Can-Crush and Spoutin' Fountain Demonstrations

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Introduction

These activities are a fun introduction to "atmospheric pressure". Atmospheric pressure (caused by the weight of the atmosphere on the Earth's surface) is an important consideration in weather.

One factor that affects atmospheric pressure is elevation. This is why the pressure is less in cities located at higher altitudes, like Denver, and greater in cities near sea level, such as Seattle. Since most students have experienced the pressure on their ears caused by swimming down into the deep end of a pool, tell them to think of Seattle as being in a "deeper part" of the atmosphere and Denver as being in the "shallow part" of the atmosphere. In fact, at sea level the atmosphere exerts over 14 pounds of pressure on every square inch of our skin. The reason this doesn't crush us it is that there is stuff (fluids) inside our skin pushing back out.

Another important factor that influences the pressure is whether the air is rising or sinking in that area. Where the air is sinking (and compressing) the pressure (as indicated on a barometer) will be higher. Where the air is rising (and expanding) the pressure will be lower. If air is rising, it is not pushing down on the surface as much. Although this rising or sinking of air is a more important consideration in forecasting weather, the can-crush and fountain demonstrations focus on the fact that atmospheric pressure is caused by the weight of the atmosphere. Once students have this understanding, the next step is to start teaching them about areas of rising and sinking air.

How I use the activities . . .

Our classes are 50 minutes long and I have about 25 freshmen per class. The 3 parts listed below can be completed in one class, or spread over more than one period. I like to do #1 near the end of a class period and then do #2 and #3 the next day.

1. First I show them the "Can-Crush Demo" without much explanation. Next, I show it to them again, explaining it as I go through step by step.

2. The next day, I let each student crush two cans. Students really enjoy this!
    a. I "dumpster dive" in the recycle bins located throughout our school to obtain the cans.
    b. I set up 12 Bunsen burners and 8 big (3 lb.) coffee cans filled with cold water.
    b. Between classes I add a little ice to the water to make sure it is cold.
    c. I tell students to wash their can (inside and out) with water, and then to add a 20 mL water to the clean can before heating it above the burners.
    d. The students need to wear goggles and they need tongs like those in the YouTube video.
    e. I designate one sink in my room as the place to put the crushed cans. I tell students to drain the water from their cans before putting them in the sink. Once the cans are dry (several days later), I return them to the recycle bins.

3. Following the can crush lab, I show students the "Spoutin' Fountain Demo," and then we discuss the two activities, using the questions on the next page. By the time they are freshmen many students have seen the can-crush as a demonstration in middle school. However, none of them seem to understand why it happens.

Questions for discussion (Choose the ones you like.)

1. What was the purpose the water that was added to the can and the flask?
   Answer: The water provides the vapor that forces the air out of the containers.

2. Which takes up more space? . . . Water as a liquid, or water as vapor?
   Answer: Water molecules in the form of vapor take up much more space.

3. How do gases inside a container (can, flask, tire, ball) actually cause "pressure"?
   Answer: The molecules are constantly colliding with the inner surface of the container.

4. Why doesn't atmospheric pressure crush the can immediately after it is removed from the heat?
   Answer: The molecules of water vapor (steam) are causing pressure on the inside of the can.

5. As the can and that flask were inverted into the cold water, what happened to the steam inside those containers?
   Answer: The steam started to condense very rapidly. The container of steam changed into a very small amount of liquid, leaving an empty space called a vacuum.

6. Why did removing the containers from the burner and inverting them in cold water cause a decrease in pressure inside?
   Answer: The gas molecules (steam, vapor) were no longer present to collide with the inner surfaces of the containers.

7. Both demonstrations were caused by the same sudden decrease in pressure inside a container. So, why was there such a difference in what happened?
   Answer: The difference was a result of the strength of the container. The cans were very flimsy, so they were crushed by the pressure difference faster than the cool water could move in from below and replace the condensing steam. Since the flask was able to withstand the pressure difference, it was not crushed. Instead the atmosphere pushed water into the flask to fill the space once occupied by the steam.

8. The can was not collapsed because of "suction". Why did it collapse?
   Answer: It was crushed by the weight of the atmosphere. There was nothing inside to "push" against the atmosphere.

9. In the fountain demo, the water rose slowly into the tube, until it reached the top of the tube. Once there, it began to "explode" into the flask. How do explain this sudden change?
   Answer: When the flask was removed from the heat, some of the steam began to condense, causing the pressure to decrease slowly. This caused the water to rise slowly into the tube. Once that rising cold water reached started entering the flask, the steam started to condense much more rapidly.

10. A fully inflated basketball taken outside on a cold day will seem less "bouncy". Explain why cooling the ball will result in lower pressure inside the ball.
   Answer: The molecules of air inside slow down, so they are not colliding with the inside of the ball as often or with as much force.

Other ideas related to teaching about atmospheric pressure . . .
1. For an interesting real world application of atmospheric pressure, go to this web site. http://formontana.net/carpenter.html

2. I also show my students the last several minutes of a Hollywood movie called "Total Recall" (starring Arnold S.). It shows an interesting situation where three people are put out onto the surface of Mars where the atmospheric pressure is much less than what their bodies are used to.

3. The mercury in a barometer in Denver (about a mile high) will be about 5.3 inches lower than in a barometer located at sea level. Meteorologists adjust barometric pressures based on altitudes. They would add 5.3 inches to the Denver reading.

4. To view YouTube videos of the Can-Crush and Spoutin' Fountain activities, go to www.formontana.net/tube.html.

Source
The fountain demonstration comes from a book called "Invitations to Science Inquiry" by Tik L. Liem. It is published by Science Inquiry Enterprises, 505 W. Madison Ave. No. 12, El Cajon, California 92020. It is a great source for demonstrations, featuring instructions for over 450 demonstrations.