**Potentials for random substances**

**Prologue**

Now we want to investigate how we may determine the functional form of these potentials introduced previously. We will consider for simplicity that our substance is homogeneous and obeys the scaling relations introduced in the previous lecture. Then our potentials satisfy,



It will suffice, then, to determine the heat capacity CV(T,V) and equation of state p(T,V), to construct the potentials. For instance, forming the differential of U(T,V) we have:



What are these derivatives? Well,



and,



So we have:



A similar procedure for the entropy would yield:



What are these derivatives? Well,



and,



So we have:



With U(T,V) and S(T,V), we can then invert to get S in terms of its canonical variables, as well as the other potentials as desired.

**Ideal molecular gas**

Suppose that the gas particles are molecular, as is allowed even above, and that we take into account the bond strength of the molecule, φ (a negative #) so that the internal energy is U = KE + Nφ. What changes then? Well I would suppose that the entropy is function of KE, V, and N, really, so that we could say:



What then is T?



What about pressure?



and so that is as before as well, which is to be expected. And so the entropy would be the same function of temperature as before,



and the free energy would therefore be:



and Gibbs energy is:

