Experiment 1: Heat Capacity Ratios for Gases

Adapted from Shoemaker *et al.* Experiment 3 (page 104)

1 Introduction

In this experiment the heat capacity of several gases will be determined using the *Adiabatic expansion method*. In particular you will be defining the heat capacity ratio of these gases under constant pressure and volume, i.e. Cp/Cv. The results will be interpreted in terms of contributions made by various molecular degrees of freedom.

The heat capacity, *C*, is a measure of the quantity of heat an object can absorb. As an example liquid water has an unusually high heat capacity. This allows the oceans to moderate the temperature on our planet (absorption of solar heat during the day and release this during evening). Without this, temperatures would soar above 100°C during the day and drop below 0° C during the evening, i.e. much like on Mars.

2 Theory

See Shoemaker (Experiment 3 in Chapter 4) for a detailed discussion of the theory behind this experiment. You will need to read this section in order to understand how to determine heat capacity ratios.

3 Experimental procedure

Follow the directions outlined in the experimental section in Experiment 3, Chapter 4, in Shoemaker. You will be using the Adiabatic expansion method (Method A). The apparatus, similar to that illustrated on page 109, is setup on the bench top (Figure 1). The Carboy does not need to be purged between successive runs using the same gas. Only purge when switching between gases. The gases you will use are Ar, N_2 and CO_2. These are all heavier than air. A digital manometer is used to read pressure variations in this experiment relative to the atmospheric pressure. You will need to record the atmospheric pressure using the barometer located on the wall in the back of the lab.

3.1 Selecting a gas

To select the proper gas valves 1 and 2 should be used. Valve 3 should be used to regulate the flow and valve 4 is used to direct the gas to a beaker for purging or to the manometer for measuring the pressure.

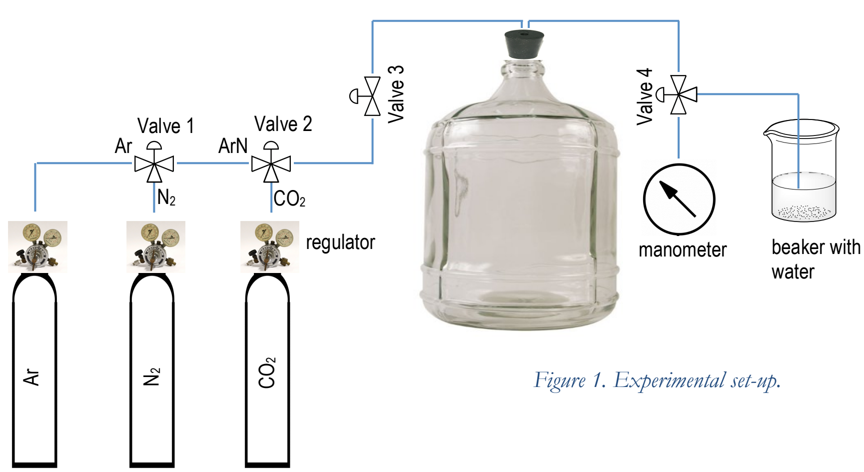

Figure 1. Experimental set-up.

For example, to select Ar or N_2 valve 1 should be in position Ar or N_2 and valve 2 in position ArN. To select CO_2 valve 2 should point to CO_2. The position of valve 1 is irrelevant in this case.

3.2 To purge the system

a) Close valve 3.
b) Open the line to the beaker with valve 4.
c) Select a gas using valves 1 and 2 (see above).
d) Open the regulator on the proper gas cylinder.
e) Very slowly open valve 3 until you see approx. 5-7 gas bubbles per second in the beaker.
f) Purge for 15 mins.

3.3 To perform a measurement

a) Close valve 3.
b) Open the line to the manometer with valve 4.
c) Select a gas using valves 1 and 2 (see above).
d) Open the regulator on the proper gas cylinder.
e) Very slowly open valve 3 while observing the pressure on the manometer. Once the desired pressure is attained (~45 mm Hg), close valve 3. The sum of the atmospheric pressure and manometer reading gives the p_1.
f) Remove the stopper entirely (a distance of 2 or 3 in.) from the carboy, and replace it in the shortest possible time, making sure that it is tight. As the gas warms back up to the bath temperature, the pressure will increase and finally (in about 15 min) reach a new constant value p_3, which can be determined from the manometer reading and the barometer reading.
g) At some point in the procedure, a barometer reading (p_2) should be taken as well.
h) Repeat the steps above two more times. For each gas studied you should perform three runs.

4 Calculations

Carry out the calculations for the adiabatic expansion method on p. 113 of the text.

5 Discussion

Answer the questions in the *Discussion* section of the text on p. 114.