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 3342]

Black body radiation in the universe

The universe is pervaded by a black body radiation corresponding to a temperature of $3K$. In a simple view, this radiation was produced from the adiabatic expansion of a much hotter photon cloud which was produced during the big bang.

(a) Why is the recent expansion adiabatic rather than, for example, isothermal? It is also known that the expansion velocity is sufficiently small. Smallness compared with what is needed? explain.

(b) If in the next 10^{10} years the volume of the universe increases by a factor of two, what then will be the temperature of the black body radiation?

(c) By what factor does the energy change in the process (b)? Explain the process by which the energy changes and show that this specific process indeed reproduces the change in energy.