EASTERN UNIVERSITY, SRI LANKA

SECOND EXAMINATION IN SCIENCE – 2016/2017

FIRST SEMESTER (October / November -2018)

PH 201 ATOMIC PHYSICS AND QUANTUM MECHANICS

Time: 02 hours

Answer ALL Questions

Calculator allowed.

You may find the following information useful.

Planck's constant $h = 6.626 \times 10^{-34}$ J s

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

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

Permittivity in free space $\varepsilon_o = 8.854 \times 10^{-12}\,\mathrm{Fm}^{-1}$

Mass of an α-particle $m_\alpha = 6.65 \times 10^{-27}$ kg

$1\mathrm{eV} = 1.602 \times 10^{-19}$ J

(1) What is photoelectric effect? Giving a labeled schematic diagram, explain the phot effect experiment together with its results. Interpret the results by means of particle n light with reference to Einstein's photoelectric equation. ... (50% ma

Light of frequency 1.5×10^{15} Hz is incident on an aluminium surface, which has function of 4.2 eV. Calculate,

(i) the maximum kinetic energy of the photoelectrons;

(ii) the stopping potential; and

(iii)the cut-off frequency.

... (35% ma

Describe De Broglie's hypothesis, and hence find the De Broglie's wavelength of the energetic photoelectrons in part (i). ...(15% mar

(2)

a. List three different types of evidences for the existence of atoms. ...(10% ma

b. Briefly describe the models of atom and their failures. ...(20% mar

c. Briefly explain the important features of Rutherford's scattering of α-particles by g and ...(15% mar

i. show that the Rutherford's scattering formula is,

$$b = \frac{Qq_\alpha}{4\pi\varepsilon_o m_\alpha v^2}\cot\frac{\vartheta}{2}$$

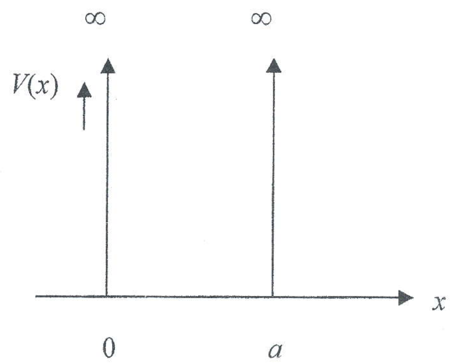
where the symbols have their usual meaning. ...(30% mar

ii. A 6 MeV α-particle is scattered by the nucleus of a mercury atom (Z=80 scattering angle of 120° in the absence of external forces. Calculate the m distance to which the α-particle approaches the nucleus and the velocity o particle at this point. ...(25% mark

(3) A particle of mass m and energy E moves inside an infinite potential well (shown in fi defined by

$$V(x) = 0 \text{ for } 0 \leq x \leq a;$$

$$V(x) = \infty \text{ for } x < 0 \text{ and } x > a$$



a. Apply time-independent Schrödinger equation for the motion of the particle inside the well and obtain an expression for general solution. ... (30% marks)

b. By applying boundary conditions show that the energy of the particle is quantized. ...(30% marks)

c. By applying normalization condition, show that the wave function of the particle is, $\Psi = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi}{a}\right)x$. ... (30% marks)

d. Show a schematic representation of wave function for the first three non-zero energy states. ... (30% marks)

(4)

a. Define the term *angular momentum* and *intrinsic spin angular momentum.* ....(20% marks)

b. Explain the physical significance of quantum numbers, which are used to characterize the energy level of an electron in a hydrogen atom. Write down the allowed values for each quantum numbers? ....(20% marks)

c. State Pauli's exclusion principle for the electron in an atom. ....(15% marks)

d. Explain the meaning of each symbol in the spectroscopic notation $(n^{2s+1}A_j)$ used for describing an atomic energy level with usual notations. ....(15% marks)

e. 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 weak magnetic field, determine the number of magnetic levels that will split up for each energy levels. State which one of these magnetic levels will have the maximum energy and justify the answer. ....(30 % marks)