Name Period Date

15. Observing Freezing Point Depression

Making Popsicles

Driving Question

What happens to the temperature of liquids as they freeze?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ Temperature sensor
- ☐ Graduated cylinder or measuring cups
- ☐ Small beaker or cup
- ☐ Measuring spoons
- ☐ Spoon or stirring stick
- ☐ Balance
- ☐ Ice cube tray
- ☐ Plastic food wrap
- ☐ Common kitchen ingredients (salt, sugar, juice,
- ☐ food dye, et cetera)
- ☐ Distilled water, 200 mL
- ☐ Freezer or dry ice

Safety

Add this important safety precaution to your normal laboratory procedures:

- Wear safety goggles for the duration of this activity.

Thinking about the Question

You know that in science, substances can be classified by their phase or state of matter. A substance is either a solid, or a liquid, or a gas. Is there any such thing as “in-between” states of matter? What happens to a substance as it is going from the liquid state to the solid state?

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Can you describe what happens to water when it freezes into ice cubes? Does it all freeze instantaneously or does it freeze a little bit at a time? What happens if you fill the ice cube tray to the brim?

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Discuss with your lab group members the conditions that exist inside a freezer that make liquid water turn into solid ice. What happens if you add sugar and food coloring to the water before freezing it? Will it freeze the same as plain water? Discuss together how freezing plain ice cubes might be different from freezing homemade popsicles.

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Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**

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Make a small hole in the covering of the tray, and insert the temperature sensor.	Make sure each lab group member is aware of safety rules and procedures for this lab.	Connect the temperature sensor to the data collection system.	Place the ice cube tray into the freezer.	Fill one compartment of an ice cube tray with distilled water.

Investigating the Question

☐ **Note:** When you see the symbol "�" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

1. ☐ Sketch your prediction for the appearance of a temperature versus time graph of plain water as it freezes.

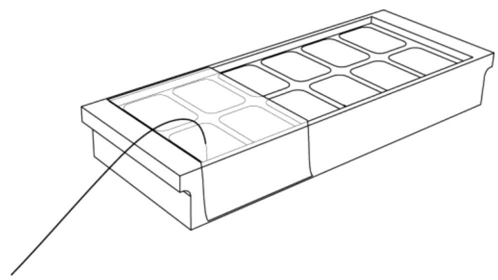
2. ☐ Sketch your prediction for the appearance of a temperature versus time graph of flavored or colored water as it freezes.

Part 2 – Testing the freezing water

3. ☐ Fill on compartment of the ice cube tray with distilled water.

4. ☐ Cover the end of the tray with plastic food wrap, so that the one filled compartment is covered.

5. ☐ Use the tip of your pencil or pen to punch a tiny hole right in the middle of the plastic wrap over the filled compartment. This is where you will insert the tip of the temperature sensor.



6. ☐ Start a new experiment on the data collection system. �(1.2)

7. ☐ Connect a temperature sensor to the data collection system. �(2.1)

8. ☐ Display Temperature on the y-axis of a graph with Time on the x-axis. �(7.1.1)(7.1.2)

9. ☐ Change the sampling rate to 1 sample per minute. �(5.1) Why it is it not necessary to sample the temperature every second in this activity? Why do you need to display this data as a graph rather than digits?

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10. ☐ Place the tip of the temperature sensor into the filled compartment of the ice cube tray.

11. ☐ Place your ice cube tray carefully into the freezer, and run the cord of the temperature sensor past the freezer's door seal. If you are using dry ice as your freezer, place your ice cube tray in the container of dry ice according to your teacher's instructions.

12. ☐ Begin recording temperature data. �(6.2)

13. ☐ Continue collecting data, while checking every few minutes to see if your water sample has frozen solid. Why is it so important to take just a quick look into the freezer and then close the door again?

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14. ☐ Stop recording temperature data as soon as your water sample has turned to ice. �(6.2)

15. ☐ Save your data. �(11.1)

Part 3 – Testing freezing water solutions

16. ☐ Choose one solid substance, such a sugar or salt, to dissolve in distilled water.

17. ☐ Use a measuring spoon to measure the amount of solid you will use. Record that amount.

    Amount of solid substance for solution1________________________

18. ☐ Use the graduated cylinder or measuring cup to measure the amount of distilled water you will use to dissolve the solid substance. Record that amount.

    Amount of distilled water for solution 1________________________

19. ☐ Mix the solid into the distilled water until the solid is completely dissolved. This is now Solution 1.

20. ☐ Fill one compartment of your ice cube tray with Solution 1.

21. ☐ Cover the end of the tray with plastic food wrap, so that the one filled compartment is covered.

22. ☐ Punch a tiny hole in the plastic wrap so you can insert the temperature sensor.

23. ☐ Set up to measure temperature exactly as in the first trial in Part II.

24. ☐ Place the tip of the temperature sensor into the filled compartment of the ice cube tray.

25. ☐ Place your ice cube tray carefully into the freezer, and run the cord of the temperature sensor past the freezer's door seal.

26. ☐ Begin recording temperature data. �(7.1.3) Note that this will be your second run of temperature data.

27. ☐ Continue collecting data, while checking every few minutes to see if your water sample has frozen solid.

28. ☐ Stop recording temperature data as soon as your water sample has turned to ice. �[6.2]

29. ☐ Save your experiment. �[11.1]

Answering the Question

Analysis

1. How did your predictions from Part I compare to the results from Part II? How closely does your predicted graph match what you actually recorded? What role did the pure water play in the experimental design of this activity?

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2. How did your predictions from Part I compare to the results from Part III? How closely does your predicted graph match what you actually recorded?

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3. Determine the freezing point of pure water and the freezing point of each solution tested. How do the freezing points compare?

Freezing temperature of pure (distilled) water: __________ °C

Solution 1 is made of ____________________________________

Freezing temperature of Solution 1: ____________ °C

4. Check with several other lab groups to see what types of solutions were made for Part III. Of the solutions made by your class, which had the lowest freezing point? Which had the highest freezing point? Which solutions do you think would make the tastiest homemade Popsicle®?

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Multiple Choice

☐ **Circle the best answer or completion to each of the questions or incomplete statements below.**

1. A mixture in which a solid substance has been dissolved in a liquid is known as

   A. A compound
   B. A solution
   C. Distilled

2. Which best describes a substance in the liquid phase?

   A. Indefinite shape, definite volume
   B. Indefinite shape, indefinite volume
   C. Definite shape, definite volume

3. Liquid volume is measured with which of the following?

   A. A test tube
   B. A balance
   C. A graduated cylinder

4. The point at which a liquid begins to change state and become a solid is known as the:

   A. Boiling point
   B. Freezing point
   C. Melting point

5. Which of the following could NOT happen?

   A. Distilled water freezing at -5^{o} Celsius
   B. A salt and water solution freezing at -5^{o} Celsius
   C. A salt and water solution remaining in the liquid phase at 0^{o} Celsius

6. A substance that is partly liquid and partly solid, but is becoming more and more liquid is said to be:

   A. Freezing
   B. In equilibrium
   C. Melting

7. Which term describes the amount of space an object takes up?

   A. Volume
   B. Mass
   C. Weight

8. Under normal conditions, at what temperature does pure water freeze?

   A. 0^o Celsius
   B. 100^o Celsius
   C. 32^o Celsius

9. Which is the best description of a substance in thermal equilibrium?

   A. A solid block of frozen ice that is being warmed in a pot on the stove.
   B. A container of water that is being heated up in a microwave oven.
   C. A glass of ice water in which the same amount of ice is melting as water is freezing.

10. Suppose you have three liquids and place an equal volume of each in a freezer. If liquid A freezes at 0^oC, while the other two do not freeze until they reach lower temperatures, which could be true of liquid A?

   A. It is distilled water.
   B. It is a solution of salt, sugar, coloring, and water.
   C. It contains no dissolved substances.