Mr. Miller

Chemistry Lab
"Ideal Gas Law Lab"
Date of Lab
Teacher's Name

Question/Problem

Can the technology present in an aluminum-can be used to support the transport of gases between 0 and 100 degrees Celsius?

Data

The container in this lab is a regular 12 oz aluminum soda can that can be bought at any supermarket. The original volume of the can is measured to be 415.0mL. In the lab, the can will be heated using a Bunsen-Burner to the boiling point of water (100.0°C) and then placed face down into an ice water bath (0.0000°C). Assuming that the gas inside of the can will behave as an ideal gas, the ideal gas law can be used to predict the behavior of the gas. The pressure of the gas (P) is inversely proportional to the volume of the gas (V), and directly proportional to the amount of gas (n) and the temperature of the gas (T). The proportionality constant (R = 0.0821) is used to calculate the exact $PV = nRT$ proportionalities.

Since the can is placed in the ice water bath upside-down, no gas is allowed to escape the container. This holds the amount of gas (n) inside the container constant. The container is made of a thin layer of aluminum, which is not resistant to large changes in pressure. Therefore the can will have to keep the internal pressure equal to the external pressure, which holds the pressure constant during the experiment. This means that the only variables in the equation that are able to change during the experiment are the temperature (T) and the volume (V). Dividing both sides by the temperature (T) and pressure (P), all of the variables are located on the same side of the equation, and all of the $\frac{V}{T} = \frac{nR}{P}$ constants on the other.

Assuming that the three constants will remain constant, any volume change should only be affected by the temperature of the gas inside the container, and any temperature change should only affect the volume of the gas inside the container. Knowing that the initial ratio of the volume and temperature must be equal to the same constant that the final ratio of the volume and temperature are equal to, Charles' Law applies, and the following equation can be used to predict the behavior of the gas.

$$\frac{V_i}{T_i} = \frac{V_f}{T_f}$$

The values that can be used in this formula are liters (L) for volume and Kelvins (K) for temperature. To convert from mL to L, you use a 1000mL:1L ratio. To convert from °C to K, you add 273 degrees °C. $T_i = 100.0°C + 273 = 373.0K$ $T_f = 0.0000°C + 273 = 273.0K$ to $V_i = 415.0mL\left|\frac{1L}{1000mL}\right| = 0.4150L$ the

By plugging in the values above, a volume can be predicted for when the can is cooled.

$$\frac{V_i}{T_i} = \frac{V_f}{T_f} \longrightarrow \frac{0.415L}{373K} = \frac{V_f}{273K} \longrightarrow V_f = \frac{(0.415L)(273K)}{373K} \longrightarrow V_f = 0.3037L$$

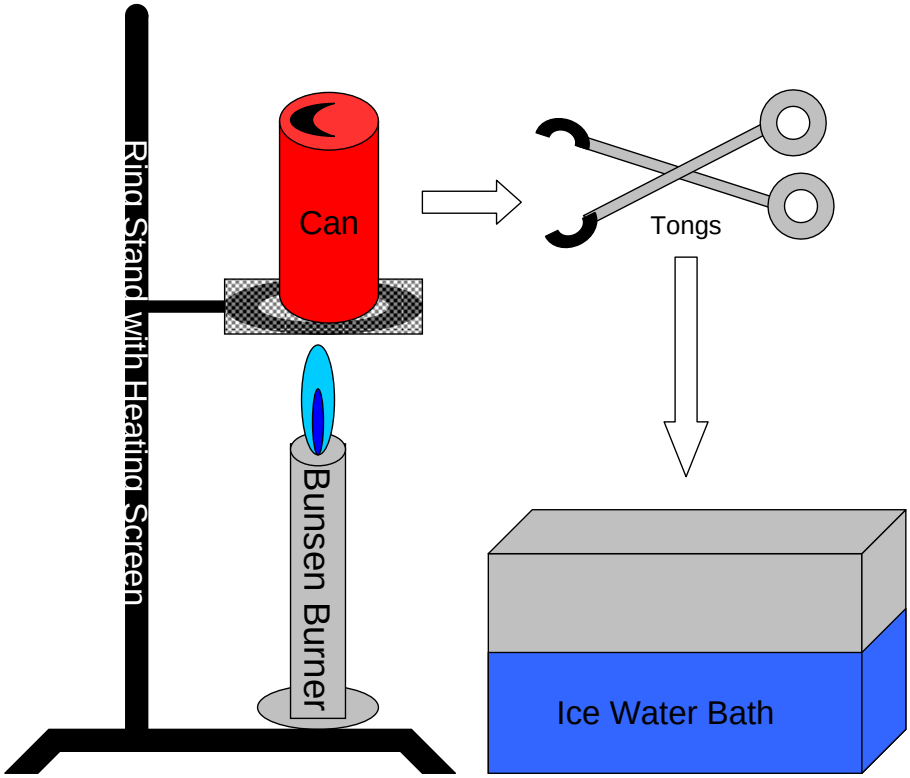
Subtracting the final volume from the initial volume gives a theoretical yield for the volume change of the container when taken from the high temperature to the low temperature.

$$0.4150L - 0.3037L = 0.1113L\left|\frac{1000mL}{1L}\right| = 111.3mL$$

Hypothesis

When a 415.0mL aluminum can is heated to 100°C and then cooled to 0°C, the volume of the can will decrease by 111.3mL. This indicates the aluminum will not be able to be used to transport the gases throughout this range of temperatures.

Experimental Procedure



1. A Bunsen-Burner is set up on the lab station, along with a ring stand and screen. A tub of water with ice was also placed at the lab station, with tongs, a graduated cylinder, and an aluminum can.
2. The aluminum can is rinsed out with water to eliminate any contamination from the can.
3. The volume is measured by filling up the can with water and pouring the volume into a graduated cylinder and reading the volume.

   95.6 mL + 97.5 mL + 95.4 mL + 95.5 mL + 31.0 mL = 415.0 mL
4. A small amount of liquid is placed into the bottom of the can.
5. The Bunsen-Burner is then lit and the can is heated until steam comes out of the top of the can.
   a. Using the tongs, the can is placed upside-down into the ice water bath. Observation – The can crushes once it touches the water
6. The can is removed from the ice water bath and filled up with water.
7. The new volume of the can is measured using the graduated cylinder the same way as step #3.

   98.3 mL + 94.7 mL + 95.4 mL + 43.1 mL = 331.5 mL

Analysis

The new volume of 331.5mL is used to determine the actual loss in volume for the can:

$$415.0mL - 331.5mL = 83.5mL$$

The percent yield for the experiment can be calculated by using the following equation:

$$\%Yield = \frac{Yield_{Actual}}{Yield_{Theoretical}} \bullet 100\% \longrightarrow \frac{83.5mL}{111.3mL} \bullet 100\% \longrightarrow 75.00\%$$

During the process of moving the can from the heating screen to the ice water bath, the gas may have cooled below the 373K which the calculation of the theoretical yield is based upon. This would cause the can to not lose as much volume as calculated due to a smaller difference in initial temperature and final temperature. Another thing that could cause a decrease in the amount of gas lost would be that there may have been some liquid water still left in the bottom of the can prior to moving it into the ice water bath. This would affect the calculation of the initial volume of the can being larger than it actually is. The theoretical yield would be lower if an initial volume that was smaller is used.

Conclusion

Taking aluminum cans and heating gas inside to the boiling point of water, then dropping the temperature to the freezing point of water to determine whether or not it is a good material to transport gases between the two temperatures leads to issues due to Charles' Law predicting that the volume within the system will drop significantly as a result. This experiment is to testing the material to see if it is a good substance to build a production facility for the company operating between 0 and 100 degrees Celsius. In this experiment, the hypothesis is verified with a 75.00% yield. The 25.00% error can be explained by the fact that the can may have cooled prior to being placed into the ice water bath, as well as the fact that any water still at the bottom of the can would affect the initial volume used in the calculation of the theoretical yield. The cooling of the gas in transport would change the theoretical yield to a smaller number, which would increase the % yield with the same results. The amount of water at the bottom of the can is also making the volume of the can slightly smaller than used in the calculation of the theoretical yield, which if measured exactly and subtracted from the full volume of the can would also lead to a smaller theoretical yield, which would make the % yield increase as well. There is a way to predict the behavior of real gases in a container if the pressure and amount of gas are kept constant and the temperature is changed. Controlling the amount of gas in the system rather than using an open can is something that must be investigated. Also, determining what thickness of the aluminum would it be able to support a pressure differential inside and outside of the can could allow for a more controllable system. Each of the variables that affect gases are important and keeping control of each of them is very important in being able to predict the behavior of a gas.