EP2827: Thermodynamics
Homework Set I*

February 12, 2019

1. Consider three systems: System A is a paramagnetic solid sample described by thermodynamic coordinates $\mathcal{H}, M$ i.e. the magnetic induction ("H field") and the magnetization (magnetic dipole moment density) respectively; system B, another paramagnetic solid with coordinates $\mathcal{H}', M'$; and system C, which is a gas described by coordinates P, V. When A and C are in thermal equilibrium (i.e. separated by a diathermal partition), the experimental data reveals that the following relation between the thermodynamic coordinates of A and C holds,

$$n\,R\,C\,\mathcal{H} - MPV = 0.$$

When B and C are in thermal equilibrium, experiments lead to the following relation among the set of thermodynamic coordinates of B and C,

$$n\,R\,\Theta M' + n\,R\,C'\,\mathcal{H}' - M'PV = 0.$$

Here n, R, C, C', Θ are a bunch of constants. What are the three functions (of the three pairs of thermodynamic coordinates) that are equal to each other at thermal equilibrium. These three functions give the temperature expression in terms of the thermodynamic coordinates for each system.
Hint: Recall what we did in class, one can equate,

$$f_{AB} = n\,R\,C\,\mathcal{H} - MPV,\ f_{BC} = n\,R\,\Theta M' + n\,R\,C'\,\mathcal{H}' - M'PV.$$

You need to find out the functions g_A, g_B, g_C which are equal at thermal equilibrium.

(5 points)

2. Set each of these functions to the ideal gas scale temperature, θ and write down the equation of state of A, B and C.

(5 points)

3. In the table below, the entries in the top row represents pressures of a gas in the bulb of a constant volume gas thermometer when the bulb is immersed in water at triple point. The entries in the bottom row on the other hand represents corresponding readings of pressure when the bulb is placed in an unknown substance at a constant unknown temperature. Calculate the ideal gas temperature of this substance.

P_{TP}, in mm of Hg	1000.0	750.00	500.00	250.00
P, in mm of Hg	1535.3	1151.6	767.82	383.95

(Use of "interpolation" function in Mathematica®is recommended:
https://reference.wolfram.com/language/ref/Interpolation.html
If you prefer Maple®or MATLAB ®that is fine as well. Attach the print out of the code and output with the HW set.) (5 points)

*Due in class on Friday, 15th Feb.