RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year – Semester II Examination – Oct/Nov 2017

PHY 2106 – ATOMIC & NUCLEAR PHYSICS

Time allowed: **1 hour and 30 minutes**

Answer **All** Questions.
Unless otherwise specified, symbols have their usual meaning.

Electron Charge (e) – 1.6×10^{-19}C,

Electron Mass (m_e) – 9.1×10^{-31} kg,

1 amu = 1.67×10^{-27} kg = 931 MeV/C^2

1. Two isotopes of Oxygen $^{16}_{8}O$ and $^{18}_{8}O$ have nuclear masses of 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. (10 Marks)

   b. Calculate the binding energy per nucleon for $^{18}_{8}O$ in MeV. (10 Marks)

   c. Which of the above Oxygen isotopes is more abundance in the nature? Explain your answer. (05 Marks)

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

      i. Calculate the decay constant of $^{226}_{88}Ra$. (05 Marks)

      ii. If a sample contains 3.0×10^{16}such nuclei at t = 0 s, determine its activity at this time. ($1\ Ci = 3.7 \times 10^{10}\ decays/s$) (05 Marks)

      iii. What is the decay rate when the sample is 2×10^3years old? (05 Marks)

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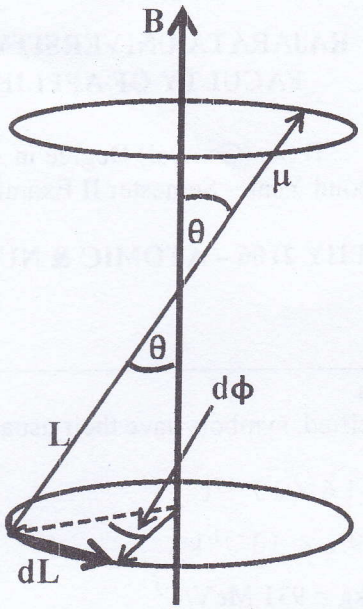
2. A Hydrogen atom with magnetic moment μ is placed inside an external magnetic field of B as shown in the following figure.



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 m and e represent the mass and the charge of an electron respectively. (10 Marks)

b. If the magnetic potential energy of an atom is given by $U = \frac{eB}{2m} L_z$, 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 B, is given by $E = E_0 + m_l \omega_L \hbar$, where E_0 is the energy of an atom in the absence of an applied magnetic field, 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)

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3. Consider an atomic electron in the $l = 4$ state.
   a. Calculate the magnitude $|L|$ of the orbital angular momentum and the allowed values of L_z and θ. (15 Marks)
   b. Draw the possible orientations of the orbital angular momentum in a vector diagram. (05 Marks)

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