Water Boiling Point

Summary

This lesson allows students to investigate one of the properties of water, boiling point, through experimentation. This lesson can easily be adapted to fulfill the requirements for The International Boiling Point Project, a worldwide project where students across the globe measure the boiling point of water at their location and submit the data to The International Boiling Point Project website, where everyone participating in the project has access to the data.

Time Frame

5 class periods of 60 minutes each

Group Size

Small Groups

Life Skills

Thinking & Reasoning, Communication

Materials

- thermometer, can be liquid-in-glass or electronic and preferably should read °C (one per group)
- beaker, anywhere in the range of 250-1000 ml (one per group)
- 500 or 1000 ml graduated cylinder (one per group)
- hot plate or Bunsen burner (one per group)
- ring stand and bracket to hold thermometer (one per group)
- crushed ice (enough to fill one beaker per group)
- distilled water (enough to fill one beaker per group, five different times)
- data notebooks

Background for Teachers

The boiling point of water is highly dependent on atmospheric pressure. At sea level distilled water boils at 100 °C; as elevation increases, and thereby atmospheric pressure decreases, the boiling point of water decreases. This lesson tasks students with measuring the boiling point of water for the elevation of their school; in the process students are engaged in the scientific process, challenged to follow specific experimental procedures in order to collect accurate data, and observe the phase change of water from a liquid and to a gas. If desired, and if all experimental procedures are followed correctly, students can post data for their school on an international website that allows comparison of water boiling point temperatures from around the world.

Student Prior Knowledge

- Ability to measure water temperature with a thermometer.
- Ability to measure a specific water volume with a graduated cylinder.
- Ability to use a hot plate or Bunsen burner to boil a beaker of water.
- Understanding that boiling is the process where a liquid is converted to a gas via input of energy to the liquid molecules.

Intended Learning Outcomes

1. Use Science Process and Thinking Skills

a. Observe objects and events for patterns and record both qualitative and quantitative information.
d. Select the appropriate instrument; measure, calculate, and record in metric units, length, volume, temperature and mass, to the accuracy of instruments used.
e. When given a problem, plan and conduct experiments.
3. Demonstrate Understanding of Science Concepts and Principles
a. Know and explain science information specified for their grade level.
d. Solve problems appropriate to grade level by applying scientific principles and procedures.

Instructional Procedures

If boiling point data is to be submitted to The International Boiling Point Project Website, this lesson requires five class periods of one to two hours, where the final three periods must be on consecutive days. If not, this lesson can be accomplished in two class periods. The experiment should be preceded by a clear outline and discussion of the experimental procedure, particularly if boiling point data is to be submitted to The International Boiling Point Project website. Students should work in small groups (two to four students per group). Each day of the experiment, the same group of students should work at the same lab station with the same equipment. Before performing the experiment, students should be engaged in a discussion of potential variables influencing the boiling point of water: elevation, amount of water, initial water temperature, room temperature, heating device. Following discussion, students should write a hypothesis for the variable that has the greatest impact on water boiling point.

Experiment

Day 1: Thermometer Calibration

Determine elevation of the school. A GPS or local topographic map can be used to find elevation, or a specific zip code can be entered into the National Weather Service Forecast webpage in order to determine elevation (http://forecast.weather.gov/MapClick.php; other websites are also available).

Thoroughly clean beaker with dish soap, rinse well with distilled water.

Fill beaker with crushed ice and distilled water. Smaller pieces of ice work better than larger pieces; snow works particularly well if it is clean. The goal is to make slush, similar to the consistency of a snow cone.

Insert thermometer in the slush and record the temperature. The slush temperature can be assumed to be 0 °C.

Derive a correction factor based on the slush temperature measurement and record data. For example, if the thermometer read 0.2 °C in the slush, the correction factor is -0.2 °C, meaning 0.2 °C should be subtracted from all subsequent water temperature measurements; and if the thermometer read -0.2 °C in the slush, the correction factor is 0.2 °C, meaning 0.2 °C should be added to all subsequent water temperature measurements.

Remove thermometer from slush and empty slush from beaker.

Day 2: Water Boiling Point Measurement -- Practice Run

Select a volume of water to boil and record data; volume must be between 250 and 750 ml in order to post data to The International Boiling Point Project website and each group should use the same water volume each time the experiment is conducted.

Evaluate current weather conditions (clear, partly cloudy, overcast) and record data.

Use graduated cylinder to measure selected volume of distilled water and pour it into beaker.

Place beaker on hot plate or over Bunsen burner.

Measure laboratory air temperature with thermometer and record data.

Insert thermometer into the bracket connected to the ring stand; submerge thermometer in water. Thermometer should be suspended in the water at least 1 cm above the bottom of the

beaker; it should not touch the bottom or sides of the beaker.
Measure initial water temperature with thermometer and record data.
Turn on hot plate or Bunsen burner to begin heating water. If hot plates or burners have adjustable heat settings, 400-500 °C is a reasonable temperature.
Record temperature every minute; boiling point is reached when the temperature reaches a constant value. It is a good idea to have students plot data as it is collected; this allows them to visually determine the boiling point from a graph of their data.
Once boiling point is reached (defined as the point where the water temperature no longer increases, but remains constant for 5 minutes), remove thermometer from water and turn off hot plate or Bunsen burner. Allow time for water to cool before dumping it out of the beaker.

Days 3-5: Water Boiling Point Measurement

Repeat steps 2-10 from day 2. Students should not need to graph data following the practice run, as they should now have an understanding of the boiling point.
After data have been collected on days 3-5, each group should average the water boiling point for the three days. If data are to be submitted The International Boiling Point Project website, a class average boiling point, initial water temperature, and room temperature should be calculated.

Extensions

Students should make the connection between air pressure and boiling point. At sea level, there are more molecules in a given volume of air (higher air density) than at higher elevations. At higher air density, more energy (more heat -- higher temperature) is required for water to change phase from a liquid to a gas, meaning more energy is required for water molecules to evaporate.

Assessment Plan

Students should create a data graph (x-axis: time since the hot plate or Bunsen burner was turned on, y-axis: water temperature) that clearly presents the results of their experiment from day 2. The graph clearly illustrates when the boiling point is reached, as the temperature will increase until the boiling point is reached, at which temperature will remain constant (within approximately 0.2 °C). Students should create a data table that clearly presents the results of their experiment from days 3-5, including boiling point temperature, initial water temperature, air temperature, weather conditions, and average measurements for each variable (calculated from data collected by the entire class). Each individual student should use the average measurements to test their own hypothesis. Students should write a brief "lab report" that provides interpretation of the results and discussion of results in relation to their hypothesis.

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