Properties of Fresh Water and Sea Water

Overview

The students will set up three demonstrations to observe the properties of water. They will explore the boiling point of water, the freezing point of water, and the ability of water to store heat. These activities can be done individually or as a set.

About 71% of the Earth's surface is covered with salt water. Life on Earth is possible because of the unique properties of water.

Concepts

- Water has unique physical properties. It is one of very few substances that occurs as all three *states of matter*--a solid, a liquid, and a gas--within the normal temperature range at Earth's surface.
- The abundance of liquid water makes life on Earth possible.
- Water has a high *heat capacity*.
- Ocean water contains salts and minerals that make it different from fresh water.
- Graphing information helps us to analyze and understand it.
- Water moderates Earth's climate

Materials for Station #1: The Boiling Point of Water

- Distilled water
- Seawater (if seawater is not available, check the pet store for "Instant Ocean" mix)
- Isopropyl alcohol (optional)
- Hot plate
- 3 Flasks, each with a rubber stopper that holds a thermometer
- 3 Thermometers that can measure from -10° to 110°C
- Graph paper

Preparation for Station #1

This activity works best as a small group activity, but can be done as a demonstration. As a demonstration, use an overhead projector to record the data for the class.

If sea water is unavailable, you can find salt water aquarium mix at any pet store that sells salt water fish. Alcohol may be used as a liquid in the experiment for comparison. Make sure that the alcohol is in a closed container and do not let it splash. Caution: alcohol is flammable.

Fill one flask with the distilled water sample, one flask with sea water and the third flask with alcohol. Insert the thermometers through the stoppers and cap the flasks. Make sure the thermometers are suspended in the liquids. Set all three samples aside for half an hour so that they are all at room temperature.

Procedure for Station #1

Engagement

In this procedure, you will explore the boiling point of water, including the differences between salt water and fresh water. Based on your intuition, which do you think will boil first: salt water or fresh water? Why?

Activity

1. Record the temperature of the distilled water, seawater and alcohol in the flasks. Turn on the hot plate.
2. Begin with the distilled water. Check and record the temperature every 30 seconds. When the water begins bubbling and the temperature levels off, the water is boiling. Keep recording the temperature for 3 minutes after you see bubbles. Plot and graph your data. What is the boiling point of distilled water? How long did it take the distilled water to reach the boiling point?
3. Repeat the experiment with seawater. Record the thermometer reading every 30 seconds. Plot and graph your data. What is the boiling point of sea water? How long did it take the sea water to reach the boiling point?
4. Optional: Repeat the experiment with alcohol. Record the thermometer reading every 30 seconds. Plot and graph your data. What is the boiling point of alcohol? How long did it take the alcohol to reach the boiling point?
5. Compare the results of the three experiments. Use your graphs. Are there any differences in the boiling points? How do you explain these differences?

Explanation

The boiling point of a liquid is the temperature at which it turns to gas. Water, when heated, *evaporates* and boils slowly compared to other liquids. This means that the *heat of vaporization* is high—the highest of all common liquids. Because of the high heat of vaporization, water evaporates slowly and absorbs a lot of heat. Water's high heat of vaporization gives it a high boiling point (100°C). This is why much of Earth's water is in liquid form.

Station #1 Extension:

Have students think about evaporation from the ocean surface in comparison to evaporation from the surface of a fresh water lake. How would these processes differ? Which evaporates more readily? Then have the students look at a map of surface salinity of the oceans. Is the pattern they see consistent with how much sunlight reaches different parts of the earth? Does the pattern of salinity coincide with that of sea surface temperature? What other factors might affect sea surface salinity?

Think about the surface temperatures of other planets and moons in our solar system. Are any others able to host liquid water? How does their surface temperature affect each planet or moon's ability to support life as we know it?

Materials for Station #2: The Freezing Point of Water

- Distilled water
- Sea water (if sea water is not available, check the pet store for "Instant Ocean" mix)
- Isopropyl alcohol
- 3 Thermometers that can measure from -10°C to 110°C
- 3 Large test tubes each with a one hole fitted stopper
- 3 Pyrex beakers
- Dry ice chunks
- Gloves
- Graph paper

Preparation for Station #2

This activity works best as a small group activity, but can be done as a demonstration. As a demonstration, use an overhead projector to record the data for the class.

If seawater is unavailable, you can find salt water aquarium mix at any pet store that sells salt water fish. Isopropyl alcohol works nicely because it contains water. When the water in the alcohol freezes, it should sink.

There are numerous stores that sell dry ice as either chunks or cubes. Ask the salespeople at the store for the best way to handle the dry ice. If you cannot find or do not wish to use dry ice, you can use a salt-ice mixture.

Procedure for Station #2

Engagement

In this procedure, you will explore the freezing point of water, including the differences between salt water and fresh water. For pure water, the freezing point is defined as 0°C, but have you ever measured it? How can we measure it? Can we put the thermometer in a solid chunk of ice or in chopped ice? What is the temperature of ice? Which will freeze more slowly, salt or fresh water? Why?

Activity

1. Fill one test tube with distilled water, the second with sea water, and the third with alcohol. Insert the thermometer through each rubber stopper and cap the test tubes. Make sure that the thermometer is suspended in the water. Record the temperature of each test tube.
2. Using tongs or heavy gloves, fill the bottom of three Pyrex beakers with chunks of dry ice. DO NOT TOUCH THE DRY ICE WITH YOUR BARE HANDS! Place each test tube in a beaker of dry ice.
3. Record the temperatures every 30 seconds until they level off. Observe the test tube of alcohol. What happens to the water that is in the alcohol? Compare it to the freezing point of the salt water and of the fresh water. Does the ice float or sink?
4. Plot and graph your data. Compare the information on the three graphs. What is the freezing point of fresh water? Seawater?

Explanation

The temperature at which a liquid becomes a solid is called the freezing point. The solid becomes a liquid at its melting point. The freezing point and melting point of water (or any other liquid) are the same.

Water also has a high *latent heat of fusion*. Latent heat of fusion refers to the amount of heat gained or lost when a substance changes from a solid to a liquid, or a liquid to a solid. When ice is formed, large quantities of heat are given off.

Most liquids become more dense as they cool. If cooled until they become solid, the solid phase is more dense than the liquid phase. However, this is not true of water. Pure water becomes more dense as it cools until it reaches 4°C and further cooling decreases the density. Thus, water ice (0°C) is lighter than liquid water and floats on it.

Station #2 Extension:

The fact that water ice is lighter than liquid water has key implications for Earth. Can your students think of why this property is so important? Have them think about the implications this has for ocean life and life in our lakes and rivers.

Another interesting property to consider is that when ice is formed it gives off heat. How might this affect our oceans, lakes, and rivers? Can they think of other ways this helps humankind? For example, how might farmers use this knowledge when protecting their crops from freezing air temperatures?

Materials for Station #3: Water's Ability to Store Heat

- Hot plate
- 2 Flasks (same size)
- 2 Thermometers
- Bucket of ice water
- Stop watch

Preparation for Station #3

This activity works best as a small group activity, but can be completed as a demonstration. Use an overhead projector to record data for the class.

Procedure for Station #3

Engagement

In this procedure, you will examine water's ability to store heat. Water has a higher heat capacity than almost any other liquid. This means that it takes a lot of heat to change water's temperature significantly. We can measure and compare the heat capacities of water and air. Based on your experience, which will heat and cool more slowly: water or air? Why?

Activity

1. Fill one flask with water and leave one flask empty. This flask is filled with air. Insert thermometers through rubber stoppers and cap the flasks.
2. Record the temperature in each flask at room temperature. Place both flasks on top of the hot plate and start the stop watch. Record the time it takes for the water to reach 33°C. Also record the time when the water reaches 33°C. Also record the temperature of the empty flask at that instant. Is the temperature in the flask of air higher or lower than the temperature of the flask of water?
3. Remove both flasks from the heat and place them in ice water. Record the time it takes for each flask to reach its original room temperature. Which flask took longer to reach its original room temperature? Record your observations.

Explanation

Water, when heated, evaporates slowly in comparison to other liquids. This means that the *heat of vaporization* is high—the highest of all common liquids. Water also has a high *latent heat of fusion*. Latent heat of fusion refers to the amount of heat gained or lost when a substance changes from a solid to a liquid, or a liquid to a solid. When ice is formed, large quantities of heat are given off. Liquid water also has an extremely high *heat capacity*, the amount of heat required to raise its temperature (between the freezing and boiling points). The high values of the heat capacity, heat of vaporization, and latent heat of fusion mean that it takes more heat to cause a change in temperature in water than in most other substances. This makes water a strong buffer against both rising and falling temperatures.

Section #3 Extension

Water covers about 71% of Earth's surface. So its ability to store heat strongly affects our climate. Have your students look at an image of day-night mean surface temperature difference. About how much does the ocean change temperature from day to night? Do land areas experience greater or lesser differences in temperature from day to night? How does this affect the climate of coastal regions?

What would happen if our oceans only covered 25% of Earth's surface? Would the day to night temperature difference on land masses be more or less extreme? How does the lack of liquid water oceans affect day to night temperature differences on some of the other planets and moons in our solar system?

Links to Related CD Activities, Images, and Movies

Image of *Surface salinity of the oceans*

Image of *Sea surface temperature*

Image of *World map showing day-night temperature differences between land & ocean*

Activity *Coastal Verses Inland Temperatures*

Activity *Ocean Currents and Coastal Temperatures*

Vocabulary

evaporate

heat capacity

heat of vaporization

latent heat of fusion

states of matter

Source

Adapted from Orange County Marine Institute Curriculum Series.

Adapted from Phleger, Charles F. and Wallace, William J. *Field Guide and Laboratory Manual for Oceanography: An Introduction.* p. 30 - 31.