

Part 2: Statistical physics

Preliminary questions

1. Explain in 5 to 10 lines what is a phonon.

Adsorption

At the surface of a solid are A sites, each of which can adsorb at most one atom. The energy of an adsorbed atom is ϵ_ℓ .

The system is in contact with a reservoir (temperature T and chemical potential μ).

1. Justify which ensemble can be used to describe this system.
2. Calculate the grand-partition function of this system. Each of the sites can be treated as independent sub-systems.
3. Calculate the mean number of atoms adsorbed on the solid side.
4. Calculate the mean energy of the system.

The solid is actually the wall of a container of volume \mathcal{V} in which we introduce N atoms of ideal gas at temperature T .

- 5 Calculate the temperature and the kemical potential of the ideal gas from the expression of the entropy
- 6 From the previous answer, calculate the mean number of atoms adsorbed on the wall.

2

We now consider that the adsorbed atoms, instead of being assigned on sites, behave as an two-dimensional ideal gas, free to explore the whole surface S (we assume a square to simplify).

- 7 We recall that the states for an ideal gas are quantized such that $\vec{k} = p_x \frac{\pi}{L} \hat{e}_x + p_y \frac{\pi}{L} \hat{e}_y$. Assume that the gas is made of fermions. Calculate the grand-partition function of each of the states of the 2D gas, then calculate the mean number of particles $\bar{n}_{\vec{k}}$ in for each state.
- 8 Calculate the density of states $\rho(\epsilon_{\vec{k}})$, using the fact that $\epsilon_{\vec{k}} = \frac{\hbar^2 k^2}{2m}$.
- 9 Explain why the mean number of particles of the surface can be written as:

$$\bar{N} = g \int \rho(\epsilon) \bar{n}_{\vec{k}} d\epsilon. \quad (6)$$

- 10 From previous results write the expression of the mean number of adsorbed atoms at high temperature.

Statistical Physics Of Materials

ML Morrison



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