(2½ Hours) **[Total Marks : 60**

N.B. : (1) **All** questions are **compulsory**.
   (2) **Figures** to the **right** indicate **full** marks.
   (3) Draw **neat** diagrams wherever **necessary**.
   (4) Symbols have usual meanings unless otherwise stated.
   (5) Use of **non-programmable** calculator is allowed.

1. (a) Attempt any **one:---**
    (i)   State different methods used to determine nuclear size. Explain the method, **8**
          Coulomb energy difference between mirror nuclei to determine nuclear
          radius parameter R_0.
    (ii) Assuming the square well potential for deuteron, obtain the depth of potential **8**
          well for deuteron, if the width of potential well is 2.1 fm.

    (b) Attempt any **one:---**
    (i)   State the expected and observed values of magnetic dipole moment and **4**
          electric quadrupole moment of deuteron. Which information is obtained for
          deuteron from small difference between measured and expected values of
          these quantities?
    (ii) Explain the properties: spin and parity of a nucleus. **4**

2. (a) Attempt any **one:---**
    (i)   Explain different modes of beta decay and obtain an expression for Q value of **8**
          each of these decay modes.
    (ii) Give an account of angular momentum and parity selection rules in gamma **8**
          decay. A nuclei decay from initial nuclear state with $I_i = 3/2$ to final nuclear
          state with $I_f = 5/2$. Obtain the allowed multipole gamma radiation emitted in
          the above decay.

    (b) Attempt any **one:---**
    (i)   What is Fermi-Curie plot in Fermi theory of beta decay. State the importance **4**
          of this plot.
    (ii) Explain how Pauli neutrino hypothesis solved the anomalies in beta-ray **4**
          spectra.

3. (a) Attempt any **one:---**
    (i)   Define Q value of a nuclear reaction. Consider the endoergic reaction **8**
          $X(x,y)Y$, where the target is initially at rest. Show that the threshold energy
          for the endoergic reaction is $E_{th} = -\frac{(M_y + M_Y)Q}{M_X - Q}$ and in the approximation
          that $Q \ll M_X$, we can write $E_{th} = -Q(1 + \frac{M_x}{M_X})$
    (ii) What is the fusion process? Explain the CNO cycle. **8**

(b) Attempt any **one:---**

   (i) In the nuclear shell model, orbitals are filled in the order, **4**
$1s_{1/2}, 1p_{3/2}, 1p_{1/2}, 1d_{5/2}, 2s_{1/2}, 1d_{3/2}, etc.$ Hence, find:

     (a) What is responsible for the splitting between the $p_{1/2}$, $p_{3/2}$ states?

     (b) Find the ground state angular momentum and parity for
O^{16} (z = 8) , $O^{15,}$, Ca^{41} (z = 20)

   (ii) If the average energy of 200 MeV is released in the fission of each U^{235}, how **4**
much U^{235} is used in one day in a reactor operating at a power of 50 MW?

4. (a) Attempt any **one:---**

   (i) Explain the eightfold way representation of elementary particles. Draw and **8**
explain the Baryons and Mesons Octets.

   (ii) Discuss the Weak Interaction process. Describe the characteristics of the same **8**
with suitable example.

(b) Attempt any **one:---**

   (i) Explain charge conjugation operator and its features. **4**

   (ii) Draw the Feynman diagrams, in terms of transitions at quark level for **4**
$\Delta^0 \to p^+ + \pi^-$reaction as a purely hadronic weak interaction and by a strong
interaction.

5. Attempt any **four:---**

(a) Explain why deuteron cannot exist in an excited state **3**

(b) Find the binding energy per nucleon for deuteron **3**
     Given: Mp == 1.007825 u, Mn = 1.008665 u, Md = 2.014102 u

(c) $_2He^6$ decay to $_3Li^6$ by β- decay and it is 0^+ to 1^+ transition. Identify whether it is **3**
pure Fermi or pure Gamow-Teller or Fermi and Gamow-Teller transition in
allowed approximation.

(d) Explain why Ii = If = 0 transition is not allowed for gamma decay and when pure **3**
multipole gamma transition is emitted in gamma decay.

(e) A beam of neutrons is incident on a piece of gold. The intensity of the beam as a **3**
function of depth t is given by $I(t) = I(0) \exp(-\sigma n t)$, σ is the capture cross
section and n is the number of target nuclei per unit volume. For $t = 0.05$ cm if the
emerging intensity is 74 % of the original intensity, find the reaction cross section.
[Given: density of $Au_{79}^{197} = 19.32$ x 10^3 kg m^{-3} , Avogadro No.=6.023 x 10^{26}]

(f) What are pick up and stripping reactions? Identify and state the type of following **3**
nuclear reactions:

   $i)$ Cu_{29}^{63} $(D_1^2, H_1^1)Cu_{29}^{64}$ $ii)$ Ca_{20}^{42} (p,d) Ca_{20}^{41}.

(g) Write a note on strange particles. **3**

(h) Explain muon decay process using Feynman diagrams. State the interaction **3**
involved in the process.