**NATIONAL UNIVESITY OF SCIENCE AND TECHNOLOGY**

**APPLIED PHYSICS DEPARTMENT**

**SPH 2205– ATOMIC PHYSICS**

**SUPPLEMENTARY EXAMINATION**

**BSc HONOURS APPLIED PHYSICS: PART II:**

**JULY 2013 DURATION: 3HOURS**

ANSWER ALL PARTS OF QUESTION ONE IN SECTION A AND ANY THREE QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

*SHOW ALL YOUR STEPS CLEARLY IN ANY*

**SECTION A**

1. (a) (i) State the exclusion principle. [3]

 (ii) Use the ground state configuration of Argon to explain the exclusion

 principle. [5]

 (iii) Write down the ground state configuration an atom with Z=15 [4]

 (b) Calculate the angle between the orbital angular momentum and the spin angular momentum for the 4D1/2 state. [5]

(c) Distinguish between Rayleigh and Raman Scattering. [4]

(d) Write down an expression of the total Hamiltonian of an atom with three interacting electrons. [5]

 (e) Using the Hartree approximation technique calculate the energy of an electron in the n = 2 orbit of a Z = 17 atom. [5]

 (f) Why do electrons in the uppermost energy levels determine the properties of solids. [4]

 (g) Explain the difference between the ionization and the dissociation energies in molecules. [5]

**SECTION B**

2. A system of two indistinguishable and non - interacting particles are in a one dimensional potential box of length **a.**

1. Write down the expression for the total Hamiltonian of this system of particles. [3]
2. Use the Schrödinger equation to find the total wave function from this

Hamiltonian. [8]

1. If the particles are Fermions, one in the ground state and the other in the first excited state write down the total wave function. [6]
2. Show that, if the particles are in the same state, the total wave function vanishes.[3]

3. (a) Find the possible values S,L,J for a configuration with two optically active electrons with quantum numbers;

 $l\_{1}=2, S\_{1}=^{1}/\_{2}, l\_{2}=1,S\_{2}$=$^{1}/\_{2}$

 Specify which J goes with each L and S combination. [6]

 (b) Write down all the possible terms for this particular configuration. [6]

 (c ) Determine which terms have lowest and highest energy. [4]

 (d) Determine the angle between J and S in the level 3D2  [4]

4. (a) Discuss and compare X-ray and Optical excitations in atoms. [6]

 (b) Determine the values of Zn for an Iron (Z=26) atom and use these values to estimate the approximate total energy of the electrons in all shells populated in the ground state of the atom. [10]

(c) In (b) above you are asked to estimate the ‘approximate’ total energy.

 Discuss whys it is approximate. [4]

5. (a) If the moment of inertia of a diatomic molecule about an axis perpendicular to the line joining the nuclei and passing through its centre of mass

 is $I=μr\_{0}^{2}$

 define : $μ and r\_{0}$. [4]

 (b) The adjacent lines in the pure rotational spectrum of 35Cl 19F are separated by a frequency of 1,12 x $10^{10}HZ. $What is the inter-atomic distance of this molecule. [6]

 (c) For the $H $molecule the equilibrium separation is equal to 1,27A.

 Compute for molecule;

 (i) The constant B for the rotational levels$ \left(Bhc=\frac{h^{2}}{2I}\right)$ [4]

1. The energies of the first two excited rotation levels. [4]

 (iii) The frequencies corresponding to the transitions $l=0\rightarrow l=1 and l=1\rightarrow l=2.$ [3]

 6. An electron in the second orbit of an atom of Z=36 is knocked out of the atom in a collision with an incident electron. This results in the ionization of the atom.

1. Sketch in an energy diagram the events that will lead to the neutralization of the

atom. [10]

1. Compare the approximate radius of the n = 1 orbit of this atom to the

radius of the hydrogen atom in its ground state? [6]

1. What is the $K\_{α}$ absorption edge in this atom? [4]

**END OF EXAMINATION**