

Shrinkage- Circumference of a balloon at cold temperatures

Grade 5

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References:

- www.harcourtschool.com/activity/states_of_matter/index.html

Benchmarks & Objectives:

PS-1: Define temperature as the measure of thermal energy and describe the way it is measured.

PS-2 Trace how thermal energy can be transferred from one object to another by conduction.

Materials:

- Balloons
- String
- Meter/Yard stick
- A cold day

Initial Demonstration:

Visit this website on an overhead projector or in small groups around computers (www.harcourtschool.com/activity/states_of_matter/index.html). This website briefly compares the atomic motion of solids, liquids and gases. It does so with words as well as images. The key message from this is that materials have thermal energy; the atoms vibrate and the amount of vibration results in different phases. The website does a good job of tying this thermal energy (vibration) with the measure of Temperature. Hot gases take up more space while cool gases take up less space.

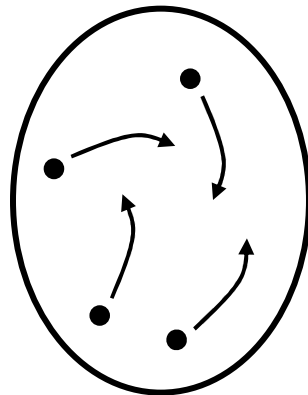
Procedure:

1. Have students break up into pairs.
2. Each group should have a balloon and a piece of string about a yard long.
3. Have the students blow up the balloon and tie a knot. Emphasize that the amount of air in the balloon (number of atoms) does not change.
4. Place a thermometer inside and outside. Make sure the thermometers are accessible to the students.
5. Demonstrate how to wrap the string around the center (equator) of the balloon. Next show how to pinch the string, stretch the string out along a ruler, and measure the circumference of the balloon. It is very important that the string not squeeze the balloon. The string should be just tight enough to fit snugly around the balloon, without making an impression in the balloon.
6. Have the students make three measurements of the balloon's circumference.
7. Have the students measure the temperature of the balloon.

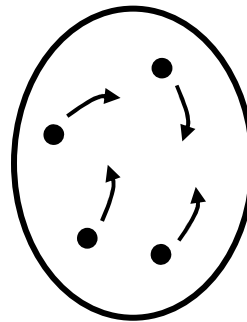
8. Have the students label the balloons. Next, collect the balloons in a large trash bag and take the trash bag outside to cool for 15 minutes.
9. Go outside and repeat steps 6-7 outside.
10. Come inside and compare the measurements. They should be smaller outside because the cold air has less thermal energy and the atoms take up less space; the balloon should contract. (You can do a simple calculation with the ideal gas law $PV = NkT$, the volume of a sphere $V = (4/3) * \pi * r^3$, the circumference of a sphere $C = 2 * \pi * r$, and the temperatures in Kelvin of a cold day [261 K] and room temperature [294 K]. It turns out that the circumference should only change by about 5%: $C_{\text{cold}} = 0.961 * C_{\text{warm}}$)

Discussion:

1. (Explain) Why did the balloon get smaller outside? (It is cold outside. The temperature is low which means the air does not have as much thermal energy. As a result the atoms do not vibrate as much and the cold air takes up less space. The balloon contracts)
2. (Explain) Label or draw the atoms inside the balloon outside in the cold, and inside where it is warm.



[WARM]



[COLD]

3. (Expand) Does this explain why hot air balloons float? (Yes, hot air balloons are filled with hot air, since it takes up so much space, and weighs the same amount it is less dense, and it floats)
4. (Expand) If you were to keep cooling the air inside the balloon to extremely cold temperatures, could the gas turn into a liquid? (Yes, it would; one can do a demonstration with liquid nitrogen!)

Science Activity- Cooling a Balloon

Name_____

Temperature Inside

Fahrenheit_____

Celsius_____

Circumference of Balloon Inside

Measurement 1_____

Measurement 2_____

Measurement 3_____

Temperature Outside

Fahrenheit_____

Celsius_____

Circumference of Balloon Outside

Measurement 1_____

Measurement 2_____

Measurement 3_____

Questions

1. (Explain) Why did the balloon get smaller outside?
2. (Explain) Draw two pictures of the atoms inside the balloon, when it was warm, and when it was cold.
3. (Expand) Why do hot air balloons float?
4. (Expand) If you were to keep cooling the air inside the balloon to extremely cold temperatures, could the gas turn into a liquid?