The Spectacular Siphon

Courtney W. Willis

Topic

Properties of fluids

Time

Parts A and B, 1 hour; Part C, 1 day

Safety

Please click on the safety icon to view the safety precautions.
Be careful with the knife when cutting the plastic bottles in half.

Materials

two 2-L plastic soda bottles
knife
water
two pieces of flexible clear plastic tubing (25 cm and 40 cm long) to fit hole in stopper
one-hole #4 rubber stopper to fit spout of bottle
small block of wood or book
about 20 cm toilet tissue
glycerin or petroleum jelly

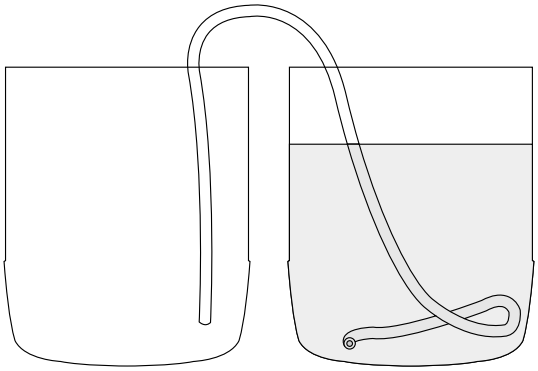
Procedure

Part A: Observing a Simple Siphon

1. Carefully cut the plastic bottles in half. Set the two top halves aside. They will be used in a later part of the experiment.
2. Fill one of the bottom halves three-fourths full of water, then set it on a table top next to the empty second bottom half.
3. Submerge the longer piece of plastic tubing into the water in the filled bottom half, and let it fill with water. Put your finger over one end of the tubing so that water cannot enter or leave. Then bring that end of the tubing out of the water and place it into the bottom of the other container so that half the tubing is in each container.
4. Remove your finger from the tubing and observe what happens. Record your observations of the water level in each side of the tube.
5. Raise one of the containers off the table top a couple of inches by slipping a block or book underneath it. What happens this time? Record your observations.
6. Try raising the second container and putting the first back on the table. When the water stops flowing, record your observations of the water levels in each side of the tube.

7. Some people believe that it is the different weights of water on each side of the tube that make the water flow. To see if this is true, try putting all the water back into one container. Fill the tubing with water. Put your finger over the end, and lift the tubing out of the filled container and into the empty container. Make sure that most of the tubing remains in the original container so that that side has the most water in it (see figure 1). Remove your finger from the tubing. What happens?

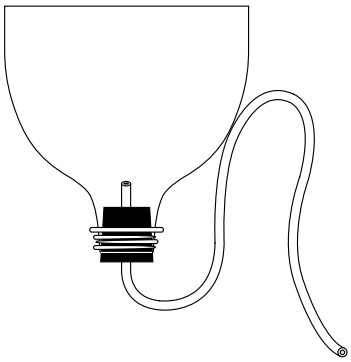
Figure 1



PART B: OBSERVING AN INTERMITTENT SIPHON

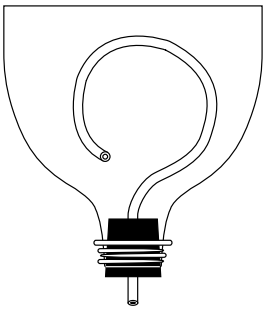
1. Insert the long piece of tubing into the rubber stopper by first gently lubricating it with some glycerin or petroleum jelly.
2. Insert the stopper and the tubing into one of the top halves of the bottles that were put aside earlier. The tubing should be inserted in the bottle's spout.
3. Turn the bottle upside down so that the tubing is now coming out of the bottom. Loop the tubing back up so that it comes about halfway up the bottle and then down below the bottom again, as shown in figure 2. Position the end of the tubing over a sink drain.

Figure 2



4. Slowly begin to fill the container with water. Does anything seem to happen at first? Keep adding water. When does the water start to flow? When the water stops flowing, how much is left in the container?
5. Another ancient intermittent siphon is called a Tantalus Cup. A simple example can be constructed by pushing the short piece of plastic tubing through the narrow end of the stopper, then inserting the tube and stopper into one of the top halves of the plastic bottles. Turn it upside down, and loop the free end of the tubing back down toward the bottom, as shown in figure 3. Slowly fill the "cup" with water. When does the water start to flow out the bottom?

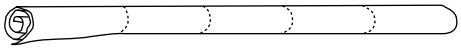
Figure 3



Part C: A Siphon without a Tube

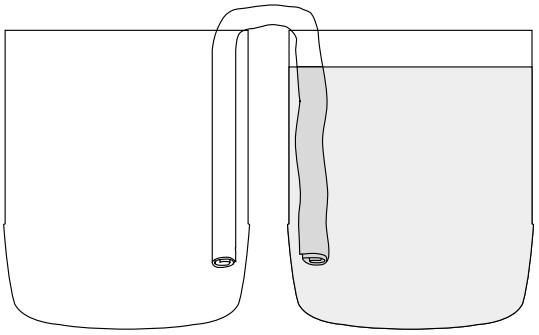
1. Set the two bottom halves of the soda bottles next to each other, with one of them filled and one of them empty.

Figure 4



2. Roll the toilet tissue lengthwise into a loose roll about 20 cm long, as shown in figure 4.
3. Put the toilet tissue into both containers so that half hangs in the filled container and half hangs in the empty container (figure 5). Observe the water start to climb up the tissue due to capillary action. Let everything sit overnight. What happens? Record your observations.

Figure 5



About Part A

1. What did you observe when you removed your finger from the tube in step 4, Part A? How did the final water levels in each side of the tube compare?
2. Did changing the relative positions of the containers in step 5 change the relative water levels in each side of the tube? Explain.
3. Did changing the length of tubing on each side affect the action of the siphon? Explain. What conclusion can you draw from this result?

About Part B

1. What happened when a small amount of water was placed in the first intermittent siphon? What happened when a larger amount of water was placed in it?

2. Can you think of an intermittent siphon in your home that operates on the same principle? Explain.
3. Explain what happened with the Tantalus Cup. Research Tantalus in Greek mythology and explain how the siphon got its name.

ABOUT PART C

1. What happened in the tubeless siphon overnight?
2. In what way is the functioning of this apparatus similar to an ordinary siphon? In what way is it different?
3. What general conclusion can you make about how siphons operate?

What's Going On

Whatever the specific factors are that cause a siphon to work, we can conclude that the action of any siphon depends on the level of water at two different places.

ABOUT PART A

Once the siphon has started, the water runs up one side of the tube and down the other until the water level in both containers is equal. It does not make any difference how long the tubing is on either side or how the containers are moved about. The only determining factor is the level of water in the two containers.

ABOUT PART B

The intermittent siphon holds water until the level reaches the top of the bent tube. Once the water reaches the top of the bent tube, the siphon begins to flow and empty the entire container. A toilet flushes because it is an intermittent siphon. A small amount of water can be added to a toilet bowl and nothing will happen; however, if a bucket of water is poured in, the water rises above the level of a bent pipe or passage through which the toilet drains, and the toilet will flush just as if the handle had been pulled. Since a Tantalus Cup holds water until the level reaches the top of the bent tube inside the cup, at which point it drains to the bottom, it is a further example of an intermittent siphon.

ABOUT PART C

Overnight, half the water is transferred to the other container. The toilet tissue siphon behaves as does the common siphon of Part A, only at a much slower rate. The water levels end up being equal. This type of siphon relies on the capillary action in the toilet tissue to raise the water, rather than on air pressure to push the water through a tube.

Connections

A siphon is a tube used to transfer liquids from one container to another. Siphons have been known since ancient times; however, exactly how a siphon works and what legitimately can be called a siphon are still under debate among scientists today. In this experiment, you looked at simple and intermittent siphons in action. Intermittent siphons are the mechanism by which toilets flush. Some scientists believe that a common siphon works mostly by air pressure working against gravity. Others believe it works because of a combination of gravity and the cohesive forces of fluid molecules. This experiment also demonstrated a siphon that works without a tube to transmit the liquid. The operation of a siphon depends on the level of water at two different places.

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