RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year – Semester II Examination – Nov / Dec 2016

PHY2106 –ATOMIC & NUCLEAR PHYSICS

Time: One and a half ($1\frac{1}{2}$) hours

Answer All Questions.

Electron Charge (e) – 1.6×10^{-19}C,	1 C^2 = 931.5 Mev/u
Electron Mass (m$_e$) – 9.1×10^{-31} kg	Mass of ${}^3_1H$ = 3.016050 u
Reduced Plank Constant ħ= 1.054×10^{-34} J.s	Mass of ${}^3_2He$ = 3.016030 u
Speed of Light C = 3.0×10^8 ms^{-1}	

1. The average binding energy per nucleon of an atomic nucleus is given by,
$\frac{B.E}{A} = a_1 - a_2 A^{\frac{-1}{3}} - a_3 Z^2 A^{\frac{-4}{3}} - a_4(A-2Z)^2 A^{-2} + \delta a_5 A^{\frac{-7}{4}}$, where terms have their usual meanings.

   a) Rewrite the above equation for a nucleus with **odd** number of A and **even** number of Z.

   b) Find Z of the most stable nucleus for a given **odd** A.

   c) If $a_3 = 0.58\ MeV$ and $a_4 = 19.3\ MeV$, show that the answer in part (b) reduces to,

$$Z = \frac{A}{0.015\, A^{\frac{2}{3}} + 2}$$

   d) Find the most stable nuclei for A = 25 and A = 77.

   e) Find the binding energy per nucleon for A = 25 nucleus.

(100 Marks)

2. Total magnetic moment of an atom is given by the following equation.

$$\mu = \frac{-e}{2m_e}\{L + gS\}$$

L, S and ***g*** represent angular momentum quantum number, spin quantum number and gyro magnetic coefficient respectively. Other terms have their usual meanings.

a) Starting from the above equation show that the total magnetic energy of an atom placed in an external magnetic field of ***B*** is given by, $E = \mu_B B\,(m_l + gm_s)$, where $\boldsymbol{\mu_B}$ stands for Bohr magnetron.

b) Assuming ***g = 2,*** write down all the possible energy values in terms of $\boldsymbol{\mu_B}$ and ***B*** for ***n = 2, l = 0*** and ***l = 1*** states.

c) Draw an energy level diagram and mark all the above energy values.

d) Considering spin-orbital coupling (LS coupling) write down all the possible energy values for ***n = 2, l = 0*** and ***l = 1*** states and mark them in an energy level diagram.

(100 Marks)

3. The activity of a radioactive material is defined as $\frac{dN}{dt} = \lambda N$, where λ and *N* represent the decay constant and number of parent nuclei respectively.

a) Show that the number of parent nuclei that will be left after time ***t*** is $N = N_0 e^{-\lambda t}$, where N_0 is the number of parent nuclei at *t = 0.*

b) If half life of ${}^{226}_{88}Ra$ is 1622 years, find the decay constant of ${}^{226}_{88}Ra$.

c) Find the activity of one gram of ${}^{226}_{88}Ra$.

d) Following reaction represents a radioactive decay.

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e^{+} + \nu_e$$

i. What is the type of the decay?

ii. What are the particles emitted during the decay?

iii. The $\boldsymbol{\nu_e}$ does not affect the ***Z*** or ***A*** of the reaction. What is the reason for including that in the equation?

(100 Marks)

END

Important Equations,

$\mu_B = \frac{e\hbar}{2m_e}$, $\vec{J} = \vec{L} + \vec{S}$