

What's so special about bottled drinking water?

Testing water for hardness

Annotation

This laboratory teaches students about water hardness, polar and non-polar molecules, and anions and cations.

Primary Learning Outcome:

After the lesson is completed students should be able to understand that polar and nonpolar ions do not usually mix without an emulsifier like soap. Students should be able to recognize a drawing of a polar and non-polar molecule. Students will also know that a cation is an ion with a positive charge and an anion is an ion with a negative charge.

Georgia Performance Standards:

SC7. Students will characterize the properties that describe solutions and the nature of acids and bases.

Total Duration:

45 minutes

Materials and Equipment:

1. 5 test tubes with rubber stoppers
2. 1 test tube holder
3. Ivory soap solution
4. Eye dropper or pipette
5. 5 types of water (distilled, spring, tap, purified, carbonated, mineral, SmartWater, etc.)
6. Graduated cylinder

Procedures:

Set up

To prepare the soap solution you will need a bar of Ivory soap. Using a knife, scrape the bar to obtain about 7 grams of powdery shavings. This makes enough for over 50 groups to do the lab. Slowly stir these into 560 ml of distilled water. Prepare this 12-24 hours before it will be used for the lab. This should result in a thick, milky white liquid.

Estimated Time:

15 minutes

Lesson materials to be attached:

Introduction
Pre-lab questions
Procedures
Data table
Post-lab questions
Grading key

Web Links:

Drinking Water: Hard Water

<http://ianrpubs.unl.edu/water/g1274.htm>

Chemistry of Hard and Soft Water

<http://chemistry.about.com/cs/howthingswork/a/aa082403a.htm>

Laboratory Procedures

1. Use the graduated cylinder to obtain 5 ml of a water sample. Pour the water into the test tube. Record the water sample's information in the data table. Return to your table.
2. Add 3 drops of soap solution to the test tube, cover the end of the tube with the stopper, and shake vigorously for 5 seconds. Check to see if there is a "lasting lather" (still present after 5 seconds). If not, add another 3 drops of soap, and repeat the shaking. Keep doing this until a lasting lather appears. On the data table, record the number of drops of soap needed to cause the lather.
3. Repeat procedures 1 & 2 for the rest of the water samples. If you use a test tube more than once, be sure to rinse it three times between trials.

Assessment:

Pre and post lab questions can be graded. A key is attached. The data table can also be graded for completeness.

Extension:

SmartWater is marketed as being vapor distilled and infused with electrolytes including calcium chloride, magnesium chloride and potassium bicarbonate

(<http://bottledwaterstore.com/smartwater.htm>) The electrolytes added to SmartWater are very similar to those in hard water. Students can be asked why this marketing claim is or is not persuasive.

Remediation:

This lab can be done as a demonstration in front of the class.

What's so special about bottled drinking water?

Testing water for hardness

Introduction

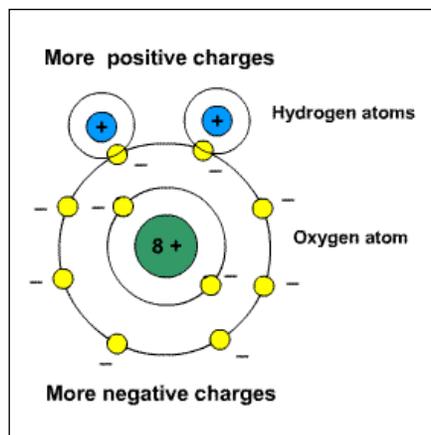
Water that is described as "hard" has high amounts of dissolved minerals, specifically calcium and magnesium. Hard water is not a health risk. The calcium in hard water may actually be beneficially for growing bones. However, hard water can be a nuisance because of poor soap performance.

Water is generally a good solvent, picking up impurities easily. Water is often called the universal solvent. As water moves through soil and rock, it dissolves small amounts of minerals and holds them in solution. For example, water that drains a limestone canyon would probably contain an abundance of calcium ions (limestone is primarily made of calcium carbonate, CaCO_3). Calcium and magnesium are the two most common minerals that make water "hard."

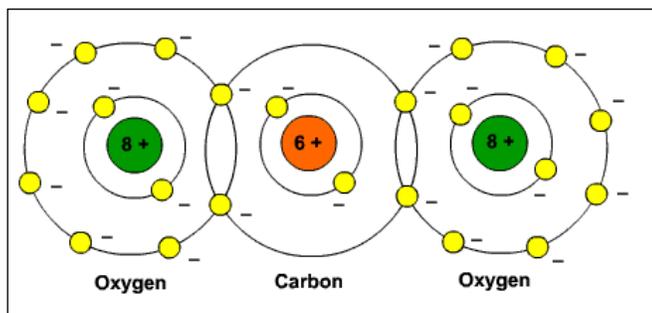
An ion is a molecule with a charge. An ion with a positive charge is called a cation. An ion with a negative charge is called an anion. Calcium and magnesium are both cations (Ca^{2+} , Mg^{2+}).

The arrangement or geometry of the atoms in some molecules is such that one end of the molecule has a positive electrical charge and the other side has a negative charge. If this is the case, the molecule is called a polar molecule, meaning that it has electrical poles. Otherwise, it is called a non-polar molecule. Polar substances mix with other polar substances. And non-polar substances mix with other non-polar substances. Polar substances do not mix with non-polar substances.

Water (H_2O) a polar molecule.



Carbon Dioxide (CO_2) a non-polar molecule



Oil is a non-polar molecule. Water is a polar molecule. So, they won't mix. But, soap allows the mixing of polar and non-polar molecules. When oil is mixed with a soap and water solution, the soap molecules work as a "bridge" between polar water molecules and non-polar oil molecules. Soap molecules have polar and non-polar properties at opposite ends. The non-polar end of the soap molecule mixes with the fatty dirt. The polar end of the soap molecule is attracted to water. Voila, emulsified dirt. (*An emulsion is a suspension of small globules of one*

liquid in a second liquid with which would usually not mix.) Other common examples of emulsions are milk and mayonnaise.

The non-polar end of a soap molecule would rather have a calcium or magnesium ion on its end than a fat. So, in hard water, calcium and magnesium ions bond to the soap before fat molecules. This magnesium or calcium and soap combination then precipitates out of the water as soap curd. This curd causes a greasy ring around sinks and bathtubs. If you use enough soap, it uses up all of the calcium and magnesium ions in the water. Then you have some soap left for cleaning. The degree of hardness becomes greater as the calcium and magnesium content increases.

Standard definitions for types of bottled water

Artesian water/artesian well water	Bottled water from a well that taps a confined aquifer (a water-bearing underground layer of rock or sand) in which the water stands at some height from the top of the aquifer.
Drinking water	Bottled water sold for human consumption, containing no additives, other flavors, extracts, or essences less than 1% by mass; calorie free and sugar free.
Mineral water	Bottled water containing not less than 250 mg/L (ppm) total dissolved solids; has a constant level and regular proportion of mineral and trace element composition at the point of emergence from the source; no minerals can be added.
Purified water	Water produced by distillation, deionization, reverse osmosis, ionization, or other suitable process; other suitable names include distilled water or reverse osmosis water.
Spring water	Bottled water derived from an underground formation that flows naturally to the surface; spring water must be collected at the spring or through a bore hole tapping the underground formation.
Sparkling water	Water that contains the same amount of carbon dioxide that is had at emergence from the source. This label does not pertain to seltzers, soda, or tonic water, which are soft drink beverages.
Well water	Bottled water from a well bored or drilled in the ground, which taps the water of an aquifer.

Preparation

To prepare the soap solution you will need a bar of Ivory soap. Using a knife, scrape the bar to obtain about 7 grams of powdery shavings. This makes enough for over 50 groups to do the lab. Slowly stir these into 560 ml of distilled water. Prepare this 12-24 hours before it will be used for the lab. This should result in a thick, milky white liquid.

Purpose

To compare the hardness of several samples of water, including tapwater, well water, bottled water, distilled water, mineral water, smart water[®] etc.

Pre-Lab Questions (Answer in complete sentences)

1. Which two ions are usually to blame for hard water?
2. Look at your periodic table. What is calcium's charge? What is magnesium's charge?
3. How do calcium ions get into water?
4. What is a polar molecule?
5. What is an emulsion?

Materials

5 test tubes with rubber stoppers, 1 test tube holder, a small bottle of soap solution, an eye dropper, several types of water, and a graduated cylinder

Procedures

1. Use the graduated cylinder to obtain 5 ml of a water sample. Pour the water into the test tube. Record the water sample's information in the data table. Return to your table.
2. Add 3 drops of soap solution to the test tube, cover the end of the tube with the stopper, and shake vigorously for 5 seconds. Check to see if there is a "lasting lather" (still present after 5 seconds). If not, add another 3 drops of soap, and repeat the shaking. Keep doing this until a lasting lather appears. On the data table, record the number of drops of soap needed to cause the lather.
3. Repeat procedures 1 & 2 for the rest of the water samples. If you use a test tube more than once, be sure to rinse it three times between trials.

	Sample 1	Sample 2	Sample 3	Sample 4
Product Name				
Carbonated (Y/N)				
Method of Purification				
Dissolved Solids (mg/L or ppm)				
Collection Source				
Drops added				

Follow-Up Questions

1. As you added soap to some of the harder samples of water, what formed instead of a soapy lather? What is this substance made of?
2. According to your results, which water sample was the “hardest”?
3. Which sample was the “softest”?
4. Would you expect water in a limestone cavern to be hard, or soft? Explain.
5. If you were to use a control for this experiment, what would you use?

Grading Key

Pre-Lab Questions (Answer in complete sentences)

1. Which two ions are usually to blame for hard water?

Calcium and magnesium are usually to blame for hard water.

2. Look at your periodic table. What is calcium's charge? What is magnesium's charge?

Calcium and magnesium both have a +2 charge.

3. How do calcium ions get into water?

Calcium ions get into ground water when water flows over limestone rock. Water dissolves the calcium and holds it in solution.

4. What is a polar molecule?

A polar molecule has a positive electrical charge on one end and negative charge on the other end.

5. What is an emulsion?

An emulsion is a suspension of small globules of one liquid in a second liquid with which would usually not mix.

Follow-Up Questions

1. As you added soap to some of the harder samples of water, what formed instead of a soapy lather? What is this substance made of?

Soap curd. Soap curd is made of calcium and/or magnesium and soap molecules.

2. According to your results, which water sample was the "hardest"?

This depends on the waters that were used. Mineral water should be fairly hard and purified water should be fairly soft.

3. Which sample was the "softest"?

This depends on the waters that were used. Mineral water should be fairly hard and purified water should be fairly soft.

4. Would you expect water in a limestone cavern to be hard, or soft? Explain.

Water in a limestone cavern would be hard, because limestone is made of calcium carbonate. The calcium dissolves in water.

5. If you were to use a control for this experiment, what would you use?

Purified or distilled water should be used as a control because it has no calcium or magnesium in it. It should lather immediately