Instructional Recipe

What Makes A Stronger Crystal… Size Or Shape

Grade 9-12: Integrated Physics and Chemistry
Cross-Curricular: Fine Arts

Online research and information resources available through a partnership between the Texas State Library and Archives Commission, the Texas Education Agency and Education Service Center, Region 20
http://web.esc20.net/k12databases

Step 1 – Ask

Click here for internet links/URLs

Objectives:
The student will learn how atoms form bonds to acquire a stable arrangement of electrons by comparing the arrangement of atoms in molecules, ionic crystals, polymers, and metallic substances; the student will be able to describe the influence of intermolecular forces on the physical and chemical properties of covalent compounds.

Introduction: As a way of introducing students to the concepts of atomic arrangement in crystals and the bonds that create strength, students will study the seven crystalline forms in order to describe their structure, symmetry, and shape. Once they have learned the seven crystalline structures and their chemical properties, they will look at the crystalline properties of various minerals. A comparison of mineral crystals and snow (ice) crystals can be made as a way of seeing various crystalline formations. Have students watch the basic chemistry video on atomic bonding as a way to introduce the unit on crystal formation
"*Basic Chemistry: Atomic Bonds*." Online. Encyclopædia Britannica Online School Edition. <http://school.eb.com/eb/art-83740>.

Copper Sulfate Triclinic image, http://wikipedia.org (public domain).

Ask:

- ★ What are the seven crystal lattice systems?
- ★ Who is Auguste Bravais?
- ★ How do crystals form?
- ★ Why study the physics of snowflakes?
- ★ What is the difference between a snowflake crystal and a mineral crystal?
- ★ Why do snow crystals have six symmetrical arms?

Vocabulary:

- ★ Ionic, covalent, metallic, molecular crystals
- ★ Translational rotation symmetry
- ★ Crystal lattice theory

TEKS:
112.42(8) Integrated Physics & Chemistry Science Concepts.
(8)The student knows how atoms form bonds to acquire a stable arrangement of electrons. (C) compare the arrangement of atoms in molecules, ionic crystals, polymers, and metallic substances; and (D) describe the influence of intermolecular forces on the physical and chemical properties of covalent compounds.
Technology Application TEKS: 126.22(5), (7)
(5) **Information acquisition.** The student acquires electronic information in a variety of formats, with appropriate supervision. The student is expected to: (A) acquire information in and knowledge about electronic formats including text, audio, video, and graphics; (B) use a variety of resources, including foundation and enrichment curricula, together with various productivity tools to gather authentic data as a basis for individual and group programming projects;
(7) **Solving problems.** The student uses appropriate computer-based productivity tools to create and modify solutions to problems. The student is expected to: (B) use a variety of resources, including foundation and enrichment curricula, together with various productivity tools to gather authentic data. individual and group programming projects (A) apply problem-solving strategies such as design specifications, modular top-down design, step-wise refinement, or algorithm development;

Step 2 – Investigate

Click here for internet links/URLs

Online Subscription Resources:

★ Using **EBSCO's Student Research Center**, search for (crystal lattices and symmetry).
Bravais, Auguste. *Britannica Biographies*, 2008, p1, 0p; Reading Level (Lexile): 1100; (*AN 32404914)*
Crystals. By: Farndon, John. Science (1-59084-471-8), 2003, p23, 0p, 1 color; Reading Level (Lexile): 920; (*AN 9380953)*
Geometric Crystal Chemical Models for Structural Analysis of Micas and Their Stacking Polytypes. By: Mercier, Patrick H. J.; Evans, R. James; Rancourt, Denis G. *American Mineralogist*, Feb/Mar2005, Vol. 90 Issue 2/3, p382-398, 17p, 7 charts, 13 diagrams; DOI: 10.2138/am.2005.1608; (*AN 16337711*)
Crystal Symmetry And The Reversibility of Martensitic Transformations**.** By: Bhattacharya, Kaushik; Conti, Sergio; Zanzotto, Giovanni; Zimmer, Johannes. *Nature*, 3/4/2004, Vol. 428 Issue 6978, p55-59, 5p; DOI: 10.1038/nature02378; (*AN 12430317)*
Observations on the Strength of Twin Planes**.** By: White, John S. *Rocks & Minerals*, Sep/Oct99, Vol. 74 Issue 5, p321, 3p, 1 color, 3 bw; Reading Level (Lexile): 1290; (*AN 2260597*)

★ **Using Encyclopedia Britannica's Advanced Search**, search for the following:
"Mineral". Encyclopædia Britannica. 2008. Encyclopædia Britannica Online School Edition. 25 July 2008 <http://school.eb.com/eb/article-80357>.
"Crystal: translation-free elements." Online Art. Encyclopædia Britannica Online School Edition. 25 July 2008 <http://school.eb.com/eb/art-2407>.

Additional Websites:

★ Example of an excellent image of a copper sulfate bond with a crystalline structure http://en.wikipedia.org/wiki/Image:Copper%28II%29-sulfate-unit-cell-3D-balls.png
★ Types of crystals: http://chemistry.about.com/cs/growingcrystals/a/aa011104a.htm#
★ Periodic Table grouped by element type: http://chemistry.about.com/library/weekly/blgroups.htm
★ Read about crystalline structure here:
liquid crystal: molecular symmetry. [Art], from Encyclopædia Britannica Online School Edition: **http://school.eb.com/eb/art-2254**

Step 3 – Create

Click here for internet links/URLs

Using a table-rubric and station rotation, students will group crystals into their seven lattice categories, noting the distinct differences of each category and find mineral representations for images of each category. Have students look at the rotation axis for each crystal form.

Technology Link Table Rubric – http://mathforum.org/alejandre/workshops/chart.html

Once students have learned the concept of a rotation axis, they can draw an imaginary line through a crystalline structure around which it may be rotated and show how it repeats itself in appearance once, twice, even up to six times during a complete rotation.

- ★ Ask groups to build both a four-sided pyramid and a cube. They can do this by stapling the ends of straws together. Which seems stronger and more rigid -- the pyramid (which is more like a diamond) or the cube (which is more like graphite)?

Step 4 – Group Discussion

Click here for internet links/URLs

- ★ Once students complete the pyramid and cube, divide them into collaborative groups. Ask them to discuss the different formations and what features they observed as they built their pyramids and cubes. Ask them which design has more strength.
- ★ Using Google's free download of SketchUp, have students complete an initial design of mineral crystalline lattice, identifying the bonds and strength of the angles in each of the crystalline structures of minerals.
- ★ Using wooden straws and beads, students can build a 3-D model of their mineral's lattice formation. The model can be used as a visual display after they have created the lattice in Google's SketchUp.

Technology Link –
Google SketchUp Link (Free download) http://sketchup.google.com/

Step 5 – Reflect

Click here for internet links/URLs

Allow students to present their projects to the rest of the class using PowerPoint slides as an electronic poster-board. Have them include a Google SketchUp lattice design and discussion of the unique bonds and strength of the angles in their crystal. Their design can be recorded on PowerPoint slides. Refer to the crystal lattice table studied earlier as a prototype. Use the following suggested rubric to assess the students' work. Make sure that the students are familiar with the rubric *before* they begin creating their project. They should refer to the rubric repeatedly to monitor their progress in creating their project.

Technology Link: You can also create your own rubric with your students at http://rubistar.4teachers.org/index.php.

Extension:

Explore the difference between a mineral crystal and an ice crystal.

- ★ Read how snowflake crystals form: http://www.its.caltech.edu/~atomic/snowcrystals/class/class.htm
- ★ Snow and Ice Crystals. *Physics Today*, Yoshinori Furukawa and John S. Wettlaufer. Dec2007, Vol. 60 Issue 12, p70-71. Reading Level (Lexile): 1250. (AN27669596)
- ★ *Kenneth Libbrecht's Field Guide to Snowflakes* St Paul, Minn: MBI Pub., 2006.ISBN:9780760326459. This book describes all the different types of crystal formations in snowflakes, including annotated sketches and many photographs.
- ★ 50 & 100 Years Ago. *Nature*, 1/24/2008, Vol. 451 Issue 7177, p407-407, 1p; DOI: 10.1038/451407a; (*AN 28561669)*
- ★ Use Flickr to view the ice-etching on smooth glass. http://www.flickr.com/photos/addieplum/3548833/

Internet Links/URLs

Articles may be located by either the accession number (AN) or the persistent URL.

Step 1 – Ask

- **"*Basic Chemistry: Atomic Bonds*" Encyclopædia Britannica**
  http://school.eb.com/eb/art-83740
  http://school.eb.com/eb/art-83740/Atoms-combine-to-form-molecules-by-transferring-electrons-which-results

Step 2 – Investigate

- **Crystals**
  http://search.ebscohost.com/login.aspx?direct=true&db=ndh&AN=9380953&site=ehost-live

- **Geometric Crystal Chemical Models for Structural Analysis of Micas and Their Stacking Polytypes**
  http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=16337711&site=ehost-live

- **Crystal Symmetry And The Reversibility of Martensitic Transformations**
  http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=16337711&site=ehost-live

- **Observations on the Strength of Twin Planes**
  http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=2260597&site=ehost-live

- **"Mineral" Encyclopædia Britannica**
  http://school.eb.com/eb/article-80357

- **"Crystal: translation-free elements." Encyclopædia Britannica**
  http://school.eb.com/eb/art-2407

  http://school.eb.com/eb/art-2407/Translation-free-symmetry-elements-as-expressed-by-the-morphology-of

- **Example of an excellent image of a copper sulfate bond with a crystalline structure**
  http://en.wikipedia.org/wiki/Image:Copper%28II%29-sulfate-unit-cell-3D-balls.png

- **Types of crystals**
  http://chemistry.about.com/cs/growingcrystals/a/aa011104a.htm#

- **Periodic Table grouped by element type**
  http://chemistry.about.com/library/weekly/blgroups.htm

- ***Liquid crystal: molecular symmetry* Encyclopædia Britannica**
  http://school.eb.com/eb/art-2254
  http://school.eb.com/eb/art-2254/Arrangements-of-molecules

Step 3 – Create

- **Table Rubric**
  http://mathforum.org/alejandre/workshops/chart.html

Step 4 – Group Discussion

- **http://sketchup.google.com/**

Step 5 – Reflect

- **Rubristar**

  http://rubistar.4teachers.org/index.php.

- **Read how snowflake crystals form**
  http://www.its.caltech.edu/~atomic/snowcrystals/class/class.htm

- **Use Flickr to view the ice-etching on smooth glass**
  http://www.flickr.com/photos/addieplum/3548833/