1) Consider a magnet for which the work differential is \( HdM \), where \( H \) is the magnetic field strength and \( M \) is the net magnetization of the sample. Assume that the magnetization density is given by

\[
\frac{M}{V} = b_0 + b_1(T - T_0)
\]

where \( V \) is volume, \( T \) is temperature, and the quantities \( T_0, b_0, \) and \( b_1 \) are functions of \( H \) and mole density, but independent of \( T \). Further, suppose \( b_1 < 0 \), which is typical of a paramagnetic substance. Determine whether the temperature increases or decreases when the system is demagnetized adiabatically. That is, determine the sign of \( \frac{\partial S}{\partial H} \) where \( S \) is entropy and \( n \) is the mole number.

2) A phase transition occurs where the magnetization changes discontinuously as a function of \( H \). In the region of the phase transition, the free energy of the magnet in the phase with relatively low magnetization is

\[
\frac{A}{n} = \frac{1}{2} km^2
\]

where \( k \) is a function only of \( T \), \( m = M/n \), and \( A = E - TS \), with \( E \) denoting internal energy. For the phase at relatively high magnetization,

\[
\frac{A}{n} = \frac{1}{2} h(m - m_0)^2 + c
\]

where \( m_0, h \) and \( c \) are functions only of \( T \), and further, \( k > h, c > 0 \) and \( m_0 > 0 \). Note the similarity of this question to problem 2.23 in Chandler.

a) Determine the equations of state \( H = H(T, m) \) for the two phases.

b) Determine the chemical potentials \( \mu = (\partial A/\partial n)_{T,M,V} \) for the two phases.

c) Show that \( \mu = A/n - Hm \) in both cases.

d) For a fixed temperature, find the magnetic field strength at which there is a discontinuity in \( m \). Express your answer in terms of \( k, h, c \) and \( m_0 \).

e) For that same temperature, determine the size of the discontinuous change in \( m \). Express your answer in terms of \( k, h, c \) and \( m_0 \).
3) Consider a rubber band under tension, $f$, with length per mole, $l = L/n$. For this system it has been suggested that the entropy $S$ is related to the energy $E>0$, and the length according to

$$S = 2cn \sqrt{\frac{E}{n}} \left(1 - \left(\frac{l}{l_0}\right)^2\right)^\gamma$$

where $|f/l_0| \leq 1$, $c>0$. The requirements of positive tension, $f \geq 0$, and stability set upper and lower bounds on the possible value of the exponent $\gamma$ (i.e., $\gamma_L < \gamma < \gamma_U$). Determine $\gamma_L$ and $\gamma_U$.

4) Examine the following phase diagrams. For each, not if it is plausible or not. If not, explain why.

5) The first programming assignment will be assigned next week. Please make sure that you have access to Matlab before next week. If you don’t have a personal copy stop by 106 Latimer and make sure you can get access there with the information I sent out last week (note: login to the Berkeley / Kerberos realm). If you’d like some practice, try creating a Matlab M file that prints out ‘hello world’ when you run it.