Physics 410 -- Spring 2018

Homework #3, due Wednesday Jan. 31

1. [1] Kittel & Kroemer, Chapter 3, problem 9.

2. [3] Kittel and Kroemer, Chapter 3, problem 1.

3. [4] Kittel and Kroemer, Chapter 3, problem 3. Break up the problem as follows:
(a) [1] Find the partition function.
(b) [1] Find the free energy, F, and the internal energy, U, from the partition function.
(c) [1] Find the entropy.
(d) [1] Compare your answers with those you obtained on problem 3 of the previous homework assignment. There you calculated the energy of N harmonic oscillators in the Microcanonical Ensemble. Is the answer you obtained there equal to N times the answer you obtained for U in this problem? (It should be.) Now compare your expressions for σ. They look very different, because one is a function of U while the other is a function of τ. Show that they are the same (except for the factor N) by substituting $U(\tau)$ into the expression for σ you obtained in the Microcanonical Ensemble.

4. [5] Kittel & Kroemer, Chapter 3, problem 2. Break the problem up as follows:
(a) [1] Find the partition function first for a single spin, then for N independent spins using the result from the first problem on this homework set.
(b) [2] Find the magnetization M directly from the partition function using the "Canonical Distribution Function", also known as the Boltzmann factor. (You don't need to find F as they say in the book.) You can work either with the energy or the spin excess s -- they are related by $\varepsilon_s = -2mBs$, so $U=\langle\varepsilon\rangle=-2mB\langle s\rangle$. M is then a function of U or s.
(c) [1] Find the magnetic susceptibility and show what it is in the high-temperature limit, i.e. part (c) in the book.
(d) [1] Compare your answer with the one you obtained on problem 2 of the previous homework assignment. There you calculated the dimensionless magnetization per atom, M/Nm, for a spin system in the Microcanonical Ensemble. (That answer was only valid at high temperatures where $s \ll N$.) Calculate the magnetic susceptibility from that problem, and compare it with your answer to part (c) above. By the way, the inverse temperature dependence you found for the magnetic susceptibility is called the "Curie Law", and is very famous.

5. [2] Kittel & Kroemer, Chapter 3, problem 4.