THE OPEN UNIVERSITY OF SRI LANKA
B.Sc. DEGREE PROGRAMME - Level 5 - 2009/2010
DEPARTMENT OF PHYSICS
PHU 3143 / PHE 5143: Atomic and Nuclear Physics

Assignment – 1 **Due date: 19th April 2010**

Answer All Questions

1. (a) Discuss briefly the experiment and its results which led to the conclusion that "electrons are fundamental constituents of matter".

   (b) Describe Millikan's method for the measurement of charge of an electron. Discuss the importance of this measurement.

   (c) In Millikan's oil drop experiment, the distance between the plates is 2.1×10^{-2} m. When a potential difference of 2250 volts is applied, a water drop of radius 7.47×10^{-7} m remains balanced. Then calculate the charge on the drop. To how many electrons does this correspond?

2. (a) What Rutherford's major contribution to atomic theory?

   (b) What experiment Rutherford did to prove his point? Describe it briefly with the experimental setup, assumptions and procedure.

   (c) What was the result of the experiment? Describe it briefly.

   (d) What was his conclusion?

3. (a) What are the Bohr's postulates?

   (b) Derive the equation for the radii of the Bohr orbits.

   (c) Show that the tangential speed of an electron in its orbit is,

   $$v = \frac{Ze^2}{2\varepsilon_0 nh}$$

   and its angular speed is,

   $$\omega = \frac{\pi m Z^2 e^4}{2\varepsilon^2 n^3 h^3}$$

   (Symbols have their usual meanings)

   (d) Calculate the binding energy of the electron in hydrogen in joules, for the three situations when n = 1, 2 and 3. Express your results also in eV.

4. (a) Describe how you could detect and distinguish between β radiations and γ radiations from a radioactive source.

   (b) A source of radioactive potassium has two isotopes, ${}^{42}_{19}K$ and ${}^{44}_{19}K$, both of which decay by emission of β radiations to stable isotopes of calcium. Give the nuclear transformation equations for the both decays.

   (c) The following data were recorded with a β radiation counter:

Time (Hrs)	0	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Count rate / per minute	10,000	3980	2125	1260	955	890	832	790	750	710	670	630	600	575

   Plot the data on a graph, adopting appropriate scales along the axes.

   From your graph, estimate the values for,

   (i) the half-life of ${}^{42}_{19}K$ which is the longer lived isotope.

   (ii) the half-life of ${}^{44}_{19}K$ which is the shorter lived isotope.

   (iii) the initial count rates due to ${}^{42}_{19}K$ and ${}^{44}_{19}K$.

   (iv) The ratio of the amounts of ${}^{42}_{19}K$ and ${}^{44}_{19}K$ present in the source at the start of the measurements.

5. (a) Discuss briefly the nuclear fission and nuclear fusion processes with suitable examples.

   (b) A nuclear power plant is generating power at the rate of 1GW. How many Uranium (235) atoms undergo fission per second? How many kilograms of Uranium (235) would be required to operate the power plant for one year? (Assume that on an average 175 MeV energy is released per fission).

   (c) (i) Calculate the Q-values for each reaction in the proton-proton cycle.

   (ii) Calculate the Q-values for each reaction in the carbon-nitrogen cycle.

6. (a) Write down the characteristics of the four fundamental forces in nature.

   (b) Discuss briefly the conservation laws in particle interaction.

   (c) Which of the following reactions are forbidden? Justify your answer?

   (i) $n^0 \longrightarrow p^+ + e^- + \tilde{\gamma}_e$

   (ii) $p^+ \longrightarrow e^+ + \gamma$

   (iii) $\pi^- \longrightarrow \mu^- + \tilde{\gamma}_e$

   (iv) $\pi^- \longrightarrow \mu^- + \tilde{\gamma}_\mu$

   (v) $p^+ + \pi^- \longrightarrow \Lambda^0 + K^0$

   (vi) $p^+ + p^+ \longrightarrow 2n^0 + 2e^+$

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