

Physics 6311: Statistical Mechanics - Homework 2

due date: Tuesday, Sep 7, 2021

Problem 1: Carnot process for a dielectric substance (20 points)

Consider a dielectric substance whose equation of state is $P = \alpha E/T$ where T is the temperature, P is the polarization, E is electric field, and α is a material specific constant. The internal energy is $U = CT$ where the specific heat C is a constant.

- Sketch a typical Carnot cycle in the $P - E$ plane.
- Compute the total absorbed heat and the work during the four segments of the cycle.
- Explicitly calculate the efficiency.

Problem 2: Entropy of the ideal gas (8 points)

The equation of state of an ideal gas is $pV = Nk_B T$ with p being pressure, V volume, N the number of particles, k_B the Boltzmann constant, and T the temperature. The internal energy is $U = (3/2)Nk_B T$. Calculate the entropy of the ideal gas as a function of T and V . What happens for $T \rightarrow 0$?

Problem 3: Maxwell relations (12 points)

For a magnetic material characterized by magnetization M , magnetic field H , and temperature T (HMT system), derive the so-called Maxwell relations between various derivatives of thermodynamic quantities. The Maxwell relations follow from the fact that the differentials of the thermodynamic potentials U , H , A and G are exact, if they are expressed in terms of their natural variables.