NaCl Lattice© Science Activities

STEM: The Science of Salt Using a Salt Lattice Model

Teacher Notes — Science Activities

A Guided-Inquiry Approach — Using the 3D Molecular Designs' NaCl Lattice Model

Classroom Activity

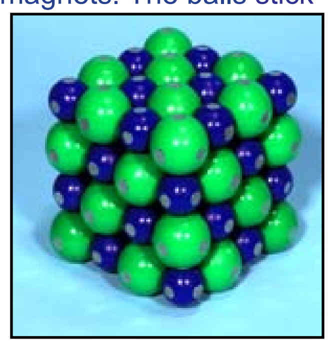
Set up

Provide each group with a 4x4x4, 3x3x3 or 2x2x2 NaCl Lattice. Set aside Water Kits, salt, beaker(s) or glass(es) and stir sticks for later use. Optional: set aside a large clear bowl.

Exploring Sodium Chloride Ions

1. Direct each student to take one ball of each color, examine each and write down their observations.

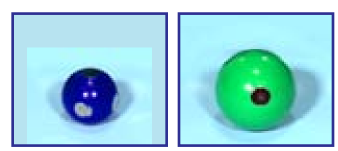
   Possible observations: One ball is blue. One is green. Both have magnets. The balls stick together.



Ask your students to guess what the green and blue balls could represent.

Ions. The blue ball represents a ***sodium ion***. The green ball represents a ***chloride ion***.

You may want students to find sodium and chloride (as chlorine) on a Periodic Table.



Note that ***atoms*** have an equal number of electrons and protons and are neutral, while ***ions*** have an unequal number of electrons and protons, which results in them having either a negative or positive charge.

- A ***chloride ion*** has one more electron than protons which gives it a negative charge. It is written ***Cl-***.
- A ***sodium ion*** has one less electron than protons which gives it a positive charge. It is written ***Na+***.

Ask your students to predict what would happen if they put one blue sodium ion together with one green chloride ion.

Ions are not stable by themselves. In this unstable state, a ***driving force*** causes the sodium ion and chloride ion to undergo a chemical reaction in which the sodium ion gives up an electron to the chloride ion. This driving force is called an ***ionic bond***.

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Ask your students if they can feel the bonding between the green chloride ion and blue sodium ion?

Ask your students what they have formed by putting a green chloride ion together with a blue sodium ion?

Sodium chloride, NaCl

Does sodium chloride have a negative or positive charge?

No, together the sodium and chloride have an equal number of electrons and protons, and they are neutral. Together they have become stable. $Na^+ + Cl^- = NaCl$

2. Sodium chloride is a common substance. Can your students guess what its common name is?

   Salt, table salt, rock salt, halite

   Can they think of other places sodium chloride might also be present?

   Sodium chloride is the substance that causes the oceans to be salty. It is also present in our bodies, including our tears.

3. Have your students examine the sodium chloride ions again. How many magnets are in each model? (Hint: if your students have trouble, they could attach other ions from the cube and then count the balls as they remove the ions from each magnet.)

   6

   Ask your students what they think the magnets represent.

   The magnets represent the negative and positive charges of sodium and chloride; however, ***positive and negative charges are not magnetic***. The magnets are ***useful*** in a model to gain a sense of the ***force*** that causes two ions to come together.

   Ask them if the magnets of two green chloride ions will bond together.

   No

   Will the magnets of two blue sodium bond together?*

   No

   Why not?

   A positive charge will only bond to a negative charge.

   What is the maximum number of blue, sodium ions they can fit around one green chloride ion?

   6

   What is the maximum number of green, chloride ions they can fit around one blue sodium ion?

   6

*Please note that your students should do these activities by putting the magnets as directly together as possible. Due to the six magnets on the sodium and chloride models, your students may find sodium or chloride clinging together between the magnets. This is due to the weakening magnetic field surrounding each magnet.

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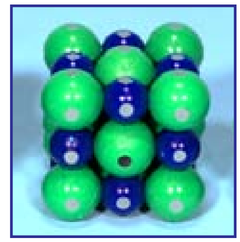
Exploring the Sodium Chloride Lattice

4. Have your students assemble a 3x3x3 or 4x4x4 sodium chloride lattice (crystal), one ion at a time.

   Review how many chloride ions surround each sodium ion on the inside of the lattice, 6 and how many sodium surround each chloride on the inside of the lattice. 6

   Ask your students if they can see inside the lattice to confirm that each is surrounded by six of the opposite ions. No.

   Then how do they know there are six opposite ions around each ion.
   They observed the pattern as they assembled the lattice, or they know from the previous activity (#6.)

   Next, have them look at the sodium and chloride ions on the outer surface of the lattice. Ask them how many sodium or chloride each ion could connect with if more sodium and chloride were available.
   The corner ions could connect with 3 more ions, totaling 6. The ones on the top, bottom and side edges could each connect with 2 more ions, totaling 6. The ions between the top, bottom and sides could each connect with 1 more ion, totaling 6.

Sodium Chloride Lattices (Crystals) Are Strong

5. Ask your students if they can think of a reason that sodium chloride assemble or pack together in this way.
   Sodium chloride becomes more stable as it achieves a maximum number of connections. This 6:6 coordination between the sodium ions and chloride ions is called ***close packing***.

   Ask your students if the sodium chloride lattice (crystal) is strong. Why or why not?
   Ionic bonds are very strong and hard to break. Close packing also makes the lattice strong.

Sodium Chloride Lattices (Crystals) Are Brittle

6. A sodium chloride lattice is strong, yet ***brittle***. You can show students how sodium chloride lattices cleave off in planes. With either a 3x3x3 or 4x4x4 lattice grip one or two rows on either side and twist in opposite directions. Two sections should slide apart. Sometimes, however, if the applied force isn't quite right and the pieces will crumble rather than cleave. With a little practice you should be able to get it to work.

   Brittleness is a characteristic of ionic substances. If pressure or stress is applied and a layer shifts slightly, ions with the same charge come together, repulsing each other and forcing the layers further apart.

   Your students may also want to try this.

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Additional Exploration of Sodium Chloride Crystals

7. If you have a piece(s) of rock salt, pass it (them) around.

   Ask your students to compare the model of sodium chloride to the piece of rock salt and write down the similarities and differences between the rock salt and the model of sodium chloride.

   Similarities

   Both are cubes; students may see some planes on the rock salt where part of the crystal sheared off.

   Differences

   The rock salt is not green and blue; it doesn't have magnets holding its ions together; students can't see individual ions in the rock salt

Optional activities

8. Look at salt under a microscope; go online to look at images of sodium chloride.

   http://www.google.com/search?q=images+of+sodium+chloride&rlz=1T4ADRA_enUS435US437&tbm=isch&tbo=u&source=univ&sa=X&ei=3cOPUY7hLIqryQGBsoHQBw&ved=0CC8QsAQ&biw=1065&bih=590

   http://en.wikipedia.org/wiki/Sodium_chloride

   http://en.wikipedia.org/wiki/Halite

   http://www.google.com/search?q=rock+salt&rlz=1T4ADRA_enUS435US437&tbm=isch&tbo=u&source=univ&sa=X&ei=f8aPUZC1L-GkyQHmsYDQDA&ved=0CEgQsAQ&biw=1065&bih=594

   http://images.google.com/search?um=1&tab=wi&hl=en&q=%22salt+crystals%22&biw=1065&bih=590&sei=X9WPUZLpMeSGyQGssYCYDw&tbm=isch

Sodium Chloride Dissolves in Water

9. Setting the sodium chloride models aside for a few minutes, dissolve salt in a beaker or glass of water, or distribute beakers of water, salt and stir sticks to the students. Have each small group dissolve salt in water.

   Ask your students to write down their observations of the salt dissolving in water.

   At first they could see the salt in water, but as they stirred the salt was no longer visible; the water tastes salty; other observations.

   Ask them to write down what was happening to the sodium and chloride ions when the salt was added to water. Review their ideas.

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10. Your students should set aside the dissolved salt in the beakers, and distribute one Water Kit to each group.

    Tell them to remove the models of the water molecules from the cups and briefly review:

    The structure of the water molecules (H_2O); (Oxygen is represented by the single red unit; hydrogen is represented by the two white units.)

    Hydrogen bonds form between the oxygen in one water molecule and the hydrogen in a second water molecule. The oxygen on two different molecules will not form a bond and two hydrogen on two different water molecules will not form a bond. They repel each other.

    

    Oxygen (red) has a negative charge and hydrogen (white) has a positive charge.

    Ask your students to predict whether or not the water molecules will bond to the sodium or the chloride.
    Yes, they will.

    Ask them to predict which atom in the water molecule (oxygen or hydrogen) will bond with the sodium ion. Which will bond with the chloride ion? They should explain the basis for their answers.
    Sodium and oxygen bond together because sodium has a positive charge and oxygen has a negative charge. Chloride and hydrogen will bond together because chloride has a negative charge and hydrogen has a positive charge.

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    Your students can test their predictions by removing sodium and chloride models from the lattice and putting various combinations together. They should write down their observations.
    Sodium and oxygen will bond. Chloride and hydrogen will bond. Sodium and hydrogen will repel each other. Chloride and oxygen will repel each other.

11. Tell your students to reassemble their 3x3x3 or 4x4x4 model lattices and to use the water molecule models to demonstrate how water can dissolve sodium chloride.
    The oxygen in some water molecules could be bonded to sodium and the hydrogen in other water molecules could be bonded to chloride.

    Ask you students if they think one water molecule is strong enough to pull one ion away from the lattice? No.

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Are 12 water molecules enough?
No. It takes a much larger mass of water to pull one ion away from the lattice.

Ask your students if they could push a water molecule between a sodium and chloride in the middle of the lattice to get it inside the lattice to dissolve the lattice from the inside?
No. Water molecules have to dissolve salt from the outer edges. Close packing and ionic bonds prevent water molecules getting inside the lattice.)

Optional activity

12. Use a clear bowl and pour in all of the water molecules from the six cups. Next, add the sodium chloride from the six cups and mix them together with your hands until all of the water molecules are dissolved.

Additional Related Topics for Discussion

Compare Crystals

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

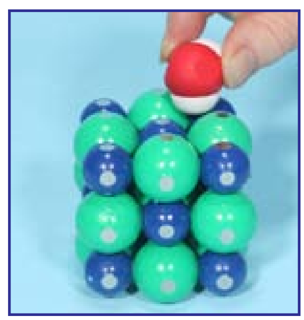
Potential Observations

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 can have different number of ions: 4 (2 x 2 x 2), 9 (3 x 3 x 3), 16 (4 x 4 x 4), 25 (5 x 5 x 5) and so forth.
- All of the faces of a water crystal have six water molecules.
- The sodium chloride crystal is closely packed, while water crystal has empty space (not air) in the middle.



14. Why does salt dissolve faster in water when you stir it?
You add energy.

15. What are the limitations and advantages of using models?
Potential answers

- No model can exactly replicate the real life phenomena.
- Models can inadvertently cause students to develop some misconceptions.
- Models can be useful to help us understand phenomena that we can't see or feel.

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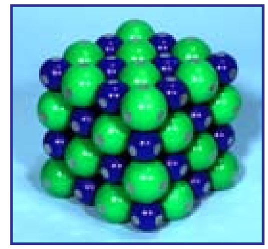
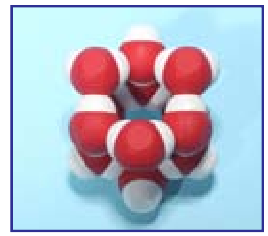
Ask your students if the models are useful to them? How were they helpful? How were they not helpful?



Ask your students what misconceptions they might have developed after working with the sodium chloride atoms.
Potential answers

- A sodium ion is not a hard blue ball with magnets.
- A chloride ion is not a hard green ball with magnets.
- Water molecules are not hard.
- An oxygen atom is not red.
- A hydrogen atom is not white.
- The positive and negative charges on sodium, chloride oxygen and hydrogen are not magnetic. The magnets help us understand bonding forces between sodium and chloride ions, and between water molecules and sodium and chloride ions.
- The models are much, much larger than real sodium, chloride and water molecules.
- The models are not edible or drinkable!
- Other observations?



Cross-Cutting Concepts*

Additional Cross-Cutting Concepts may apply, please see page 5.

Patterns. Observed patterns of forms and events guide organization and classification, 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.

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.

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

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

*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