Physics 237, Midterm Exam #3

Thursday April 22, 2010

12.30 pm – 1.45 pm

Do not turn the pages of the exam until you are instructed to do so.

Exam rules: You may use *only* a writing instrument while taking this test. You may *not* consult any calculators, computers, books, or each other.

1. Problems 1 and 2 must be answered in booklet # 1.

2. Problems 3 and 4 must be answered in booklet # 2.

3. The answers need to be well motivated and expressed in terms of the variables used in the problem. You will receive partial credit where appropriate, but only when we can read your solution. Answers that are not motivated will not receive any credit, even if correct.

At the end of the exam, you need to hand in your exam, your "cheat sheet", and the two blue exam booklets. All items must be clearly labeled with your name, your student ID number, and the day/time of your workshop.

Name: _____

ID number: _____

Workshop Day/Time: _____

Problem 1 (30 points) **ANSWER IN BOOKLET 1**

A system has N distinguishable atoms. The atoms are distributed over two energy levels:

$$\varepsilon_1 = 0$$
$$\varepsilon_2 = \varepsilon$$

a) What is the total energy of this system of atoms if the temperature of the system is T?

b) What is the heat capacity at constant volume of this system at temperature T?

Your answers need to be well motivated. A correct answer without any motivation will not receive any credit.

Problem 2 (30 points) **ANSWER IN BOOKLET 1**

Consider a system of three indistinguishable particles in a potential well. Assume that the particles do not interact with each other and can be described by the following normalized wavefunctions: $\psi_\alpha, \psi_\beta, \psi_\gamma$. The subscripts α, β, and γ correspond to sets of different quantum numbers that specify the spatial and spin quantum states of the wavefunctions.

a) Construct the total asymmetric wavefunction for this system of particles. Note: make sure that the total wavefunction is properly normalized. You must show that the total wavefunction is asymmetric with respect to the exchange of the labels of any two particles.

b) Show that the wavefunction obtained in part a) can describe a system with three fermions.

c) Construct a total wavefunction that can describe a system of three bosons. Make sure that the total wavefunction is properly normalized.

Your answers need to be well motivated. A correct answer without any motivation will not receive any credit.

Problem 3 (35 points) **ANSWER IN BOOKLET 2**

Consider the two optical electrons in a ^{12}C atom. In the ground-state configuration, the electrons are in a $2p^2$ configuration.

a) Using proper spectroscopic notation, specify what states can be formed when the two electrons are in a $2p^2$ configuration?

b) Rank the states obtained in part a) in terms of energy (starting with the state with the lowest energy and ending with the state with the highest energy). Note: ignore energy shifts due to the spin-orbit coupling.

c) One of the electrons of the atom is excited to the 3s subshell. Using proper spectroscopic notation, specify what states can be formed when the two electrons are in a $2p^1\ 3s^1$ configuration?

d) Rank the states obtained in part c) in terms of energy (starting with the state with the lowest energy and ending with the state with the highest energy). Note: ignore energy shifts due to the spin-orbit coupling.

e) Make a schematic energy level diagram of all the states obtained in parts a) and c). The diagram must show the states, identified by their spectroscopic notation, in the correct order.

f) Indicate all transitions that can be observed between the states in the energy level diagram obtained in part e) and explain why the transitions you indicated can occur.

Your answers need to be well motivated. A correct answer without any motivation will not receive any credit.

Problem 4 (5 points) **ANSWER IN BOOKLET 2**

Yogi Berra presents Yankees shortstop Derek Jeter with his World Series ring.
Chris Trotman/Getty Images

The New York Yankees have played 14 games when you take this exam. What is their ratio of Wins to Losses after these 14 games?

1. 14:0
2. 13:1
3. 12:2
4. 11:3
5. 10:4
6. 9:5
7. 8:6
8. 7:7
9. 6:8
10. 5:9
11. 4:10
12. 3:11
13. 2:12
14. 1:13
15. 0:14
16. Who are the Yankees?