

Exercises in Statistical Mechanics

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This exercises pool is intended for a graduate course in “statistical mechanics”. Some of the problems are original, while other were assembled from various undocumented sources. In particular some problems originate from exams that were written by B. Horovitz (BGU), S. Fishman (Technion), and D. Cohen (BGU).

===== [Exercise 0160]

Partition function for AB and AA molecules

A diatomic molecule AB can be regarded as two atoms that are connected by a spring of length r_0 , and vibration frequency ω_0 . The total angular momentum is $\ell = 0, 1, 2, \dots$. The masses of the atoms are m_A and m_B , and they have spins S_A and S_B .

- (a) Explain what are the conditions that allow to ignore all the excited vibrational levels, so you can treat the molecule as a rigid body (“rotor”).
- (b) Calculate the partition function of the diatomic molecule, assuming that it is like a classical rigid rotor. Define the condition on the temperature for this approximation to hold.
- (c) Calculate the partition function of the diatomic molecule, if the temperature is very low, taking only the $\ell = 0, 1$ states into account.
- (d) How the previous answers are modified for an AA molecule that is composed of two identical spin 0 atoms?
- (e) How the previous answers are modified for an AA molecule that is composed of two identical spin 1/2 atoms? What is the probability to find the spin configuration in a triplet state? Relate to the two limits in (b) and (c).