

1. How do you interpret negative temperatures? Show that an object with negative temperature is "hotter" than an object with positive temperature, i.e. heat flows from a negative temperature object to a positive temperature object.
2. What does "non-interacting" mean? If the particles forming the system do not interact, the system will never reach equilibrium. Hence how is it possible that one can talk about non-interacting systems?
3. Consider the non-interacting spin system considered during the lecture. The hamiltonian is given by:

$$\hat{H} = \sum_{i=1}^N \frac{\mu B \hbar}{2} \sigma_z^i$$

(a) Consider a subsystem consisting of two spins. What are the possible states that the sub-system can be in? What are the probabilities that the sub-subsystem can be found in these states?

(b) What is the average energy of the subsystem?

(c) What is the relative energy fluctuation of the subsystem?

4. Calculate  $C_v$  and  $C_p$  for the ideal gas.
5. Calculate  $F$ ,  $W$ , and  $\Phi$  for a gas of  $N$  noninteracting atoms.