NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 2205 – ATOMIC PHYSICS

BSc HONOURS PART II: *MAY 2006* *DURATION: 3 HOURS*

ANSWER ALL QUESTIONS FROM SECTION A AND ANY 3 QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

SECTION A

1. (a) (i) Write down the ground state configuration of Lithium. [4]

(ii) Calculate the angle between the total and orbital angular momentum for the ${}^4D_{3/2}$ state. [6]

(iii) Which selection rules govern the emission of spectral lines between atomic states that have quantum numbers assigned to them. [4]

(b) Find the energy level terms corresponding to the configuration 2s3p. [5]

(c) (i) Develop the time – independent Schröedinger equation for two non– interacting identical particles. [5]

(ii) Write down the Hamiltonian of two interacting electrons of an Helium atom. [6]

(d) State the Lande interval rule for the energy separetion $\in$ in terms of the quantum numbers. [5]

(e) Evaluate the Lande factor for the ${}^3P_1$ level in the 2p3d configuration. [5]

SECTION B

2. (a) An electron changes its value of m_s from $+\frac{1}{2}$ to $-\frac{1}{2}$ as a result of an interaction with a magnetic field .

(i) Calculate the change in angular momentum. [4]

(ii) If this happens in a magnetic field of 2T, calculate the change in the electron´s energy. [6]

(b) (i) Given that J=L+S verify that the spin-orbit energy correction is $E_{SL} = A[j(j+1) - l(l+1) - s(s+1)]$ where A is a proportionality constant [6]

(ii) Find values of E_{SL} when $j = l \pm 1$ and $s = \frac{1}{2}$ [4]

3. (a) How does the anomalous Zeeman effect arise ? [6]

(b) Show that the expression for the total magnetic dipole moment of an atom is $\mu = \frac{\mu_b}{\hbar}[L + 2S]$. Define all the quantities involved. [6]

(c) If the oriental potential energy in a magnetic field B is $\Delta E = \frac{\mu_b B}{\hbar} \frac{(3J^2 + S^2 - L^2)}{2J^2} J_Z = \mu_b g B M_J$, express g in terms of j, l and s and hence find g for the $^3D_3$ energy level. [8]

4. (a) Give two examples each of Bosons and Fermions and state which of these is subject to the exclusion principle. [6]

(b) Two particles are in a one-dimensional potential box of length *a*.

(i) Write down the wave functions of the particle systems of Bosons and Fermions. [10]

(ii) Find the normalization constants in both cases. [4]

5. The following K_α lines have been measured

^{12}Mg 9.87 $\overset{0}{A}$	^{16}S 5.36 $\overset{0}{A}$
^{20}Ca 3.35 $\overset{0}{A}$	^{24}Cr 2.29 $\overset{0}{A}$
^{27}Co 1.79 $\overset{0}{A}$	^{29}Cu 1.54 $\overset{0}{A}$
^{37}Rb 0.93 $\overset{0}{A}$	^{74}W 0.21 $\overset{0}{A}$

(a) Plot the square –root of the K_α - frequency against the atomic number Z of the element. [8]

(b) From the plot : (i) verify the relation $\sqrt{\nu} = A(Z - C)$, [4]

(ii) estimate the values of A and C, [4]

(iii) comment on this result. [4]

6. An electron in the inner most orbit of an atom of Z=26 is knocked out of the atom in a collision with an incident electron. This results in the ionization of the atom.

(a) Describe in brief the events that will lead to the neutralization of the atom. [10]

(b) What is the frequency of a possible K_β process in the above process? [10]

- END OF EXAMINATION -