LESSON 1 - INVESTIGATING THE CHEMICAL PROPERTIES OF WATER

Overview:
Students learn about the properties of water through a series of demonstrations, a reading and question package, a Water Olympics activity, and a laboratory investigation.

Suggested Timeline: 3.5 hours

Materials:
- Chemistry: Our Liquid World – Unit Organizer (Teacher Support Material)
- blank unit organizer (1 per student)
- globe or map of the Earth
- The Word on Water (Student Handout)
- The Word on Water (Teacher Support Material)
- for 'The Word on Water' demonstrations:
  - bowl of prepared JELL-O in a clear glass bowl
  - flashlight
  - chocolate syrup
  - tablespoon
  - glass of water
- Water Olympics (Teacher Support Material)
- Water Olympics (Student Handout)
- for 'Water Olympics':
  - beaker with narrow spout
  - yarn (soaking wet)
  - container to hold water
  - colored water
  - paper and pencils
  - clear plastic cups
  - two dollars in pennies
  - eyedropper
  - several brands of paper towel
  - tape
  - sheets of stiff cardboard
  - scissors
  - soap chips (shaved from a bar of soap)
  - large aluminum trays
  - stopwatch
  - paper clips
  - fork
  - magnifying glass
  - tall glasses
  - ruler
- The "Abnormal" Behavior of Water Lab (Student Handout)
- for 'The "Abnormal" Behavior of Water Lab'
  - large beaker (1000 mL)
  - crushed ice
  - salt
  - water
  - 250 mL flask
  - transparent tape
  - thermometer (-10 to 110 degrees Celsius)
  - 2-hole rubber stopper
  - fine glass tubing
  - ruler
  - ring stand
  - adjustable clamp
- QUIZ – The Chemical Properties of Water (Student Handout)

Method:

INDIVIDUAL FORMAT:

1. Have students preview the unit via an examination of a completed unit overview sheet.
2. Tell students that they will have the opportunity to learn about the unique properties of water that make it well-suited to forming the basis of life on Earth.
3. Have students complete their vocabulary list, reading and questions on their handout 'The Word on Water' (Student Handout). Review the questions with students.
4. If possible, introduce the 'Water Olympics' activity by the demonstration on 'Water Olympics' (Teacher Support Material).
5. Have students move through the stations to complete the water activities and answer questions on their worksheet. Have students submit their worksheet for assessment.
6. If possible, brainstorm with students about what they know about solids, liquids and gases. Lead them to discuss the difference in density of these three states of matter. **Key Q:** How is water different?
7. Facilitate students' completion of 'The "Abnormal" Behavior of Water Lab' (Student Handout). Have students hand in their lab for grading.
8. Announce a date for the quiz on material learned in this lesson.

GROUP FORMAT:

1. Preview the unit by having students fill in the unit organizer as you go through it with them.
2. Show students a globe or map of the world.
   Key Q: What color is approximately 70% of the globe? (Blue for water)
   Key Q: If one zooms in on a single cell of an organism on Earth, what % of that cell's mass do you think is water? (approx. 70%)
   Key Q: Why do you think that water forms the majority of the Earth and the majority of living things? Why not vinegar or mercury or oil?
3. Tell students that they will have the opportunity to learn about the unique properties of water that make it well-suited to forming the basis of life on Earth.
4. Have students complete their vocabulary list, reading and questions on their handout 'The Word on Water' (Student Handout).
5. Review the questions with students. Use the demonstrations on 'The Word on Water' (Teacher Support Material) to test further their understanding.
6. Introduce the 'Water Olympics' activity by the demonstration on 'Water Olympics' (Teacher Support Material).
7. Have students move through the stations to complete the water activities and answer questions on their worksheet. Have students submit their worksheet for assessment.
8. Brainstorm with students about what they know about solids, liquids and gases. Lead them to discuss the difference in density of these three states of matter. **Key Q:** How is the behavior of water different? Why is the behavior of water essential for life to exist in lakes and ponds?
9. Facilitate students' completion of 'The "Abnormal" Behavior of Water Lab' (Student Handout). Have students hand in their lab for grading.
10. Announce a date for the quiz on material learned in this lesson.

Assessment and Evaluation:

- Assessment of students' understanding of solutes and solvents through questioning
- Assessment of students' 'Water Olympics' handout
- Affective assessment of students' ability to work in a group
- Student grade on lab
- Student grade on quiz

ACTIVITY OVERVIEW:

Suggested Sequencing:			
Activity	Suggested Timeline	Description	Assignment
1	1 hour	As a class or individually, preview unit using unit overview. Have students complete the vocabulary list, reading and questions. Review the questions. If in a group setting, perform the demonstrations on solutions to solidify students' understanding.	The Word on Water (SH) reading and questions
2	1 hour	Introduce the 'Water Olympics' activity by performing a demonstration on capillary action. Facilitate students' completion of the 'Water Olympics' activity as they work through stations in the classroom.	Water Olympics (SH) handout
3	1.5 hours	Brainstorm properties of solids, liquids and gases, discussing the usual changes in density with changes of state. Intrigue students with the opportunity to investigate the unusual behavior of water. Guide students in completing 'The "Abnormal" Behavior of Water Lab.'	The "Abnormal" Behavior of Water Lab (SH)

The Word on Water

Demonstrations – Are They All Solutions?

Prepare a package of JELL-O in a clear glass bowl and allow it to set overnight.

- **Key Q –** Think about all of the transparent things in your refrigerator – a bottle of 7-Up, maple syrup, a container of apple juice. Are they all solutions?
- Place the bowl of JELL-O in front of the students and tell to observe it closely.
- **Key Q** – Is the JELL-O transparent? Is it a solution? (Hint: Can you see more than one part?)
- Shine a flashlight through the bowl and have students observe the JELL-O closely. Ask the last question again!

Have the following materials at the front of the class – a glass of water, a bottle of chocolate syrup and a tablespoon

- **Key Q** – Do you think that chocolate syrup will form a solution in water?
- Add a tablespoon of chocolate syrup to a glass of water and stir until the syrup and the water are thoroughly mixed.
- **Key Q** – Is the mixture homogeneous or heterogeneous? Is it a solution?
- Let the mixture stand for a while, then observe it again.
- **Key Q –** What do you notice? Can you think of any other mixtures that are like chocolate syrup and water?

TSM Teacher Support Material 2

Water Olympics

Summary:
Students explore the unique properties of adhesion and cohesion of water through five activities. Students can make connections to signs of water's properties seen daily (e.g., beading on the surface of a glass) which allows them to further explore the structure and behaviour of the water molecule.

Duration:
Prep time: 40 minutes
Activity time: 50 minutes

Materials:
- Beaker or measuring cup with narrow spout
- Yarn (soaking wet)
- Container to hold water
- Coloured water
- Copies of Water Olympics Score Sheet (Student Handout)
- Water
- Paper and drawing materials
- For each event water is required in addition to the following materials:

Station 1
- Clear plastic cups
- Two dollars in pennies

Station 2
- Eyedropper
- Penny

Station 3
- Boat pattern
- Stiff cardboard
- Scissors
- Soap chips (shaved from a bar of soap)
- Large aluminum trays
- Stopwatch

Station 4
- Paper clips
- Fork
- Magnifying glass
- Clear plastic cups

Station 5
- Several brands of paper towels
- Tall glasses
- Tape
- Ruler
- Scissors

Key terms:
Adhesion – the attraction of water molecules to other materials like glass or soil.
Cohesion – the attraction between water molecules.
Surface tension – the cohesive force between water molecules causes the water surface to behave as though it is covered by an elastic sheet.
Capillary action – the movement of water up or along a surface which results from the cohesive and adhesive properties of water.

Procedure:

Set: Water Walks a Tightrope
1. Setup a beaker partially filled with coloured water, an empty container, and the pre-soaked yarn as described below as a demonstration for the students.
2. Hold the beaker with coloured water approximately 10cm off the table with the yarn stretched across the mouth of the beaker to the empty container which is sitting on the counter the length of the yarn away. The yarn should be held tight between the two containers and should be allowed to drip into the empty container.
3. Slowly pour the water down the yarn.
4. Have students try to explain how water appears to be defying gravity by moving down the yarn. Explain that the following activities will help them explore this and other unique properties of water.

Activity:
1. Setup 5 stations around the classroom.
2. Divide the class into a maximum of 5 small groups.
3. Direct students to the stations. They can be completed in any order. Directions for each station are provided on student handouts. Results may be recorded on their score sheets.

Conclusion:

1. Ask students to explain how each of the key terms (adhesion, cohesion, surface tension, and capillary action) could be used to explain the various activities.
2. Have the students explain the motivational set*: Water Walks a Tightrope*
   a. How does water's cohesive forces work to keep the water from falling off the yarn?
   b. What happens if the water is poured too quickly?

3. To extend this activity have students compare the unique properties of water to that of other liquids (alcohol, hydrogen peroxide, oil). How do they differ? Can a paper clip be supported on each of these liquids?

Adapted from H_2Olympics, pp. 30-34 *Project Wet Curriculum and Activity Guide*

Student Handout

Name: _____ Date: _____ Period: ___

The Word on Water

VOCABULARY

polar molecule –

adhesion –

cohesion –

surface tension –

capillary action –

mixture –

solution –

solvent –

solute –

homogeneous –

heterogeneous -

acid –

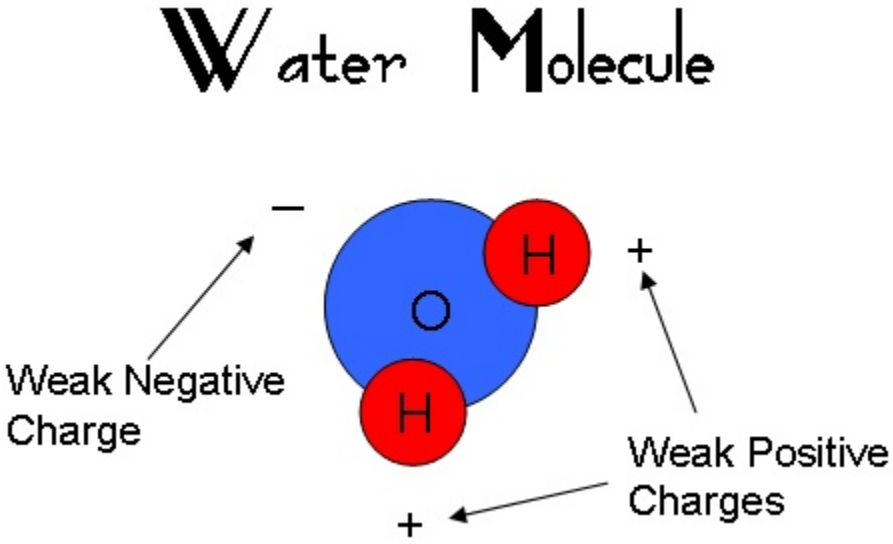
base –

pH –

Student Handout

After watching an insect walk on water or watching the droplets of water roll down the outside of a glass, you may have some questions. Why doesn't the insect sink? Why does water form droplets? Many of the features of water that we experience are due to its unique properties.

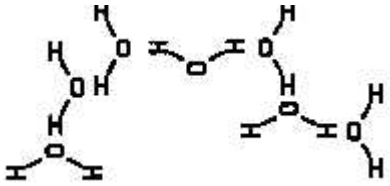
The chemical formula for water is H_2O. This means that it is made up of two hydrogen atoms and one oxygen atom.



As can be seen in the diagram above, the oxygen end of the water molecule has a weak negative charge and the hydrogen end of the molecule has a weak positive charge. In the water molecule, the electrons (which have a negative charge) are more attracted to the larger oxygen atom, causing the oxygen end to become negatively charged. Water is therefore a **polar molecule** – it has oppositely charged regions. This is just like how a magnet has a north pole and a south pole.

As you may remember from other science classes, when the south pole of one magnet is brought close to the north pole of another magnet, they attract. In the same way, when the positively charged part of a polar molecule comes close to the negatively charged portion of another polar molecule, they attract. In the case of water, a hydrogen bond forms between water molecules, causing them to link up together. This is why water forms a stream when you pour it – the molecules are clinging together!

Student Handout



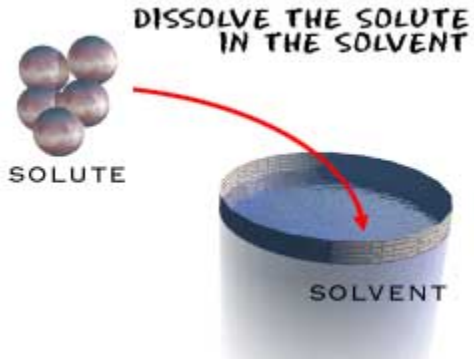
A spider resting on the surface of water!

The tendency of polar molecules to cling to one another is called **cohesion**. This creates **surface tension**, causing water to form droplets and allowing objects to rest on the surface of water!

Adhesion is the attraction of water molecules to other molecules, like glass or soil. When you see water trickling down the side of a glass, it is due to cohesion *and* adhesion. The water molecules are attracted to each other, so they form a train (cohesion). They are also attracted to unlike molecules, in this case the glass, and stick to it (adhesion). When water moves up or along a surface like this, due to cohesion and adhesion, it is called **capillary action**.

Many centuries ago, scientists were looking for a substance that they called the universal solvent. If it existed, everything that was poured into the universal solvent would dissolve or mix so thoroughly that if you looked at the substance, you couldn't tell that two substances had been mixed. The early scientists never found a universal solvent, but they came close! As you know, many substances, from juice crystals to salt, dissolve in water!

A **mixture** is a combination of substances in which each substance keeps its individual properties. When a mixture looks uniform or the substances are mixed so well that you can't see them individually, it is called a **solution**. In a solution, there are two parts – a solvent and a solute. The **solvent** is the substance in which another substance is dissolved. The **solute** is the substance that is dissolved. For example, if you were making iced tea, the water would be the solvent and the iced tea powder would be the solute.



Some useful solutions:

Student Handout

maple tree sap
solute: sugar (solid)
solvent: water (liquid)
solution type: solid-liquid
use: feeds trees and pancake eaters!

soft drinks
solute: carbon dioxide (gas)
solvent: water (liquid)
solution type: gas-liquid
use: beverage

brass
solute: zinc (solid)
solvent: copper (solid)
solution type: solid-solid
use: decorative metal

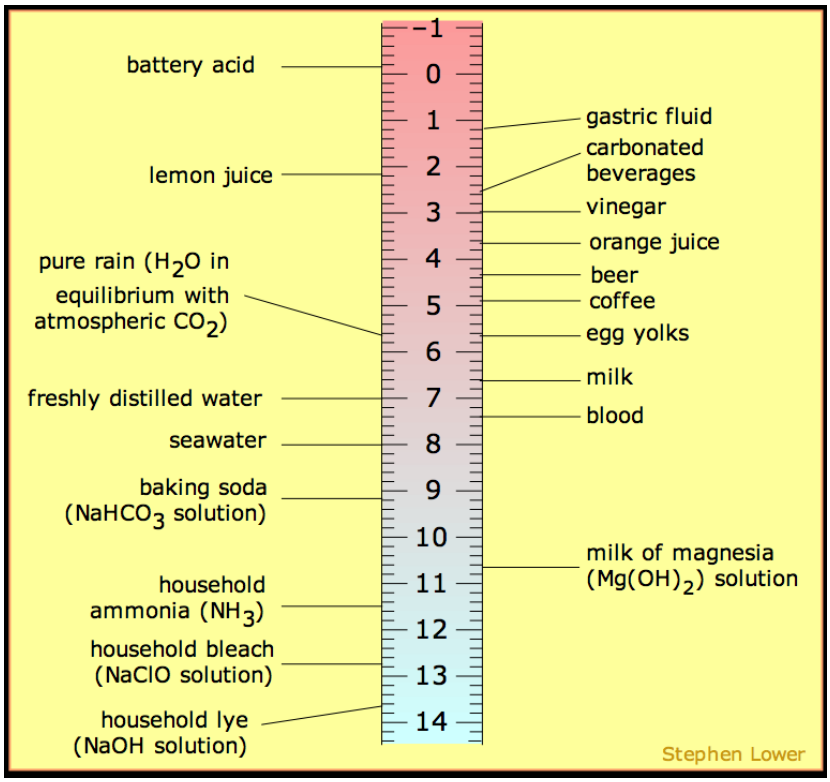
air
solute: oxygen (gas)
solvent: nitrogen (gas)
solution type: gas-gas
use: breathing!

Remember that the parts of a solution that make it up cannot be seen. Solutions are therefore described as being **homogeneous** ("homo" means same and "genos" means kind).

If a solute does not dissolve in a solvent or only partially dissolves, the mixture is a **mechanical mixture**. Mechanical mixtures are not homogeneous. Since the two or more substances mixed can be seen and have quite different properties, such a mixture is called **heterogeneous** ("hetero" means different). For example, when you mix oil and water, the oil sits on top of the water. This is a heterogeneous mixture.

Can you recall the burning feeling in your throat after throwing up? This feeling is due to the acid from your stomach burning the soft tissues in your throat. All solutions can be classified as acids or bases. Scientists have come up with a good way to measure how acidic or how basic a solution is. It is called the **pH** of a solution. **Acids** have pH values lower than 7. **Bases** have pH values higher than 7. Pure water is neutral and is said to have a pH = 7. Note the pH of everyday solutions on the pH scale below.

Student Handout



QUESTIONS:

1. After a rain, you may notice that water forms droplets on the leaves of trees. What property of water, a polar molecule, causes this to happen? Explain your answer.

_____

_____

_____

_____

_____

2. As usual, you are studying hard for science and place a glass of water close to your notebook. Some water that has condensed on the outside of the glass leaves a small puddle of water on your desk. You accidentally place a piece of paper next to the wet spot and soon the whole piece of paper is wet! The water seems to have moved across the paper, soaking it! What property of water causes this to happen? Explain your answer.

_____

_____

Student Handout

_____

_____

3. You pour some bath salts into the bathtub as you get ready for an evening soak.

   a) In this situation, the solute is the _____. The solvent is the _____.

   b) Will the bathtub contain a solution or a mechanical mixture? Explain your answer.

      _____

      _____

      _____

4. How is a solution different from a mechanical mixture? In your answer, include the terms homogeneous and heterogeneous.

   _____

   _____

   _____

   _____

   _____

5. Classify each of the following as a solution or a mechanical mixture. Explain each choice.

   a) wood _____

   b) tap water _____

   c) orange juice _____

   d) loonie coin _____

6. Make a list of 10 liquids found at home. For each liquid, do the following:
   b) Examine the contents by reading the labels on the containers.
   c) Identify liquids that meet your newly learned definition of a solution.
   d) Write down the names of these liquids.
   e) For each, list the solvent and solute that make up the solution.

Student Handout

Water Olympics Score Sheet

Team Name: _____ Date: _____

Team member(s): _____

Be sure to read the directions all the way through before beginning each activity.

Station 1: Pushing the limits

Prediction: How many pennies can you add before the water spills over? _____

Directions:
Using water fill the plastic cup until it is even with the rim. Add pennies one at a time, continuing until water spills over the side. Keep track of the number of pennies added in the space below. Repeat for each team member.

Team member	Number of pennies added

Describe or draw the surface of the water:

Station 2: Here a drop, there a drop, everywhere a drop, drop.

Prediction: How many drops of water will you be able to fit on a penny? _____

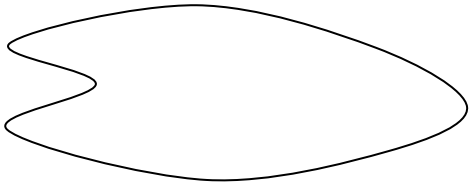
Directions:
Use an eyedropper to place as many individual droplets of water on the surface of a penny as possible. Continue until the water drop collapses or the water spills over the edge of the penny. Use the table below to record the number of drops added. Repeat for each team member.

Team member	Number of drops added

Describe or draw how the water appeared on the penny before the drop collapsed:

Station 3: Cutting the tension

Directions:
Using the pattern provided cut out 2 boat shapes from a piece of cardboard. Place a soap chip in the notch at the rear end of one of the boats. Place the boats in the tray of water and describe what happens:



Place a drop of water on the table. What happens to it when you put a soap chip in it? What caused the boat to move?

It is your turn – experiment to design a boat that will move faster! Adjust the boat shape, placement of the soap chip, and the size of the soap chip. Choose your best design and time how long it takes for your boat to travel from one end of the tray to the other. Record your time below:

Team member	Time

Student Handout

Station 4: Floating along

Prediction: How many paper clips can your team float on the surface of the water? _____

Directions: Use the prongs of a fork to lay the paper clips on the surface of the water. Record the number of paper clips you could suspend in the table below. Repeat for each team member.

Team member	Number of paper clips added

Observe the surface of the water where it comes in contact with the paper clip using a magnifying glass. Draw a picture or describe what this looks like below:

Station 5: Bop, bop, bop. Reach for the top.

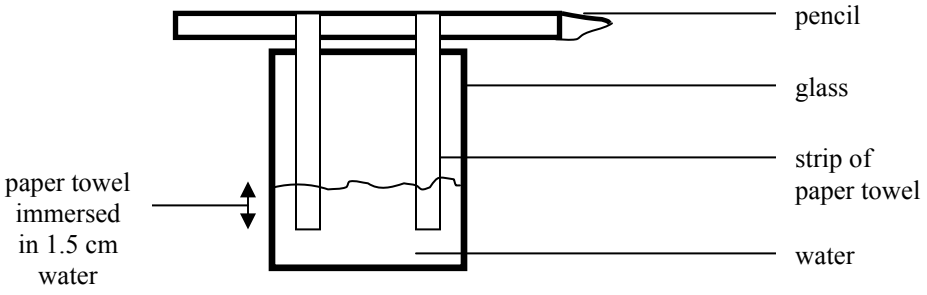
Prediction:
Which brand of paper towel will absorb the least water? _____

Which brand of paper towel will absorb the most water? _____

Explain your reasoning:

Directions:
Cut out strips of two of the brands of paper towel. Tape one end of each towel to the middle of a pencil. Lay the pencil on top of a tall glass. Measure out enough water to immerse the ends of the paper towel up to 1.5cm into the water (see the diagram below).

Student Handout



Remove the towels, fill the container to that level, and put the towels back in. Let the paper towels absorb water until the water stops rising. Measure the height absorbed above the water for each towel using a ruler. Record your data in the chart below:

Paper Towel Brand	Height of water (cm)

Summary questions:

1. Place an (x) or (√) in the box that indicates which property of water was shown by each activity:

Activities	Adhesion	Cohesion	Surface tension	Capillary action
1. Pushing the limits				
2. Here a drop, there a drop, everywhere a drop, drop!				
3. Cutting the tension				
4. Floating along				
5. Bop, bop, bop. Reach for the top.				

Student Handout

2. For each term, choose one of the activities that demonstrated the property and explain how the activity showed this property of water:
   a. Cohesion

   b. Adhesion

   c. Surface tension

   d. Capillary action

Adapted from H_2Olympics, pp. 30-34 *Project Wet Curriculum and Activity Guide*

Student Handout

Name: _____ Partner(s): _____ Date: _____
Period: ____

12

The "Abnormal" Behaviour of Water – Lab

The survival of much of the life in ponds and lakes depends on the abnormal or strange behaviour of water. Most liquids become denser as they are cooled and become most dense at their freezing point.

Problem: What is abnormal about the behaviour of water?

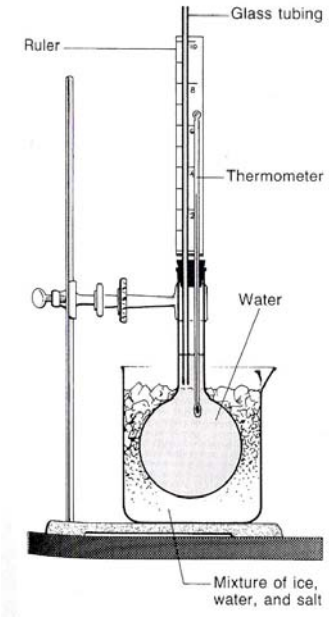
Materials:
- large beaker (1000 mL)
- thermometer (-10 to 110 degrees Celsius)
- crushed ice
- 2-hole rubber stopper
- salt
- fine glass tubing
- water
- ruler
- 250 mL flask
- ring stand
- transparent tape
- adjustable clamp

Procedure:
a) Copy out the following table in your notebook. (You will need to leave space for more time).
Completed table – 2 marks

Time (min)	Level of water (mm)
1	
2	
3	
4	
.	
.	

Student Handout

b) Set up the apparatus as shown. Use transparent tape to attach the ruler to the tubing.



c) Every minute, note and record the level of the water in the tube.
d) Stir the ice-salt-water mixture from time to time to make it as cold as possible.
e) Continue to take readings until the temperature of the water is 0 degrees Celsius.
f) Remove the flask from the mixture. Let it warm up. Note and record the level of the water in the tube every minute. Continue until the temperature of the water is back up near room temperature.

Discussion:

1. Describe carefully what happens to the volume of water as the temperature drops to 0 degrees Celsius. **1 mark**

2. What happens to the density of water as the temperature drops to 0 degrees Celsius? **1 mark**

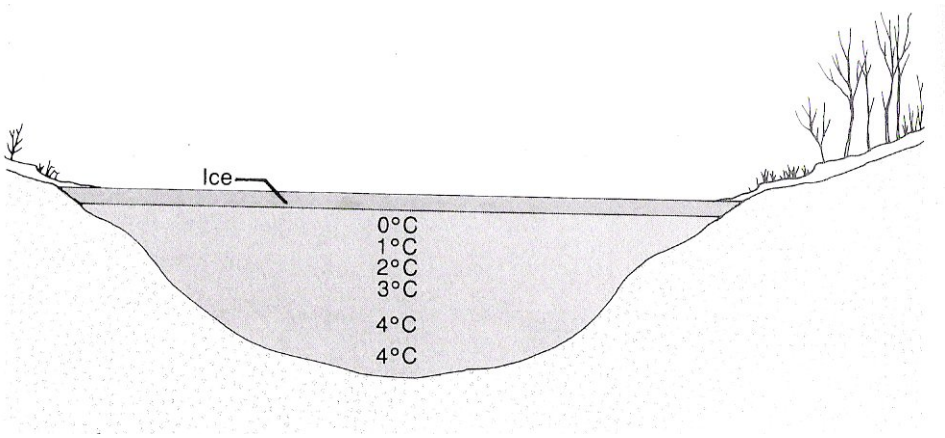
Student Handout

3. At what temperature does water have its smallest volume (and greatest density)? **1 mark**

4. Why does ice float on water? **1 mark**

5. What is abnormal about the behaviour of water? **2 marks**

6. View the following diagram, showing a pond in mid-winter. Account for the various temperature readings. **2 marks**



7. If water did not have this abnormal behaviour, fish could not live in ponds and lakes in areas where freezing occurs. Why? **2 marks**

Adapted from Activity 4.2 – Investigating the Abnormal Behavior of Water, pp. 69-70
Investigating Aquatic Ecosystems

Student Handout

_____
10

Name: _____ Date: _____ Period: ____

QUIZ – The Chemical Properties of Water

Instructions – Circle the correct answer.

1. The oxygen end of a water molecule has a slight negative charge. The hydrogen end has a slight negative charge. For this reason, water is called a(n) _____ molecule.
   a) soluble b) cyclical c) non-linear d) polar

2. 

   Note how water forms droplets in the photo. What term best explains this behaviour of water?
   a) cohesion
   b) magnetism
   c) adhesion
   d) solubility

3. You are up late studying for science and decide to make a cup of hot chocolate for a quick caffeine 'pick-me-up'. You add the boiling water to the hot chocolate powder and mix up the toasty drink. Which of the following statements about the mixture that you have created is correct?
   a) The hot chocolate powder is the solvent and the boiling water is the solute.
   b) The hot chocolate powder is the solute and the boiling water is the solvent.
   c) The mixed up hot chocolate and boiling water is heterogeneous.

4. Soft drinks have a pH less than 7 on the pH scale. Which of the following statements about soft drinks is therefore correct?
   a) They are basic b) They are neutral c) They are acidic

5. Water striders are insects that are capable of walking on the surface of water. The water tends to bond to itself rather than wetting the insect's feet and the insect is light enough to remain on the surface of the water. What word or phrase best describes this behaviour of water?
   a) capillary action b) surface tension c) adhesion d) homogeneity

6. When water is a _____ it is the MOST dense.
   a) liquid b) gas c) solid

Student Handout

For the next 4 questions, classify each as: a) homogeneous mixture or b) heterogeneous mixture. Write a) or b) beside each question.

7. sandy water

8. coffee

9. soil

10. fruit salad