

**QP Code : 76247**

(3 Hours)

[ Total Marks : 75

- N.B. :** (1) Attempt six questions.  
(2) Answers to the two sections must be written in separate answer sheets.

**Section I**

1. (a) What are Clebsch-Gordon (CG) coefficients? Obtain C.G. coefficients for the addition of two angular momenta  $j_1 = 1/2$  and  $j_2 = 1/2$  6  
(b) Show that  $\exp(-i\beta \cdot \sigma/2)$  is a rotation operator of a spinor by an angle  $\beta$ . 7
2. Enunciate the Wigner-Eckart theorem and show that a particle with spin 1/2 can not possess an electric quadrupole moment. 13
3. Write n-p scattering amplitude in the "effective range expansion". Discuss the inferences which can be drawn from the singlet scattering length,  $a_s = 23.2\text{fm}$  obtained from the scattering data. 13
4. What are exchange forces in a nucleon-nucleon interaction? Describe different types of N-N forces, and discuss how they lead to the saturation of nuclear binding. 13
5. What are 'prompt' and 'delayed' neutrons in fission? Discuss the role of latter in nuclear reactors. 12

**OR**

6. What is 'Fermi Momentum'? Determine its relation with the density of nuclear matter. For a nuclear matter of density,  $\sigma = 10^{13} \text{ gm/cm}^3$  what would be the corresponding Fermi Momentum. 12
7. p) Give the expected shell-model spin and parity assignments for the ground states of  
(a)  ${}^7\text{Li}$       (b)  ${}^{11}_5\text{B}$       (c)  ${}^{20}_{10}\text{Ne}$       (d)  ${}^{67}_{30}\text{Zn}$       (e)  ${}^{31}_{15}\text{P}$       (f)  ${}^{141}_{59}\text{Pr}$ . 6
- q) Explain Nilsson model of Nucleus. 7

**OR**

- 8 a) A certain decay process leads to final states in an even-Z, even-N nucleus and gives only three  $\gamma$  rays of energies 100, 200 and 300 keV, whose multipolarities are E1, E2 and E3 respectively. Construct two possible level schemes for this nucleus and label the states with their most likely spin-parity assignments. 6
- b) Discuss various potentials used to explain the complete set of magic numbers within the framework of single particle shell model. Explain the role of spin-orbit interaction. 7
- 9 Describe collective vibrations in nuclei starting from the shape parameterization for the distortion from spherical shape for a liquid drop model. Discuss the physical meaning of the various multipole orders for increasing values of lambda ( $\lambda$ ) such as  $\lambda = 0, 1, 2, 3$ . Draw the possible harmonic energy spectra for the quadrupole and octupole surface oscillation. 12

OR

- 10 Write a note on
- a) Yrast line and statistical and quadrupole gamma cascades 6
- b) Rotational bands in odd-A Nuclei. 6
- 11.a) Explain the concept of differential cross-section and total cross-section and give their significance. 6
- b) Discuss Optical model for nuclear reaction. 6

OR

12. Discuss the Direct nuclear reaction. Explain their types. Give the kinematics of stripping and pick-up nuclear reaction. 12