Registration Number:

Date & Session

PH6123: Elements of Nuclear Physics and Nuclear Instruments

(For current batch students only)

Time: 2 Hours   **Max Marks: 60**

This paper contains 2 printed pages and 3 parts

PART-A

Answer any **FOUR** questions. Each question carries **EIGHT** marks.   [4X8=32]

1. (a) Mention any four properties of nuclear forces

   (b) Write a note on nuclear magnetic dipole moments   (4+4)

2. Discuss in detail the theory of successive radioactive disintegration.

3. In a nuclear reaction a bombarding particle 'a' is incident on a target nucleus 'A'. After the reaction takes place, the ejected particle 'b' is emitted at an angle 'θ' and the residual nucleus 'B' recoils in such a way that the momentum is conserved. With a neat diagram, show that the Q-value of the reaction is given by

$$Q = k_b \left(1 + \frac{m_b}{m_B}\right) - k_a \left(1 - \frac{m_a}{m_B}\right) - \frac{2}{m_B} \left(k_a k_b m_a m_b\right)^{1/2} \cos\theta$$

4. Write a note on the following:

   (a) mesons and baryons

   (b) Color quantum number of quarks

   (c) Time reversal symmetry

   (d) CP violation

5. Describe the construction and working of a GM tube. What is the meaning of quenching of GM tube? What is its significance?

6. (a) Mention any four radioisotopes and its uses in radiation therapy.

   (b) Discuss any two diagnostic applications of radioisotopes.   (4+4)

PART-B

Answer any **FOUR** questions. Each question carries **FIVE** marks.   [4X5=20]

7. The nucleus $^{27}Si_{14}$ decays to its mirror nucleus $^{27}Al_{13}$ by positron emission with a maximum energy of 3.48 MeV. Find the difference in the Coulomb energy between the two nuclei and hence estimate the value of R_o in the expression for the nuclear radius. $R = R_o A^{1/3}$.

8. A sample of radioactive material initially contains 10^{12} atoms of a parent isotope with a half-life of 5 days. After certain period, it is found that the number of parent atoms has decreased to 2×10^{10}. At the same time, the number of daughter atoms in the sample has increased to 5×10^{11}. Determine if the sample is in transient equilibrium or secular equilibrium and calculate the time that has passed since the sample was prepared.

9. (a) Compute the Q-value for the nuclear reaction $C^{14}(\alpha, p) O^{17}$ based on the masses of the reacting particles. The atomic mass values of ^{14}C, ^{4}He, ^{1}H and ^{17}O are 14.00753u, 4.00386u, 1.00813u and 17.0045u.

   (b) Complete the following reaction:

$$ {}^{6}_{3}Li + ? \rightarrow {}^{7}_{4}Be + {}^{1}_{0}n $$
(4+1)

10. Which of the following reactions is possible? Justify.

   (a) $\pi^{+} + n^{0} \rightarrow \Lambda^{0} + k^{+}$

   (b) $\pi^{+} + n^{0} \rightarrow \pi^{-} + p$
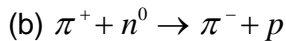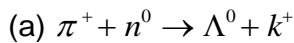
11. The cyclotron accelerates protons to 5 MeV. To what energy will the cyclotron accelerate (a) Alpha particles and (b) Deuterons.

12. A radioactive sample is counted for 10 minutes and gives N_g counts, while a 10-minute background count gives N_b counts. If the net count is 2500, the standard deviation is 120 and the background count is 20% of the sample count, find the values of N_g and N_b.

PART-C

Answer any **FOUR** questions. Each question carries **TWO** marks. [4X2=8]

13. Can spherical nuclei have quadrupole moment? Explain.

14. $^{4}He_2$ is more stable than $^{3}He_2$. Why?

15. Leptons are considered as more fundamental particles than hadrons. Why?

16. Mention any two quantities which are not conserved in nuclear reactions. Explain why they are not conserved.

17. An alpha particle loses energy when passes through air. Why?

18. Proton therapy is one of the most desirable among the modern radiation therapy. Justify.