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3 (Sem 6) PHY M 1

2015

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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 ${}_1\text{H}^2 + {}_1\text{H}^2 \rightarrow {}_2\text{He}^4$

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 : ${}_2\text{He}^4$, ${}_3\text{Li}^7$ and ${}_8\text{O}^{16}$.

[Turn over

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

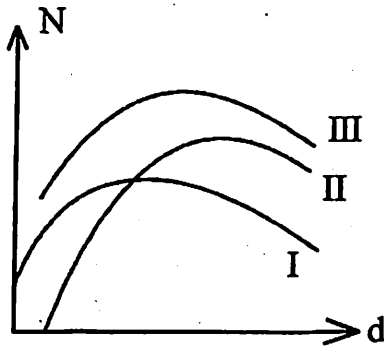
relation:

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

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

- (e) The packing fraction of ${}_3\text{Li}^7$ 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 $n=1,2,3,\dots$? 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 : $5 \times 3 = 15$

- (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 ${}_6\text{C}^{12} = 12.000$ amu, ${}_1\text{H}^1 = 1.007825$ amu, ${}_0\text{n}^1 = 1.008665$ 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 = 6.023×10^{23} per gm mole.

4. Answer (a) or (b), and any *two* from (c), (d) and (e) :

$$10 \times 3 = 30$$

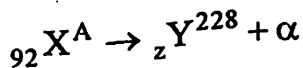
- (a) Give a brief account of Yukawa's meson theory. Neutron and proton are themselves not composed of mesons ; then how do they emit these particles inside the nucleus ? Draw the plot of Yukawa potential. How are these Yukawa particles connected with cosmic rays ?

$$3+2+3+2=10$$

- (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



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

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- (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 ${}_5\text{B}^{12}$ it is seen that ${}_6\text{C}^{12}$ is formed. If ${}_6\text{C}^{12}$ 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 ${}_{5}\text{B}^{12}$, ${}_{6}\text{C}^{12}$ 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: $5 \times 2 = 10$

- (i) Origin of cosmic rays
- (ii) Alpha decay and tunnel effect
- (iii) Thermonuclear reaction
- (iv) Ionization chamber.