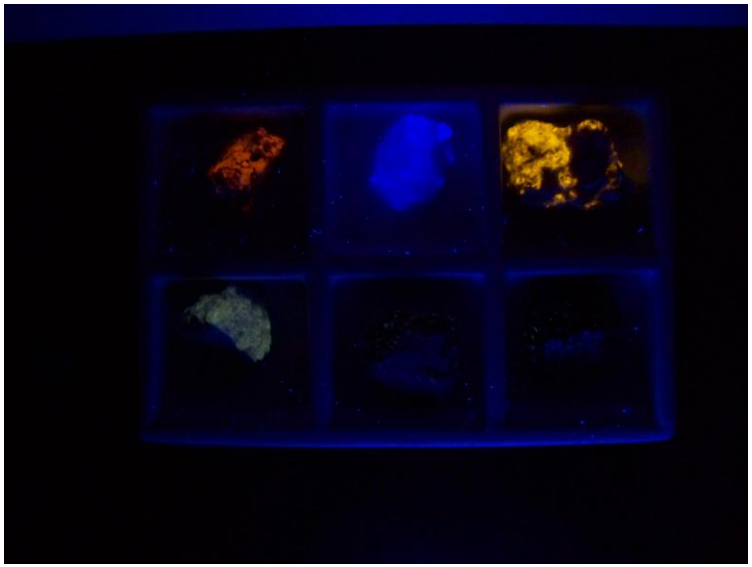
Interference often produces rainbows due to the differences in the time that it takes for different colors of light to pass through a material. Look at the crystal of bismuth to the right. Bismuth's rainbow colors are due to the varying thickness of an oxide coating. Interference causes CDs and DVDs to show rainbow colors.

Birefringence is the splitting of light inside a crystal, causing double vision when looking through the crystal.



Fluorescence is happening when a crystal glows when exposed to ultraviolet light.

Crystals exposed to white light.



Crystals exposed to ultraviolet light.

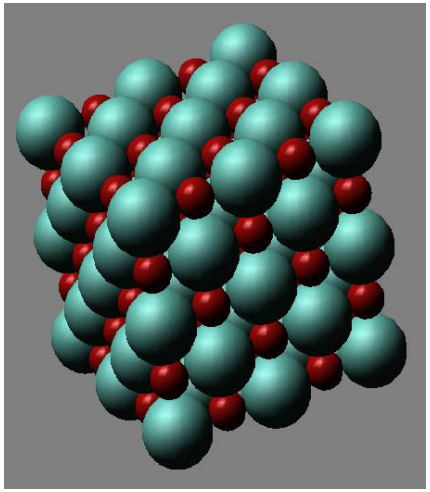
So what are some crystals that you can find around you?

Table salt, which has the chemical name of sodium chloride, is a white crystal with a cubic shape. It is made of sodium (Na^+) and chloride (Cl^-) ions.

Sugar, ice and diamonds are all crystals.

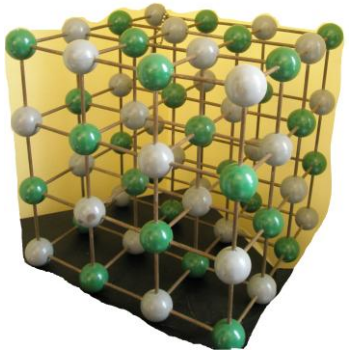
Each has their own shape. Other crystals can be formed from powders that you may have around the house. For example, the detergent booster, borax, contains sodium borate which makes crystals easily. Later in this booklet, you will find a recipes for making sodium borate, sodium chloride and Epsom salt crystals.

ATOMS, IONS AND THE UNIT CELL



The Crystal Lattice of Sodium Chloride
(teal balls = Cl^-, red balls = Na^+)

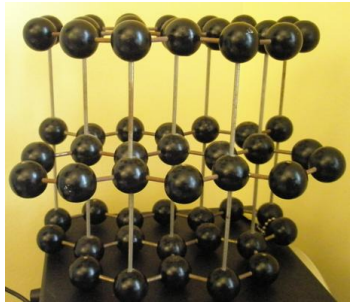
Crystals form as a result of **bonds** (attractions) between atoms, ions and/or molecules. The particles align themselves to maximize the number of attractions. For example, the Cl^- and Na^+ ions in sodium chloride attract each other. Look at the picture above. Can you see how each Cl^- touches only Na^+ and each Na^+ touches only Cl^-? The **unit cell** is the smallest repeating portion of the crystal. The unit cell is like a brick and the entire crystal is like a brick wall.



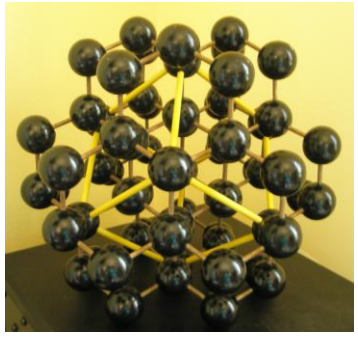
Crystal of Sodium Chloride, also called Halite and its ball and stick model.

Diamond and graphite (pencil "lead") are forms of carbon. They are very different. Diamond is colorless and very hard. Graphite is black and very soft. These differences come from the different arrangement of atoms in diamond and graphite.

Graphite

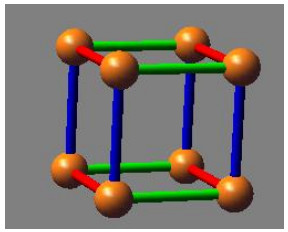


Diamond

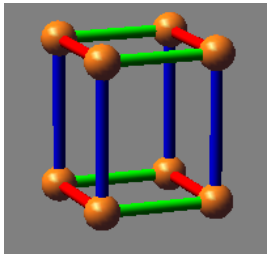


Crystal Shapes

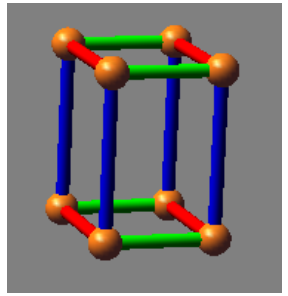
Crystals form in seven different shapes called crystal systems. The crystal systems are named cubic, tetragonal, orthorhombic, monoclinic, triclinic, hexagonal, and rhombohedral. Each crystal system has a unique shape (symmetry). For example all edges (red, green, and blue) in a cubic crystal have the same length. But in a tetragonal crystal one of these lengths (blue) is different than the other two. And in orthorhombic crystals all three are different from one another.



Cubic

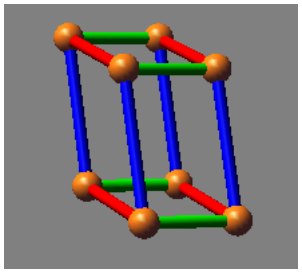


Tetragonal

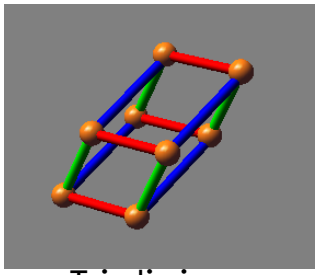


Orthorhombic

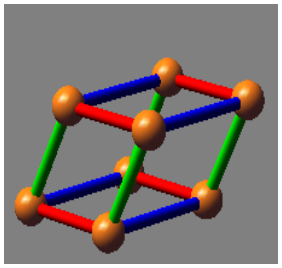
crystals cause crystals to grow or cleave in geometric shapes. The atoms in glass are not arranged in regular patterns.



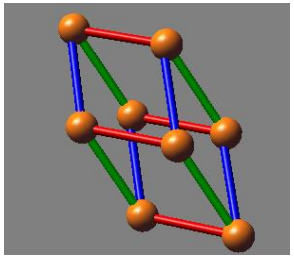
Monoclinic



Triclinic



Hexagonal



Rhombohedral

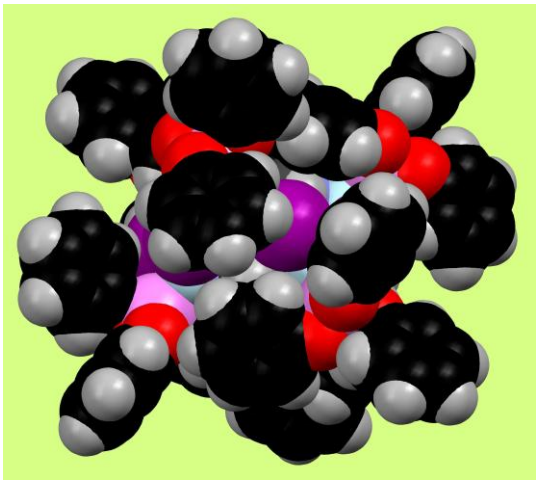
Can you guess what shape this crystal of pyrite is?

X-Ray Crystallography

Picture of an X-ray diffractometer

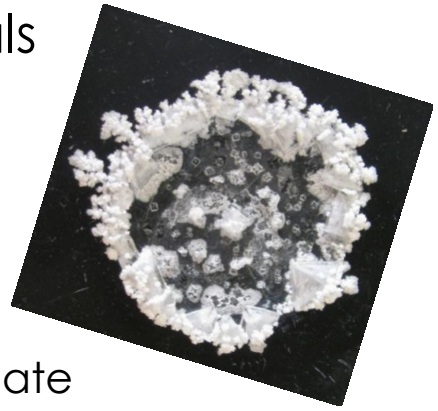
Crystallography is the study of the molecular structure of crystals. One way that scientists study crystals is through **X-ray crystallography**. X-rays make up a part of the light spectrum. X-rays are not visible to the human eye, but they can be "seen" using special equipment for instance in a medical X-ray. Since X-ray beams carry high energy ("ionizing") radiation, they must be handled with great care and only by trained specialists. In X-ray crystallography, X-rays are used to "look inside" the crystal. The X- rays **diffract** (bounce off of) the layers

of atoms that make up the **crystal lattice**. The diffracted X-rays were once detected using photographic film, but now special imaging plates are used. The collection of diffracted X-rays can be turned into a map of the crystal's structure. This map shows the locations of atoms in the unit cell. By "looking" at the crystal in this way, a scientist can tell a great deal about the crystal's structure.



X-ray structure of a molecule containing many atoms

Recipes for Making Your Own Crystals



Salt Crystals:

Materials:

- table salt, NaCl
- pie pan or glass plate
- water (distilled is best)
- stove or microwave oven
- measuring cup
- teaspoon

Procedure:

1. Measure out ½ cup of distilled water and heat to nearly boiling.
2. Stir in 3 teaspoons of salt and stir until dissolved.
3. Pour into a pie pan or glass plate and allow water to evaporate.
4. Observe the crystals.

Sodium Borate Crystals:

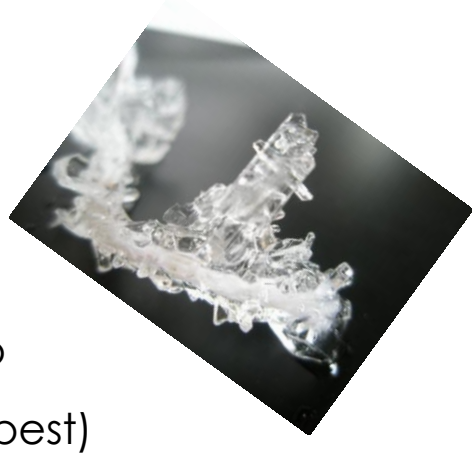
Materials:

- borax
- clear glass or cup, a pint jar will also work
- water (distilled is best)
- stove or microwave oven
- measuring cup
- teaspoon
- string and pencil

Procedure:

1. Measure out ½ cup of distilled water that has been warmed to nearly boiling.
2. Stir in 2 teaspoons of borax and stir until dissolved.
3. Tie a piece of string to a pencil, place the string in the liquid and set the pencil across the top of the glass. Let stand for several days and observe crystals.

Epsom Salt Crystals



Materials:

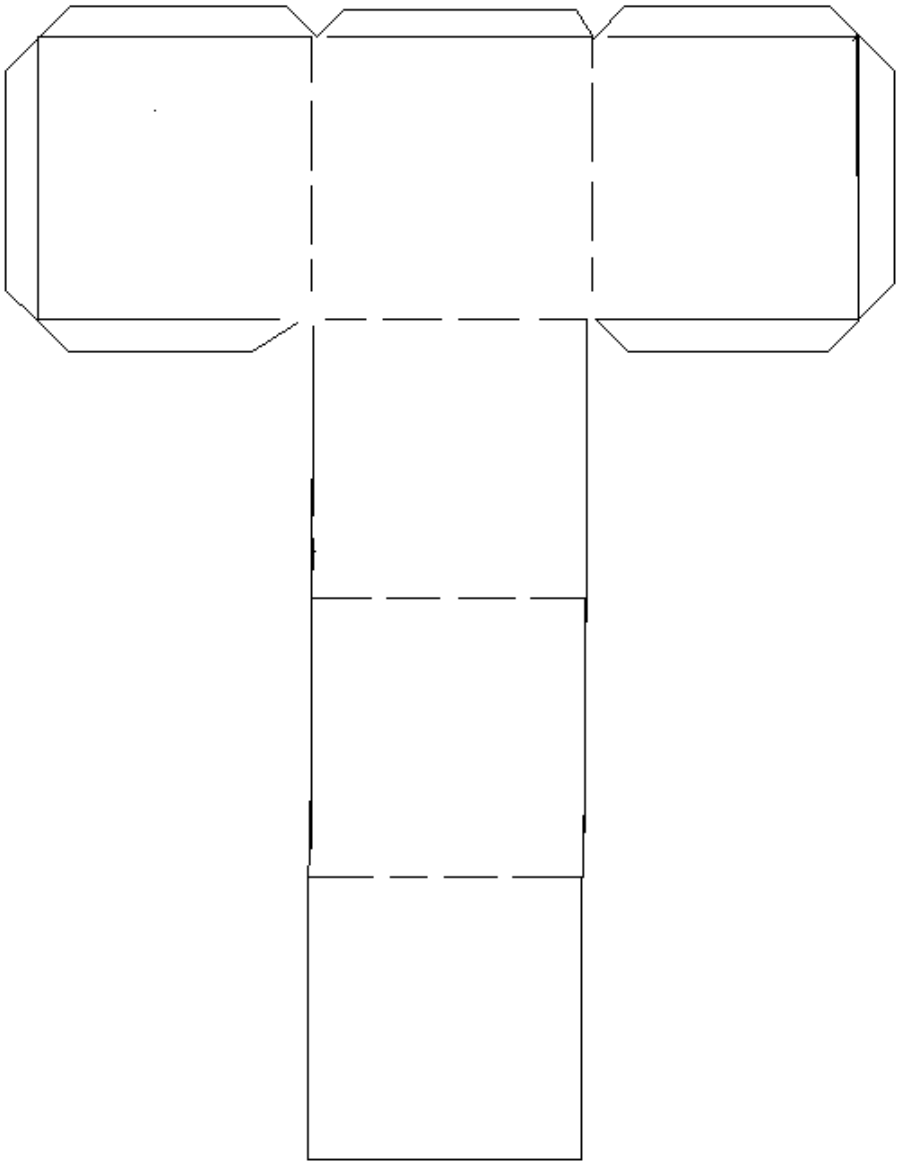
- Epsom salt
- clear glass or cup
- water (distilled is best)
- stove or microwave oven
- measuring cup
- teaspoon
- string and pencil

Procedure:

1. Measure out ½ cup of distilled water that has been warned to nearly boiling.
2. Stir in 7 teaspoons of Epsom salt and stir until dissolved.
3. Tie a piece of string to a pencil, place the string in the liquid and set the pencil across the top of the glass. Let stand for at least two weeks and observe crystals.

Make Your Own Models

Trace the pattern below on a separate sheet of paper, cut it out and form your own cubic paper "crystal".



Octahedron

Trace the pattern onto another piece of paper, cut along the bolded lines, taking care to not cut tabs. Fold along the dashed lines and tape structure.