Physics 112, B.C. Regan, Problem Set #1. KK refers to Kittel and Kroemer's *Thermal Physics*

1. Concerning Figure 1.9 in KK,
    a. The curve shown is normalized such that its integral over [-50,50] gives what value? Give an exact answer and an approximate decimal answer.
    b. The vertical dotted lines are how many standard deviations from the mean value?
    c. Speaking of the mean value of s, what is it?
    d. What is g(100,0) exactly?
    e. What is the fractional error between the Gaussian approximation and the exact value of g(100,0)?
    f. What is g(100,σ), approximately?
    g. What is the value of g corresponding to the horizontal dotted line, approximately?
2. To supplement his income, your professor is considering opening a small casino. He wishes to gauge your interest in the following game. In this game, you flip a fair coin. If it is tails, he pays you $1. If it is heads, you flip again. If you flip tails on the second try, he pays you $2. If it is heads, you flip again. If you flip tails on the third try, he pays you $4. If it is heads, you flip again, and so on according to the same pattern. You flip until you flip tails, and then you get paid. How much would you pay for the privilege of playing this game? Please write a paragraph explaining the principal considerations involved. We do not expect (or wish) for you to spend too long on this question, so don't turn it into a thesis.
3. Consider the Poisson distribution $P(n) = \frac{\mu^n}{n!} e^{-\mu}$.
    a. Show that $P(n)$ is properly normalized.
    b. Calculate $\bar{n}$.
    c. Calculate $\overline{(\Delta n)^2} = \overline{(n - \bar{n})^2}$. (You can brute-force this problem – I did. Or you can use the identity $n^2 = n(n-1) + n$ to get to the answer slightly faster.)
4. (Reif 1.11) Assume that typographical errors committed by a typesetter occur completely at random. Suppose that a book of 600 pages contains 600 such errors. Use the Poisson distribution to calculate the probability
    a. that a page contains no errors
    b. that a page contains at least three errors
5. KK C.1 Random pulses.
6. At one version of "standard" temperature and pressure (STP) there are $\simeq 6.02 \times 10^{23}$ molecules in a volume of 22.4 liters. Take the positions of the molecules in a volume to be the points of a Poisson random scatter in three dimensions. Let $N(x)$ be the random number of molecules in a cube with sides of length x meters.
    a. Calculate the mean $\mu(x)$ and the standard deviation $\sigma(x)$.
    b. At what size x is $\sigma(x)$ 1% of $\mu(x)$, so that fluctuations in number density of $\sim$ 1% over a cube of dimension x are likely to occur?
7. A drunk starts out from a lamppost in the middle of the street, taking steps of equal length either to the right or to the left with equal probability. What is the probability that the woman will again be at the lamppost after taking N steps
    a. if N is even?
    b. if N is odd?