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 4446]

Relative abundance of isotopes

The partition functions of a diatomic molecules AB or A_2 (within an ideal gas) has the form

$$f_{AB} = g_{AB}(T)(m_A m_B)^{3/2} \qquad \text{or} \qquad f_{A_2} = \tfrac{1}{2} g_{A_2}(T) m_A^3$$

where m_A, m_B are atomic masses and B is an isotope of A; g_{AB} and g_{A_2} are independent of the isotope masses.

(a) a) Explain the origin of the factor $\frac{1}{2}$.

(b) In the reaction H_2+Cl_2 $\leftrightarrows$2HCl the Cl atom has two isotopes Cl^{35} and Cl^{37}. Write the relevant four reactions and their laws of mass action.

(c) Show that the relative abundance of Cl^{35} and Cl^{37} in Cl_2 is the same as in HCl, i.e. the various densities n satisfy

$$\frac{2n_{Cl_2^{37}} + n_{Cl^{35}Cl^{37}}}{2n_{Cl_2^{35}} + n_{Cl^{35}Cl^{37}}} = \frac{n_{HCl^{37}}}{n_{HCl^{35}}}$$