**Cooling Rate of Water**
Developed by Nicole Hume, 07/2017

**Teacher notes:**

This lab is designed to expose students to the Vernier equipment. It is a good opportunity to teach about controls and variables along with safety in dealing with hot liquid and hot glass. You can have students hypothesize which container will cool more quickly and why (surface area and insulators/conductors of heat). You can use it to teach graphing skills, as well.

There are 3 parts to this lab. You can choose which parts to use as time permits. Part 1 and part 3 deal with surface area and part 2 deals with insulators and conductors.

The teacher can heat water on a hot plate or in a hot water pot for students to obtain. Be sure to instruct them about the proper handling of hot glassware and how to use beaker tongs or hot hands mitts. Alternatively, students may be instructed to heat their own water, and the procedure amended accordingly.

If your students know how to graph, or you want to teach graphing, you can use this lab to cover those skills. Plot time on the x axis and temperature on the y axis and calculate the slope to find the rate of cooling. Alternatively, students may find the rate by dividing the overall change in temperature by time. You can adjust the procedure to match your objectives.

For part 3, you can crush the ice using a mortar and pestle. It will work better if you wrap the ice in a paper towel so it does not shift on you.

**2016 Integrated Chemistry & Physics Science Standards:**

ICP.4.4 Qualitatively and quantitatively analyze various scenarios to describe how energy may be transferred into or out of a system by doing work through an external force or adding or removing heat.

ICP.5.3 At the particle level, describe the relationship between temperature and the average kinetic energy of particles in the system and describe how a thermometer measures the temperature of a system.

ICP.5.4 Distinguish “temperature” from “thermal energy,” compare and contrast the Fahrenheit, Celsius, and Kelvin temperature scales, and convert temperatures between them.

ICP.5.7 Analyze a heating / cooling curve to describe how adding or removing thermal energy from a system changes the temperature or state of an object and be able to identify the melting and freezing temperatures of the system.

|  |  |
| --- | --- |
| **Science Express equipment to order** | **Other Materials** |
| Set of 12 Hot plates | ≈200mL TOTAL hot water per group (Parts 1 and 2) |
| Set of 6 Scout Pro Balances | Graduated cylinder – 50mL or 100mL |
| Set of 12 Vernier Temperature probes | Styrofoam cups (1 per group for Part 2) |
| Vernier Interface (Choose ONE): | Crushed and Cubed ICE (for Part 3) |
|  Set of 12 Laptops AND Set of 12 Go Links | Hot hands mitts or Tongs to handle hot glassware |
|  Set of 12 LabQuests | 3 beakers per group – 50mL, 150mL, 250mL\* |
|  Set of 12 LabQuest 2’s |  *\*Choose beaker sizes based on availability.* |
|  | Ring stand and clamp (for Temperature probes) |
|  | Small plastic cups (2 per group for Part 3) |

**Cooling Rate of Water – Part 1**

**Purpose**: To investigate the rate at which water cools and how this rate is affected by different variables.

**Materials:**Vernier temperature probes (2 per group)

Vernier interface (1 per group)

Ring stand and clamp (for Temperature probes)

≈100mL HOT water (per group)

1 Graduated cylinder per group (50mL or 100mL)

3 Beakers per group (50 mL, 150 mL, 250 mL)
Hot hands mitts or Beaker tongs

**Procedure:**

\*\*Caution: Hot glass looks just like cool glass. Do not touch a beaker on a hot plate with your hands. Be careful when transporting hot liquid. Follow your teacher’s instructions.

1. Set up your Vernier temperature probes. Set the data collection to collect data for 10 minutes, taking 2 samples per minute. The temperature probes can be clamped to a ring stand so that they do not tip over your beakers.
2. Using the 150 mL beaker, obtain about 100 mL of water from the hot water station set up by your teacher and carefully return to your station. Handle all glassware with hot hands mitts or beaker tongs as demonstrated by your teacher.
3. Measure out 45 mL of water and pour it into your 50 mL beaker.
4. Measure out 45 mL of water and pour it into your 250 mL beaker.
5. One partner will place the thermometers in each beaker of water, but do not start data collection yet.
6. When the temperature stabilizes, record the starting temperatures in the table below.
7. The other partner will click “collect” (green arrow) on the Vernier interface.

**Data:**

|  |  |  |
| --- | --- | --- |
|  | **50 mL beaker** | **250 mL beaker** |
| Starting temperature |  |  |
| Final temperature |  |  |
| Temperature change |  |  |

**Calculations:** Based on the chart, calculate the rate of cooling for both beakers as instructed by your teacher. Be sure to include units!

Cooling rate for the 50 mL beaker \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cooling rate for the 250 mL beaker \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Conclusion for Part 1:**

**Cooling Rate of Water – Part 2**

**Purpose**: To investigate the rate at which water cools and how this rate is affected by different variables.

**Materials:**Vernier temperature probes (2 per group)

Vernier interface (1 per group)

Ring stand and clamp (for Temperature probes)

≈100mL HOT water (per group)

1 Graduated cylinder per group (50mL or 100mL)

2 Beakers per group (150 mL and 250 mL)
Hot hands mitts or Beaker tongs

Styrofoam cup

**Procedure:**

\*\*Caution: Hot glass looks just like cool glass. Do not touch a beaker on a hot plate with your hands. Be careful when transporting hot liquid. Follow your teacher’s instructions.

1. Set up your Vernier temperature probes. Set the data collection to collect data for 10 minutes, taking 2 samples per minute. The temperature probes can be clamped to a ring stand so that they do not tip over your beakers.
2. Using the 150 mL beaker, obtain about 100 mL of water from the hot water station set up by your teacher and carefully return to your station. Handle all glassware with hot hands mitts or beaker tongs as demonstrated by your teacher.
3. Measure out 45 mL of water and pour it into your 250 mL beaker.
4. Measure out 45 mL of water and pour it into your Styrofoam cup.
5. Place the thermometers in each container of water, but do not start data collection yet.
6. When the temperature stabilizes, record the starting temperatures in the table below.
7. The other partner will click “collect” (green arrow) on the Vernier interface.

**Data:**

|  |  |  |
| --- | --- | --- |
|  | **Styrofoam cup** | **250 mL beaker** |
| Starting temperature |  |  |
| Final temperature |  |  |
| Temperature change |  |  |

**Calculations:** Based on the chart, calculate the rate of cooling for both the beaker and the Styrofoam cup as instructed by your teacher. Be sure to include units!

Cooling rate for the Styrofoam cup \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cooling rate for the 250 mL beaker \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Conclusion for Part 2:**

**Cooling Rate of Water – Part 3**

**Purpose**: To investigate the rate at which ice melts and how this rate is affected by different variables.

**Materials:**Vernier temperature probes (2 per group)

Vernier interface (1 per group)

Scout Pro Balances (1 per group)

Ring stand and clamp (for Temperature probes)

Crushed and Cubed ICE

Small plastic cups (2 per group)

1 Graduated cylinder per group (50mL or 100mL)

3 Beakers per group (150mL or 250mL)

**Procedure:**

1. Set up your Vernier temperature probes. Set the data collection to collect data for 10 minutes, taking 2 samples per minute. The temperature probes can be clamped to a ring stand so that they do not tip over your beakers.
2. Using a 150 mL beaker, obtain about 100 mL of tap water.
3. Measure out 45 mL of water and pour it into your first 250 mL beaker.
4. Measure out 45 mL of water and pour it into your second 250 mL beaker.
5. Using a balance, measure out about 50 g of cubed ice in an empty plastic cup. Record the actual mass of cubed ice in the table below. Then measure out about 50 g of crushed ice in an empty plastic cup. Record the actual mass of crushed ice in the table.
6. Place the thermometers in the beakers with water, but do not start data collection yet.
7. When the temperature stabilizes, record the starting temperatures in the table below.
8. One partner will pour the ice from each plastic cup into each beaker. The other partner will click “collect” (green arrow) on the Vernier interface.

**Data:**

|  |  |  |
| --- | --- | --- |
|  | **Water and crushed ice** | **Water and cubed ice** |
| Mass of ice in grams |  |  |
| Starting temperature |  |  |
| Final temperature |  |  |
| Temperature change |  |  |

**Calculations:** Based on the chart, calculate the rate of cooling for both the water and crushed ice and water and cubed ice as instructed by your teacher. Be sure to include units!

Cooling rate for the beaker with crushed ice \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cooling rate for the beaker with cubed ice \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Conclusion for Part 3:**