8.5: The Clément-Desormes Experiment

This is a simple, quick and effective experiment often seen in teaching laboratories for measuring γ for air, or, with some extra effort, any other gas.

Sometimes this experiment is referred to as the experiment of Clément and Desormes, and sometimes as the experiment of Clément-Desormes. Apparently Charles-Bernard Desormes was the uncle of Nicolas Clément, and they both worked on the experiment. Nicolas Desormes later legally changed his name to Nicolas Clément-Desormes. Thus you can refer either to the experiment of Clément and Desormes or to the experiment of Clément-Desormes!

A bottle of air starts at P_1, T_1. P_1 is a little greater than atmospheric pressure P_0. T1 is the ambient room temperature. The bottle is provided with some device for measuring pressure (for example, a manometer). We'll see that there is no need to measure temperatures. The stopcock is quickly opened and immediately closed. The pressure at that moment is just atmospheric pressure, which I'll call P_0, and the temperature is T_2, which is a little cooler than the original room temperature T1. The bottle of gas is now allowed slowly to warm up isochorically to its original temperature T_1, by which time the new pressure P_2 is greater than atmospheric pressure P_0 but not as large as the original pressure P_1. You should sketch these two stages on a *PV* diagram.

For the adiabatic process,

$$P_1^{-(\gamma-1)} T_1^{\gamma} = P_0^{-(\gamma-1)} T_2^{\gamma}. \tag{8.5.1}$$

For the isochoric process,

$$P_0/T_2 = P_2/T_1. \tag{8.5.2}$$

I'll leave you to do the algebra and eliminate T_2/T_1 from these equations and hence show that

$$\gamma = \frac{\ln(P_1/P_0)}{\ln(P_1/P_2)}. \tag{8.5.3}$$

In the above analysis, we assumed that the gas was ideal and the expansion was adiabatic and reversible. The gas is nearly ideal if it is a long way above its critical temperature and there are no enormous ranges of P and T. The expansion is adiabatic if P_2 is measured immediately after the stopcock is opened and closed, so that there is no time for heat to enter or leave the system. It is reversible only if $P_1 - P_0 << P_0$. If you want to do the experiment yourself right now without getting up from your comfortable seat, have a look at http://www.univ-lemans.fr/enseignements/physique/02/thermo/clement.html