

2023-24

Time - 3 hours

Full Marks - 80

Answer all groups as per instructions.

Figures in the right hand margin indicate marks.

*Candidates are required to answer
in their own words as far as practicable.*

GROUP - A

1. Answer (all) questions by choosing the correct answer from the given alternatives. [1 × 12]

(a) Neutrino is :

- (i) Chargless and has no spin
- (ii) Chargless and has spin
- (iii) Charged like electron and spin
- (iv) Uncharged but has mass nearly that of proton

(b) The radius of a nucleus (r) depends on mass number A of the nucleus as :

- (i) $r = r_0 A^{2/3}$
- (ii) $r = r_0 A^{1/3}$
- (iii) $r = r_0 A^{-1/3}$
- (iv) $r = r_0 A^{-2/3}$

[2]

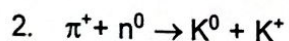
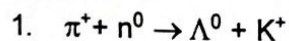
(c) The maximum energy of a proton beam that can be achieved using a cyclotron of radius 0.4 m and magnetic field of 1.5 weber/m² is (take mass of proton as 1.6×10^{-27} kg) :

- (i) 5.2 MeV (ii) 8.5 MeV
 (iii) 12.7 MeV (iv) 17.3 MeV

(d) In the process of electron capture :

- (i) Neutron converts to a proton
 (ii) Proton converts to a neutron
 (iii) Neutron emits a positron
 (iv) Proton emits a positron

(e) Determine which of the following reactions are possible ?



- (i) Only reaction 1 is allowed.
 (ii) Only reaction 2 is allowed.
 (iii) Both reactions are allowed.
 (iv) Both the reactions are not allowed.

[3]

(f) After 10 hours, the radioactivity of a nuclide is 1/8 times its original level. The half life of the sample is :

- (i) 5 hours (ii) 2.5 hours
 (iii) 1.25 hours (iv) 0.625 hours

(g) The approximate amount of energy that is obtained when mass of one proton is converted to energy :

- (i) 200 MeV (ii) 511 MeV
 (iii) 725 MeV (iv) 931 MeV

(h) A radioactive nucleus (initial mass number A and atomic number Z) emits three α -particles and two positrons. The ratio of the number of neutrons to that of protons in the final nucleus will be :

- (i) $\frac{A-Z-8}{Z-4}$ (ii) $\frac{A-Z-4}{Z-8}$
 (iii) $\frac{A-Z-12}{Z-4}$ (iv) $\frac{A-Z-4}{Z-2}$

(i) When ${}^7_3\text{Li}$ nuclei are bombarded by protons and the resultant nuclei and ${}^8_4\text{Be}$, the emitted particles will be :

- (i) gamma photons (ii) neutrons
 (iii) alpha particles (iv) beta particles

- (b) Explain how a semiconductor detector works ?
- (c) Draw a graph showing variation of binding energy per nucleon as a function of mass number of nuclei and outline its important features.
- (d) What the term isospin indicates ? What is its importance ? Why isospin numbers are not associated with leptons ?
- (e) What do you mean by parity ? In the processes involving what type of interactions the parity is seen to be conserved ?
- (f) What do you mean by Q-value of a nuclear reaction ? Write down its expression ? How from Q-value, one can know the reaction to be endothermic or exothermic ?
- (g) What is the principle of working of a Scintillation counter ? What are its advantages ?
- (h) What are mirror nuclei ? Give two examples.
- (i) Though neutron is neutral, yet it has a magnetic moment. What is the value of this magnetic moment ? How can you give an account of it ?
- (j) Theoretically quarks are supposed to be very heavy, much heavier than nucleons. But known properties of strongly interacting particles suggest that mass of quark is about one-third of mass of proton. Give an account for this discrepancy.

GROUP - D

4. Answer any four of the following within 500 words each.
- (a) State the semi-empirical mass formula explaining the significance of various terms. Use it to discuss stability limit of heavy nuclei. What are its limitations ? [4+2+1]
- (b) With a neat schematic diagram discuss the construction and working of a Van de Graff generator. [7]
- (c) Discuss the principle and working of a GM counter. What are its merits and demerits ? [7]
- (d) Give a brief outline on Shell model of the nucleus. Explain the role of magic numbers and quadrupole moments. [7]
- (e) Discuss Gamow's theory of α -decay and hence obtain the expression for transmission probability of α -particle from a nucleus. [7]
- (f) What are β -rays ? Discuss the important features of β -ray spectra emitted by radioactive nuclides. What is neutrino hypothesis in β -decay process and why it is required ? [1+4+2]
- (g) (i) Write a note on classification of elementary particles. [3½]
- (ii) Give a brief note on the different types of interactions that the elementary particles can undergo. [3½]