Thermodynamics

Do two of the following three problems, each on a separate sheet (or sheets). Staple together the sheets for each problem, if using multiple sheets, but do not staple all problems together. Write at the top of the first sheet of each problem your name, subject, and problem number.

Problem 1

Consider a simple model of a crystalline solid which treats the system as a collection of N independent three-dimensional quantum harmonic oscillators of the same frequency ω. Let E be the total energy of the solid. You may assume that $E >> N\hbar\omega$ and $N >> 1$.

a) Calculate the multiplicity of this solid.

b) Derive an approximate expression for the entropy of this solid using Stirling's formula.

Problem 2

Every night at midnight, the KRWG announcer closes with the following line: "*KRWG is authorized by the Federal Communications Commission to broadcast at a frequency of 90.7 megahertz with an effective radiative power of 100,000 Watts*," or something very similar. How many photons were emitted from the KRWG antenna during this sentence?

Problem 3

2. A set of N (where N is very large) distinguishable classical particles are distributed in m (also very large, with $N >> m$) boxes (labeled by 1, 2, $\ldots$, m). Each box can accommodate any number of particles. The number of particles in each box can be written as $n(i)$ (where $i = 1, 2, \ldots, m$).

(1) Find the entropy of the system S, in terms of $n(i)$.

(2) Find the distribution $n(i)$ where the entropy is maximized. What is the entropy now?

(3) Find out the distribution $n(i)$, where the entropy is minimized. What is the entropy now?

Hint: $ln(N!) \approx NlnN - N$ when N is very large.