Patterns in Crystal Structures

STEM: The Math, Science, and Art of Water Molecules Using Magnetic Models

Teacher Notes

A Guided-Inquiry Approach — Using the 3D Molecular Designs' Water Kit© Models

Grades 4-5

Learning Objectives

Students will:

- Work with 3-dimensional models.
- Practice pattern recognition.
- Make and build 3-dimensional structures by following a pattern.

Time

20-30 minutes.

Additional time is needed to explore science concepts.

Pre-Class Preparation

1. Print *Hexagonal Ice* and *Cubic Ice* instructions at 3dmoleculardesigns.com/Teacher-Resources/Water-Kit.htm

2. If you plan to integrate science and math in this lesson, you may wish to explore topics in the Water Kit© Basic Lessons at 3dmoleculardesigns.com/Teacher-Resources/Water-Kit.htm for more information on the properties of water that can be demonstrated with the Water Kit©.

3. Build a hexagonal ice structure for each group of students. These can be stored and transported on a metal cookie sheet.

Classroom Activity

1. Provide each group with 12 water molecules in the shape of hexagonal ice.

   How many hexagons are in the structure?
   [Hint: If students place a finger in each hole surrounded by a hexagon, counting will be easier.]

   There are five hexagons in the structure.

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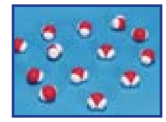


2. If you wish to integrate science and math, you can discuss any of the following topics. See Water Kit© Basic Lessons at 3dmoleculardesigns.com/Teacher-Resources/Water-Kit.htm for a discussion of these points:
   - Snowflakes always have six sides, and no two snowflakes are alike.
   - States of matter – water can be a solid, liquid or gas.
   - Ice floats.

3. Once students explore the properties of water, have them construct cubic ice. (Elementary students really enjoy building this structure following the *step method* in which they construct a dragon!)

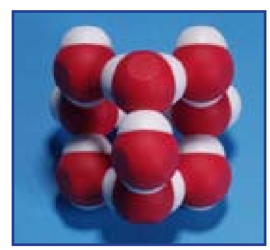
   Is this the same structure you started with?
   It is ***not*** the same structure.

   How do you know?
   There are two water molecules left over.

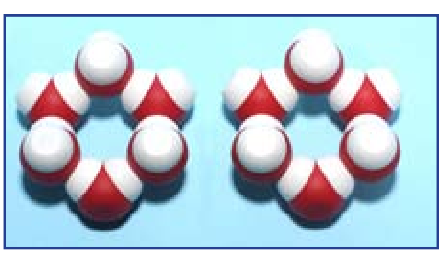
   Identify the number of hexagons in cubic ice.
   There are only four.

Discuss

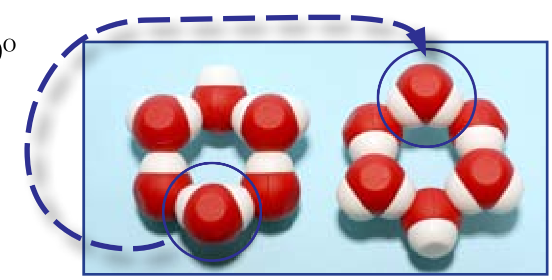
Sometimes there are multiple ways to determine that two structures are not the same.
Two ways to compare cubic and hexagonal ice are to count the water molecules in each structure and to count the number of hexagons in each.



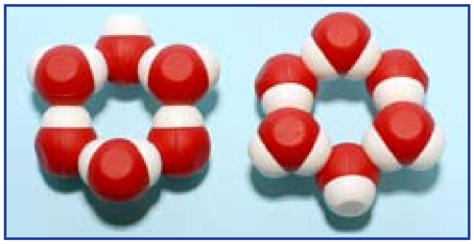
4. Tell students to place their cubic ice on the table so that six water molecules are touching the table. The remaining four water molecules are on the top. Tell them to:
   - Carefully remove the top four water molecules.
   - Build a second hexagon, using the first hexagon of water molecules on the table as your pattern. Once the second hexagon is completed, verify that the two are the same, then place them on the table. Keeping them flat on the table, rotate one hexagon 180°.



180°

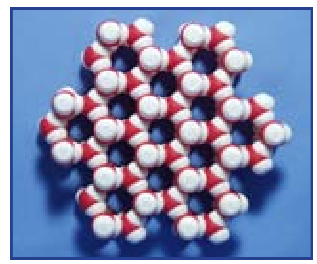


- Place one of the hexagons (without further rotation) directly on top of the other hexagon.



5. Have students place their hexagonal ice back on the cookie sheet or white board, to form a snowflake (instructions at 3dmoleculardesigns.com/Teacher-Resources/Water-Kit.htm). Note that if students have not built their ice to exactly follow the pattern, or they have over- or under-rotated the hexagon before stacking it on their pattern, the snowflake will not build correctly.

   This is a great way to:
   - Check the construction of the hexagonal ice.
   - Store the materials for the next class.
   - Reinforce the concept that snowflakes are hexagonal.



Extensions

(Beyond the 30 minute time frame.)

Compare Crystals

Have students compare the model of a sodium chloride crystal with the model of a hexagonal water crystal (ice) and write their observations. How are they similar? How are they different?

Potential Observations

Similarity
- Both the sodium chloride crystal and water crystal consist of repeating patterns.

Differences
- The sodium chloride crystal is a cube.
- The water crystal is a hexagon.
- All of the faces of the sodium chloride crystal are square, but each crystal can have different numbers of ions: 4 (2x2x2), 9 (3x3x3), 16 (4x4x4), 25 (5x5x5) and so forth.
- Water crystals can also be small or large, but are hexagonal in shape.
- The sodium chloride crystal is closely packed, while the water crystal has empty space (not air) in the middle.

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Extension — Art

- Have students draw or cut out snowflakes.
- Discuss how crystals are beautiful structures. View various crystal structures online or print copies: *theguardian.com/science/gallery/2009/jan/07/1*

Cross-Cutting Concepts that May Apply to Your Lessons*

Patterns. Observed patterns of forms and events guide organization and classifications, and they prompt questions about relationships and the factors that influence them.

Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Scale, proportion, and quantity. In considering phenomena it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and system models. Defining the system under study — specifying its boundaries and making explicit a model of that system — provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Stability and change. For natural and built system alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

For more information about the MSOE Center of BioMolecular Modeling visit our website at: http://cbm.msoe.edu. The MSOE Library, MSOE Center for BioMolecular Modeling and 3D Molecular Designs collaborate to make the MSOE Lending Library available.

*National Research Council. (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* http://www.nap.edu/catalog.php?record_id=13165