PHY 101 Lab 9: Behavior of Gases

Your name:

Other team members:

Goals:

Gases are all around us, literally -- without air, we couldn't live. From a physics point of view, air at room temperature is a pretty good approximation to an ideal gas. Chemically, it is a mixture of nitrogen (N_2 molecules, 78% by volume), oxygen (O_2 molecules, 21% by volume), and tiny amounts of lots of others.

In this lab, we'll explore a few properties of ideal gases in general and air in particular. Helium is our best example of an ideal gas. Some things about gases are best learned when you turn gas into a liquid, so liquid nitrogen and liquid oxygen will be part of our studies as well.

Materials:

Balloons

Paper clips

Tank of helium

Large and small dewars of liquid nitrogen

Graduated cylinder partly filled with water

Rulers

Oxygen liquefaction apparatus: soft-drink can on adjustable stand, glass beaker, tray for liquid nitrogen

Magnets

Safety gear for working with cryogens: safety glasses, tongs, insulating gloves

Activity

Circulate from one station to another in any order.

1. What is the mass of a balloon's worth of air?

How much mass would you guess that a balloon's worth of air has? Write down a number, and your reason(s). It is OK to write down "guess", but better if you can estimate it in a richer way (say using knowledge from chemistry.)

A balloon filled with helium will float. What does that say about the mass of a helium molecule compared with the average mass of a molecule of air? Use the Ideal Gas Law in your reasoning.

We'll use a helium-filled balloon to weigh the air. Because we don't aspire to good precision, we will make the approximation that helium is weightless. (This isn't true, but only messes things up at the 10% level.) Fill a balloon with helium, using the special nozzle on the helium bottle. Tie off the nozzle, and hold onto it carefully.

Now, add a paper clip to the tied-off nozzle, and see if the balloon is still tempted to float away. If so, add another, then others as necessary to just counteract its tendency to float.

How many paper clips are necessary to hold the balloon down?

So, how much does the air in a balloon-sized volume weigh? (If you want a little more precision, you can weigh a larger number of paper clips and scale. How about the weight of the balloon's skin?)

Compare with your original estimate. Were you close?

2. How cold is liquid nitrogen?

Inflate a balloon with helium. (Don't blow it up very large, since it needs to fit into some jars that are only about 10 cm across.)

Holding the balloon with tongs, dunk the balloon in the small open dewar of liquid nitrogen. What happens?

Why? Use the Ideal Gas Law to explain.

Measure the volume of the cold balloon, using the liquid displacement method. First, measure the depth of the liquid nitrogen with no balloon present, using the ruler. Then, dunk the cold balloon (you may have to wait until the balloon is in equilibrium at the low temperature), and measure the depth again. From the change in depth of the liquid and the cross-sectional area of the dewar, figure out how much volume the cold balloon occupies. What is the volume?

Next, let the balloon warm back up to room temperature. Then, dunk the warm balloon in the water in the graduated cylinder, and measure its volume in the warm state. What is its volume?

What is the ratio of volume of the cold balloon to that of the room temperature balloon?

What does that say about the ratio of the absolute temperature of liquid nitrogen to the absolute temperature of a typical room? Use the Ideal Gas Law in your reasoning.

If room temperature is about 300 K, what is the absolute temperature of liquid nitrogen?

3. Properties of liquid oxygen

Here is how to make some liquid oxygen. Pour some liquid nitrogen into the copper cone. Describe what you see as you look at the cone.

Notice the drops of liquid that appear at the bottom of the cone. Can they be water? Explain.

Can they be liquid oxygen? Explain.

Collect some of this cold liquid in a glass beaker that is chilled by sitting in liquid nitrogen. Wait until several ml of liquid have collected. Then, using an insulating glove pick up the beaker, and gently pour the liquid into the gap between two magnets. How does it behave?

Compare the magnetic properties of the liquid oxygen with that of liquid nitrogen, by pouring some liquid nitrogen into the gap between the magnets. What do you see then?

Have you ever seen any substance other than iron respond so strongly to magnets?