In the name of God

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STATISTICAL FIELD THEORY AND CRITICAL PHENOMENA

Exercise Set 1: Review on necessary parts

(Due Date: 1403/07/24)

1. Thermodynamical potentials: enumerate different types of thermodynamical potentials. Deduce why we need to more than one potential in thermodynamical systems while for a gravitational system we can examine a typical gravitational system with only one gravitational potential.

2. Different regimes in Physics; Determine the specific measure accordingly one can distinguish between each following regimes:
A: Classical and Quantum regimes
B: Relativistic and Non-relativistics regimes
C: Interactive and Non-interactive regimes
D: Collisional and Non-collisional regimes

3. According to the Vander Walss equation

$$(P + (N/V)^2 a)(V - Nb) = NKT$$

Compute the internal energy and entropy in terms of temperature and volume.

4. In a box isolated from environment with volume V. We divide it into two parts with xV and $(1-x)V$ parts. Pressures and temperatures in both partition are equal. There are xn and $(1-x)n$ moles in the left and right parts, respectively. Now we remove the partition, how many changes will be occurred in Entropy?

5. Derive the most probable speed of an ideal classical Gas in D-dimension.

6. A tire of a typical car was getting punctured due to a pin.
A: Calculate the flux of exhaust air.
B How much time does it take for the tire to achieve out of service?

7. Density of energy sate for i deal gas: According to Laplace transformation between partition function and density of energy state as:

$$Z(\beta) = \int_0^\infty dE\, g(E)\, e^{-\beta E}$$

where $Z(\beta)$ is canonical partition function and $\beta = 1/k_B T$ and $g(E)$ is density of energy state. By computing canonical partition function of ideal gas in 3-dimension and then using the inverse of Laplace transformation, calculate $g(E)$. To check the reliability of your results, use the $g(E)$ and by applying Laplace transformation of $g(E)$ derive the $Z(\beta)$.

8. Occupation number: The general form of Grand canonical partition function reads as:

$$\mathcal{Z}^\diamond(\beta, V, \mu) = \sum_{\{n_k\}} g^\diamond(\{n_k\}) e^{-\beta \sum_{k=1}^\infty n_k (E_k - \mu)}$$

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here $g^{\diamond}(\{n_k\})$ is defined as statistical weight of a set of occupation number. Taking into account the degeneracy (g) for each energy state (E_k), determine the explicit definition of $g^{\diamond}(\{n_k\})$ for $\diamond \equiv BE, FD, MB$. And show that:

$$\lim_{\beta\mu\to 0} g^{BE}(\{n_k\}) = g^{FD}(\{n_k\}) = g^{MB}(\{n_k\})$$

9. What is the physical concept of $\mu = 0$ for Photon gas?

Good luck, Movahed