Chapter 7. Does Air Have Weight? How Do You Know? A Structured-Inquiry Activity

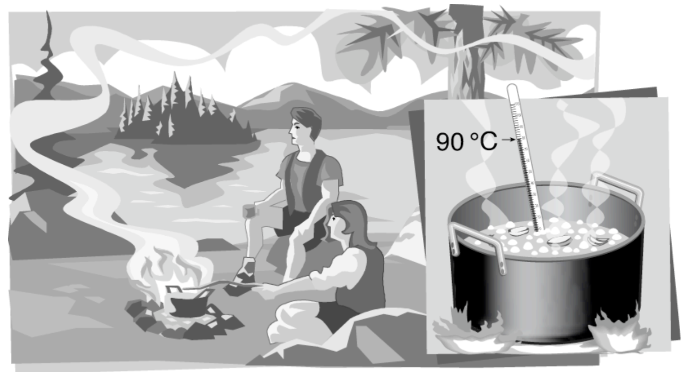
Think About This!

What is the boiling point of water? Can this question be answered with a short answer? Why? Why not?

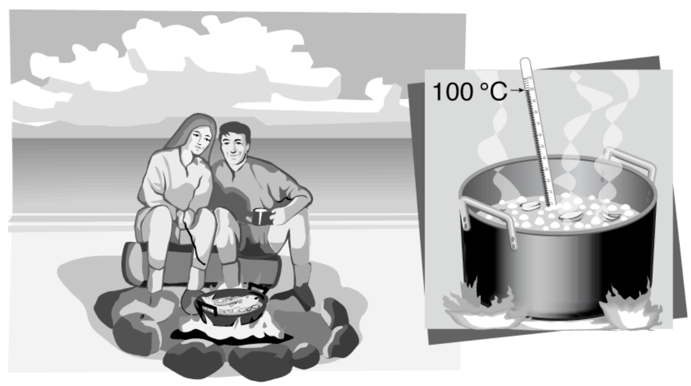
Do you think it is possible to put your hand in boiling water and not be burned? Why? Why not? DO NOT ATTEMPT TO DO THIS!!!

Campers at high elevations (Figure 7-1) who try to cook food (like potatoes) in an open container often discover that the food does not completely cook, although the water boils. How might you explain this? Sometimes campers at high elevations cook their food in pressure cookers. What mechanism might help explain the reason that pressure cookers cook food more completely at these elevations than an open container?

What does the term "boiling point" mean? Does it have anything to do with the change of state of materials (solid, liquid, gas)? How does atmospheric pressure affect this process?



At 3 km (10,000 ft)



At sea level

Figure 7-1. Boiling point decreases with increase in altitude.

Probing Further

What changes would you expect in the recording of your barometer if you were to take it up the various levels of elevation? Why?

The purpose of the following activity is to verify that air has weight and that this fact can be concretely illustrated. Eventually and through more experience gained by conducting mind-engaging activities, the learner should come to a basic understanding that a given volume of air at higher elevations is less dense (weighs less) and has fewer molecules per volume than a similar volume at lower elevations.

NOTE: A complicating factor that needs to be explored is that air usually becomes cooler (more dense) at higher elevations. See Appendix V for more information on boiling point.

Materials

1 piece of wood for base

2.5 cm thick × 5 cm wide × 30 cm long
(1 in. thick, 2 in. wide, 12 in. long)
1 piece of wood for pivot

2.5 cm thick × 2.5 cm wide × 30 cm long
(1 in. thick, 1 in. wide, 12 in. long)

2 rubber balloons

2 large paper clips

Ruler (wood or plastic)

Small nail with large head

Hammer

Tape

Objectives for the Learner (Essentials of Inquiry)

Conceptual Theme: To develop a basic understanding of the change in the position of a bar balancing a balloon inflated with air on one end and a noninflated balloon on the other end, and the cause for this change.

Content: Developing basic information about the weight of air and its basic importance to understanding meteorology.

Skills: The focus is on the handling of laboratory equipment, making careful observation, describing weight differences, drawing conclusions, and describing and communicating results.

Scientific Habits of Mind: The importance of careful observations, respect for data, and verifying results.

Preparation

Nail the 1-inch-wide piece of wood to the center of the 2-inch-wide piece of wood at a 90° angle.

Make a hole in the center of the ruler, large enough to allow the ruler to move freely once attached.

Place a nail through the hole at the center of the ruler and, using a hammer, attach it to the top center of the 2-inch piece of wood, creating a pivotal balance.

Bend the two paper clips so that the larger ends hook over and slide easily along the ruler. The smaller ends of the paper clips will serve to attach the balloons.

Place the paper clips at each end of the ruler and bring to a balance.

Next, hook the neck of each deflated balloon on the small ends of the paper clips on either side of the pivotal balance, and again bring to a balance.

Use a piece of tape to hold the pivotal arm in place (as shown in Figure 7-2) and remove one of the balloons.

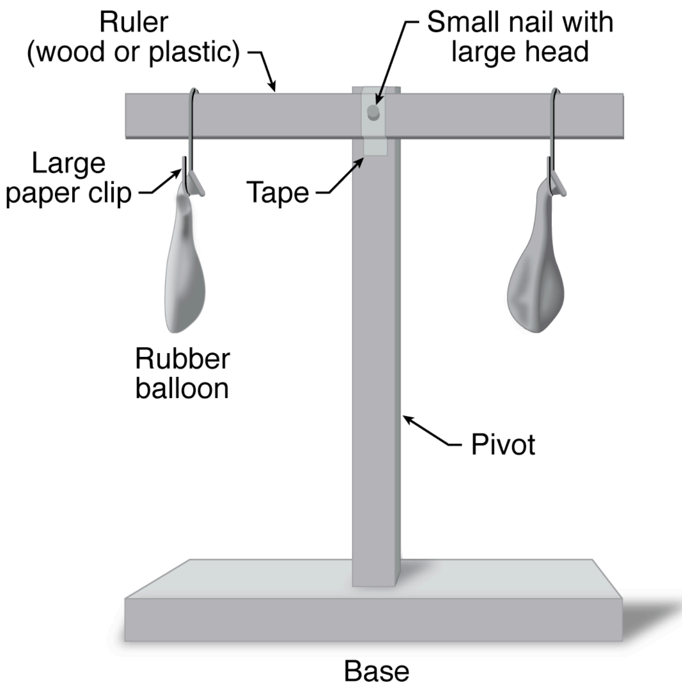


Figure 7-2. Experiment setup.

Inflate this balloon and reattach it to the pivotal arm. Remove the tape.

Observe the results (Figure 7-3).

Figure 7-3. Experiment results.

Examining Results

The purpose of this activity is to help the learner verify that air has weight.

Describe your observations relating to the beginning and the end of this investigation.

In what way do you view the weight of air influencing the understanding of meteorology?

What do you think was the most important change that you observed in this investigation? Why do you feel this is the most important change?

Why is it important to bring the two deflated balloons to a balance before proceeding with the next steps of this investigation?

What do you understand to be the most important outcome of this investigation? Why?

Conclusion

After conducting this investigation, what did you conclude about air having weight?

What data (observation) enabled you to arrive at this conclusion?

What is the most important factor in verifying this conclusion for you?

Going Further

Can you suggest additional investigations that could be used to further verify that air has weight?

Challenge

How could you determine if cooler liquids weigh more than warmer liquids?

Background for the Teacher

This activity facilitates the understanding of air having weight. The deflated balloons achieved a balance when placed on the pivotal balance. However, when one balloon was removed, inflated, and placed back at the same location, the balance was disrupted, thus indicating that the inflated balloon has additional weight caused by the air inside. While the barometer activities indicate that cooler air contracts and warmer air expands by the action of the rubber balloon, they also firmly verify that cooler liquids or gases weigh more than warmer liquids or gases.

Boiling can take place when the vapor pressure of the water vapor, at the temperature of boiling, equals that of the overlying atmosphere. At higher altitudes, the air is less dense. Thus, there is less weight of air in the column of atmosphere above the liquid, and it is easier for the water vapor to "escape" from the liquid (i.e., boil). Water does not have to be at 100 °C (212 °F) to boil at high altitudes. It can boil at 90 °C (201 °F) at 1.5 km (6000 ft), but boiling at 90 °C does not cook it as thoroughly. Therefore, at high altitudes, to get the food "done," you have to boil it longer, or use a pressure cooker.

NOTE: *Pressure caps on car radiators allow the water to be 230 °F or higher. Above 19.2 km (63,000 ft) altitude, your blood would boil if you were not in a pressure suit.*