Thermal Physics II – Problem Sheet 2

Part I: Questions

1. How many macrostates can follow is the microstate is well-defined?

2. How do you determine the most likely value of an measurement for a given distribution?

3. Is the number of possible microstates, that is accessible to the system, sufficient information to determine the thermodynamics of the system?

4. Given the fact that a quantity A strongly fluctuates in a measurement, what can you say about the particle number of the system?

Part II: Problems

1. Number of Specific Macrostates
Find the number of permutations of the letters in the word 'ENGINEERING'. Do not count permutations that look alike. In how many ways, we have 'EEE'?

2. The Meaning of VERY Unlikely
For the lottery your are supposed to pick six numbers out of 49 where, of course, the order does not play a role. What is probability to get the jackpot (all numbers picked correctly) by buying only one ticket?

3. The Meaning of NEVER
A group of monkeys plays with a typewriter and hits random letters. How likely is it that the come up with

'To be, or not to be - that is the question;' ?

4. Stirling's Formula
$\ln n! \approx n \ln(n) - n$

Justify this formula by comparing the integral of $y = \ln n$ (n continuous) with the upper and lower bounds $B_u = \ln n!$ and $B_l = \ln n! - \ln n$, respectively.

5. Calculate Fluctuations – Teaser
Consider the example of a gas in a volume V that is split into two parts V_1 and V_2. Calculate the root mean square deviation of the particle number in part V_1. That is, calculate $\langle N_1 \rangle$ and $\langle N_1^2 \rangle$.
Hint 1: use $p_N(N_1)$ and treat the probabilities p_1 and p_2 as free functions; use the relation $p_1 + p_2 = 1$ just at the end.
Hint 2: create the factor N_1 by differentiating $p_N(N_1)$ with respect to p_1:

$$\langle N_1 \rangle = p_1 \frac{\partial}{\partial p_1} \sum_{N_1=0}^{N} w_N(N_1)$$

Do this twice when calculating $\langle N_1^2 \rangle$.