Category V Physical Science Examples

Guiding student interpretation and reasoning

Material C
This program is designed for five years—three years of middle school and the first two years of high school. Typically, in the middle school materials, a general question is typically posed at the end of an activity in the student book asking what the activity showed or what conclusions one might draw from it. The questions are not specific enough to help students connect their observations to the ideas the lesson is trying to develop or to their own ideas. For example, students are asked to put a tea bag with tea in it into water and observe what happens to it (Level C, p. **56s**). Students tear open a tea bag and examine with a microscope the paper it is made from. A *single* question is provided ("What does this suggest to you about the bits of tea that spread out in the water?") to guide student interpretation of the activity. The question is too general to help students connect what they observe to the idea the activity is trying to develop ("the particles of dissolved solids are too small to be seen").

In several instances, the middle school materials require students to make big leaps from observation to inferences. For example, in Level C, Chapter 3: Gulp!, students do some activities that show a solid residue (calcium carbonate) is left when tap water evaporates (p. **53s**). The *Teacher's Guide* (p. **130t**) suggests that "In discussion of the results the students *can see that* the solid residue must have come from the water, which had tiny particles of the dissolved substance spread out through it." This is the first introduction to the notion of tiny particles in this chapter. Not only is this too big a leap from observation to inference, there are no questions that engage students in considering this phenomenon using the particle theory in the student book.

The high school materials in some instances include relevant questions to help students make sense of readings and activities related to the kinetic molecular theory (Level I, p. **316s**). However, in other instances they do not (Level I, p. **320s** "getting an airing").

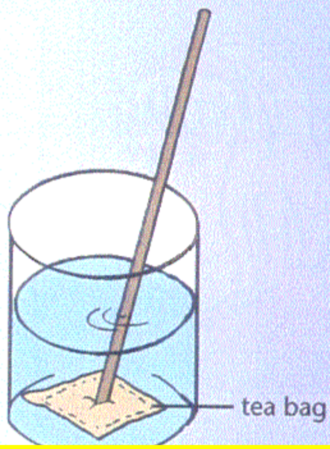
Making drinks

What happens when you make a drink?

You often make something to drink by adding a flavoring to water to make it more interesting. The activities on these pages involve the process of making drinks. As you start each activity, concentrate on collecting your evidence and then discuss your ideas about what is happening. Eventually you should develop your understanding of some theories that will help you explain the evidence.

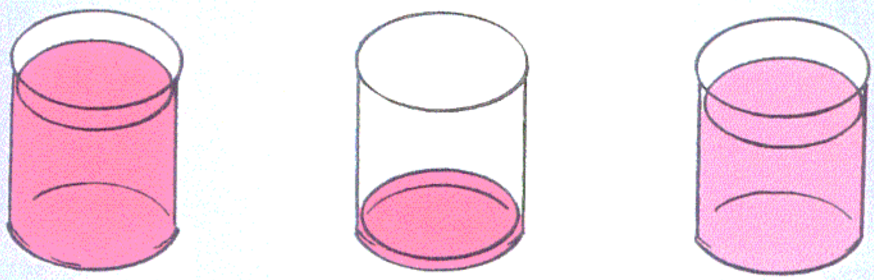
What happens when you make tea?

- Fill a large beaker halfway with cold water.
- Put a tea bag into the water and use a glass rod to hold it on the bottom of the beaker. Do not stir the water.
- Watch what happens and record your evidence.
- Determine how the rate at which the tea spreads out is influenced by the temperature of the water.
- Tear open a tea bag and, using a microscope, look at the paper it is made from.



? 1. **What does this suggest to you about the pieces of tea that spread out in the water?**

How far will your drink spread out?



- Make 100 mL of a colored drink. Make the color fairly strong.
- Measure out 10 mL of the drink and pour it into another 100 mL beaker. Add 90 mL of water for a total of 100 mL in the second beaker.
- Keep doing this until you cannot see the color of the drink.

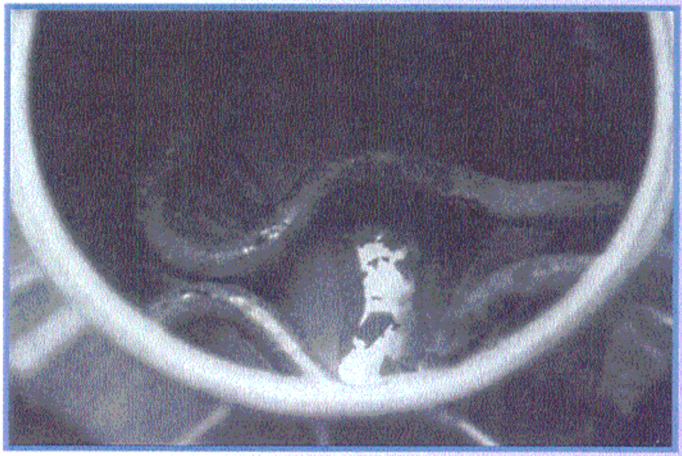
? 2. **If you had diluted all the original drink in each step, instead of just 10 mL of it, what would be the final volume of the drink? What do you think is happening when you dilute a drink?**

3. **Do substances that give drinks flavor and color spread out faster in hot or cold water? What do you think is happening when the drinks are made?**

Is tap water pure?

Tap water is safe to drink. It looks clean, and harmful bacteria have been removed. But is it pure?

- Put a few drops of water on a microscope slide. Evaporate the water by leaving it in a warm place. The "scale" or "lime scale" that forms on the microscope slide is calcium carbonate (the chemical name for limestone).



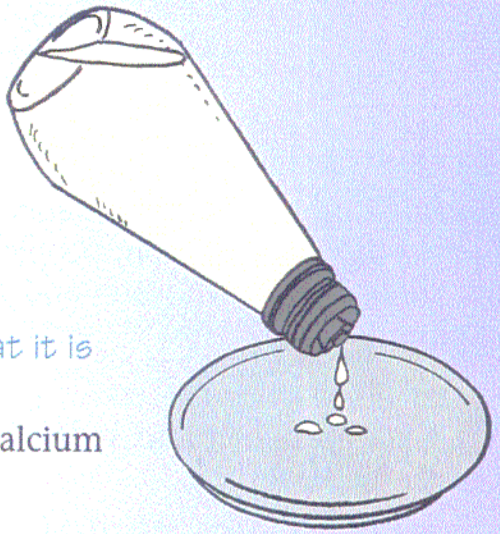
The inside of the teakettles in many parts of the country becomes coated in scale.

If you have scale in your teakettle at home, you can test to show it is limestone.

- Add vinegar to a small piece of scale. Vinegar is acidic, and limestone fizzes when an acid is added to it.

The mixture fizzes because the gas **carbon dioxide** is given off.

- Try to find out how you could test the gas to check that it is carbon dioxide.



The "scale" or "lime scale" that forms in the teakettle is calcium carbonate.

BACKGROUND

Lab work 1
20 minutes

Student Book pages 52-53
Pure Water?

Students place a few drops of water on a glass slide and leave it in a warm place. If the local tap water supply is hard, then it may be used. If the local water is very soft, more convincing results may be obtained by using water that has been stirred with calcium sulfate before use, then decanted, leaving any undissolved solid behind.

In discussion of results, students can see that the solid residue must have come from the water, which had tiny particles of the dissolved substance spread out through it.

If a teakettle with scale is not available, coarsely crushed chalk (calcium carbonate) may be tested. However, it adds conviction if scale can be scraped out from a kettle in front of the class for testing.

Addition of dilute acid to "kettle scale" causes it to fizz (this is a positive reaction for the presence of carbonate, because the acid reacts with this compound to release carbon dioxide gas, which fizzes). If students are not already familiar with the limewater test for carbon dioxide, demonstrate this test.

A spatula-tip of "kettle scale" is placed in a test tube. Have another test tube ready containing about 2 cm depth of limewater. Add about 2 cm depth of dilute acid to the kettle scale and immediately connect a rubber tube leading into the limewater.

Note that the first few bubbles to pass will simply be displaced air, so it may take a few moments for the limewater to become cloudy. If too much carbon dioxide is passed, the limewater may go clear again. Students are instructed to watch carefully, and take any sign of cloudiness as a positive result.

Warn students not to attempt to repeat this test at home unless they have explained to their parents what they propose to do and have obtained permission. Also warn them not to attempt it unless the kettle is both disconnected and cold, and to be careful not to damage the kettle when trying to loosen scale, which may often be firmly attached.

Answer to Student Book page 52:
"Pure" means safe to drink. "Chemically pure" means no other substances are present.

Lab work 2
20 minutes

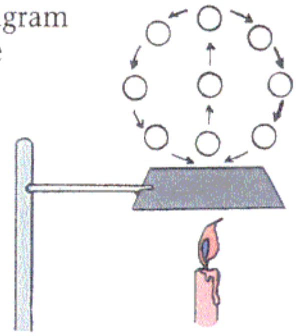
Student Sheet 4a
A Scaly Problem

In the previous test, the water was separated from the dissolved solid, but was lost into the atmosphere. Students may be asked how they could catch the pure water that evaporated.

Students carry out distillation on a small scale as shown on Student Sheet 4a. Water containing a few drops of ink may be used. Add a few boiling chips or pieces of broken crucibles (porcelain) to the flask to reduce the likelihood of "bumping" (sudden boiling). Advise students to heat gently.

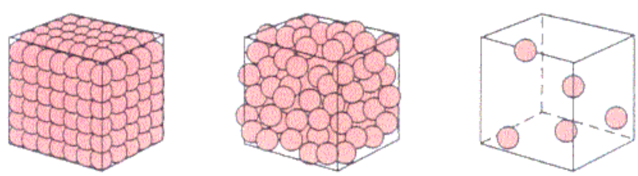
Why does warm air rise?

Here is a diagram showing the path that some soap bubbles took when they were blown over a hot surface.



The bubbles rise for awhile, but then they slowly fall towards the fire only to be carried upwards again. It is sometimes helpful to picture materials as being made up of very small molecules.

1. Which of these three pictures best represents how the molecules are arranged in a gas? Explain your answer.



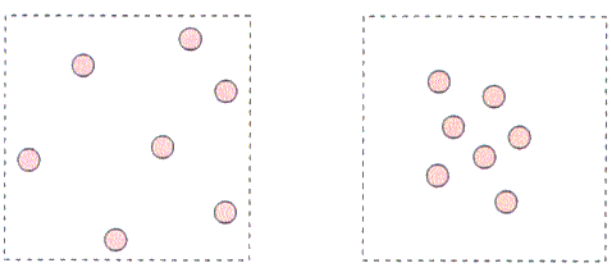
A B C

2. Finish this sentence choosing words from the following list to fill in the blanks.

   slower faster smaller greater

   When a substance is heated, its molecules move ______________, and the distance between the molecules becomes ______________.

3. These two pictures represent seven molecules in a sample of air before and after it is heated. All other conditions remain the same. Which do you think is the hot air? Explain your answer.



D E

4. Place a quarter on an index card and trace the outline of the quarter. Cut out the circle on the index card and place the circle over the air molecules in diagram D (try to get as many molecules in the circle as possible). Count the number of whole molecules you have inside the circle. Repeat this for diagram E.

   If the circle represents a bubble of air, which bubble:
   a. Contains more molecules?
   b. Weighs more?

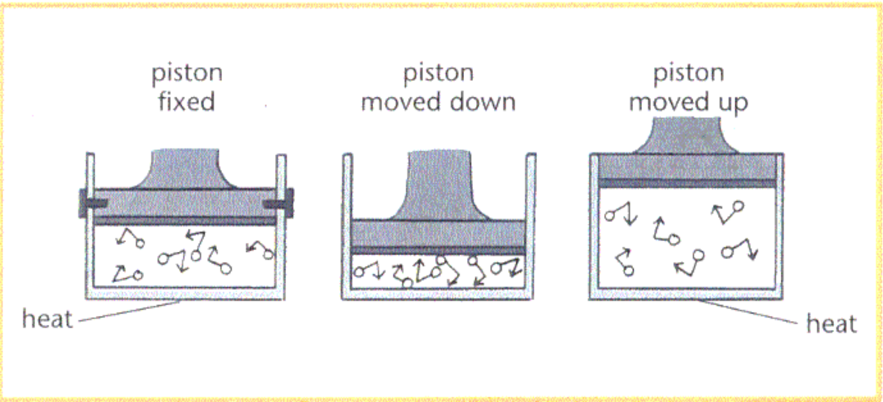
5. Explain why a volume of hot air has a lower mass than the same volume of cold air.
6. Explain why a hot air balloon rises when it is filled with hot air.

Getting an airing

These are some of the points that we have covered thus far in this chapter:

- Air presses on objects. The column of air from the surface of an object to the top of the atmosphere has weight and pushes down on the object.
- Air particles are constantly moving, so objects are pressed by air from all sides.
- If air pressure is equal on all sides, then the object remains as it is. If pressures are not equal, the object may be moved or crushed— remember the collapsed can!

Over 200 years ago the Swiss mathematician Daniel Bernoulli suggested that gases might consist of large numbers of tiny particles moving around rapidly in all directions. The hotter the gas, the faster the particles move. Pressure is caused by the gas particles colliding with the sides of their container. Today, these particles are called **molecules**. Bernoulli's model is called the **kinetic theory of gases.** It explains three gas laws that describe how a gas behaves.



Pressure and temperature:

If you heat a gas sample inside a container, the molecules move faster. They collide more often with the walls and the collisions are harder. So the pressure increases.

Pressure and volume:

If you squeeze a gas sample into a smaller volume, you pack the molecules closer together. More molecules collide with each square centimeter of the walls every second. The pressure increases.

Volume and temperature:

As you heat a gas, its molecules move faster. They hit the walls harder and more often. The extra force pushes the piston outwards. The gas expands.