

## The Structure of Water—Introductory Lesson

**Abstract:** This is an introduction to the chemical nature of water and its interactions. In particular, this lesson will explore evaporation, molecular movement, and salt as a solute in water. Students will play a “Jeopardy” game focused on these subjects—evaporation, water, salt, and temperature. Answers will be ranked with more amounts of money awarded according to difficulty of subject. As the teacher, you will give more background and have discussions on those answers the students have difficulty with. Through this game students will receive a review on the chemistry of water, plus gain an even more knowledgeable expansion of these main subjects.

**Grade Level:** 7<sup>th</sup> grade

### **Utah Educational Core Curriculum Standards:**

**Standard 1:** Students will evaluate the particulate nature of matter.

**Objective 2:** Demonstrate the role of motion in the particulate description of matter.

- ✓ Compare motion of particles in a liquid and gas.
- ✓ Generalize the effect of heat on the motion of particles.

**Standard 5:** Students will create, use, and understand the applications of classification schemes.

**Objective 1:** Classify matter based upon observable properties of water related to changes in states of matter.

- ✓ Formulate hypotheses about physical properties of water related to changes in states of matter.

### **AAAS 2061 Benchmarks:**

- All matter is made up of atoms, which are far too small to see directly through a microscope. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.
- Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.

### **NRC-National Science Standards:**

#### ▪ **Properties and Changes of Properties in Matter:**

- A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.
- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical

reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways.

▪ **Transfer of Energy:**

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
- In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.

**In-Class Instructional Time:** 1 class period

**Terminology:**

**Atom**—particles in constant motion, that make up matter (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963).

**Ion**—positive and negative charges atoms give off (*Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965)

**Polarity**—water molecule has both positive and negative charged ends (*Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998,

<http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html>).

**Molecule**—a combination of 2 or more atoms (*Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965).

**Compound**—a substance which consists of 2 or more chemical elements (*Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965).

**Evaporation**—the conversion of water from a liquid into a gas ([http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/evap.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/evap.rxml)).

**Temperature**—the sense of being cold or hot (*Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965).

**Solid**—not a liquid or gas.

**Liquid**—a substance that flows in its natural state (*Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965).

**Gas**—when molecules are separated from one another and so have free paths (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963).

**Intended Learning Outcomes:**

- Students will describe the atoms that make up water and salt molecules.
- Students will explain how water molecules act in states of liquid and gas.
- Students will be able to explain the process of evaporation.

**Background Information:**

Atoms make up molecules and in fact, water is a molecule made up of 1 oxygen atom and 2 hydrogen atoms (H O). Water is unique, because of its charges, making it a polar molecule—the oxygen having a negative charge, and the 2 hydrogen having a positive charge, creating weak bonds between the hydrogen and oxygen (*Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998, <http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html>). Water can be found in a state of solid, liquid or gas, depending on the movement of molecules, which is

relative to the temperature (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963).

For example, when water is in its solid form (ice) there is a decrease in movement of the water molecules, because of the low temperature, which causes the molecules to pack more closely together. As the temperature increases the molecules increase in movement, forming a liquid. But when the increase in temperature remains continuous and constant, the molecules move so fast that they pull apart from each other causing water to turn into gas (steam) (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963). This process is called evaporation ([http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/evap.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/evap.rxml)).

In evaporation there is a connection with the water molecules on the surface and the molecules in the air (water vapor). For example, the water molecules on the surface (which are moving) get knocked off the surface into the air by the rapid moving molecules in the air (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963).

Water is a very useful solvent, which means it can dissolve many compounds. An example of a compound that dissolves in water is table salt, or sodium chloride, which is composed of sodium (Na) and chlorine (Cl) (*Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998). The sodium atom has a positive charge, while the chlorine atom has a negative one. When sodium chloride combines with water, ionic bonds form, while the positive ends of the water molecule (hydrogen) attract the chlorine ions. This causes the sodium and chloride ions to dissociate in water (*Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998, <http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html>).

**Materials:** Jeopardy questions, title subject cards, number cards and answers to Jeopardy questions. Plus paper, and drawing and coloring materials are needed.

**Prior Knowledge Assessment:**

- Who knows what water is? Its chemical make-up?
- Does anybody know anything about salt and its make-up?
- Has anyone ever boiled water? What did you notice?
- How does the process of evaporation occur?
- What is Jeopardy?

**Procedures:**

Introduction:

With students at their desks or tables ask them questions to assess their prior knowledge. If students are weak in one area make sure to discuss and explain that specific area a little bit before the game, and then go over it after the game. Then explain to students that they are going to play a game of Jeopardy to learn more and see how knowledgeable they are about water, sodium and evaporation.

Body: Game of Jeopardy

- First divide your students into 3 groups. If you want, give each group a name to distinguish them from one another. Plus you can write these group names on the board and keep a tally of each group's score. Examples are liquefiers (for water), stingers (for table salt), and vanishers (for evaporation).

- To decide who gets to start the game and choose the first question, you (the teacher) pick a number between 1 and 10 and write it down on a piece of paper. Then have each group say a number (between 1 and 10), and whichever group guessed the closest to the number you picked, starts the game.
- Now, play the game of Jeopardy and let the answers and questions (attached) direct how you decide to teach certain points brought up. For example, if students have a difficult time with one question—take time to explain the question, so your students understand. You may use drawings to help you explain—in fact, many students will understand better with pictures.
- Plus, throughout the game, assess your students' understanding by questioning them.
- When the game is finished, and if you want, see if your students can make up any more questions about evaporation, water, salt, and temperature.

### **Closure/Assessment:**

Give all students some saltwater taffy for contributing to the game. And the group with the most points give 2 taffies, instead of 1. Finally, ask students questions (to review) regarding salt and water combined.

- What makes up water? Salt?—have students draw a picture of each one on the same piece of paper.
- What would happen if salt and water were combined?—have students draw a picture representing their answer.
- Ask students to draw pictures of water in its 3 different states (solid, liquid and gas) and the transitions it makes to change states.

### **References:**

- *Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998
- <http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html>
- [http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/evap.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/evap.rxml)
- *Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965.
- *The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963

## Jeopardy Answers and Questions

Questions Answers	<u>States Of Matter</u>	<u>Chemistry</u>	<u>Molecular Movement</u>
<b>100</b>	<p>Not a liquid or gas.</p> <p>What is a solid?</p>	<p>2 hydrogen atoms and 1 oxygen atom.</p> <p>What is the make-up of water?</p>	<p>When an increase in temperature remains continuous and constant and water molecules get pulled apart from each other and turn into gas.</p> <p>What is evaporation?</p>
<b>200</b>	<p>Water feely flowing.</p> <p>What is an example of a liquid?</p>	<p>NaCl</p> <p>What is sodium chloride or table salt?</p>	<p>Molecular movement in a gaseous state.</p> <p>What state are molecules flying around at a rapid pace?</p>
<b>300</b>	<p>Can be found as a solid, liquid, or gas.</p> <p>What are the states of water?</p>	<p>2 or more atoms combined.</p> <p>What is a molecule?</p>	<p>Oxygen, water and nitrogen.</p> <p>What is water vapor?</p>
<b>400</b>	<p>Water molecules tightly packed together</p> <p>What is ice?</p>	<p>Having both a positive and negative charge.</p> <p>What is polarity?</p>	<p>Little movement in molecules, because they are tightly packed, forming a crystalline shape.</p> <p>What happens to molecules when there is a decrease in temperature?</p>
<b>500</b>	<p>Rising vapors from boiling water.</p> <p>What is steam?</p>	<p>The negative ends of the water molecule attract the sodium ions, while the positive ends of the water molecule attract the chlorine ions.</p> <p>What is the chemical reaction between salt and water?</p>	<p>Molecules moving at a steady and comfortable pace.</p> <p>What is the molecular movement in a liquid?</p>

## Does Sodium Chloride Interfere with Evaporation?—Experimental Lesson

**Abstract:** This is an experimental lesson dealing with evaporation of water in the presence and absence of salt (sodium chloride). As the teacher you will present the students with the question “Do you think salt interferes with evaporation? Your students will then be able to use their knowledge about water, salt, and evaporation to make a hypothesis and set up an experiment to test this question. Students will be responsible for checking their experiments, gathering data and drawing conclusions from their experiment. In addition, to enhance this lesson taking a field trip out to Great Salt Lake would be great, because the amount of salinity that will be used in this lesson relates to certain salinities in Great Salt Lake.

**Grade Level:** 7<sup>th</sup> grade

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**Objective 2:** Demonstrate the role of motion in the particulate description of matter.

- ✓ Compare motion of particles in a liquid and gas.
- ✓ Generalize the effect of heat on the motion of particles.

**Standard 5:** Students will create, use, and understand the applications of classification schemes.

**Objective 1:** Classify matter based upon observable properties of water related to changes in states of matter.

- ✓ Formulate hypotheses about physical properties of water related to changes in states of matter.
- ✓ Conduct experiments to test hypotheses.

### **AAAS 2061 Benchmarks:**

- No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same.
- Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.

### **NRC-National Science Standards:**

#### ▪ **Properties and Changes of Properties in Matter:**

- A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.

- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways.
- **Transfer of Energy:**
  - Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
  - In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.

**In-Class Instructional Time:** 1 class period to set up experiment and then over an extended period of time.

**Terminology:**

**Evaporation**—the conversion of water from a liquid into a gas ([http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/evap.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/evap.rxml)).

**Temperature**—the sense of being cold or hot (*Dorland's Illustrated Medical Dictionary, 24<sup>th</sup> Edition*—W.B. Saunders Company, Philadelphia and London, 1965).

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**Gas**—when molecules are separated from one another and so have free paths (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963).

**Beaker**—a tool of measuring liquid.

**Balance**—measuring in grams.

**Salinity**—the percentage of salt water

([http://www.hcn.org/servlets/hcn.Article?article\\_id=11170](http://www.hcn.org/servlets/hcn.Article?article_id=11170)).

**Intended Learning Outcomes:**

- Students will use prior knowledge to set up an experiment based on the process of evaporation.
- Students will create a hypothesis, gather data and draw conclusions that address the hypothesis.
- Students will be able to explain and understand that sodium chloride does not get evaporated with water and that it remains constant even when dissolved.

**Background Information:**

Great Salt Lake is the largest saltwater lake in the Western Hemisphere. The lake is found near Salt Lake City, Utah and is a remnant of the original Lake Bonneville that once covered the entire Salt Lake Valley. Over many years the lake evaporated, leaving a body of water with a high salt content ([http://www.hcn.org/servlets/hcn.Article?article\\_id=11170](http://www.hcn.org/servlets/hcn.Article?article_id=11170)). Today the salinity of Great Salt Lake ranges between 5 to 25 percent salinity, while the south salinity levels are approximately around 10 percent (*High Country News*—article on Great Salt Lake). In fact, USGS satellite images of Great Salt Lake depict the varying levels of salinity, showing different colors in different regions based on varying densities.

When molecules are cold they get closer together and when they are warm they spread apart. This is how the different states solid, liquid and gas are created—by the movement of the molecules. For example, when water is in its solid form (ice) there is a decrease in movement of the water molecules because of the lower temperature. As a result, the molecules are packed more closely together. As the temperature rises, the molecules increase in movement, forming a liquid. But when the increase in temperature remains continuous and constant, the molecules move so fast that they pull apart from each other causing water to turn into gas (steam) (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963). This process is called evaporation ([http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/evap.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/evap.rxml)).

In evaporation there is a connection with the water molecules on the surface and the molecules in the air (water vapor). For example, the water molecules on the surface (which are moving) get knocked off the surface into the air by the rapid moving molecules in the air (*The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963).

Water is a very useful solvent, which means it can dissolve many compounds. An example of a compound that dissolves in water is table salt, or sodium chloride, which is composed of sodium (Na) and chlorine (Cl) (*Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998). The sodium atom has a positive charge, while the chlorine atom has a negative one. When sodium chloride combines with water, ionic bonds form, while the positive ends of the water molecule (hydrogen) attract the chlorine ions. This causes the sodium and chloride ions to dissociate in water (*Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998, <http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html>).

**Materials:** table salt (lots of it), distilled water, 9 beakers or 9 clear measuring cups, digital balance (measuring grams) or kitchen scale (measuring ounces) along with measuring teaspoons, metal spatula or Popsicle sticks, and 3 heat lamps.

This experiment is written with gram measurements. If using a kitchen scale, use these measurements to get accurate 10% and 20% salinity solutions:

- 250ml  $\cong$  1 cup
- 1½ t. salt  $\cong$  10 grams
- 14 t. salt (100 grams) in 1 cup (250ml) makes a 10% salinity solution.
- 28 t. salt (200 grams) in 1 cup (250ml) makes a 20% salinity solution.

**Prior Knowledge Assessment:**

- Has anyone been to Great Salt Lake? What makes Great Salt Lake unique? Is there the same amount of salt throughout the lake? Is it saltier or less salty than the ocean? (ocean is ~5% salt)
- How did Great Salt Lake come about?
- What is evaporation? How does it work?

**Procedures:**

Introduction:

With students at their desks or tables quickly review with them the structure of water lesson by asking questions and by looking at some students' drawings. Then ask students the prior knowledge assessment questions about Great Salt Lake and evaporation. If your students' knowledge is pretty high, then continue on with the lesson. But if your students' knowledge is

kind of low, ask them what they do not understand. Then explain the concepts they do not understand in better terms so they will--before continuing on with the lesson.

Body:

- Once the Great Salt Lake discussion is over introduce the question, “Does sodium chloride interfere with evaporation?” Listen to students’ answers and see what comes about?
- Then ask your students, “Who remembers what happens when sodium chloride and water combine? Again, listen to your students’ answers.
- Once again, present the question, “Does sodium chloride interfere with evaporation?” Then tell students that they are going to set up an experiment to test this question and find answers. See if any students have any good ideas about how to set up the experiment—if they are reasonable go along with it, but if not guide them in this direction:
  1. Have students begin recording in their lab notebooks. They should record their hypothesis. As they are setting up the experiment, they should be recording materials, and procedures down into their lab notebooks as well.
  2. Divide class into groups of 3—one group to set up each experiment—there will be 3 different experiments (using beakers: 1 distilled water, 10% salinity solution, and 20% salinity solution).
  3. Have one student in each group gather 3 beakers for their group—1 for a distilled solution, 1 for a 10% salinity solution, and 1 for a 20% salinity solution. You should have provided 9 beakers.
  4. Tell each group to label their 3 beakers with the number corresponding to which group they are in.
  5. Have each group fill one beaker up to 250ml with distilled water. Then have them begin to measure out how much salt they are going to use for their 10 and 20 percent salinity solutions. While they are doing this have each group of students record the set up of the experiment in their lab notebooks.
  6. Incorporate a math lesson and see if your students can determine how much salt would be needed. For the 10% salinity solution have students measure out 25 grams of salt and to put that 25 grams of salt in a different beaker from the distilled water one. Then have each group of students fill that beaker up to 250ml with distilled water. Tell each group that after they have combined the 25 grams of salt with distilled water, they need to mix it up to allow for the salt to dissolve. They can use the Popsicle sticks to mix it up with.
  7. Once your students have completed making a 10% salinity solution tell them to grab their last empty beaker to make their 20% salinity solution. Have each group measure out 50 grams of salt this time and put it into that beaker and then to pour distilled water into the beaker until it reaches 250ml. Again, have students use Popsicle sticks to mix up solution.
  8. When each group has made up their 3 different solutions have each group place their 3 beakers under a heat lamp.
  9. Once students are done explain to them that for the next several weeks (depending on how quick the experiment moves) it is their responsibility (as a group and individually) to check their heat lamp 3 times a week, and record data on their 3 different solutions.

**Closure/Assessment:**

Optional—incorporate technology! After explanation of #9 have each group get to a computer (if possible) and open up Excel. Have each group create a chart so they can use to record their data on their 3 different solutions. If you do not have access to computers there is a sample chart attached for your students to use.

When students have completed creating a chart have them record their first day of data on their 3 different solutions.

Once the experiment is completed have students gather into their original groups. Tell each group that they are going to scrape out the salt that is present in their test tubes (one at a time) and then weigh the salt using the digital balance. Have them then compare the weight of the salt they scraped out of the beakers to the weight that they began with at the beginning of the experiment. Ask your students what they are seeing? And why they might be seeing that—make a connection that salt does not evaporate, because it is a solid, only the water evaporated. Have each student record in his or her lab notebook what they just did, and a response to the questions you asked.

Now have each group (each individual in each group will do this) look at their data and then graph to show results. When each group has finished their graph, have each group of students compare their data with one another and have a discussion. Tell students to include the graph they created in their lab notebooks and then to draw a conclusion to the original question, “Does sodium chloride interfere with evaporation?”

**References:**

- *Biology*—Mader, Sylvia S., 6<sup>th</sup> edition, 1998
- <http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html>
- [http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/evap.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/evap.rxml)
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- *High Country News*—article on Great Salt Lake
- *The Feynman Lectures On Physics*—Feynman, Leighton, Sands, volume 5, 1963