

## Chemistry 030.307 Fall 2008

### Experiment 1: Joule-Thomson Effect.

The familiar cooling of a compressed gas upon expansion is a result of the non-ideal behavior of real gases. When this process is performed adiabatically (i.e. with no change in the heat content of the system), the Joule-Thomson coefficient may be obtained as

$$\mu \equiv \left( \frac{\partial T}{\partial p} \right)_H = \lim_{\Delta p \rightarrow 0} \left( \frac{\Delta T}{\Delta p} \right)_H .$$

At room temperature, the molecules in a compressed, non-ideal gas experience attractive forces due to the overlap of their van der Waals radii. The Joule-Thomson coefficient gives a measure of how much potential energy stored in these forces is converted into kinetic energy (or *vice versa*) upon adiabatic expansion. Small molecule, nearly ideal gases (such as helium and hydrogen) experience only weakly attractive forces near 300 K and exhibit the opposite behavior from gases that are less ideal. This property of gases is the basis of the Linde process for gas liquefaction.

#### Experimental

The experiment is fully described in Experiment 2 of Garland *et al.* (pp. 96–104). Our apparatus is essentially as described in the text. One major difference is that the porous frit is held within a double-walled glass cylinder having a vacuum between the two walls. This arrangement allows for better thermal insulation for the expanding gases. A pair of copper-constantan (type T) thermocouples are used to measure the temperature differential across the frit. The single constantan wire runs between the two thermocouple ends and two separate copper wires lead to the digital voltmeter (Keithley 2000).

Follow the experimental procedure as outlined in the text. The barometric pressure in the room should be noted at the beginning and end of the laboratory session (the T.A. will give instructions for reading the barometer). A purge time of 1-2 minutes at ~5 p.s.i.g ("pounds per square inch gauge", i.e., above atmospheric pressure) should be sufficient. Record the bath temperature immediately before and after each run. Use this temperature when reporting your results. Pressure readings should be made in bar (1 bar =  $10^5$  Pa).

#### Calculations

Use a standard calibration table (NIST or the CRC Handbook are good sources) to plot the temperature dependence of the millivolt potential for a type T thermocouple junction. Fit this data over a range from -50 to 50 degrees with a second order polynomial and use this curve to extrapolate  $\Delta T$  values from your experimental potential readings. Remember that changes in temperature and pressure are calculated as the difference between the final and initial states; therefore, choose the sign of  $\Delta T$  and  $\Delta p$  carefully. Complete the calculations as requested in the text, omitting the optional square-well potential calculations.