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 4014]

Chemical equilibrium volume-surface

Consider a tank with water volume V,and over it oil is floating.The surface contact between the water and the oil is S. In the water and over the contact surface between the water and the oil, large molecules with mass m are moving. Assume that the potential energy of each molecule is E_1 when it's in the water, and E_2 when it's on the boundary between the water and the oil ($E_2 > 0, E_1 > 0$) $E_2 - E_1 = E_0 > 0$.
Assume that the large molecules are classical ideal gas (which means there's no interaction between the large molecules).What is is the system's temperature T ?

a Calculate the chemical potential μ_l of the large molecules in the water.

b Calculate the chemical potential μ_s of the large molecules on the boundary between the water and the oil.

c What is the ratio between the large molecules density in the water, and their density on the boundary between the water and the oil in equilibrium?

d What is the total energy of the large molecules?