Statistical Physics B

Classes 26.10.2022

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1. **Exercise 1:** (Ex 3.5 Pathria) Helmholtz free energy is defined as:

$$A = U - TS$$

   Show that:

$$A + pV = \mu N$$

2. **Exercise 2:** (Ex 3.6 Pathria)
   (a) The number of microstates accessible to a given statistical system is Ω. Calculate the probability of beeing in given macrostate p_r for which entropy $S = -k\sum_r p_r \log p_r$ is maximised
   (b) If, on the other hand, we have an ensemble of systems sharing the energy (with mean energy $\bar{E}$), then find the probability p_s that given system has energy E_s.
   (c) ***Homework:*** Now the system not only energy but also particles (with mean value $\bar{N}$). Show that the entropy will be maximised for $p_{s,r} = exp(-\alpha N_r - \beta E_s)$.

   Hint 1: *Use Lagrange multipliers*

3. **Exercise 3:** (Ex 3.8 Pathria) Show that for classical ideal gas we have:

$$\frac{S}{Nk} = T\Big(\frac{\partial \log(Q_1)}{\partial T}\Big)_{V,N} + \log\Big(\frac{Q_1}{N}\Big) + 1$$

   Hint 1: *In a classical ensemble Helmholtz free energy equals* $A = -kT\log(Q_N)$. *Establish the relation* $Q_N = f(Q_1)$.