

63/1 (SEM-5) DSE2/PHYHE5026

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(Held in 2023)

PHYSICS

Paper : PHYHE5026

(Nuclear and Particle Physics)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

1. Choose the correct answer from the following : **1×6=6**

(a) The average binding energy of a nucleus is the order of

(i) 8 eV

(ii) 8 keV

(iii) 8 MeV

(iv) 8 GeV

(b) When ${}^8_3\text{Li}$ decays to ${}^8_4\text{Be}$, it does so by

(i) positron emission

(ii) electron emission

(iii) γ -ray emission

(iv) alpha decay

(2)

- (c) Which of the following quantities is not conserved in nuclear reactions?
- (i) Total energy
 - (ii) Quadrupole moment
 - (iii) Linear momentum
 - (iv) Total angular momentum
- (d) The unit of reaction cross-section is
- (i) barn
 - (ii) fermi
 - (iii) ms^{-2}
 - (iv) rutherford
- (e) To accelerate electrons a Van de Graaff generator uses
- (i) electromagnetic radiation
 - (ii) magnetic fields
 - (iii) varying electric fields
 - (iv) electrostatic energy
- (f) Photons and gravitons are names associated with a category of particles called
- (i) mesons
 - (ii) bosons
 - (iii) leptons
 - (iv) baryons

(3)

2. Answer the following questions : 2×5=10

- (a) State the significance of magic number nuclei.
- (b) Radioactivity is a random phenomena. Elaborate.
- (c) Define (i) amu and (ii) nuclear reaction cross-section.
- (d) An α -particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. Calculate the distance of closest approach.
- (e) State four differences between proportional counter and GM counter.

3. Answer any six of the following questions : 5×6=30

- (a) Show that the electric quadrupole moment of a nucleus with single charge is

$$Q = \frac{1}{2} e (3z^2 - r^2)$$

where z and r are position coordinates.

- (b) (i) Show that density of nucleus is independent of mass number A and it is equal to $2 \times 10^{17} \text{ kg/m}^3$. 3
- (ii) Calculate ratio between nuclear magneton and Bohr magneton. 2

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(4)

- (c) (i) What is the basic point of differences between liquid drop model and shell model of the nucleus? 2
- (ii) Using semi-empirical mass formula, calculate atomic number of the most stable nucleus for a given mass number A . Given for a stable nucleus of mass number A

$$\left(\frac{\partial E_b}{\partial z} \right)_{A \text{ constant}} = 0 \quad 3$$

- (d) (i) Explain the significance of Q -value of nuclear reaction. 3
- (ii) Derive geometrical significance of nuclear reaction. 2
- (e) A certain radioactive element disintegrated for an interval of time equal to its mean life. What fraction of the element remains? What fraction has disintegrated? 3+2=5
- (f) Explain briefly various types of nuclear reactions which may occur when high energy particles approaches a nucleus. 5
- (g) Describe classification of elementary particles based on rest mass, spin statistics and interaction. 5

(5)

- (h) Derive Geiger-Nuttall law using tunnelling probability calculated by Gamow. 5
- (i) Write the principle of cyclotron and its working. What is its limitation? 1+3+1=5

4. Answer any two of the following questions : 10×2=20

- (a) (i) Name two fermions. Explain how nucleus is considered to be similar to gas in Fermi gas model. State few important assumptions of Fermi gas model. 1+2+2=5
- (ii) State few evidences that favours idea of shell model. Explain the existence of magic number 28 with the help of shell model. 2+3=5
- (b) (i) What is mass defect and binding energy of a nucleus? Plot variation of binding energy with mass number and explain its important features. 5
- (ii) Define parity and its significance and magnetic moment. 3+2=5

- (c) (i) Derive rate of loss of energy of charged particle passing through a medium. 5
- (ii) State Bethe and Bloch modification and write down Bethe-Bloch formula. 5

5. Answer any *one* of the following questions : 14

- (a) (i) State few assumptions of Coulomb-Rutherford scattering and derive expression for Rutherford scattering formula. $2+5=7$
- (ii) What do you mean by quenching of a GM counter? What is its necessity? How is it achieved internally? $2+2+3=7$
- (b) (i) Explain briefly baryon number and lepton number. $3+3=6$
- (ii) What are different types of quark? Write the compositions of proton and neutron by quark model. Write briefly about quark model. $3+2+3=8$
