THE OPEN UNIVERSITY OF SRI LANKA
B.Sc. DEGREE PROGRAMME - LEVEL 05
FINAL EXAMINATION – 2010/2011
PHU3143/PHE5143 – ATOMIC AND NUCLEAR PHYSICS
TIME ALLOWED : TWO AND A HALF (02 ½) HOURS

Date : 18th June 2011 Time : 10.00 a.m. 12.30 p.m.

[Avogadro's Number	=	6.025×10^{23} atoms per mol,
Plank's constant	=	6.63×10^{-34} J.S,
Mass of the electron	=	9.11×10^{-31} Kg,
Velocity of light in a vacuum	=	3.0×10^{8} ms^{-1},
Charge of the electron	=	1.60×10^{-19}C,
Atomic mass unit 1 u	=	1.661×10^{-27}kg]

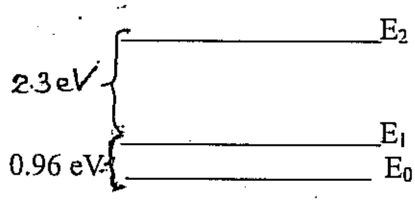
01. (a) An electron is accelerated from rest through a potential difference V, and then enters a region where there is a uniform magnetic field B perpendicular to the direction of motion of the electron. Derive an expression for the radius of the circular orbit of the electron.

What is the period of an electron in its circular orbit in a uniform magnetic field of strength 9.1×10^{-6} T?

(b) The beam of light from a certain laser has a power of 1 mW and a wavelength of 6.33 nm. How many photons are emitted per second by the laser?

(c) The first excitation energy of the hydrogen atom is 10.2 eV. Calculate the speed of the slowest electron that can exite a hydrogen atom.

(d) Figure below shows three energy levels of the thallium atom.



To exite electrons from energy level E_0 to E_2 requires light of wavelength 378 nm. What wavelength of light is emitted when electrons fall from E_2 to E_1.

(e) 50W discharge lamp radiates in the visible region (400 to 700 nm wavelength). Estimate the number of photons produced each second by the lamp.

02. (a) The stability of a nucleus of an atom depends on the relative number of neutrons (N) and protons(Z) in the nucleus. Draw a clearly labelled diagram involving a plot of N against Z (or Z against N) showing,

i. the region in which nuclei are stable,

ii. the region in which the unstable nuclei decay by β^- emission.

(b) If a radioactive source contains n_0 unstable nuclei of one type of radio isotope at a given instant (t = 0) then the number n remaining after time t is given by $n = n_0 \exp(-\lambda t)$ where λ is the decay constant or the disintegration constant. What is meant by the half life $T_{\frac{1}{2}}$ of a radio isotope?

Show that the halflife and the decay constant are related by $\lambda T_{1/2} = 0.693$.

(c) A thin radio active foil which is emitting β^- rays has an activity which is decreasing with a half life of approximately one hour. An experiment was performed to determine the half life of the thin radio active foil and found to be 3240 seconds (0.90 hours). When the experiment is completed, the foil is found to have residual activity of 6.4×10^5 Bq (1 Bq = 1 disintegration per sec), but regulations forbid the disposal of the source with domestic waste until the activity has decreased to 3.7×10^4 Bq or less. Find the minimum time which must elapsed before disposal of the foil.

(d) The activity of a radioisotope in a source is equal to the product of the decay constant and number of nuclei of the radio isotope in the source.
A certain source has an activity of 5.00×10^6 Bq due to the decay of the radioisotope ^{14}C, which has a half life of 6.81×10^{11} seconds.

i. How many atoms of ^{14}C are contained in the source?

ii. Calculate the mass of ^{14}C in the source.

iii. What is the specific activity (the activity per kilogram) of ^{14}C?
[Relative atomic mass of $^{14}C = 14.00$)

03. (a) Outline the assumptions made by Bohir in lies theory of the emission of electromagnetic radiation of a hydrogen atom. Use these assumptions to derive an expression for the Rydberg constant for a hydrogen – like atom taking into consideration the effect of the finite mass of the nucleus.

(b) It is found spectroscopically that the ration of the Rydeberg constants of ionized helium and hydrogen is 1.000407. Calculate a value for e/m, given that $\frac{e}{m} = 0.9576 \times 10^8$ Ckg^{-1}, $\frac{M}{M'} = 0.252$ where e is the electronic charge and m, M and M' are masses of the electron, proton and helium nucleus respectively.

04. (a) Give the main assumptions of liquid drop model of the nucleus. Justify the name liquid drop model.

(b) Discuss the semi-emperical mass formula explaining the importance of each term. Show the graph of binding energy per nucleon as the sum of volume, surface, Coulomb and asymmetry energies.

(c) What are the achievements and failures?

(d) Calculate the atomic number of the most stable nucleus for a given mass number A on the liquid drop model. Hence explain why out of $^{6}_{2}He,\ ^{6}_{4}Be\ and\ ^{6}_{3}Le$ only the last one is stable.

05. (a) Discuss various conservation laws in nuclear reaction with illustrative examples.

(b) Define Q – value of a nuclear reaction. Derive an expression for the Q – value of the reaction x (a, b) Y interms of kinetic energies of the incident and product particles and masses of the various particles and nuclei. Assume the target nucleus to be at rest in the laboratory.

(c) Discuss the energetic of exothermic or exoergic reactions. Derive an expression for the threshold energy of an endothermic or endoergic reaction.

06. Given

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{X}_{45}Rh + ^{113}_{Y}Ag + 2^{1}_{0}n$$

and $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + A,$

i. explain what is meant by the 235 and 92 in $^{235}_{92}U$;
ii. determine X, Y and A;
iii. describe the importance of the reactions;
iv. write down a similar equation for the fusion of two atoms of deuterium to form helium of atomic mass number 3.
Give the mass of the deuterium nucleus is 2.015u, that of one of the isotopes of nelium is 3.017u and that of the neutron is 1.009u, calculate the energy released by the fusion of 1kg deuterium. IF 50% of energy were used to produce 1MW electricity continuously for how many days would the station be able to function?