

Physics 4311: Thermal Physics - Homework 2

due date: Tuesday, Feb 6, 2024, please upload your solution as a pdf on Canvas

Problem 1: Boltzmann factors (10 points)

- Compute the characteristic thermal energy $k_B T$ at room temperature.
- Convert the result to electronvolts (eV)
- The dissociation (binding) energy of a hydrogen molecule is about 4.5 eV. Do you expect hydrogen molecules to be appreciably dissociated at room temperature?
- Estimate the temperature at which hydrogen molecules start dissociating appreciably!
- Do you expect the rotational energy levels of a diatomic molecule to be excited at room temperature? (The excitation energies are about 10^{-4} eV.)

Problem 2: Absorbed molecule (30 points)

Consider a molecule absorbed on the surface of a solid. The molecule can be in one of two positions on the surface. In the first position, it has an energy $E_1 = -\epsilon$. In the second position, its energy is $E_2 = -2\epsilon$. The solid and molecule are in thermal equilibrium at temperature T .

- Compute the probability for the absorbed molecule to be in position 1.
- Compute the probability for the absorbed molecule to be in position 2.
- What is the average energy $\langle E \rangle$ of the molecule as function of the temperature?
- Determine the limiting values of $\langle E \rangle$ for $T \rightarrow 0$ and $T \rightarrow \infty$.
- Compute the heat capacity $C = d\langle E \rangle/dT$ as function of T .
- Determine the limiting values of C for $T \rightarrow 0$ and $T \rightarrow \infty$.
- Find the maximum of C . (This is called the Schottky anomaly.)
- Sketch or plot the $\langle E \rangle$ vs. T and C vs. T curves. Qualitative hand sketches are OK, but they should reflect the features you found in parts d), f), and g).