NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

ATOMIC PHYSICS - SPH 2205

EXAMINATION

BSc HONOURS PART II : DECEMBER 2004 *DURATION : 3 HOURS*

ANSWER **ALL** QUESTIONS IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

SECTION A

1. (a) What is the deBroglie wavelength of an electron accelerated through a potential difference of 100V? [2]

   (b) Find the standard deviation in the velocity of an electron, if the uncertainty in its position is 100×10^{-10} m [2]

   (c) Define the following terms: (i) a line component (ii) multiplet and (iii) a transition array. [3]

   (d) Write the spectroscopic notation for a neutral gold (Au) atom. The atomic number for gold is 79. [3]

   (e) What are the L, L_z and E for the state with J = I ? [6]

   (f) Calculate the value of the orbital angular momentum for a hydrogen like atom with a 3d electron.
   If the atom is placed in a magnetic field of IT, find the relative values of the possible energy levels. [5]

   (g) Using vector diagrams, determine the possible values of the total angular momentum of an *f* electron according to

   (i) the vector model,
   (ii) wave mechanics.

   Determine the angle between the vectors S and L from g (ii) - the wave mechanics model. [6]

(h) The Debye temperature for gold is 164K and that of silver 229K. Which metal has a higher specific heat at room temperature (20°C) ? [5]

(i) The mass absorption coefficient of silver is $38cm^2/gm$ for X-rays of wavelength $0.4 \times 10^{-10}m$ and $11cm^2/gm$ for a wavelength of $0.5 \times 10^{-10}m$.

(i) Determine the atomic absorption coefficients of silver for these wavelengths. [4]

(ii) Compare these values with the geometric cross section of silver atoms. [2]

(j) What is a Bohr magneton? [2]

SECTION B

2. (a) Two electrons have orbital angular momenta $l_1 = 1$ and $l_2 = 3$

(i) What are the possible values of L, S and J? [6]

(ii) Write the spectroscopic notation for all states available to these two electrons. [4]

(b) (i) What are the L, S and J values for the ground state of the carbon atom ? [6]

(ii) List the other possible states for excited states of carbon which have the same configuration ($1s^2\ 2s^2\ 2p^2$) as the ground state. [4]

3. (a) (i) Distinguish the characteristic X-rays from the continuous X-rays. [4]

(ii) Explain what $K\alpha$, $L\alpha$ and $K\beta$ X-ray transitions are? [4]

(b) The L_1 absorption limit for Bismuth is $0.75 \times 10^{-10}m$. Determine the minimum energy of a beam of X-ray photons which can produce the L and M fluorescent spectral series of Bismuth. [6]

(c) An auger electron is ejected from a tungsten atom leaving the latter ionised in the L and M states. Calculate the kinetic energy of this electron if the L_1 absorption limit of tungsten is $1.025 \times 10^{-10}m$ and the M_1 absorption limit is $4.41 \times 10^{-10}m$. [6]

4. (a) What is the normal Zeeman Effect ? [3]

(b) Explain how the anomalous Zeeman effect arises [6]

(c) (i) What is the Lande 'g' factor and the Lorentz limit ? Explain their significance [5]

(d) For the $3^2 S_{½}$ energy level with L = O

S = ½ and J = ½, determine

(i) the Lande 'g' factor.

(iii) m_j and
(iii) gm_j [6]

5. Write brief notes on the following:

(a) radiationless transition, [4]
(b) the Josephson effect, [4]
(c) coherent and incoherent radiation, [4]
(d) population inversion, [4]
(e) shell model of the nucleus. [4]

6. (a) (i) State the Lande interval rule

(ii) Prove the Lande interval rule from the expression.

$$\frac{1}{2}\{J(J+1)-L(L+1)-S(S+1)\}\frac{h^2}{4\pi^2}$$ [10]

(b) What are the allowed electronic transitions between the terms of the p^2 and the pd configurations in the case of Russel-Saunders coupling? [10]