2017

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) Mention two properties of nucleus which are very similar to those found in liquid drop.

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

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

(d) What is charge-independent nature of nuclear force?

(e) Mention two effects by which quantitative detection of γ-rays is possible.

(f) How does range of alpha particles in gas depend on pressure and temperature of the gas?

(g) In pair annihilation, an electron combines with a positron and both disappear producing γ-rays. How is momentum conserved in the process?

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

(a) How can resonance acceleration be made possible in spite of relativistic increase in mass of ions in fixed frequency cyclotron?

(b) Although matter consists of a large number of protons and neutrons, still there is no strong force exists between them at macroscopic distance. Why?

(c) Consider a radioactive nucleus A which decays into a stable nucleus C following sequence $A \rightarrow B \rightarrow C$. Here B is an intermediate nucleus which is also radioactive. Consider that there are N_0 number of atoms of A initially. Plot the graph showing the variation of number of atoms of A and B versus time.

(d) Define cross-section of nuclear reaction and give its unit.

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

(a) (i) When a neutron is absorbed by a target nucleus, the resulting compound nucleus is usually more likely to emit γ-rays than a proton, a deuteron or an alpha particle. Why? 2

(ii) Find the energy released, if two $_1H^2$ nuclei fuse together to form $_2He^4$ nucleus. The binding energies per nucleon of $_1H^2$ and $_2He^4$ are 1·1 MeV and 7·0 MeV respectively. 3

(b) (i) When fission occurs, several neutrons are released and the fission fragments are beta-active. Why? Give reason. 2

(ii) Using semi-emperical mass formula, estimate *Q*-value of nuclear fission reaction. 3

(c) (i) Show that the radius of curvature *R* of the path of a particle inside the dees of a cyclotron is proportional to $N^{\frac{1}{2}}$, where *N* is the number of times the particle has been accelerated across the space between the dees. 3

(ii) Neglecting the emission of neutrons, show that the kinetic energies of the fission fragments are inversely proportional to the ratio of their respective masses. 2

(d) Describe a method for determination of the range of alpha particle. What is straggling of range of α-particles? 3+2

(e) How did Yukawa come to a conclusion that exchanging particle producing the exchanged forces between the proton and the neutron in the nucleus were not positive or negative electron, but meson positive or negative? Give an account with the help of 'meson field theory'. 5

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

(a) Describe the principle of working of an ionization chamber. What is integrating type of ionization chamber?

Draw a curve relating total ion collection and applied voltage for gas filled detectors of electrical radiation and identify ionization, proportional and Geiger-Muller region. 5+2+3=10

(b) What are cosmic rays? Where do the primary cosmic rays originate and how do they acquire the enormous energies they posses? Why does the intensity of cosmic rays coming from the west exceed than those coming from the east? 1+4+2+3=10

(c) What is self-sustained chain reaction? How can fission process be explained with the help of liquid drop model? What is critical size of a reactor? Define multiplication factor of a reactor.

Distinguish between fission and fusion processes. 1+3+2+2+2=10

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

(i) Geiger-Nuttall law

(ii) Linear accelerator

(iii) Pauli's neutrino hypothesis

(iv) Extensive air shower

(v) Nuclear stability

(e) How does interaction of gamma rays with matter is different from that of charged particles such as alpha or beta particles?

A γ-ray photon interacts with an atomic electron which is initially at rest. Show that the maximum kinetic energy of the recoil electron can be expressed as

$$T_{max} = \frac{h\nu_0}{1+(m_0c^2/2h\nu_0)}$$

where ν_0 is the frequency of photon before collision. 3+7=10

(f) Classify different types of nuclear reactions.

Give a brief account of the energetics of nuclear reactions.

A nuclear reaction is represented by $X(x, \gamma)Y^*$. Identify the type of reaction.

3+6+1=10

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