3 Deviations from Ideality

3/2:

1. An "ideal" rubber band is at 300 K and a mass of 200 g stretches its length by 10 mm. Give the stretch length at 330 K.

2. A pill of 0.1 mol of gadolinium (III) sulfate ($Gd_2(SO_4)_3$) is used for adiabatic demagnetization.

   (a) Give the molar mass.

   (b) Assuming all electrons unpaired in the f orbital, give the magnetic moment.

   (c) Calculate the heat transferred from the lattice to the spin degree of freedom as the field is varied from 1 T to 0 T.

   (d) Estimate the heat capacity of the pill, and determine its lattice temperature if it starts at 4 K.

3. A Joule-Thomson expansion is an adiabatic and reversible expansion from a pressure P_1 to a pressure P_2, made closer to reversible by having a porous section that slows down the gas.

   (a) Show that the Joule-Thomson expansion conserves enthalpy.

   (b) Show that an ideal gas's temperature is unchanged during a Joule-Thomson expansion.

   (c) Argue why a real gas can cool (or heat up) during a Joule-Thomson expansion.

   (d) Show that the temperature change is given by $(\partial T/\partial P)_H$.

   (e) Problem 22-48: Show that

   $$\left(\frac{\partial T}{\partial P}\right)_H = \frac{V}{C_P}(\alpha T - 1)$$

   where α is the coefficient of thermal expansion.

   (f) Problem 22-49: Show that a gas with only excluded volume cools upon expansion.

   (g) Problem 22-51: Give the sign and estimate the magnitude of $(\partial T/\partial P)_H$ for N_2 gas around 300 K from 100 atm to 1 atm based on van der Waals parameters.