Mission 7
Water!

SETI INSTITUTE

How Can We Recognize Water?

Overview

In mission 7.1, students play the role of comparative planetologists who have received clear, colorless liquid samples from their robot spacecraft. Students test these unknown liquids and identify which one is water by its freezing point.

Notes

In mission 6, students saw that life requires suitable environmental conditions. But certain chemicals, such as water, are also essential to life as we know it. Every cell contains water, the solvent in which our other essential chemicals of life are dissolved. It runs through the circulatory system of complex animals, carrying dissolved nutrients and wastes. Would wafer be as important to life on other planets? Exobiologists think so. There is no other liquid we know of that can dissolve so many things and can carry out so many of the chemical reactions that are vital to life's functions.

Mission 7.1
Materials

For a Class of 30

- 3-4 pounds of dry ice
- rubbing alcohol (2 pints total)
- Water (2 pints total)
- Peroxide (2 pints total)
- Paper towels
- Stick-on labels or grease pens
- Clear glass containers (or beakers)
- Overhead projector
- "Ice Bath" transparency
- (optional) additional clear colorless liquids (e.g., white vinegar, ammonia, glycerin)

For Each Team

- Beaker
- 3 test tubes
- Thermometer

- Tongs, scoops, or work gloves (for handling dry ice)
- "Making an Ice Bath!" directions

For Each Student

- "Mystery Liquids" worksheet
- Pencil

Getting Ready

1. Copy the "Making an Ice Bath!" directions for each team and the "Mystery Liquids" worksheet for each student.

2. Prepare the "Ice Bath" transparency. Set up the overhead projector.

3. Put the peroxide, water, and any other clear colorless liquids (all should be nontoxic; avoid strong bases and acids) into clear glass containers, labeled "Mystery Liquid # 1," "Mystery Liquid # 2," and so forth. (To especially test students, fill two containers with water.) Be sure to make a key identifying the samples.

4. Set up a central work station where students can get the "Mystery Liquid" samples and other materials, including dry ice and alcohol. Provide an area with water and paper towels where students can wash and clean their equipment.

5. Just before class, break up the dry ice into small pieces. If dry ice is not available, put the alcohol in a freezer to chill it as much as possible. Just before class, add ice cubes to the chilled alcohol. This ice bath will work, but it will take longer than an ice bath made with dry ice.

Classroom Action

1. **Discussion.** Discuss the importance of water to the existence of life as we know it. Point out that blood is mostly water; our bodies are mostly water. A search for life on Mars or Venus might include a search for water. But could we recognize water on another planet? Introduce the idea that not all clear, colorless fluids that look like water are water. It requires more than visual data to decide whether or not a colorless fluid is water.

2. **Optional Demonstration.** Pass around a test tube containing vinegar to demonstrate that some fluids that look like water do not smell (or taste) like water. Note that it is not a good idea to taste, or even smell, unknown liquids. If necessary bring students around to this idea with ammonia!

3. **Discussion.** Ask students how a spacecraft could recognize water on another planet. Water is a clear liquid in most Earth climates, a white solid in cold Earth climates (remember the snow in the winter), and an invisible (sometimes visible) gas in Earth's atmosphere. If a

spacecraft or lander found a clear liquid or white solid or invisible gas on another planet, how would we know it to be water or ice or water vapor, and not alcohol or peroxide or frozen carbon dioxide (dry ice) or carbon dioxide gas? It could not be tasted or smelled. If students did the optional dry ice activity in mission 3, recall how the dry ice turned into a gas without first melting into a liquid. Water on Mars behaves the same way as dry ice does here on Earth, evaporating directly from a solid.

Tell students that they will be considering liquid water. If we were on another planet, a white solid (ice) could be melted before testing and a vapor (gas) could be condensed before testing. Although clear colorless liquids might look identical, they have different molecular structures, and that gives them different physical properties. For instance, they each have characteristic freezing and boiling points. Water freezes at 0^0 C, and boils at 100^0 C.

4. **Activity.** Hand out the "Making an Ice Bath!" directions to each team and the "Mystery Liquids" worksheet to each student. Have each team test samples of three (or more) Mystery Liquids. They should make sure that each one is labeled with the proper number, such as "Mystery Liquid #1," so they can verify their results.

5. **Transparency.** Show the "Ice Bath" transparency to explain the experimental setup.

6. **Activity.** Divide the class into teams. Students should follow their directions. They start out by making an ice bath. They fill their beakers one-third full of alcohol and use tongs, a scoop, or gloves to add small pieces of dry ice until the bath is near -10^0 C. Caution them not to handle dry ice with their bare hands-dry ice can burn exposed skin!

   Students should then put one test tube (or all of their test tubes) into the ice bath and monitor the temperature of the liquid inside to find the one that freezes at 0^0 C. They should rinse and wipe the thermometer each time so as not to contaminate the samples and depress the freezing points. They will see that some liquids stay liquid below 0^0 C. This activity will take time. Emphasize that waiting and observing are what "real science" often requires! Students will also need to monitor the temperature of the bath throughout their investigation to make sure that it remains at about -10^0 C. (optional) If extra thermometers are available, students can leave one thermometer in the ice bath and use the other one in the samples.

7. **Discussion.** After everyone is finished, have students state their hypotheses about their Mystery Liquids. Then reveal which of the "Mystery Liquids" was water. How many students correctly identified them? Reveal to students the identities of the other liquids.

   Pose a question to students: How could a spacecraft and lander be designed to perform the same experiment that you just did? Would this experiment be useful as a remotely controlled part of a life detection device on another world? Make sure students understand the difference between imagination and design: some things that people can do are fairly difficult for a machine, even a robot, to do.

Going Further

Activity: You've Reached My Boiling Point!

Checking the boiling point is another good way to test for water. Tell students that water boils at 100^0 C. If you have the equipment and feel that it can be done safely, have teams heat the Mystery Liquid samples to determine which one boils at 100^0 C. A hot-water bath allows for a more even heating of the samples. You would need to saturate the hot water with salt to elevate its boiling point above 100^0 C so the water samples boil before the water bath (this would obscure the view).

Research: Water on Mars and Venus?

Ask students to research water on Mars and Venus. What are the clouds of Mars composed of? The clouds of Venus? What kind of "ice" are the polar caps of Mars made of? Would they melt? What forms the "frost" that is seen on the surface of Mars? Does Venus have polar caps? Are there geologic features which suggest that Mars or Venus once had liquid water?

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Mystery Liquids-Teacher 's Key

1. All the Mystery Liquid samples are clear (colorless) fluids at room temperature. No, you cannot tell just by looking which samples, if any, are actually water. Some samples may have odors that would lead you to believe that they are not water. Students' tables will vary, depending upon the liquids that were chosen. See Table 7.1 on page 140.

Table 7.1-Teacher's Key**.**

"Mystery Liquid" Sample Number	Original Appearance of the "Mystery Liquid"	Temperature at which the "Mystery Liquid" Freezes
Number will vary Water	Clear, colorless liquid	0 degrees C.
Number will vary Saltwater	Clear, colorless liquid	-20.5 degrees C
Number will vary Peroxide	Clear, colorless liquid	-1.7 degrees C
Number will vary Ammonia	Clear, colorless liquid	-1.1 degrees C
Number will vary White Vinegar	Clear, colorless liquid	-1.6 degrees C
Number will vary Alcohol	Clear, colorless liquid	-89.5 degrees C
Number will vary Glycerin	Clear, colorless liquid	+17.8 degrees C

2. Any liquid with a freezing point below that of water will still be liquid at this point. Yes, any of these would freeze at a lower temperature, at their own freezing points.

3. 0 Degree Celsius

4. Yes. Any liquid that froze at 0 C is assumed to be water.