($2\,{}^{1}/_{2}$ Hours) **[Total Marks: 60]**

**N.B. :**(1) **All** questions are **compulsory**.

(2) **Figures** to the **right** indicate **full** marks.

(3) **Symbols** have their usual **meaning** unless otherwise **stated**.

(4) Use of **log tables / non-programmable** calculator is **allowed**.

1. (a) Attempt any **one : -** **8**

(i) Give a simple theoretical description of the deuteron and obtain an expression that relates the binding energy of the two nucleon system to width and depth of the assumed square wave potential.

(ii) Give an account of Nilsson's model of the nucleus. Sketch the Nilsson diagram up to nucleon number 20. Use it to predict the ground state spin and parity of $_{9}F^{19}$ and $_{11}Na^{23}$.
Given: deformation of these nuclei is 0.10 and 0.11 respectively.

(b) Attempt any **one : -** **4**

(i) What is the prediction of the simple shell model regarding the ground state angular momentum and parity of nuclei when the nucleus is
$(i)$ even $Z$ – even $N$ $(ii)$ odd $A$ $(iii)$ odd $Z$ – odd $N$

(ii) Define nuclear quadrupole moment. What information does the measurement of the electric quadrupole moment of a nucleus provide? What are prolate and oblate nuclei?

2. (a) Attempt any **one : -** **8**

(i) Obtain the conditions under which different types of $\beta$ decays are energetically possible.

(ii) Explain in brief the principal process by which the $\gamma$ rays interact with matter.

(b) Attempt any **one : -** **4**

(i) What led Pauli to postulate the existence of neutrino?

(ii) Check whether $_{92}U^{238}$ is unstable against $\alpha-$ emission.
Given: $M(U^{238}) = 238.048608\ U$, $M(Th^{234}) = 234.043583\ U$ and $M(He^{4}) = 4.00260\ U$

**{Turn Over}**

3. (a) Attempt any **one : -** **8**

(i) Discuss the Solar Fusion and CNO cycle.

(ii) Define Q value of a nuclear reaction. Obtain an expression for non-relativistic Q Value. State the conditions for exoergic and endoergic reactions.

(b) Attempt any **one : -** **4**

(i) Calculate the energy required to remove the least tightly bound neutron from $Ca^{40}$. Given: $M\ (Ca^{40}) = 39.962589\ U$ , $M\ (Ca^{39}) = 38.970691U$, $M(n) = 1.008665\ U\ \ and\ 1\ U = 931.5\ MeV$

(ii) Discuss the mass distribution of Fission fragments.

4. (a) Attempt any **one : -** **8**

(i) Draw and explain in detail the Baryons and Mesons Octets.

(ii) Discuss in detail the November revolution.

(b) Attempt any **one : -** **4**

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

(ii) Explain the primitive vertex for quantum electrodynamics and quantum chromodynamics. State the mediating particles in these cases.

5. Attempt any **four:** - **12**

(a) How does larger angular momentum of the projectiles in nuclear scattering experiments affect its de Broglie wavelength? What are its advantages?

(b) Which nuclei have radius equal to half that of $Te^{128}$?

(c) Find the energy of a neutrino in the following K-capture relation: ${}_{55}Cs^{131} + {}_{-1}e^{0} \rightarrow {}_{54}Xe^{131} + \nu$ . The total energy released in this process is 35.5 keV and the binding energy of the K-electron in $Xe^{131}$ is 35 keV. The daughter nucleus is formed directly in the ground state. **{Turn Over}**

(d) What are the selectin rules for $\gamma$ – decay?

(e) Explain the term Direct Reaction. State its characteristics.

(f) Find the unknown particle $X$ in the nuclear reactions given below:

1) ${}_{13}Al^{27}(X,p) = {}_{14}Si^{30}$
2) ${}_{9}F^{19} + {}_{1}H^{1} \rightarrow {}_{8}O^{16} + X$
3) ${}_{11}Na^{23} + X \rightarrow {}_{10}Ne^{20} + {}_{2}He^{4}$

(g) List all the leptons and their corresponding numbers in a tabular form.

(h) What are strange particles? Justify their name.

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