Title of lesson plan
Temperature and Pressure

Length of lesson
One to 2 class periods

Grade level
6–8

Subject area
Physical science

Credit
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Objectives
Students will understand the following:

1. The relationship between temperature and pressure
2. How to collect data and graph the relationship between pressure and temperature
3. How to compare the information collected between both Fahrenheit and Celsius temperature scales

Materials
For this lesson, you will need:

- Two Celsius and 2 Fahrenheit thermometers (0.1 degree increments preferred)
- Two clear, plastic, 20-ounce bottles of carbonated soft drink at room temperature
- Two 2-hole rubber stoppers (the right size to fit the opening of the soft drink bottle used in this study)

- One Temperature and Pressure Data Sheet for every student (click here to print)
- Two pieces of graph paper for every student, one to chart Celsius measurements and one to chart Fahrenheit
- Ruler

Procedure

1. Divide students into small lab groups. Explain that they will be collecting data on the relationship between pressure and temperature. Each lab group should have 2, clear, 20-ounce bottles of a carbonated soda; two 2-hole rubber stoppers that will fit the opening of each of the soft drink bottles; and 2 Celsius and 2 Fahrenheit thermometers. Each student should have a copy of the Temperature and Pressure Data Sheet to record her or his findings.

2. Briefly explain the experiment. Students will be shaking a half-full carbonated drink to increase the pressure within the bottle. They will shake it twice, 4 times, 6 times, and so on, recording the change in temperature after every 2 shakes. Students will be performing this experiment 2 times, first using a Celsius thermometer and a second time using a Fahrenheit thermometer. They will be recording the data on their data sheet, then creating graphs with the recorded data.

3. Make sure to follow proper safety precautions and guidelines outlined in science texts. Have students carefully insert one of the Celsius thermometers into one hole of a 2-hole rubber stopper. Push the thermometer until 2 to 3 inches of it extend below the stopper bottom.

4. Note the room temperature. Now gently open one of the carbonated soda bottles. Try to lose as little of the carbonation in the liquid as possible. Insert the second Celsius thermometer into the carbonated drink to determine if the soda is at room temperature. It is important for the purposes of this lesson that the soda is at room temperature before the experiment begins. Remove thermometer and set aside.

5. Now slowly pour out half the beverage. Again, try not to lose any of the carbonation.

6. Carefully insert the rubber stopper with the thermometer into the top of the bottle of soda. Make certain the stopper is seated firmly in place and the thermometer tip **is not** touching the liquid inside the bottle. Observe the temperature on the thermometer and record it on the Temperature and Pressure Data Sheet.

7. Firmly cover the second hole of the rubber stopper with one finger. Pick up the bottle of soda and vigorously shake it **twice only**. Set the bottle on a flat surface

and observe the temperature and record it on your Temperature and Pressure Data Sheet. IMPORTANT: Be sure to **keep your finger over the second hole of the rubber stopper** so you do not lose any pressure built up inside the bottle.

8. Pick up the bottle once again and shake it **2 more times**. As before, make sure you do not remove your finger from the second hole. Place the bottle on a flat surface and observe and record the temperature. Continue to shake the bottle twice and observe and record temperature until no further increase is observed. Carefully and slowly remove your finger from the covered hole of the rubber stopper.

9. Have students open the second bottle of soft drink and repeat steps 3 through 7 using a Fahrenheit thermometer. It is important to use a new bottle because of the loss of carbonation during the Celsius measurement.

10. When they have finished gathering their experimental data, pass out 2 sheets of graph paper to each student so she or he may begin plotting her or his data. Explain that students will create one graph to represent pressure and Celsius data, and one for pressure and Fahrenheit observations.

11. Have students graph their data by labeling the x-axis on their graph with the number of shakes of the soda bottle, representing pressure. Have students label the y-axis on their graph with degrees. (One graph will show degrees Celsius and the second graph will show degrees Fahrenheit.) Make sure the graph fills as much of the page as possible and that students title their graphs.

12. Ask students to plot the data points from their data tables on their graphs and draw a line connecting the points.

13. Compare the results of Celsius and Fahrenheit data sheets and graphs.

Adaptations for older students

- High school students might choose to use computer lab probes available in some high school science labs. They could then record the actual pressure changes and resulting temperature changes as the pressure builds and then as it is released.

- If computer probes are not available, high school students can vary the conditions of the procedure in 2 ways. Students can experiment with bottles at room temperature and bottles that have been chilled. When they have completed their lab, students can write a short explanation of why the varying starting temperatures affected the results of the experiment. This explanation should be based on the concept of gas solubility and its correlation with temperature.

- Students can also vary the procedure by using bottles of carbonated beverage that are at room temperature but have different volumes. Prepare one set of bottles half filled with liquid and one set one-quarter or three-quarters filled. At the end of the experiment students can provide a short explanation of why the results were different for the different volumes of liquid used in the experiment. This explanation should be based on the fact that gases expand to fill containers, and that pressure is a force per unit area.

- To economize class time these variations can be done using only the Celsius temperature scale. Graphs for both sets of data (room temperature and chilled carbonated beverage; half-filled bottles compared with another volume determined by instructor) can then be plotted on the same set of axes for easier comparison.

Discussion questions

1. Which results had a greater number of degree temperature changes in your lab: the Celsius or Fahrenheit measurements? Does this have any effect on the resulting graphed data? Why?

2. How might the amount of beverage in the container have an effect on temperature changes during this exercise? Would the type of carbonated beverage have an impact on the results? Why or why not?

3. Consider the concept that pressure, volume, and temperature are all related. What can be concluded about this relationship based on the lab just completed?

4. Consider the concept that an increase in pressure causes an increase in temperature. How does this relate to the making of a snowball?

5. Ice skates work because of the same principle—an increase in pressure causes the temperature to increase. Explain what actually happens to the ice at the point of contact between the ice skate blade and the ice itself. Is it possible that ice could be so cold that ice-skating would **not** be possible? Explain.

6. Why don’t basketballs feel warm? After all, they contain air under pressure.

Evaluation

Ask students to consider the following and write a response: If you have ever released air from any pressurized container, such as a tire, you might notice that the air doesn’t feel warm at all. Based on the principle that pressure generates heat, come up with an explanation for why the air released from a tire is **not** warm but is in fact cool.

You could also create a rubric based on student participation, accuracy in collecting and graphing data, and the final response paper:

- Contribution to the group exercise (1 to 4 points)

- Accuracy in collecting data on data sheet (1 to 4 points)
- Graphing the data (1 to 4 points)
- Response paper (1 to 4 points)

Extensions

Solar Effects on Thermal Expansion

Pick several different balloons of different colors. Choose a few with dark colors, such as black, dark blue, or purple, and a few with light colors such as white, yellow, or pink. In a cool location, inflate the balloons so that they are of nearly equal size. This can be accomplished by looping a string around the balloons as they are being inflated to measure their circumference. Next, take the balloons outside to a bright, sunny location and allow the sun to heat them up. Then record the circumference of the balloons. Is there any difference between the original, cool circumference and the warm circumference? What does this example reveal about volume and temperature relationships? Was there a difference between the light and dark balloons?

Hot Air Balloons

Divide students into groups and have them try this experiment: Pick a thin-walled plastic bag, like the dry cleaning bags used to cover freshly cleaned garments. At the top of the bag, where the hanger usually extends, tape the opening closed with transparent tape. Lay the bag flat and measure the width of the bottom opening (the side opposite the end just taped shut). Double this measurement and use your result to cut a length of wire. After cutting a length of wire, form it into a hoop that will neatly fit inside the bottom of the plastic bag. At the very bottom edge of the bag, use transparent tape to attach the wire hoop to the inside edge of the bag. (By using small pieces of tape attached every 6 inches, the wire hoop will be sufficiently held in place.) The wire should now hold the bag open. Now, carefully hold the bag by the top so that the hoop at the bottom is just off the floor. Have another member of your group turn on a blow dryer to the cold setting and aim it into the plastic bag, inflating it. Release the bag and observe what happens. Next, inflate the same bag only this time using the blow dryer set on the hottest setting. Again, allow the bag to inflate fully, and then release the bag. Observe what happens this time. What does this experiment demonstrate concerning the differences in the density of air in both situations?

Suggested readings

Science Projects About Heat and Temperature

Robert Gardner and Eric Kemer. Enslow Publishers, 1994.

This book is full of projects that demonstrate the science behind heat and temperature. You’ll find out the difference between the 2, learn how to create several different thermometers, and find out what causes heat and how to measure it.

Molecules and Heat
Robert Friedhoffer. Franklin Watts, 1992.
The author of this book uses everyday examples of heat and the behavior of molecules to explain the underlying scientific principles. Simple experiments and magic tricks that anyone can do illustrate everything from molecular motion to the conduction of heat.

Web links
Welcome to the Pressure Chamber
Watch those pressure gauges while changing the temperature of a confined gas, and try not to blow yourself and the lab up in the process of using this online simulation to learn about the ideal gas laws.
http://jersey.uoregon.edu/vlab/Piston/index.html

Temperature and Absolute Zero
How low can the temperature go? This interactive text and its animations will help you to extrapolate a theoretical value for the lowest possible temperature, a temperature that you would have a snowball's chance in Tahiti of ever experiencing first hand.
http://www.colorado.edu/physics/2000/bec/temperature.html

Vocabulary
carbonate
To charge (a beverage, for example) with carbon dioxide gas.
Context:
Soft drinks are often carbonated, giving them a fizz when poured into a clear container.

circumference
The perimeter of a circle.
Context:
Magellan attempted to sail around the circumference of the Earth.

control
An individual or group in an experiment for which the procedure or agent being tested is omitted; this group is then used as a standard to compare the results of the other groups.
Context:
In this experiment we need a control group with which to compare our results.

density
The quantity of something per unit measure, especially per unit length, area, or volume.
Context:
One difference between lead and aluminum is that lead has a higher density than aluminum.

pressurize
To confine the contents of a pressure greater than that of the outside atmosphere.
Context:
The air inside a car tire needs to be pressurized to the proper level for the best level of handling and wear.

transfer
To convey or cause to pass from one place, person, or thing to another.
Context:
The newly formed government received an uninterrupted transference of power from the old governing power.

Academic standards

Grade level
6–8
Subject area
Science

Standard
Understands energy types, sources, and conversions, and their relationship to heat and temperature.

Benchmarks
Knows that energy is a property of many substances (e.g., heat energy is in the disorderly motion of molecules and in radiation; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; electrical energy is in the attraction or repulsion between charges).

Grade level
9–12
Subject area
Science

Standard
Understands energy types, sources, and conversions, and their relationship to heat and temperature.

Benchmarks
Understands the relationship between heat and temperature (heat energy consists of the random motion and vibrations of atoms, molecules, and ions; the higher the temperature, the greater the atomic or molecular motion).

Grade level
6–8
Subject area
Science

Standard
Understands energy types, sources, and conversions, and their relationship to heat and temperature.

Benchmarks
Knows that heat can be transferred through conduction, convection, and radiation; heat flows from warmer objects to cooler ones until both objects reach the same temperature.

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