



**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) – $1.6 \times 10^{-19} \text{C}$,

$1 \text{ C}^2 = 931.5 \text{ MeV/u}$

Electron Mass (m_e) – $9.1 \times 10^{-31} \text{ kg}$

Mass of ${}^3_1\text{H} = 3.016050 \text{ u}$

Reduced Plank Constant $\hbar = 1.054 \times 10^{-34} \text{ J.s}$

Mass of ${}^3_2\text{He} = 3.016030 \text{ u}$

Speed of Light $C = 3.0 \times 10^8 \text{ ms}^{-1}$

1. The average binding energy per nucleon of an atomic nucleus is given by,

$$\frac{B.E}{A} = a_1 - a_2 A^{-\frac{1}{3}} - a_3 Z^2 A^{-\frac{4}{3}} - a_4 (A - 2Z)^2 A^{-2} + \delta a_5 A^{-\frac{7}{4}}, \text{ where terms have their usual meanings.}$$

- 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 $a_3 = 0.58 \text{ MeV}$ and $a_4 = 19.3 \text{ MeV}$, 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.

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

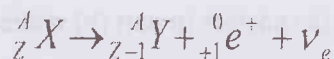
L , S and g represent angular momentum quantum number, spin quantum number and gyro magnetic coefficient respectively. Other terms have their usual meanings.

- 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, $E = \mu_B B (m_l + g m_s)$, where μ_B stands for Bohr magnetron.
- Assuming $g = 2$, write down all the possible energy values in terms of μ_B and B for $n = 2$, $l = 0$ and $l = 1$ states.
- Draw an energy level diagram and mark all the above energy values.
- 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.

- 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 $t = 0$.
- If half life of ${}^{226}_{88}\text{Ra}$ is 1622 years, find the decay constant of ${}^{226}_{88}\text{Ra}$.
- Find the activity of one gram of ${}^{226}_{88}\text{Ra}$.
- Following reaction represents a radioactive decay.



- What is the type of the decay?
- What are the particles emitted during the decay?
- The ν_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,

$$\mu_B = \frac{eh}{2m_e}, \quad \vec{J} = \vec{L} + \vec{S}$$