Ge 212 Problem Set 4

Due Monday November 2, 2015

1. Calculate the entropy of a perfect crystal of solid neon of terrestrial atmospheric composition at absolute zero. There are three isotopes (20, 21, and 22) and the isotope ratios are 20Ne/22Ne = 9.80 and 21Ne/22Ne = 0.0290.
2. Consider the argument given in class that, for example, the isochoric heat capacity *CV* = (∂*E*/∂*T*)V must be *greater than zero*. The argument as stated showed what is wrong with the case *CV* < 0. What is wrong with *CV* = 0? (Hint, look at our definition of equilibrium)
3. Show that, for any stable phase, *T* = –1/*V* (∂*V*/∂P)*T* (the isothermal compressibility) is positive.
4. In class we derived the Boltzmann distribution and obtained equations for the energy per atom, the probability of occupancy of each energy level, the partition function, and the total derivative of entropy. We did not derive an expression for the absolute value of the entropy in terms of the total energy per atom, the partition function, and *T* (in which the individual probabilities no longer appear), but there is such an expression.
   1. Find *S* per atom for a Boltzmann distribution (in terms of *E* per atom, the partition function *Z*, the temperature *T*, and constants). Show your work – even if you know the answer ☺.
   2. Recall that in thermodynamics *S* has an absolute value but *E* does not. *E* is always relative to an arbitrary standard zero for energy. It should never make any difference to anything (for example, the value of *S*) if we add a constant offset to all the energy levels. Does this appear to be true for the expression you obtained in (a)?
   3. Go back to the Boltzmann distribution equations for the probability of each energy level and for the total energy and show that if we replace i with (i + o) then: the probabilities do not change, the entropy does not change, and the total energy per atom simple increases by o.