Crystallization

Chemistry, Physics
Target age group: Elementary school students (12-16 yo)

Description: This learning module exposes students to the concept of crystallization and some methods to get crystallization to occur. Students will be able to visualize 3D chemical structures and how they pack together in repeating patterns to form crystals. These activities can be run in series as part of a science learning day event or can be incorporated into classroom practical activities.

Expected Outcomes

- Familiarity with the prevalence of and different types of crystal structures
- Ability to set up a crystallization experiment
- Understanding of the concepts of nucleation and crystallization
- Understanding of some properties of crystals
- Awareness of different methods of crystallization

Materials

Required

- Printed hand-outs (common crystals, methods of crystallization, nucleation, step by step practical guides)
- Examples of different crystals
    - quartz, bismuth, sodium chloride, sugar, geodes, amethyst, fluorite
- Computer with internet access
- Deionised water
- Either copper(II) sulfate pentahydrate or sodium acetate

Optional

- 3D printed models of compounds
- VR Googles with ability to connect to internet content

Unit Outline

1. Investigate crystalline samples
2. Nucleation practical experiment / demonstration
3. Visualise 3D representation of the structure on the computer and via VR headset if available.
4. Crystallization of copper(II) sulfate crystallization (either practical options or video)
5. Different methods of crystallization

Section descriptions

Section 1 – Investigate crystalline samples

Instructor activities

- Present a variety of crystalline objects (e.g. sodium chloride, sugar, amethyst, fluorite, quartz, bismuth, copper(II) sulfate crystallization) and an information sheet on each object (including chemical name, chemical formula, maybe crystal habit or how it is formed in nature, or where it is found on the Earth)
    - Common crystals like sodium chloride (salt) and sugar can be easily obtained. If you have access to a rock or gem shop you can often find interesting crystalline samples there.
    - Make a card for each sample with the formula, where it is found and other interesting facts you may know.
- Discuss each molecule's interesting features, highlighting properties common to crystals
    - Sharp edges, well defined faces, shiny, transparent, etc.

Student activities

- Inspect each crystalline object and for each write down: a short description of how it looks/feels, chemical name and formula and any other facts of interest.
- Discuss what you think the properties common to all crystals are

Section 2 – Nucleation/Crystallization practical experiment or demonstration (note: sections 1 & 4 could be incorporated into this section, while the solution is cooling)

Instructor activities:

- Explain steps of practical activity
- Explain what a super saturated solution is
- Explain what happens to the atoms when the sodium acetate is dissolved (bond breaking, endothermic)
- Explain what happens when it crystallises (bond making, exothermic)
- Encourage students to carefully feel for temperature changes
- Discuss practical applications (e.g. hand warmers)
- Prepare equipment for student practical or demonstration:
    - 160 g of sodium acetate trihydrate
    - scale
    - Spoon / spatula
    - beaker
    - 30 mL deionised water
    - Measuring cylinder
    - Hot plate & oven gloves
    - Stirring rod
    - Wire
    - Plate

Student activities:

- Weigh 160 g of sodium acetate trihydrate into a beaker

- Measure 30 mL deionised water
- Pour the water into the beaker with the sodium acetate
- Place the beaker on a hot plate and gently heat with stirring until all the sodium acetate is dissolved and you have a clear solution. Note any observations.
- Gently remove the beaker from the hot place and leave to cool without disturbing the beaker
- Either: pick up a few sodium acetate crystals using a thin piece of wire and place into the center of your cooled solution. Watch the crystallization take place. Note any observations.
- Or: put a few sodium acetate crystals on a plate and pour your cooled solution onto the crystals, keeping the stream of the solution as continuous as possible. Note any observations.

Section 3 - Visualize 3D representation of the molecule

Instructor activities

- Assist students with 3D visualization; manipulating the molecule on the screen
- Provide VR headset for further exploration

Student activities

- Navigate to https://www.ccdc.cam.ac.uk/structures
- Search for "sodium acetate trihydrate" in the "Compound name" search box
- Note the chemical formula and the 2D representation
- Manipulate the visualisation in the 3D viewer and investigate the different packing options to understand how the atoms and molecules are organised inside the 3D space of the crystal

Section 4 – Crystallization of copper(II) sulfate – view video OR practical with copper(II) sulfate solution OR practical with copper oxide and sulfuric acid reaction.

Instructor activities

EITHER

- Prepare equipment for video viewing (https://youtu.be/FFR4nei9qv8)

OR

- Prepare equipment for reaction of copper oxide and sulfuric acid to make copper(II) sulfate and subsequently copper(II) sulfate crystals (http://www.rsc.org/learn-chemistry/resource/res00001917/reacting-copper-ii-oxide-with-sulfuric-acid)

OR

- Equipment for crystals from solution
    - Weighing scales
    - Beaker
    - Spatula
    - Measuring cylinder
    - Stirring rod
    - Hot plate
    - Wire/thread
    - Copper(II) sulfate pentahydrate (70 g)
    - Deionised water (100 mL)

Student activities

EITHER

- Watch video viewing (https://youtu.be/FFR4nei9qv8)

OR

- Follow steps to react copper oxide and sulfuric acid to make copper(II) sulfate and subsequently copper(II) sulfate crystals (http://www.rsc.org/learn-chemistry/resource/res00001917/reacting-copper-ii-oxide-with-sulfuric-acid)

OR

- Using the weighing scales, beaker and spatula, weigh 70 g of copper(II) sulfate pentahydrate into your beaker
- Measure out 100 mL of deionised water into your measuring cylinder
- Pour the 100 mL of deionised water into your beaker with the copper(II) sulfate
- Stir the contents of the beaker while heating on the hot plate until all the copper(II) sulfate has dissolved. You are making a saturated solution of copper(II) sulfate.
- Find a location where your beaker can be left undisturbed for 24 h and cover the top loosely with some foil to avoid any contamination. This is for the solution to cool.
- On returning to your cooled solution, you will find some copper(II) sulfate has precipitated out of the solution. You have made crystals!

EXTENSION

- Pour off the solution into a clean beaker
- Choose a crystal from the precipitate that has smooth surfaces and is without cracks or defects
- Tie one end of the thread to this crystal and the other end of the thread to a pencil/rod
- Carefully submerge your crystal into the remaining solution and leave to grow for as long as you like!
- You can repeat this process with new saturated solutions of copper(II) sulfate to make your crystal as big as you like (beaker size limiting)!

Section 5 – different methods of crystallization

Instructor activities

- For information about different methods of crystallization, see here: https://web.mit.edu/x-ray/cystallize.html

- Explanations of different crystallization techniques
    - Solvent evaporation
    - Slow cooling
    - Solvent diffusion
    - Vapour diffusion
    - Vacuum sublimation

Student activities

- Awareness of different crystallization techniques

Using these activities in the classroom:

This activity was originally designed as part of The Cambridge University Science Festival. If you are interested in using this as part of your course curriculum, please see below for some places where this might fit into your classroom.

Guide to Science Curriculum from Ontario, Canada:

http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf

Areas where this activity might fit in your courses:

Grade six (12 year old) science students address issues like the following:
http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec18currb.pdf
1.2 evaluate the social and environmental costs and benefits of space exploration, taking different points of view into account (e.g., the point of view of health care workers and workers in other agencies that compete with space programs for public money; astronauts and their families; the general public; scientists) Sample issue: Space exploration has brought many benefits to society. High-quality radio and television signals are now relayed around the globe by satellite. Biological experiments in space, such as the growing of insulin crystals, are contributing to our ability to fight disease. The technology used for space shuttle fuel pumps is now being used to make better artificial hearts. Geographical data obtained by satellites have improved the quality of maps and made navigation safer. But space exploration is also very expensive, involves risks to the lives of astronauts and others, produces pollution, and creates space junk that may eventually fall back to Earth. Are the benefits worth the costs and risks? (pg. 122)

Grade 7 (12/13 year olds) science students address issues like the following:
2.4 use scientific inquiry/experimentation skills (see page 12) to investigate the properties of mixtures and solutions (e.g., the amount of solute required to form a saturated solution; differences between pure substances and mixtures) Sample guiding questions: How does changing the amount of solute or solvent affect the solution? What factors affect the amount of solute that can dissolve in a solvent? What factors affect the speed at which a solute dissolves? 2.5 use appropriate science and technology vocabulary, including mechanical mixture, solution, solute, insoluble, saturated, unsaturated, and dilute, in oral and written communication (pg. 133)

From the Ontario curriculum guide, SCH3U (Grade 11) Chemistry:
http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf
B2.6 build molecular models, and write structural formulae, for molecular compounds containing single and multiple bonds (e.g., CO_2, H_2O, C_2H_4), and for ionic crystalline structures (e.g., NaCl) (pg. 95)

From the Ontario curriculum guide, SCH4U (Grade 12) Chemistry:
C1.1 assess the benefits to society of technologies that are based on the principles of atomic and molecular structures (e.g., magnetic resonance imaging [MRI], infrared spectroscopy, X-ray crystallography, nuclear energy, medical applications of spectroscopy and mass spectrometry) (pg. 110)

From the Ontario curriculum guide, SES4U (Grade 12) Space and Earth Sciences:
E2.6 investigate metamorphic rocks (e.g., slate, phyllite, schist, gneiss, quartzite, marble), using a hand lens, and classify them on the basis of their characteristics (e.g., foliation, crystallinity) in order to identify their parent rock and the temperature, pressure, and chemical conditions at their formation [PR, AI]

E2.8 plan and conduct an inquiry to investigate the factors that determine the size and form of mineral crystals (e.g., the temperature of the solution, the type of salt, the level of saturation, the temperature of slides containing melted salol) [IP, PR]

Get your students involved outside the classroom:

There are multiple crystal-growing competitions including:

https://uwaterloo.ca/chem13-news-magazine/september-2018/feature/canadian-crystal-growing-competition

https://www.uscrystalgrowingcompetition.org/

https://www.iucr.org/outreach/crystal-growing-competition-2019

View the video "Mystery of the Giant Crystals" here:
http://www.trianatech.com/index.php?option=com_content&view=article&id=148&Itemid=131&lang=en

Share crystallization experiences with younger students

Use the pamphlet developed by Prof. Robert Pike at The College of William and Mary included in this packet to share more crystallization activities with younger students.

Keep in touch:

We'd love to learn more about your experiences using this activity in your classroom or science festival. Please share your feedback with us at teaching@ccdc.cam.ac.uk

Thanks!
- The CCDC Education Team

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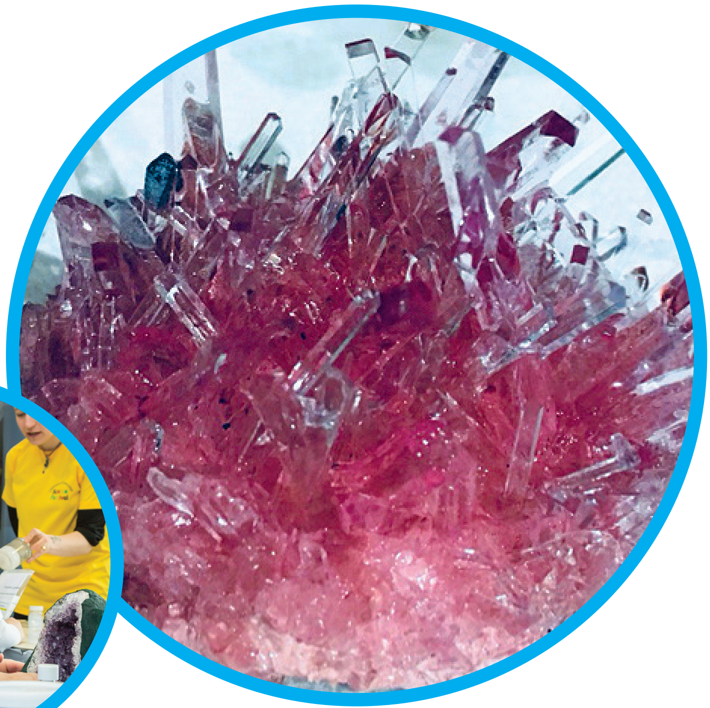
Crystallization.



Crystallization is a separation technique that is used to separate a solid that has dissolved in a liquid.

- Solid (e.g. salt, the solute) is dissolved in a liquid (e.g. water, the solvent) making a solution.
- The solid (solute) is added to the solvent until no more will dissolve. This makes the solution saturated.
- As the solvent evaporates from the saturated solution, the solid will come out of the solution and crystals will start to grow. The crystals can then be collected and allowed to dry.

www.ccdc.cam.ac.uk

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Crystallization.

- **Crystallization is a separation technique**
- **There are different methods of crystallization**
- **To make these crystals:**
  - Solid (solute) is dissolved in a liquid (solvent) until no more will dissolve
  - As the solvent evaporates the solid comes out of the solution in the form of crystals
  - The crystals are collected and dried
- **Other methods include:**
  - Cooling
  - Evaporation
  - Precipitation
  - Layering
  - Sublimation
  - Ion exchange

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Nucleation.

Activity sheet

Arrange the SALT and WATER molecules to represent the SOLID crystalline state, after nucleation has occurred.

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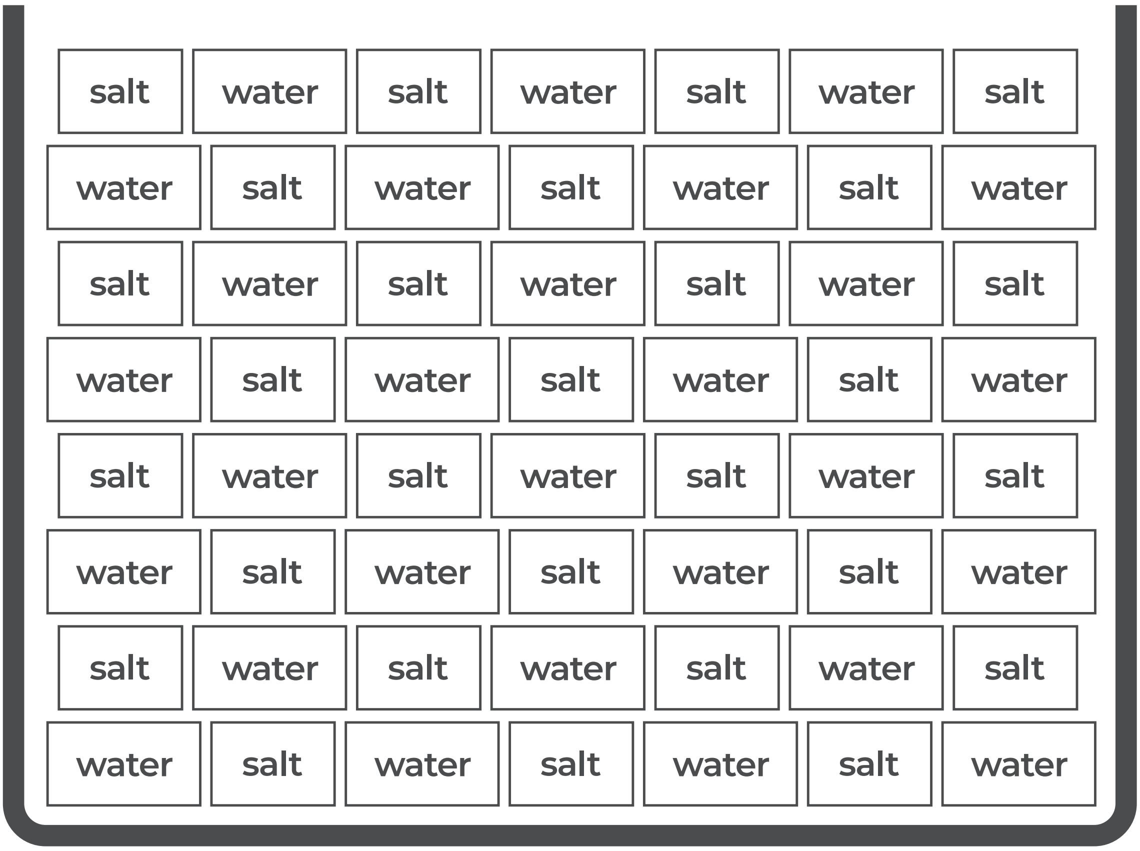
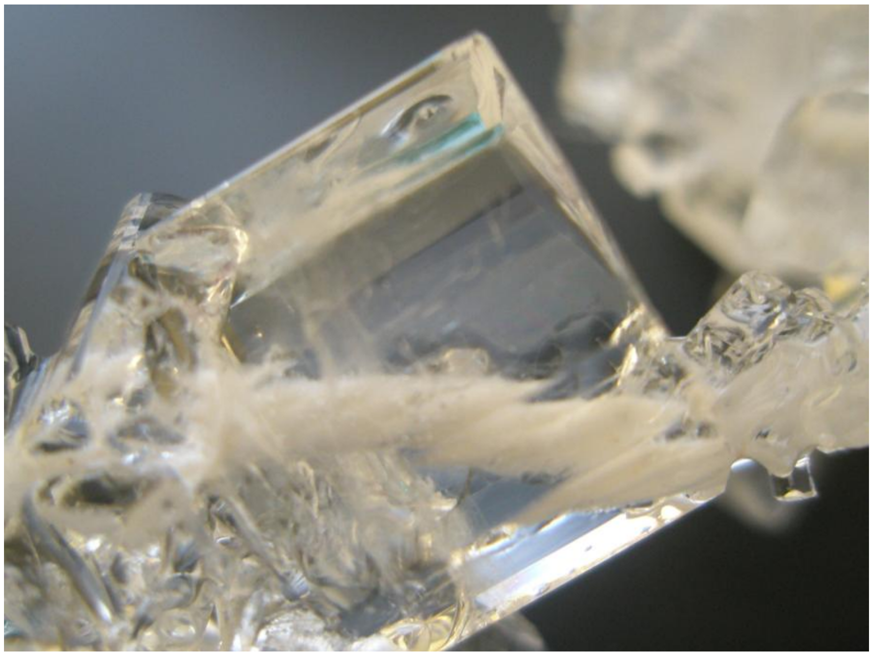
Nucleation.

Answers

- Introducing a single crystal of the sodium acetate salt to this supersaturated solution acts as a nucleation point.
- Rapid crystallization occurs resulting in a phase change from the super saturated solution liquid phase to the solid phase.
- Bonds are formed between sodium ions and the acetate ions.
- Bond making gives out energy, in this case in the form of heat, an exothermic reaction.
- All the molecules are now aligned in a regular repeating pattern, the solid state
- Nucleation is a change of phase



Crystals!



A Booklet for Elementary Students

by Robert D. Pike, Ph.D. and Robin M. Carey

College of William & Mary

Department of Chemistry

Williamsburg, VA

Table of Contents

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.

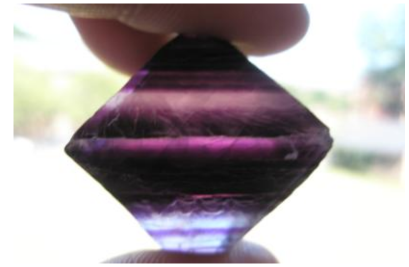
Bonds – the forces that hold atoms together

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)



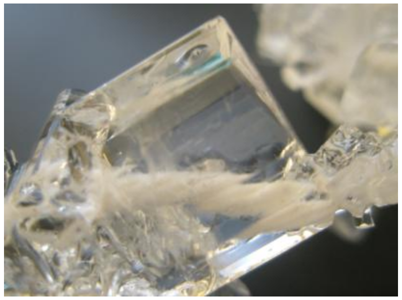
Saturated solution – a solution containing the maximum amount of solute dissolved in a certain amount (volume) of solvent at a given temperature.

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.



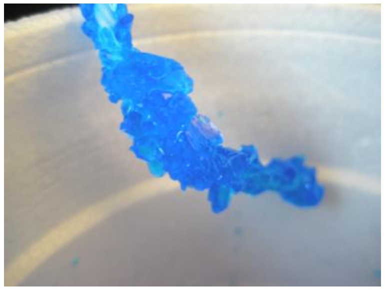
Supersaturated solution – a solution where more than the maximum amount of solute is temporarily dissolved in a certain amount of solvent at a given temperature

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

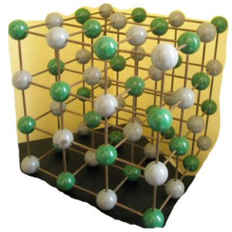
Fluorite

Mica

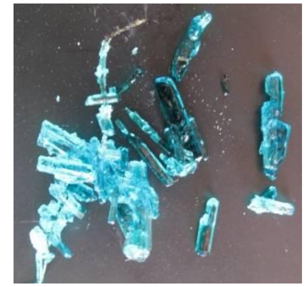
Vocabulary Word Search

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?

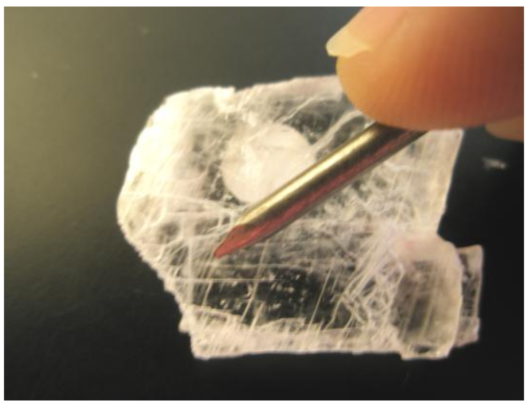


If you were asked to name a crystal, what would you choose? Would it be the "crystal" chandelier in a fancy hotel or your grandmother's good glassware that she calls her good "crystal"?

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,

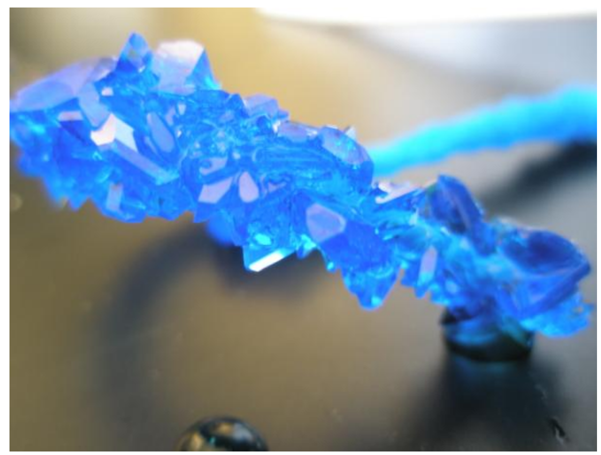
but crystals form these shapes naturally. The atoms or ions in crystals are held together by attractive forces often referred to as **bonds**. The **hardness** of a crystal results from the strength of the bonds. When mineralogists study rocks



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.

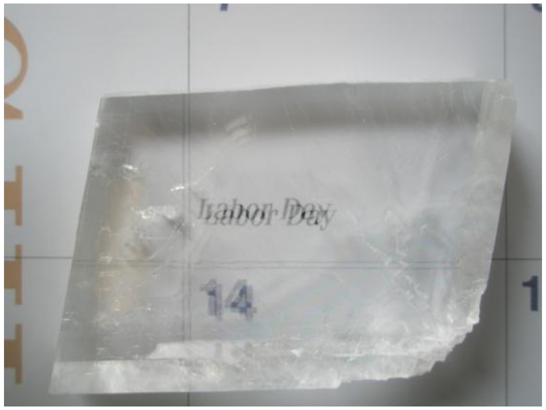
Crystals often have a characteristic **color** due to absorption of light, for example hydrated copper(II) sulfate crystals are a characteristic royal blue color.



Color may also be caused by interference.

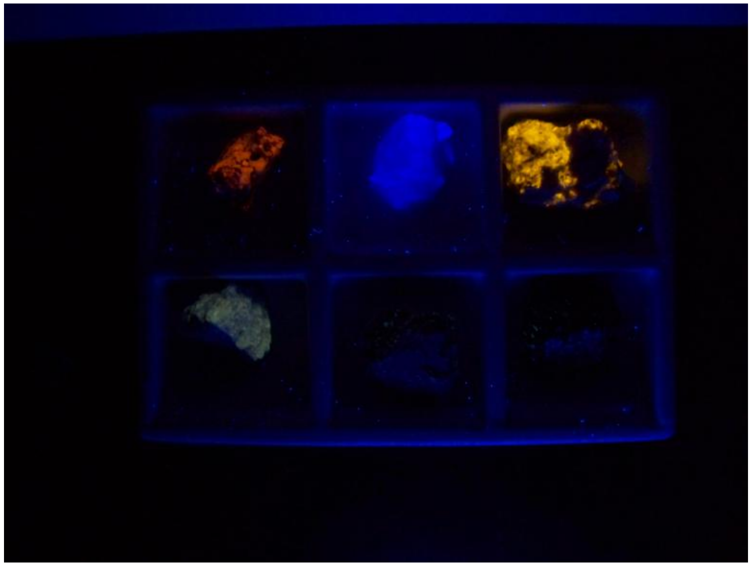
Interference often produces rainbows due to the differences in the time that it takes for different colors of light to pass through a material. Look at the crystal of bismuth to the right. Bismuth's rainbow colors are due to the varying thickness of an oxide coating. Interference causes CDs and DVDs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

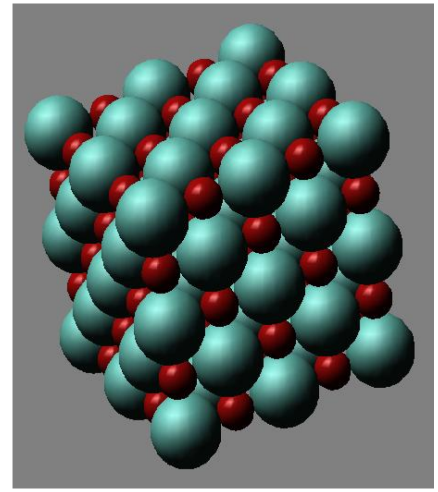
So what are some crystals that you can find around you?

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.

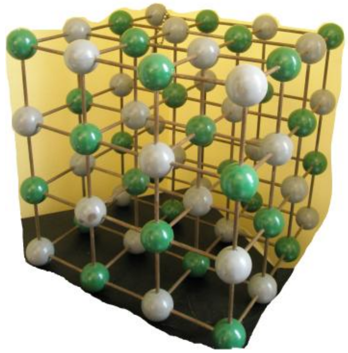
Each has their own shape. Other crystals can be formed from powders that you may have around the house. For example, the detergent booster, borax, contains sodium borate which makes crystals easily. Later in this booklet, you will find a recipes for making sodium borate, sodium chloride and Epsom salt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

ATOMS, IONS AND THE UNIT CELL



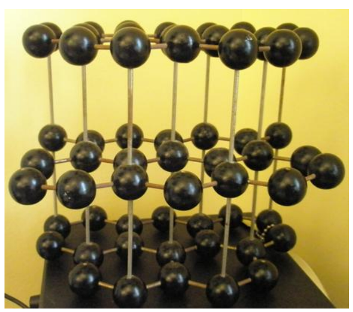
The Crystal Lattice of Sodium Chloride
(teal balls = Cl^-, red balls = Na^+)

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.



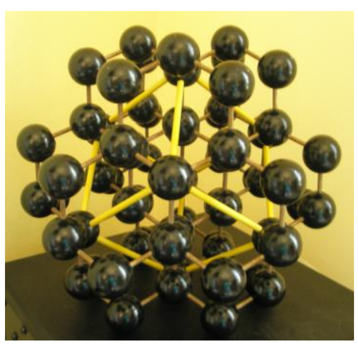
Crystal of Sodium Chloride, also called Halite and its ball and stick model.

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.



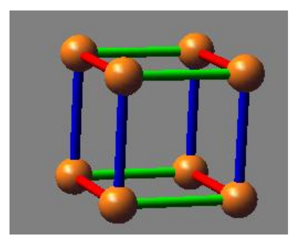
Graphite

Diamond

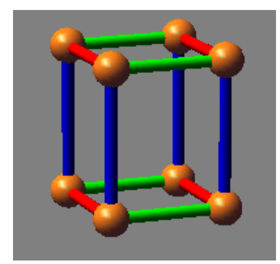


Crystal Shapes

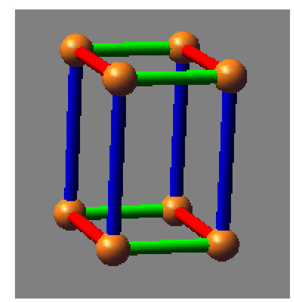
Crystals form in seven different shapes called crystal systems. The crystal systems are named cubic, tetragonal, orthorhombic, monoclinic, triclinic, hexagonal, and rhombohedral. Each crystal system has a unique shape (symmetry). For example all edges (red, green, and blue) in a cubic crystal have the 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

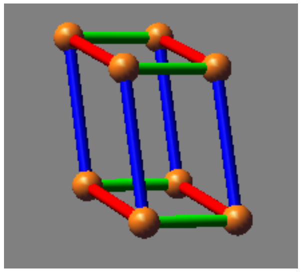


Tetragonal

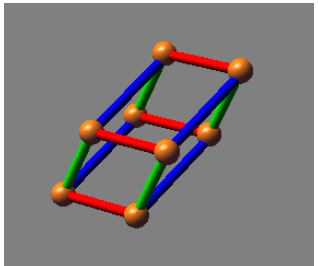


Orthorhombic

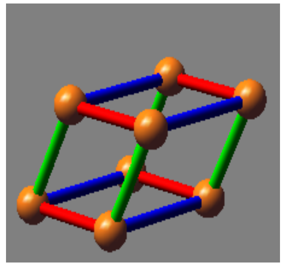
crystals cause crystals to grow or cleave in geometric shapes. The atoms in glass are not arranged in regular patterns.



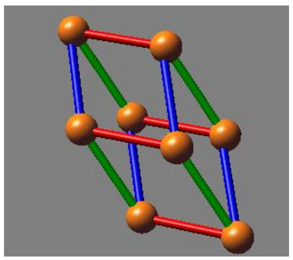
Monoclinic



Triclinic



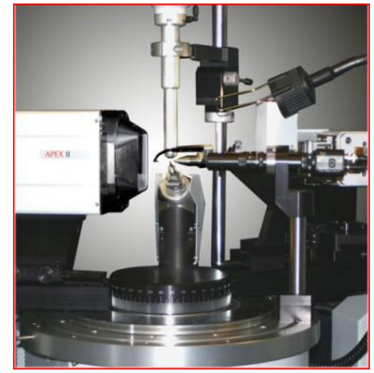
Hexagonal



Rhombohedral

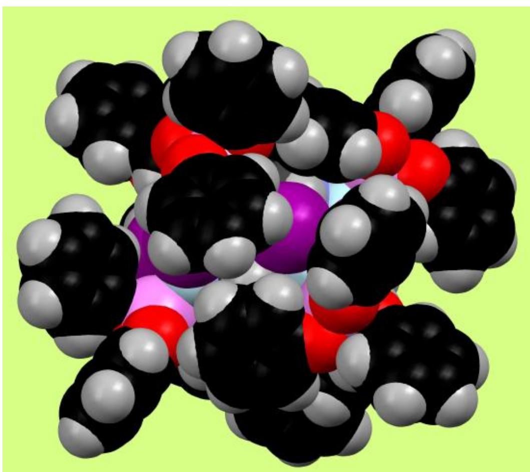
Can you guess what shape this crystal of pyrite is?

X-Ray Crystallography



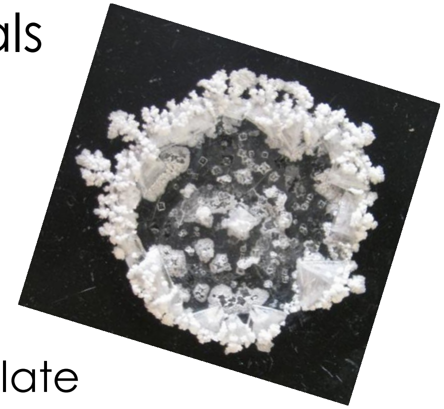
Picture of an X-ray diffractometer

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:

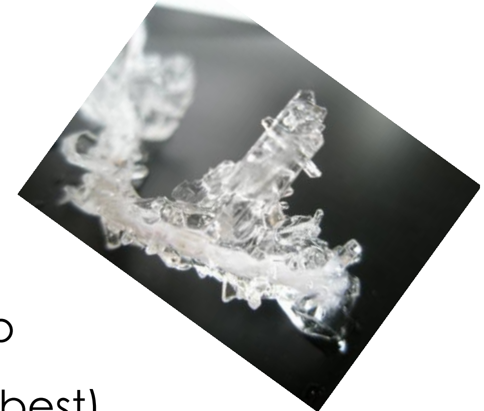
Materials:

- 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:

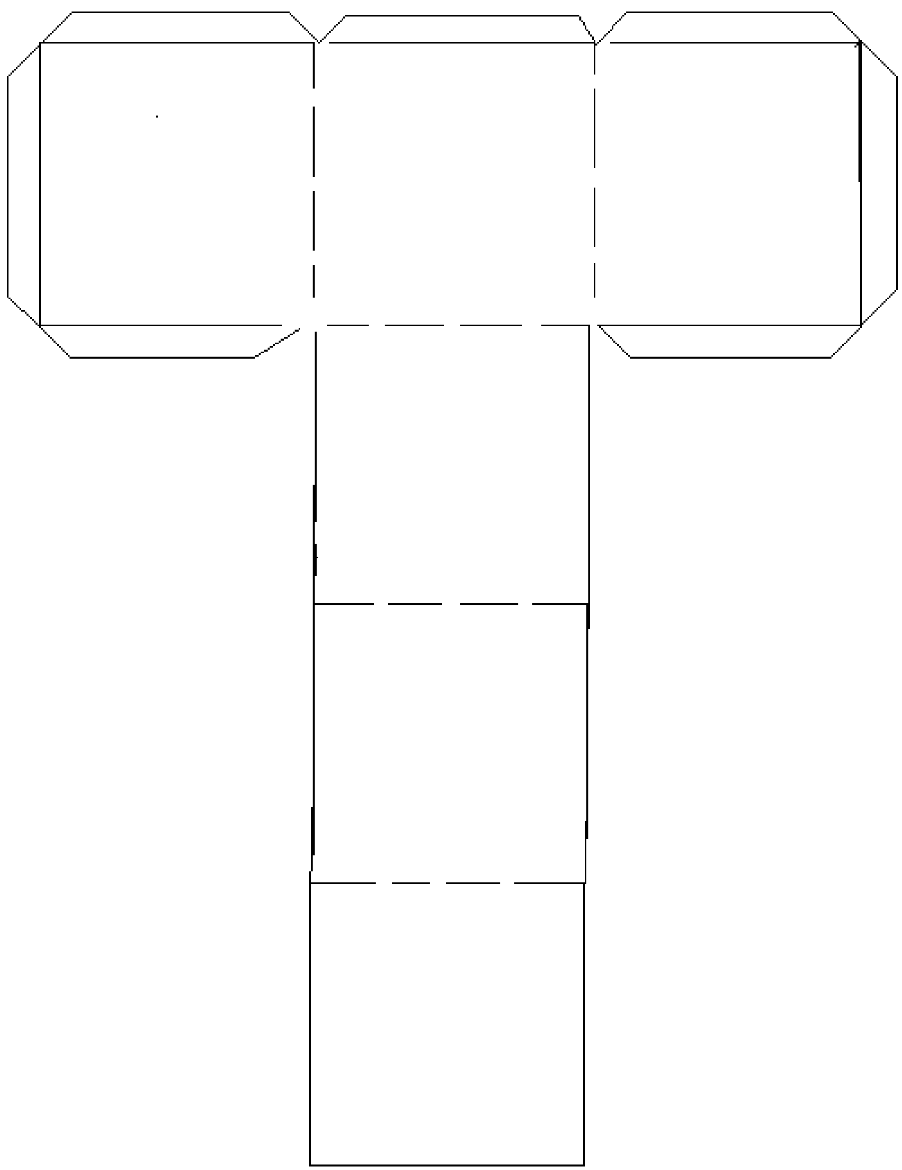
- Epsom salt
- clear glass or cup
- water (distilled is best)
- stove or microwave oven
- measuring cup
- teaspoon
- string and pencil

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.

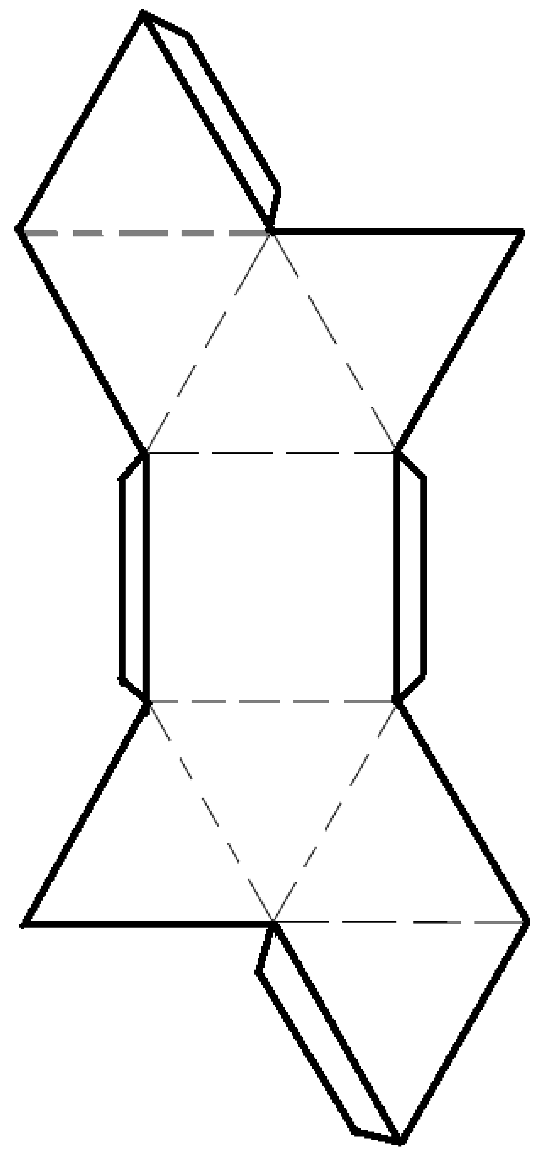
Make Your Own Models

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



Octahedron

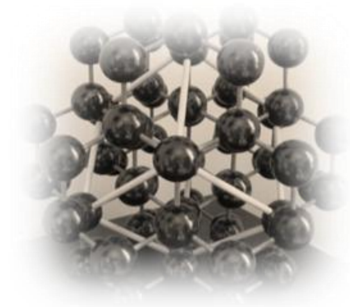
Trace the pattern onto another piece of paper, cut along the bolded lines, taking care to not cut tabs. Fold along the dashed lines and tape structure.



CCDC

Lab Procedure

Sodium Borate Crystals



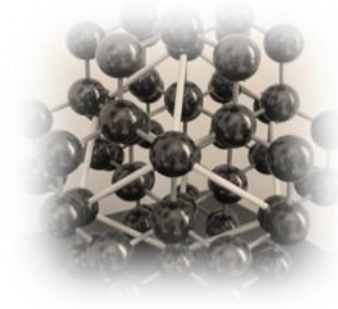
Materials:

- Plastic cup, marked for 50 mL
- Styrofoam cup
- 50 mL of deionized water
- 2 teaspoons of sodium borate
- String
- Plastic spoon
- Scissors

Procedure:

1. Label a styrofoam cup, Sodium Borate solution.
2. Place 2 teaspoons of sodium borate in the Styrofoam cup.
3. Place 50 mL of water that has been warmed into the cup as well.
4. Using a plastic spoon, stir solution until all of the sodium borate is dissolved.
5. Using scissors, cut a piece of string slightly longer than the height of the cup and tie to the plastic spoon.
6. Place the string into the mixture and rest the plastic spoon across the top of the cup.
7. Place a piece of paper over the cup and let it sit undisturbed overnight to one week.

Lab Procedure



Nickel Sulfate Crystals:

Materials:

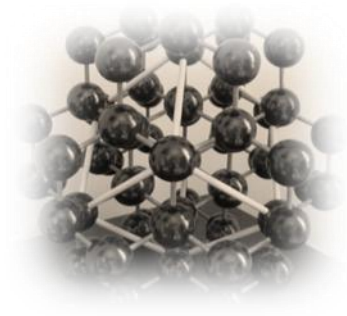
- 6 teaspoons of nickel sulfate hydrate
- Plastic cup, marked for 50 mL
- Styrofoam cup
- 50 mL of deionized water
- Plastic spoon
- String
- Scissors

Procedure:

1. Label a Styrofoam cup, "Nickel Sulfate solution.
2. Place 6 teaspoons of nickel sulfate hydrate in a Styrofoam cup.
3. Place 50 mL of deionized water, which has been warmed, into the Styrofoam cup.
4. Using scissors cut a length of string slightly longer than the height of the cup.
5. Place the string into the mixture, resting the spoon across the top of the cup.
6. Place a piece of paper over the cup and let it sit undisturbed overnight to one week.

Lab Procedure

Chrome Alum Crystals



Materials:

- Solution of alum
- Solution of potassium chromium sulfate
- Graduated cylinder
- Plastic cup, marked for 50 mL
- Styrofoam cup
- String
- Spoon
- Scissors

Procedure:

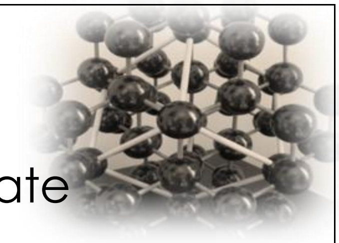
1. Label the Styrofoam cup with the percentage of potassium chromium sulfate solution to be added.
2. Based on the percentage that your group is assigned, measure out the amount of potassium chromium sulfate solution needed in a graduated cylinder.

   0% - 0 mL potassium chromium sulfate

   5% - 2.5 mL potassium chromium sulfate

   10% - 5 mL potassium chromium sulfate

Lab Procedure

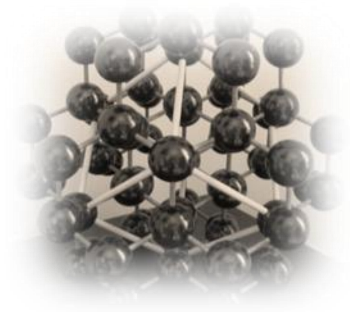


25% - 12.5 mL potassium chromium sulfate

50% - 25 mL potassium chromium sulfate

3. Pour the potassium chromium sulfate solution into the plastic cup.
4. Add potassium aluminum sulfate solution to the cup, filling to the 50 mL mark
5. Stir the solution well and pour it into the labeled Styrofoam cup.
6. Cut a piece of string slightly longer than the height of the Styrofoam cup and tie to the spoon.
7. Lay the spoon across the cup allowing the string to dangle into the solution.
8. Place a piece of paper over the cup and let it sit undisturbed overnight to one week.

Lab Procedure



Copper Sulfate Crystals

Materials:

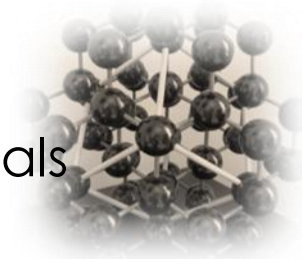
- 4 teaspoons of copper sulfate hydrate
- Plastic cup, marked for 50 mL
- 50 mL of deionized water
- Styrofoam cup
- Plastic spoon
- String
- Scissors

Procedure:

1. Label a Styrofoam cup, "Copper Sulfate solution".
2. Place 4 teaspoons of copper sulfate into a Styrofoam cup.
3. Obtain 50 mL of warmed deionized water from the lab station, using your marked plastic cup.
4. Pour the warm water into the Styrofoam cup and stir with the plastic spoon until all solid is dissolved.
5. Cut a piece of string slightly longer than the height of the Styrofoam cup and tie it to the spoon.
6. Lay the spoon across the cup allowing the string to dangle into the solution.
7. Cover and let stand overnight to one week.

Lab Procedure

Ferrous Ammonium Sulfate Crystals



Materials:

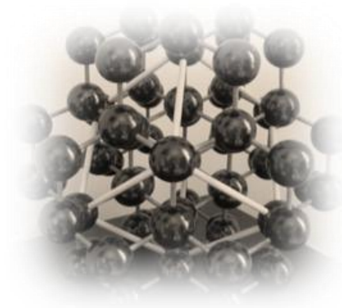
- 3 teaspoons of ferrous ammonium sulfate
- Plastic cup, marked for 50 mL
- Styrofoam cup
- Plastic spoon
- 50 mL of deionized water

Procedure:

1. Label a Styrofoam cup, "Ferrous Ammonium Sulfate solution".
2. Place three teaspoons of ferrous ammonium sulfate in the Styrofoam cup.
3. Place warmed water in the plastic cup to the mark.
4. Place the warmed water from the plastic cup into the Styrofoam cup.
5. Using the plastic spoon stir until the ferrous ammonium sulfate is dissolved.
6. Using scissors, cut a length of string slightly higher than the cup.
7. Tie the string to the plastic spoon.
8. Lay the spoon across the cup allowing the string to dangle into the solution.
9. Cover and let stand overnight to one week.

Lab Procedure

Rochelle Salt Crystals



Materials:

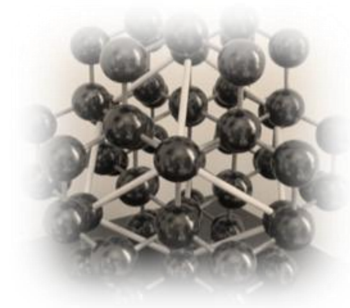
- 10 teaspoons of Rochelle Salt (potassium sodium tartrate)
- 50 mL of deionized water
- Plastic cup, marked for 50 mL
- Styrofoam cup
- Plastic spoon
- String
- Scissors

Procedure:

1. Label a Styrofoam cup, "Rochelle Salt solution".
2. Place 10 teaspoons of Rochelle Salt in a Styrofoam cup.
3. Measure out 50 mL of warmed water in the marked cup and pour into the Styrofoam cup.
4. Stir the salt until dissolved in water.
5. Using scissors, cut a length of string slightly longer than the height of the Styrofoam cup.
6. Tie one end of the string to the plastic spoon.
7. Place the other end of the string into the solution and rest the spoon on top of the cup.
8. Cover the cup with a piece of paper and let stand undisturbed overnight to one week.

Lab Procedure

Mineral Hardness Test



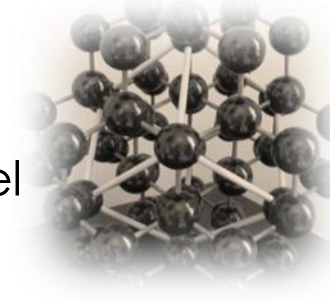
Materials:

- Nail
- Copper penny
- Mineral sample
- Finger nail
- Magnifying glass

Procedure:

1. Using the nail, attempt to scratch the mineral, by dragging the nail across the mineral. Observe the mineral using a magnifying glass if necessary.
2. If the mineral was scratched, repeat the procedure for number 1, using the copper penny instead of the nail.
3. If the mineral is scratched again, repeat with your finger nail.
4. Make a statement about the hardness of your mineral. For example, a nail has the hardness of 5, if it scratched the mineral then the mineral's hardness is less than 5, however a copper penny has a hardness of 3. If the mineral was not scratched by the copper penny, then the hardness of the mineral was 3.5 to 4.5. A finger nail has the hardness of 2.5.
5. Repeat with several other minerals.

Lab Procedure



Making a Ball and Stick Crystal Model

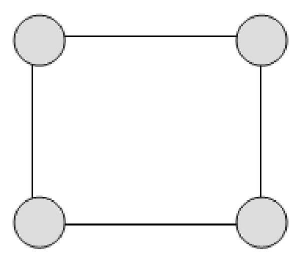
Materials:

- Toothpicks
- Bamboo skewers (cut in two equal lengths)
- Small Styrofoam balls
- Protractor

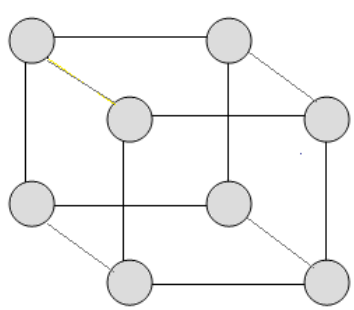
Procedure:

Cubic Crystal:

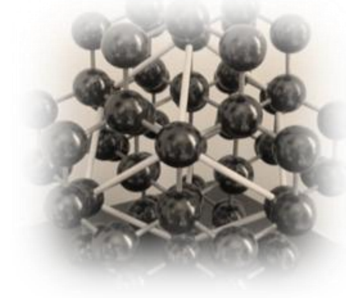
1. Obtain eight (8) small Styrofoam balls and twelve (12) toothpicks.
2. Connect four Styrofoam balls to form a square shape using four toothpicks. Use a protractor to make the angles in the square exactly 90^0. Repeat this for the other 4 Styrofoam balls.
3. Using four more toothpicks, connect your two squares to form a cube. Use a protractor to make all the angles between the squares exactly 90^0.



4. Your structure should look similar to the drawing below.

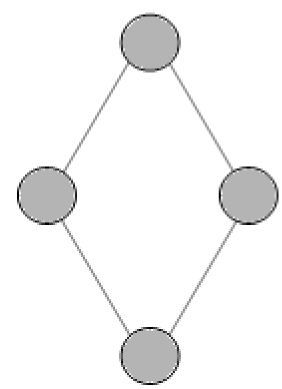


Lab Procedure

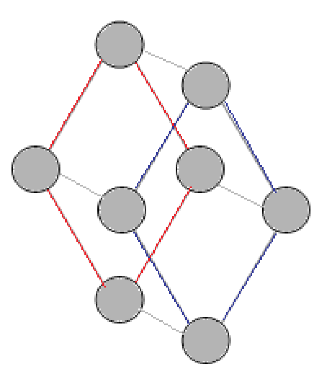


Procedure: Hexagonal Crystal

1. Obtain eight (8) small Styrofoam balls, eight (8) toothpicks, and four (4) bamboo skewers that have been cut into two equal pieces.
2. Connect four Styrofoam balls to form a parallelogram with two angles of 60^0 and two angles of 120^0. Use a protractor to make the angles in the parallelogram exactly 60^0 and 120^0. Repeat this for the other 4 Styrofoam balls.
3. Using four more toothpicks, connect your two squares as you did with the cube. Use a protractor to make all the angles between the parallelograms exactly 90^0.

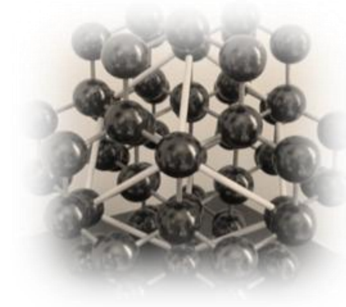


4. Your structure should look similar to the drawing below.



Lab Procedure

Examining Crystals Part One



Materials:

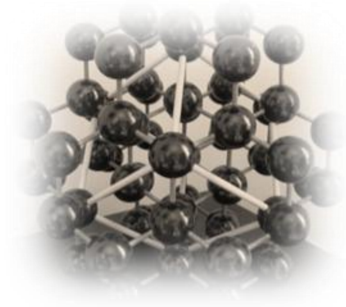
- crystal growing experiments from Day 1
- stirring rod
- waste container
- magnifying glasses
- Paper towels

Procedure:

1. Obtain crystal growing experiments from Day 1.
2. Lift the string from the cup and lay spoon, string and crystals on paper towel.
3. Take cup to the waste container and decant the liquid from the cup by pouring the liquid from the cup into a funnel attached to the waste container.
4. Examine crystals on the string as well as in the cup. Look at the crystals and make observations. Then take a magnifying glass and make observations of what you see through the magnifying glass.
5. Clean up according to your instructor's directions.

Lab Procedure

Examining Crystals Part Two



Materials:

- collection of crystals
- magnifying glass
- data sheet

Procedure:

1. Obtain materials.
2. Make observations of each of the crystals and try to determine which optical property the crystal has. Do this by:
    a. placing the crystal on a white sheet of paper.
    b. placing the crystal on the print of this paper or you data sheet.
    c. holding the crystal toward a light and looking through the crystal.
3. Make all written observations on your data sheet.