RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

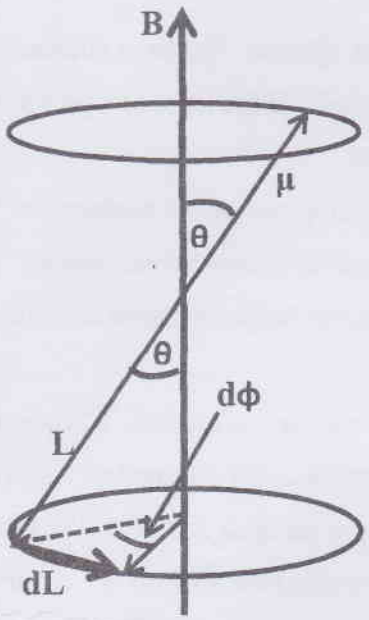
B.Sc. (General) Degree in Applied Sciences
Second Year – Semester II Examination – April / May 2015

PHY 2106 – ATOMIC & NUCLEAR PHYSICS

Answer **All** Questions. Time allowed: **One hour**

Electron Charge (e) – 1.6×10^{-19}C, Electron Mass (m_e) – 9.1×10^{-31} kg

1. A Hydrogen atom with magnetic moment $\boldsymbol{\mu}$ is placed inside an external magnetic field of $\boldsymbol{B}$ as shown in the following figure.



a) If the change in the orbital angular momentum is $|dL| = L \sin\theta \; d\varphi$, show that the precession frequency (Larmor Frequency) of the above atom is given by, $\omega_L = \frac{d\varphi}{dt} = \frac{e}{2m} B$, where $\boldsymbol{m}$ and $\boldsymbol{e}$ represent the mass and the charge of an electron respectively. (15 Marks)

b) If the magnetic potential energy of an atom is given by $\boldsymbol{U} = \frac{\boldsymbol{eB}}{\boldsymbol{2m}} \boldsymbol{L_z}$, where L_z is the z component of the orbital angular momentum vector, show that the total magnetic energy of an atom placed in an applied magnetic field $\boldsymbol{B}$, is given by $\boldsymbol{E} = \boldsymbol{E_0} + \boldsymbol{m_l \omega_L \hbar}$, where $\boldsymbol{E_0}$ is the energy of an atom in the absence of an applied magnetic field, $\boldsymbol{m_l}$ is the magnetic quantum number and $\hbar$ is the reduced Planck constant. (10 Marks)

c) Explain the Normal Zeeman Effect using transition between $(n = 2, l = 1)$ and $(n = 1, l = 0)$ levels in a Hydrogen atom. (10 Marks)

d) If the transitions in part (c) occur in a magnetic field of 0.6 **T** and the wavelength before the field was turned on was 5000 Å, determine the wavelengths that are observed. (10 Marks)

e) What is *Anomalous Zeeman Effect?* *(05 Marks)*

2. Two isotopes of Oxygen $^{16}_{8}O$ and $^{18}_{8}O$ have nuclear masses 15.990523 **amu** and 17.994768 **amu** respectively. If the mass of a proton is 1.007276 **amu** and mass of a neutron is 1.008665 *amu*,

a) Calculate the binding energy per nucleon for $^{16}_{8}O$ in MeV. (05 Marks)

b) Calculate the binding energy per nucleon for $^{18}_{8}O$ in MeV. (05 Marks)

c) Which of the above Oxygen isotopes is more abundance in the nature? Explain your answer. (10 Marks)

d) The half-life of radioactive nucleus $^{226}_{88}Ra$ is about 1.6×10^3years.

i. Calculate the decay constant of $^{226}_{88}Ra$. (10 Marks)

ii. If a sample contains 3.0×10^{16}such nuclei at t = 0 s, determine its activity at this time. ($1\ Ci = 3.7 \times 10^{10}\ decays/s$) (10 Marks)

iii. What is the decay rate when the sample is 2×10^3years old? (10 Marks)

END