

Laboratory #6
Absolute Zero

In this laboratory we will use very simple equipment to see that the volume of a fixed amount of gas is proportional to the temperature as long as the pressure of the gas doesn't change. And we will be able to estimate the temperature of "absolute zero".

A gas consists of lots of little molecules that bump around like a bunch of bee bees; and the typical speed is great enough that it doesn't change appreciably. In fact, the speed of individual molecules is not too much smaller than the speed of sound. Every time a molecule of gas hits a wall of a container it exerts a little force. There are enough molecules (about 10^{23} in a bottle full) that they are hitting the container walls quite often and end up exerting a pressure that seems to be steady.

Now, when a gas heats up, the molecules move more quickly, strike the wall more often and exert a larger force in every collision. But if the container has a moveable piston which always exerts the same force, then the gas lifts the piston and expands when it is heated. Similarly, a gas at fixed pressure contracts when it cools.

Now when an "ideal" gas is as cold as it can be (absolute zero), the molecules stop moving around and just sit at the bottom of the container, taking up essentially no space, and the gas then has no volume. Careful analysis of this bee bee picture of a gas predicts that the volume of a specific amount of gas, kept at a constant pressure, is proportional to the kinetic energy of the molecules and to the temperature above absolute zero.

In today's laboratory we trap a specific amount of gas in a plastic syringe and use water as a moveable piston. The volume of the gas is easily determined for different temperatures by reading the depth of water in the syringe.

Start with an empty syringe with the stopper at the 8 cm^3 mark. Now immerse the syringe in water and pull back on the stopper until it is at 12 cm^3 . From now on it is absolutely essential that **no air be allowed in or out of the syringe**. So when you carry the syringe around keep it upright with your finger stopping up the bottom.

Around the room are a number of buckets of water at different temperatures. At each of them, put the syringe under water for two minutes, with your finger off the hole at the bottom. With the syringe still immersed, read the level of the water and subtract it from 12 cm^3 to obtain the volume of the gas. Record the measurement, volume and temperature in your lab book. You can take repeat measurements in the same buckets; just be sure to take new temperature measurements as well.

After taking the data, make a **BIG** graph which covers two pages in your lab book, and put it as close to the top as you can. Put the temperature on the vertical scale (use one square for every 5°C) and the volume on the horizontal scale (use four squares for 1 cm^3). With any luck, the data should fall on a straight line. So draw a straight line (with a ruler) that matches the data as well as possible. Extend the line far enough that you can see at what temperature the volume of the gas would be zero—this is the temperature of "absolute zero"!