Total No. of printed pages = 6

3 (Sem 6) PHY M 1

2015

PHYSICS

(Major)

Theory Paper : M-6.1

Full Marks – 60

Time – Three hours

The figures in the margin indicate full marks for the questions.

1. Give short answers to the following questions : 1×7=7

(a) Mention a reason why beta rays are more penetrating than alpha rays.

(b) In the reaction ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4$

the total numbers of protons and neutrons are conserved. Then how does the reaction produce energy ?

(c) Pick out the nucleus which obeys Fermi - Dirac Statistics from the group : ${}_2He^4$, ${}_3Li^7$ and ${}_8O^{16}$.

[Turn over

(d) It is seen that the mass m of a nucleus varies with its charge number z according to a relation :

$$m = a + b + cz + (d - e) z^2$$

Show the shape of the graph that would be obtained between z and m.

(e) The packing fraction of ${}_3Li^7$ is $\frac{2}{875}$. What is the mass of the nucleus in atomic mass unit ?

(f) Why high vacuum is essential inside a particle accelerator ?

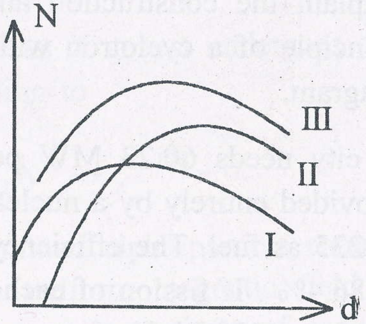
(g) How is an anti-neutrino different from a neutrino, considering that both are chargeless and almost massless ?

2. Briefly answer the following : 2×4=8

(a) What peculiarity in binding energy per nucleon is seen in case of light nuclei with mass number A = 4n, where n = 1,2,3,.....? How do you explain the peculiarity ?

(b) A negative muon enters matter. It is seen that X-rays come out from the matter. How ?

(c) The variation of the number of cosmic ray particles (N) per unit area per unit time, with atmospheric depth (d) — measured from the top of the atmosphere — for three different type of particles is shown in the figure. Which one is the graph for muons ? Give reason in support of your answer



(d) Nuclear forces saturate. How is it evident from the binding energy curve ?

3. Answer any *three* of the following : 5×3=15

(a) Distinguish between primary and secondary cosmic rays.

(b) It is intended to break a carbon –12 nucleus so that each neutron and proton come out of the nucleus. If the masses are ${}_6C^{12}$=12.000 amu, ${}_1H^1$=1.007825 amu, ${}_0n^1$=1.008665 amu, then find the amount of energy needed for the purpose.

(c) A source emits 6 MeV alpha-particles ; and it has an activity of 10^6 disintegrations per second. The alpha-particles pass through the gas in a detector. If the energy needed to produce an ion-pair is 30 eV, find the current produced in the detector.

(d) Explain the construction and the working principle of a cyclotron with the help of a diagram.

(e) A city needs 60.23 MW power, which is provided entirely by a nuclear reactor using U-235 as fuel. The efficiency of the reactor is 86.4% . If fission of each U-235 nucleus produces 200 MeV of energy, find the mass of U-235 needed per day. Avogadro's number $= 6.023 \times 10^{23}$ per gm mole.

4. Answer (a) or (b), and any *two* from (c), (d) and (e) : 10×3=30

(a) Give a brief account of Yukawa's meson theory. Neutron and proton are themselves not composed of mesons ; then how do they emit these particles inside the nucleus ? Draw the plot of Yukawa potential. How are these Yukawa particles connected with cosmic rays ? 3+2+3+2=10

(b) Derive Bethe-Weizsaecker semi-empirical mass formula and explain the terms involved. Plot the variation of binding energy per nucleon as a function of mass number of nuclei. Show that the curve can explain why fusion is possible for light nuclei. 5+2+3=10

(c) A nucleus X at rest undergoes alpha-decay according to

$$_{92}X^{A} \rightarrow {}_{z}Y^{228} + \alpha$$

The emitted alpha-particle enters normally into a uniform magnetic field of 2.002T and moves in a circle of radius 0.1m. If $m_\alpha = 4.008\,u$ and $m_y = 228.04\,u$ then find the energy released (in MeV) in the above reaction. Take $1u = 1.6 \times 10^{-27}$ kg and $4.008/228.04 = 0.018$. 10

(d) Show that β^- decay is possible if the mass of the parent nucleus is greater than that of the daughter nucleus ; and β^+ decay is possible if the parent-daughter mass difference is at least equal to twice the electronic mass.

In the β^- decay of $_5B^{12}$ it is seen that $_6C^{12}$ is formed. If $_6C^{12}$ remains at rest while the β^- particle and the anti-neutrino share the energy in the ratio 3:1, find the energy carried by the anti-neutrino. Take rest masses of ${}_5B^{12}$, ${}_6C^{12}$ and electron as 12.014u, 12.000u and 0.51 MeV respectively. 3+3+4=10

(e) Write short notes on any *two* of the following : 5×2=10

(i) Origin of cosmic rays

(ii) Alpha decay and tunnel effect

(iii) Thermonuclear reaction

(iv) Ionization chamber.