Experiment 8

Temperature & Thermometers

▲ Warning: Liquid nitrogen may be used. University regulations require students to have splash proof safety goggles, long pants, and closed toe shoes.

In this experiment you "build" a **thermometer** by **calibrating** the output of a thermometric system. The system is a sealed container of air at fixed volume. The output is the pressure of the gas in the container. The calibration is achieved by relating the pressure to temperature in units of degrees Celsius. Once you have a working thermometer, you use it to determine some temperatures.

Preliminaries.

Temperature scales are based on convenient and accessible points, usually the freezing and boiling points of water. The Celsius scale assigns 0 ^{o}C to the freezing point and 100 ^{o}C to the boiling point, evenly splitting these points with 100 divisions. Once the degree size is determined, the Celsius scale is extended above 100 ^{o}C and below 0 ^{o}C. But how far does this linearity go? All the way to *zero* thermal energy?! At this point, the molecules hitting the walls of the vessel are not moving? The pressure they exert is zero? Can we show this? This point would be called *Absolute Zero,* or 0 K, for Kelvin. Do you think things can get colder than this?

State the ideal gas law, and using this fluid model, what do you expect to happen to the pressure of the gas as the temperature drops?

State the assumption of kinetic gas theory, and what does this say about what should happen as the temperature of the gas drops?

Physical systems cannot be cooled beyond a certain limit, called **absolute zero**. This observation underlies the **Kelvin** scale, which is the most useful in physics. The Kelvin scale has units of Kelvins (K). A Kelvin is the same size as a Celsius degree. Absolute zero is, by definition, at 0 K.

You may notice that, on some gauges, the interval from 0 to 5 psi is subdivided into only four divisions, not five. In fact, 1 psi is not included on the gauge. To read the gauge properly for pressures less than 5 psi, read down from 5 rather than up from zero.

As you change the temperature of the bulb, what changes, and what is always the same?

At one point, you can open the valve of the bulb – when the valve is open, what do we know for sure about the gas in the bulb? What does this action change?

Procedure.

• How do you make sure that the bulb is thermalized (all at one constant temperature)?

• Atmospheric pressure is about 14.7 psi. What if the treading doesn't agree with this because the needle has been pushed? What will you do?

• Make a graph of temperature and pressure. Should this be linear, or is there some other way you should graph it? Extrapolate your graph to be where the pressure is zero. What temperature does this correspond to?

• Do this experiment for different amounts of air in the bulb, at least two. How would you change the amount of air in the bulb? Put these data on your graph. What do you notice.

Questions (Answer clearly and completely).

1. What value do you determine for the Celsius value of absolute zero? What is the percent difference from the accepted value? Is this within your expected uncertainty?

2. What value do you determine for the temperature of the carbon dioxide / alcohol solution? What is the percent difference from the accepted value?

3. Estimate how many moles of air, molecules of air, and grams of air are in the bulb

My expectations:
Please submit to me a Lab Report complete with:

1) A statement of purpose
2) A drawing
3) A graph
4) A conclusion that must use the words… something like:

a) "our findings are consistent (inconsistent) with…." Or "our findings support (conflict) with…."
b) …based on the xyz of our graph
c) A calculation of % error and explanation of if this is within your expected uncertainty and why you know this.

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