

## NUCLEAR AND PARTICLE PHYSICS - III

**Time Allowed : Three Hours**

**Maximum Marks : 75**

**Note :** The candidates are required to attempt at least one question each from Section A, B and C carrying 15 marks each and five questions from Section E consisting of 8 short answer type questions carrying 3 marks each.

### Section - A

1. (a) What do you mean by binding energy of a nucleus ? Further discuss its variation with mass number of the nucleus. 5
- (b) Derive the expression for semi-empirical mass formula and discuss its limitations. 10
2. (a) Why electrons cannot exist inside the nucleus ? 4
- (b) Derive the expression for electric quadrupole moment of the nucleus by expressing the electrostatic energy possessed by nucleus in terms of electric moments and discuss its physical significance. 7
- (c) Calculate the binding energies of the following isobars and their binding energies per nucleon. It is given that  ${}_{28}\text{Ni}^{64} = 63.9280 \text{ amu}$ ,  ${}_{29}\text{Cu}^{64} = 63.9298 \text{ amu}$ . 4

### Section - B

3. (a) Discuss the law of successive radioactive transformation and deduce the expression for number of atoms of the nth member in the decay chain. 6
- (b) Specify and briefly explain different radioactive decay modes. 5
- (c) Discuss the reasons for hypotheication of neutrino and specify its properties. 4
4. (a) Find the number of  $\alpha$ -decays the occur in 1 g of  $\text{Th}^{232}$  in one year, if its disintegration constant is  $1.58 \times 10^{-18} \text{ s}^{-1}$ . 5
- (b) Briefly discuss different conservation laws governing the nuclear reactions. 10

### Section - C

5. (a) State and explain the Bethe's formula for specific energy loss of heavy charge particles in matter. 5
- (b) Compare the energy loss mechanisms for heavy charge particles and fast electrons in matter. 7
- (c) In an absorption experiment with 1.14 MeV  $\gamma$ -radiation from  $\text{Zn}^{65}$  it was found that 25 cm of Al reduced intensity to 2%. Calculate the half value thickness and the mass absorption coefficient of Al for this radiation. 3
6. (a) Discuss qualitative features of different interaction processes of  $\gamma$ -rays with matter. 6
- (b) A betatron operating at 50 cycles/s with a stable orbit diameter of 60 inches was having maximum magnetic field of 4000 Gauss. Calculate the average energy gained per revolution and final energy of the electrons. 4
- (c) Specify and briefly discuss different components of a cyclotron. 5

### Section - D

7. (a) Describe the working principle of a gas filled radiation detector with the help of output signal verses applied voltage curve. 5
- (b) A GM counter with a cathode of diameter 5 cm and wire of diameter 0.012 cm is filled with argon to a pressure such that the mean free path is  $7.8 \times 10^{-4} \text{ cm}$ . Calculate the value of the voltage that must be applied to just produce an analanche. 5
- (c) What do you mean by Baryon number and Lepton number Explain with the help of examples. 5
8. (a) What do you mean by isospin ? How is it related to the baryon number ? 4
- (b) What is the basic principle of a scintillation counter ? Briefly discuss essential components of a scintillation counter. 7
- (c) Why must the quarks in a hadron have different colours ? Would they have to have different colours if their spins were 0 or 1 ? 4

### Section - E

9. Attempt any five parts in brief :
  - (a) What is charge conjugation ? Explain with help of an example.
  - (b) Why does the Geiger plateau show a small slope ?
  - (c) What are the necessary conditions for pair production process to take place ?
  - (d) What is the difference between gamma-rays and X-rays ?
  - (e) What is the difference between neutrino and a photon ?
  - (f) What do you mean by magic numbers for a nucleus ?
  - (g) What do you mean by electron capture ? Give example.
  - (h) What does Q value of a nuclear reaction signify ?

5×3=15