Physics 222 CID ____________

Homework 15

Score ________ / 30

1. (3 pts) Use the table of electron configurations in table 7.4 or the periodic table to predict a chemical formula for molecules made up of (a) hydrogen and sulfur, (b) hydrogen and phosphorus, and (c) hydrogen and antimony. Assume that hybridization does not occur.

2. (3 pts) Consider the wave function of the electrons in an H_2 molecule. Why can the spatial part of the wave function be symmetric when electrons are Fermions?

3. (4 pts) In your own words, what does $n(\epsilon)d\epsilon$ physically represent (not just its name, but what it means)?

4. (4 pts) In your own words, what does $g(\epsilon)d\epsilon$ physically represent (not just its name, but what it means)?

5. (4 pts) In your own words, what does $f(\epsilon)$ physically represent (not just its name, but what it means)?

For the problems below, remember that $g(\epsilon)$ can have two meanings. If we treat the system has having quantized energy levels, $g(\epsilon)$ is the degeneracy. If we ignore the fact that energy is quantized and treat the problem classically, then $g(\epsilon)$ is the density of states (which we typically have to multiply by $d\epsilon$ to calculate anything useful).

6. (6 pts) Consider N non-interacting spinless particles of mass m in a one-dimensional infinite square well of size L. (Note that even non-interacting particles can come into thermal equilibrium with each other by independently coming into thermal equilibrium with their container — the square well.)

(a) What is the degeneracy $g(\epsilon)$?

(b) If the temperature is high enough, I can blur out the individual energy levels and treat this as a continuous problem. When I do this, what is the density of states $g(\epsilon)$?

7. (6 pts) Consider N non-interacting spinless particles a two-dimensional infinite square well. The energies in such a well are given by $\epsilon = E_0(n_x^2 + n_y^2)/2$ (where n_x, and n_y can be any positive integer).

(a) What is the degeneracy of the $n_x = 1$, $n_y = 1$ state?

(b) What is the degeneracy of the $n_x = 1$, $n_y = 3$ state?

(c) What is the degeneracy of the $n_x = 5$, $n_y = 5$ state?

(d) If I treat this as a continuous problem, what is the density of states? Give your answer in terms of ϵ, E_0 (the energy of the ground state), and fundamental constants.

<u>Extra problems I recommend you work (not to be turned in)</u>

- What is the degeneracy and density of states for a two-dimensional harmonic oscillator? The energies are given by $\epsilon = (n_x + n_y + 1)\hbar\omega$.
- If I have N non-interacting particles in a one-dimensional infinite square well of size L, how many of them will be in the ground state if the system is in equilibrium at a temperature T? Assume that the system is at a high enough temperature that you can use Maxwell-Boltzmann statistics.
- How would problems 6 and 7 have been different if I used spin 1 particles instead of spinless (spin zero) particles?