Departmental set 6.1, 6.2, 6.3, 6.4, only.

2019

PHYSICS

(Major)

Paper : 6.1

(Nuclear Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

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

(a) How do neutrino and antineutrino differ from each other?

(b) How is the radius of nucleus related to the mass number?

(c) When $_3Li^7$ nucleus is bombarded by a proton, $_4Be^8$ nucleus is produced. What will be the emitted particle?

(d) What limits the size of a stable nucleus?

(e) What nature of primary cosmic ray indicates that it consists mainly positively charged particles?

(f) Give the names of two detectors which are based on detection of free charge carriers.

(g) What nature of nucleons permits us to consider their collective behaviour in determining the properties of the nucleus?

2. Answer the following questions in brief : 2×4=8

(a) Binding energies of ${}_{8}O^{16}$ and ${}_{17}Cl^{35}$ are 127·35 MeV and 289·3 MeV respectively. Which of the two nuclei is more stable?

(b) Give two evidences to show the existence of shell structure within the nuclei.

(c) Explain why it is necessary to increase the lengths of the successive tubes of a linear accelerator to maintain resonance condition.

(d) What are mirror isobars? Give example.

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

(a) A cyclotron in which the flux density 0·7 weber m^{-2} is employed to accelerate proton. Calculate the frequency of the rf voltage. Given the mass of proton = $1 \cdot 66 \times 10^{-27}$ kg. Give the reason why cyclotron cannot be used to accelerate electrons. 3+2=5

(b) Give an account with the help of the 'meson field theory' how Yukawa had come to a conclusion that exchanging particles producing exchanged force between protons and neutrons in the nucleus were not positive or negative electrons, but mesons positive or negative. 5

(c) How did Pauli become able to eliminate the problems related to continuous energy distribution, apparent failure to conserve linear and angular momenta, and conservation of statistics as well, in the beta decay process? 5

(d) What is meant by self-propagating fission reaction? How can fission process be explained with the help of liquid-drop model of nucleus? 2+3=5

(e) What are cosmic rays? Where do the primary cosmic rays originate and how do they acquire the enormous energies they posses? 1+2+2=5

4. Answer any *three* of the following questions : 10×3=30

(a) *(i)* How are alpha and beta particles absorbed in matter? 3

(ii) What is meant by range of alpha particles? Describe a method used to determine range of alpha particles. What is straggling of range? 1+5+1=7

(b) *(i)* Define *Q*-value of nuclear reaction, and explain its significance. Define nuclear reaction cross-section. 1+2+2=5

(ii) Using semi-empirical mass formula, estimate *Q*-value of nuclear fission reaction. 5

(c) *(i)* Mention two effects by which the quantitative detection of gamma ray is possible. 1

(ii) "Interaction of gamma rays with matter is different from that of charged particles such as alpha and beta particles." Explain. 3

(iii) What are the processes by which a gamma ray of 0·85 MeV will lose energy in passing through matter? 2

(iv) How can you explain gamma rays as a source of information about nuclear energy levels? How can you relate internal conversion with gamma ray emission? 4

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

(i) Ionization chamber

(ii) Linear accelerator

(iii) Geiger-Nuttall law

(iv) Thermonuclear reaction

(v) Extensive air shower

(e) *(i)* Calculate the fission rate for U^{235} required to produce 2 watt, and the amount of energy that is released in the complete fissioning of half kilogram of U^{235}. Explain why U^{235} is fissionable and U^{238} is not. 3+2=5

(ii) A linear accelerator for the acceleration of protons to 45·3 MeV is designed so that, between any pair of accelerating gaps, the protons spend one complete radio-frequency cycle inside a drift tube. The radio frequency used is 200 Mc/sec. Calculate the length of final drift tube and kinetic energy initially present in the injected proton. Given the length of first drift tube is 5·35 cm. 5

Or

(f) *(i)* Calculate the neutron separation energy of nuclei $_{20}Ca^{41}$ and $_{13}Al^{27}$.

Given—

$$m(_{20}Ca^{40}) = 39 \cdot 962591\,u$$

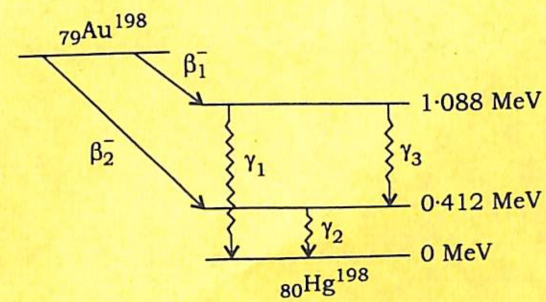
$$m(_{20}Ca^{41}) = 40 \cdot 962278\,u$$

$$m(_{13}Al^{26}) = 25 \cdot 986895\,u$$

$$m(_{13}Al^{27}) = 26 \cdot 981541\,u$$

$$m(\text{neutron}) = 1 \cdot 008665\,u$$ 3

(ii) Obtain the maximum kinetic energy of beta particle and the radiation frequencies of gamma decay in the decay scheme shown below :



Given—

$$m(_{79}Au^{198}) = 197 \cdot 968233\,u$$

$$m(_{80}Hg^{198}) = 197 \cdot 966760\,u$$ 5

(iii) Explain how the neutron to proton ratio changes in the following reaction : 2

$$_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$$

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