Adiabatic demagnetization

3. Consider a classical ideal gas of identical non-interacting particles of mass m in a container of volume V at initial temperature T_i. Let the particles have spin one-half and magnetic moment μ, and let the container be placed in a strong magnetic field H.

   (a) Compute the classical partition function for this system, taking proper account of particle identity. It may help you to know that the partition function for a single classical particle (ignoring the spin degree of freedom) is $Z_1 = n_Q V$ where $n_Q = (mkT/2\pi\hbar^2)^{3/2}$.

   (b) Calculate the total energy and entropy for this system

   (c) Now suppose that the container is thermally isolated and that the magnetic field is slowly reduced (i.e. adiabatically). Show that the temperature decreases continuously as H is decreased.

   (d) Show that if H is reduced all the way to zero the final temperature satisfies the inequality $T_i > T_f > 2^{-\frac{2}{3}} T_i$.