Popcorn Density

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Topic

Density

Time

1 hour

Safety

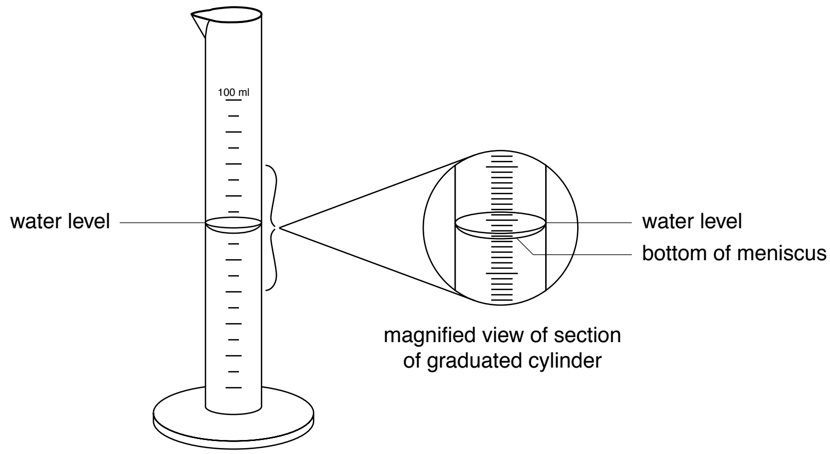
Please click on the safety icon to view the safety precautions. Adult supervision is required. The popcorn popper will get very hot. Use hot pads or padded gloves, and be very careful not to touch hot places with your bare hands. Some of the kernels will come out very hot. They should stand in the bowl a few minutes to cool before you handle them.

Materials

popcorn
hot-air popcorn popper
15-mL scoop or tablespoon
500 mL sand
balance or food scale
500 mL water
1-L graduated cylinder or 1-qt or 1-L measuring cup
large bowl for popcorn
additional bowl for sand

Procedure

1. Use the balance or food scale to determine the mass—in grams (g)—of a scoop or tablespoon of unpopped popcorn. Record the mass on data table 1.
2. Determine the volume—in milliliters (mL)—of the unpopped popcorn by using the volume-by-displacement method described later. Partially fill the graduated cylinder or measuring cup with water. Read the water level at the *bottom* of the meniscus (curved surface between water and air; see the figure), and record as water level 1: __________ . Add the scoop or spoon of unpopped corn to the water in the cylinder and wait for the water to settle. Read the level again, and record as water level 2: __________ . Subtract the two readings to determine the volume of the unpopped corn: water level 2 1 water level 1 = __________ . Record this on data table 1.
3. Determine the density of the unpopped popcorn by dividing the mass by the volume. The units will be g/mL.
4. Discard the water and corn from the cylinder or measuring cup, and determine the mass of a second scoop of unpopped corn.
5. Place the large bowl under the popper's spout, and pop the second scoop of corn as your teacher directs or as you follow the directions on the popper's box.



magnified view of section of graduated cylinder

Data Table 1		
Popcorn (scoop 1)		
Unpopped mass (g)	Unpopped volume (g)	Unpopped density (g/mL)

6. Collect all the popped and unpopped kernels from the bowl and popper. All these kernels together, *including kernels that did not burst*, count as the "popped corn."
7. Determine the mass of all the popped corn using the balance or food scale. Record on data table 2.

Data Table 2			
Popcorn (scoop 2)			
Unpopped mass (g)	Popped mass (g)	Popped volume (g)	Popped density (g/mL)

8. Determine the volume of the popped corn using the following method: Measure 300 mL sand in the cylinder or cup. Carefully pour the measured sand into another container and set aside. Place all the popped corn in the cylinder, and carefully pour the sand in over it. Read and record this level: volume of popped corn and sand. Subtract the 300 mL sand from this reading, and record the result on your data table as the volume of the popped corn.
9. Determine and record the density of the popped corn. Remember, density = mass/volume.
10. Did the volume of the corn change after it was popped? How?
11. Why did you need to use the water and sand when measuring the volumes of the unpopped and popped kernels? Which volume measurement was probably more accurate? Explain.
12. Which corn kernels had the greater density, popped or unpopped?

13. Did the mass of the corn change after it was popped? Why or why not?
14. How many times greater was one density than the other? How many times greater was one volume than the other?

What's Going On

The popped corn has greater volume than it did when it was unpopped. The volume of a substance is the measure of the amount of space it occupies. Solids like corn kernels are separated by space and therefore hard to measure accurately. The water and sand both fill these spaces. By subtracting the premeasured volume of the water or sand from the total volume, you get a more accurate measurement of the corn's volume. The measurement obtained using water is more accurate, because water is a liquid and has no air spaces, so it completely fills the spaces between kernels. Sand is a granular solid, so while it fills the spaces between kernels, it also contains spaces between grains, and since these can't be accounted for the measurement is less accurate. Unfortunately we can't use water to measure the popped corn because popcorn floats in water and also absorbs water, which would make it impossible to get an accurate measurement.

The unpopped corn has greater density than the popped corn. The mass of the corn decreases slightly after popping. Popping corn contains a small amount of water. During the popping process this water turns to steam and escapes into the atmosphere. In this way a small amount of mass is lost. This amount may be too small to appear in your measurements, depending on the precision of your instruments. If kernels are lost due to experimental error during the various steps of the procedure, the mass will appear to decrease by a larger amount. The amount of change in both volume and density depends on how many of the kernels actually pop. A volume increase of 10 to 20 times is not unusual. The decrease in density is primarily due to volume increase (except for the small loss of mass explained above), so volume and density will change by about the same factor. In other words, if volume is 10 times greater after popping, then density will be about one-tenth what it was originally.

Connections

Density is the ratio of an object's mass to its volume. If for some reason the object's mass or volume changes, then its density will also change. A striking example of a volume change occurs when popcorn is heated. The high temperature in the pot or popper causes air trapped inside the hard kernels to expand and also acts on any water inside the kernels, vaporizing it. When the pressure of these expanding gases becomes great enough, the kernel's shell bursts and it "pops," greatly increasing the corn's volume.

In this experiment, you studied the effect of the popping process on the volume and density of corn.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES