

Dear ThermoHELP:

In the solution for the adiabatic demagnetization problem (ps2, 2.10) it is stated that $(dM/dT)_H$ is less than zero. Where does this come from? Please don't say the Maxwell relation because the problem uses this fact that to prove the other half of the Maxwell relation $(dS/dH)_T$ is less than zero!

Also, why does adiabatic demagnetization consist of two steps? I thought adiabatic and isentropic were synonymous (since $ds = ds/T$) but this is not true if there is an isothermal step involved in an adiabatic demagnetization (or, ostensibly I suppose, an adiabatic expansion, adiabatic depolarization, etc).

Actually we have never proven this. We have accepted this as a fact, just like we accepted that heat capacity and compressibility are always positive, and that thermal expansion is mostly positive. Some of these statements can be proven with stability theory, which we have skipped in this class, to keep the level of theory we have to go through reasonable. Sorry about that. In the end, $(dM/dT)_H$ is a "materials" input property (remember it is one of the entries in the matrix of second derivatives of the TD potential). So see, I did not say it was from a Maxwell relation ...

I am away from my office without access to the problem set, and won't be back till Wednesday morning. So I can't quite look at the problem. I will ask Raymundo to answer your question re problem 2.10.

G. Ceder

As Prof. Ceder said, in this course we have not seen stability theory, which basically consists in making sure that the potential that needs to be minimized to achieve equilibrium has to have a positive curvature with respect to intensive properties or negative with respect to extensive properties.

Now, to the problem:

In the problem, we are told that the material obeys Curie Law:

$M = C/T \cdot H$ where C is positive due to stability conditions.

At constant H ,

$dM/dT = -C/(T^2)H$, therefore, $dM/dT < 0 \dots$

Adiabatic demagnetization has to consist of two steps: One adiabatic and the other one isothermal:

During the first step, the field is increased isothermally. Once the material has been magnetized, it is then insulated and the field is removed adiabatically.

In principle, you can start at a high field condition and then adiabatically decrease the field, which in turn decreases the

temperature. This process, however, does have only one step. The isothermal process is needed if one is to further remove heat from the system.

Raymundo