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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Second Year – Semester II Examination – February/March 2019

PHY 2106 – ATOMIC & NUCLEAR PHYSICS

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

Answer **All** Questions.
Unless otherwise specified, symbols have their usual meaning.
Use of a non-programmable calculator is allowed.

Electron Charge (e) – 1.6×10^{-19}C, Avogadro number – 6.022×10^{23} atoms/g.mol.

Electron Mass (m_e) – 9.1×10^{-31} kg, Reduced Plank Constant ($\hbar$) = 1.054×10^{-34} J.s

1 a.m.u. = 1.67×10^{-27} kg = 931 MeV/C^2 1 C^2 = 931 MeV/u

Speed of Light c = 3.0×10^8 ms^{-1}

1. According to the normal Zeeman effect energy levels of a single electron atom placed in an external magnetic field would split into equally spaced sublevels with the spacing $\frac{e\hbar}{2m}B$.

   a. Show that the normal Zeeman splitting of an atom when placed in an magnetic field B is given by, $d\lambda = \frac{\lambda^2 dE}{hc}$, where symbols have their usual meaning. (20 Marks)

   b. If an atom placed in an external magnetic field of 4 T, find the Zeeman splitting of the spectral line at 5000 Å. (20 Marks)

   c. In a normal Zeeman experiment the calcium 4226 Å line splits into three lines separated by 0.25 Å in a magnetic field of 3 T. Determine the e/m ratio for the electron from these data. (20 Marks)

   d. Transition occurs in an atom between $l = 2$ to $l = 1$ state in a magnetic field of 0.6 T. If the wavelength before the field was turned on was 5000 Å, determine the wavelengths that are observed. (30 Marks)

   e. What is Anomalous Zeeman effect? (10 Marks)

2. The activity of a radioactive element is defined as the number of atoms that decay per unit time ($A = \frac{dN}{dt}$).

   a. If $A = -\frac{dN}{dt} = \lambda N$, show that the time dependence of the activity is $A(t) = A_0 e^{-\lambda t}$, where A_0 is the activity at the beginning ($t = 0$) and λ is the decay constant. (20 Marks)

   b. Explain what is meant by "half-life" in radioactive decay and show that the half-life of a material is equal to $\frac{0.693}{\lambda}$. (20 Marks)

   c. What is the activity of 1 g of $^{226}_{88}Ra$, whose half-life is 1622 years? (20 Marks)

   d. During a radioactive decay a $^{3}_{1}H$ atom converts into $^{3}_{2}He$ atom.

      i. Name the type of the decay and represent the decay in a reaction form. (20 Marks)

      ii. Calculate the maximum energy emitted during the decay. (Mass of $^{3}_{1}H$ = 3.016050 U, mass of the $^{3}_{2}He$ = 3.016030 U) (20 Marks)

3. The magnetic energy of an atom placed inside an external magnetic field B is given by the equation $U = \mu_B B(m_l + g m_s)$, where g and m_s are the gyromagnetic coefficient and spin quantum number respectively.

   a. Write down all possible energies for the $n = 2$ and $l = 1$ level in terms of $\hbar$, ω *and* E_2, where E_2 is the Energy in the absence of an external magnetic field. (Assume $g = 2$) (60 Marks)

   b. Draw the split in $l = 1$ level on an energy diagram. (40 Marks)

END