2014

PHYSICS

(Major)

Paper : 6·1

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following questions in single sentence each : 1×7=7

(a) The density of $_6C^{12}$ nucleus is of the order of 10^{17} kg-m^{-3}. What is the corresponding value for $_{26}Fe^{56}$ nucleus?

(b) The diameter of a hydrogen nucleus is 2·4 fm. What is the diameter of $_{52}Te^{125}$ nucleus?

(c) An e^--e^+ pair can be produced by a gamma photon. What minimum energy such a photon must possess?

(d) At which place among Guwahati, Indore and Chennai, do you expect to find the maximum intensity of comic rays?

(e) Electron or positron does not exist inside the nucleus. Then how do beta particles come out of the nucleus?

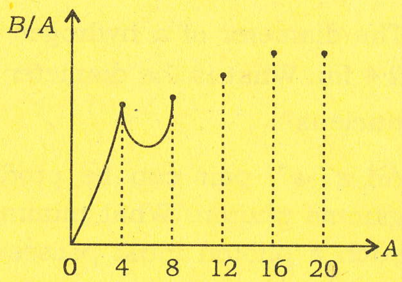
(f) Name the different types of neutrinos that exist in nature.

(g) Name a nuclear device in which magnetic mirror is used.

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

(a) What particular nuclear characteristic does the quantity $\frac{\hbar}{m_\pi c}$ represent? Which theory introduced this quantity?

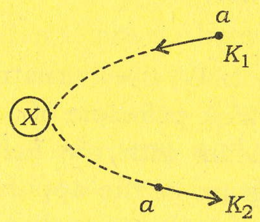
(b) The figure shows a partially drawn plot between mass number (A) and binding energy per nucleon (B/A) for the nuclei He^4, Be^8, C^{12}, O^{16} and Ne^{20}. Complete the curve.



What conclusion is drawn regarding the spins of protons and neutrons in these nuclei?

(c) If K-electron capture is also a form of beta-decay, then what comes out of a sample in which this process takes place? Is L-electron capture possible or not?

(d) The figure shows a projectile a with kinetic energy $K_1 = 16$ MeV incident on a target nucleus X. The final kinetic energy of the projectile is $K_2 = 12$ MeV. The target remains practically at rest all along.



How has $(K_1 - K_2) = 4$ MeV been utilized? What is the most likely form of reappearance of this 4 MeV energy?

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

(a) If R be the radius of a nucleus with mass number A, then show qualitatively the shape of the curve drawn between $\ln A$ and $\ln R$. Mention any two processes through which a nuclear reactor core may lose neutrons. What is enriched uranium?

(b) An alpha particle is projected into a $_{92}U^{238}$ nucleus. The product nucleus formed has a radius of 9×10^{-15} m. What is the maximum height, in MeV, of the potential barrier the alpha particle has to overcome?

Had the process been in reverse order? Would the alpha particle need the same amount of energy to come out of the nucleus? Give reason in support of your answer.

(c) Describe the construction and the working principle of a gas filled nuclear detector with the help of a schematic diagram of the apparatus.

(d) A rectangular lake has the dimensions 5 km × 3 km × 0·6 km. Find the amount of energy that can be obtained if all the deuterium atoms in the lake are used up in a fusion reaction :

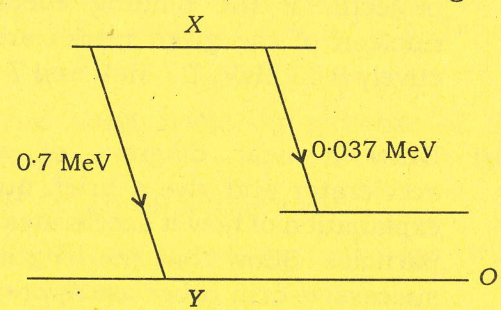
$$_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + {}_1H^1 + 4 \text{ MeV}$$

Assume that the relative abundance of deuterium in water molecule is 0·02%, Avogadro's number $= 6 \times 10^{26}$ per kg-mole.

(e) What roles the magnetic field and the electric field play in a cyclotron? The diameter of the dee in a cyclotron which uses a magnetic field of 1T is 2m. What is the energy up to which protons can be accelerated in the cyclotron? Mass of proton $= 1 \cdot 6 \times 10^{-27}$ kg.

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

(a) Draw a characteristic beta ray energy spectrum. Explain how beta decay seemed to viotate the laws of conservation of energy and momentum. How did Pauli solve the problem? Explain. A beta emitter *X* is found to emit beta rays of energies 0·037 MeV and 0·7 MeV as shown in the figure.



It is also found to emit gamma rays. What is the wavelength of the gamma rays emitted? 2+4+2+2

(b) What are the majority particles found in the primary cosmic rays and the secondary cosmic rays? What is an extensive air shower (EAS)? Why is it not called simply as secondary cosmic rays? What is the order, in eV, of highest energy particle detected with the help of EAS set up so far?

Explain the cause of east-west asymmetry in cosmic rays with the help of a diagram. 2+4+1+1+2

(c) Write and briefly explain the various correction terms in the binding energy of a nucleus. Show that the dependance of mass of the nucleus on nuclear charge is parabolic. In an experiment, an ${}_{10}Ne^{20}$ nucleus is broken down by a projectile into a ${}_{6}C^{12}$ nucleus and two ${}_{2}He^{4}$ nuclei. Find the energy of the projectile if the binding energies per nucleon of the given nuclei are respectively 8·03 MeV, 7·7 MeV and 7·1 MeV. 5+2+3

(d) Draw a neat diagram of a linear accelerator and give a brief, qualitative explanation of how it accelerates charged particles. Show that the lengths of the successive drift tubes are approximately proportional to $1:\sqrt{2}:\sqrt{3}:\ldots$.

Mention two advantages of a linear accelerator over a cyclotron. 5+4+1

(e) Mention any two different types of nuclear reactions. Give examples. Identify the types to which the following reactions belong :

(i) ${}_{8}O^{16} + {}_{1}H^{2} \rightarrow {}_{8}O^{15} + {}_{1}H^{3}$

(ii) ${}_{27}Co^{59} + {}_{0}n^{1} \rightarrow {}_{27}Co^{60} + \gamma$

What is *Q*-value of a nuclear reaction? Find an expression for *Q*-value of a nuclear reaction in terms of the mass of the particles involved. In the reaction

$${}_{5}B^{11} + {}_{2}He^{4} \rightarrow {}_{7}N^{14} + {}_{0}n^{1}$$

the alpha particle strikes the target with a kinetic energy 5·25 MeV. If ${}_{5}B^{11}$ and ${}_{7}N^{14}$ nuclei are always at rest, then find the kinetic energy with which the neutron is ejected. Given, masses of ${}_{5}B^{11}$, ${}_{7}N^{14}$, ${}_{2}He^{4}$ and ${}_{0}n^{1}$ are respectively 11·01280 u, 14·00752 u, 4·00387 u and 1·00899 u. 1+2+2+1+2+2

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

(i) Origin of cosmic rays

(ii) Interaction of gamma rays with matter

(iii) Nucleon-nucleon forces

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