EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE - 2003/2004

(NOV/DEC 2004)

PH 201 ATOMIC PHYSICS AND QUANTUM MECHANICS

FIRST SEMESTER

Time: 02 hours.

Answer ALL Questions

You may find the following information useful

Charge of an electron $e = 1.602 \times 10^{-19} C$

Mass of an electron $m_e = 9.109 \times 10^{-31} kg$

Plank's constant $h = 6.625 \times 10^{-34} Js$

Velocity of light $c = 3 \times 10^8 ms^{-2}$

1. State the postulates of Bohr's theory and deduce an expression for the energy of the n^{th} orbit of hydrogen like atom. Hence, derive Moseley's equation for K lines using the result of Bohr's theory for the hydrogen like atom.

   X-rays from tube with a cobalt target show a strong K_α line at $1.785A^0$ for cobalt and at $2.285A^0$ due to some impurity. Using the Moseley's law and taking the screening constant to be 1, identify the impurity using the following table.

Element	Atomic Number (Z)
Calcium (Ca)	20
Vanadium (V)	23
Chromium (Cr)	24
Cobalt (Co)	27
Nickel (Ni)	28
Copper (Cu)	29
Germanium (Ge)	32

2. (a) Explain the physical significance of the four quantum numbers, which characterize the eigenstates of the electron in a hydrogen atom. What are the allowed values for each?

   (b) State Pauli's exclusion principle for electron in an atom and show that each shell has a maximum of $2n^2$ electrons where n is the principle quantum number.

   (c) Write brief description on the following coupling schemes;

   i. Russel-Saunders (or LS) coupling

   ii. J J coupling

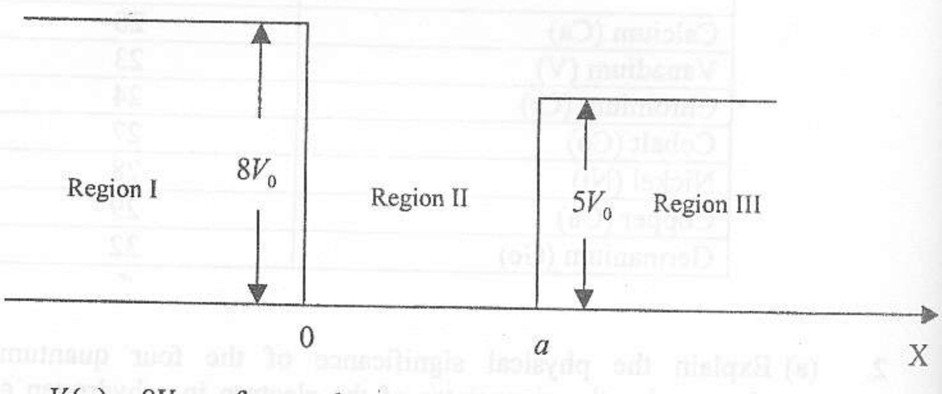
   (d) For a one-electron atom, write down the spectroscopic notation for the possible energy levels of an electron with $l = 2$. If the atom is placed in a week magnetic field, into how many magnetic levels will each of the above levels split up? Which one of these magnetic levels will have the highest energy and justify answer.

3. State Heisenberg's uncertainty principle and write down the expression. Considering the parallel beam monoenergetic electrons of momentum p has waves of wavelength $\lambda = h/p$, describe and explain what you expect to happen when the electron pass through a single narrow slit and strikes a screen. Show that the result is in conformity with the uncertainty principle.

An electron falls through a potential difference of 100 Volts. Calculate the momentum of the electron and the length of the wave associated with electron in motion. Explain how these waves could be detected.

4. Write down the time independent Schrodinger equation in a rectangular Cartesian coordinate system, for a particle of mass m and the energy E moving in a potential V.

A particle of mass m and total energy $9V_0$ moves to the positive side of the X- axis in a one-dimensional potential well with different heights is shown in the figure.



$V(x) = 8V_0 \quad$ for $x < 0$

$V(x) = 0 \quad$ for $0 < x < a$

$V(x) = 5V_0 \quad$ for $x > a$

(a) Write down the time independent Schrodinger equation for the motion of the particle.

(b) Using the boundary conditions, find the transmission coefficient through the positive side of the X-axis, $x > a$.