The Ideal Gas Law

This is the outline of exercises that we want you to do in lab. This is a complement to the material in the lab manual. Please read the manual to learn about the tools and techniques; use this document to guide your experiments and calculations in the lab.

You should complete the first three problems below, and in your remaining time work on a fourth of your choice.

You may want to make use of hot or cold water, if so **be very careful** around it!

Problem #1: Finding Absolute Zero

The question you are to answer: How can you determine Absolute Zero?

First, let's answer a question:

- How does the pressure of a gas vary if the temperature changes?

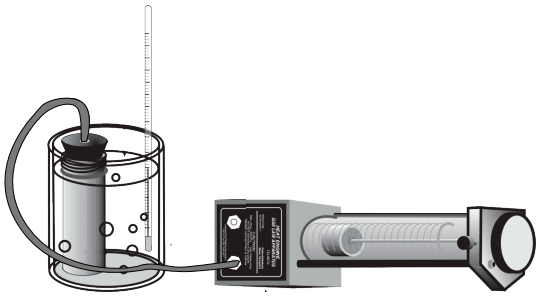
Your goal in this part of the experiment is to use the gas container with pressure valve to deduce the value of absolute zero on the Celsius scale. There are a series of temperature baths at the front of the room - please share these with your labmates. Start with the cold bath, and work your way up!

Record your methods, data, and be sure to sketch out your data!

- What is your estimation of absolute zero? How reasonable is your value?
- Can you think of a practical reason why you might arrive at a temperature less then the textbook result?

Problem #2: Fill 'er Up!

The question you are to answer: What is the volume of an unlabeled cylinder?



Your goal in this part of the experiment is to calculate the volume of the air inside aluminum cylinder (and the attached tubing), using the change in volume of air inside a piston (on it's side) when the cylinder is placed in different temperature baths. The atmospheric pressure in the room is measurable (or will be noted on the front board), though not necessary.

- Make a few measurements of bath temperature and corresponding *piston height* as the water heats up while stirring the water with the cylinder. (Note: The numbers on the side of the piston indicate the height, not the volume.
- Calculate the volume at each height, knowing that the diameter of the piston is 32.5 ± 0.1 mm).
- This is all the information you need. Your job is to develop, with your lab partners, a means to calculate the total volume of the aluminum cylinder when it is at room temperature. Once you have a value for the volume, record your technique and results in your writeup. Be sure to sketch out a graph of your data in your report.
- How reasonable is your determined volume? Make some measurements on the cylinder and tubing, then compare.
- Discuss: How does this experiment mirror Problem #1?
- Discuss: Why would we have you put the piston on its side, instead of standing it up?

Problem #3: Dense, Man!

The question you are to answer: What is the local density of air?

This week we will start with an experiment written up by Robert DeSerio from the University of Florida. Start by holding the ipad (or your own smart device) fairly high up - at least 2 meters above the ground floor.

- Record pressure data (P1) at that elevation for 30 seconds, and measure the height (h) of your phone.
- Then, place the phone on the floor and record 30 seconds of pressure (P2) at that elevation.

If your pressure graphs show a steady increase or decrease, there is likely a weather system moving through town. You should wait a bit for the weather front to pass, but if you are in a pinch, note how you accommodate for this background change.

- Determine the change in pressure between the two heights.

Bernoulli's Equation is typically used to find the pressure change between sections of a tube of differing diameter and fluid velocities, but the full equation also includes terms that calculates differences in pressure due to elevation change. You can often find this piece of the equation by itself for calculating pressure in a column of fluid. (Though not a liquid, air can be considered a fluid!)

- Use this equation to calculate the density of the static air in your room. Do you get a reasonable value?

Problem #4: Further Activities

Here are some suggestions of specific activities you can try, and questions you can explore:

- Can you measure your weight (and that of your bike) by measuring the tire's footprint? How about your car's weight?
- Calculate the force you apply when squeezing a bag of air
- If you have a floating balloon available, can you determine its density?
  - Note: Nowadays, most "helium" balloons are not pure helium!
- A bit of a twist, but can you calculate the buoyant force acting on you? You'll need to estimate your cross-sectional area, and measure the air pressure at your feet and head...

Report

Work with your lab group to write a report that sums up your process and your results. Keep it short and sweet, please. And then submit this as an assignment on Canvas. Since everyone is remote, your TA won't be looking over your shoulder to observe what you do, and so be sure to add some detail as to your process.

Looking Ahead: Choose Your Own Adventure

This isn't something to calculate today, but something to think about: You figured out how the density of the air by looking at the ambient pressure, but there are other intrinsic properties of materials you could investigate. We'll be looking at specific heat next week - how much energy it takes to warm or cool a certain mass of a material. A material's specific heat and density have a rough relationship to each other - though there are other considerations to take into account. Do you expect denser materials to have a higher or lower specific heat in general?