# M. Sc. Physics Examination, 2023

( 2nd Year, 1st Semester )

## Nuclear and Particle Physics

## Paper –PG/SC/CORE/PHY/TH/110/2023

Time : Two hours                                                 Full Marks : 40

### Group-A(16 Marks)

**Answer any four questions**                                              4x4=16

1.  What do you mean by allowed and first forbidden beta decay? Discuss the selection rules for first forbidden beta decay process.                                              [2+2]

2.  What are the processes by which a gamma beam can interact with matter? Discuss how the importance of different processes change as the energy of the gamma beam increases.
    Suggest a process of de-excitation for the transition between the nuclear states $0^+ \to 0^+$·            [1+2+1]

3.  Indicate the origin of surface energy term and Coulomb energy term in semi empirical nuclear mass formula. How do they depend on the mass number of the nucleus?
    Find the ground state spin of the nucleus: $^{15}O_8$                                              [2+1+1]

4.  The nuclear force is charge independent. A neutron and a proton form a bound state but there is no bound state for two neutrons or two protons -- explain. What information does this provide on the nature of nucleon-nucleon force?                                              [4]

5.  What do you mean by resonance phenomena in nuclear reactions? Write down the expression for cross section of a nuclear reaction in the neighbourhood of a single resonance and explain each term.      [4]

6.  What is the basic difference of operation of an ionisation chamber and a proportional counter? Alpha-particles of 10.5 MeV pass through an ionisation chamber and lose their energy completely. If 35 eV energy is required to produce one ion-pair, and if the capacitance of the chamber is 4pF, calculate the height of the output voltage pulse.
                                                                                  [1+3]

### Group-B (24 Marks)

**Answer any two questions**                                              2x12=24

8.  Why quantum concept has to be introduced for explaining Alpha decay? Find the barrier transmission coefficient for the actual barrier faced by an alpha particle during the decay process.      [2+10]

9.  (a) Explain the concept of strangeness and associated production. Discuss the Gell-Mann- Nishijima relation. A particular non-strange baryon has charge -1. What is the isospin of the particle? Identity the particle. Name the other members of the same isospin multiplet group.

(b)    Discuss whether the following interactions are possible. If possible, mention the type of interaction.

   (i)    $\Sigma^- \to n + e^- + \bar{\upsilon}_e$

   (ii)    $\pi^- + p \to \Sigma^- + K^+$

(c) Why the colour degree of freedom has been assigned to the quarks? What do you mean by colour confinement?                                                                    [(2+3)+(2+2)+(1+2)]

10. (a) Discuss Rutherford's scattering experiment. Hence obtain an expression for the impact parameter and its relation with the distance of closest approach.

(b) Discuss the basic principle of operation of a betatron and determine the betatron condition.

A 250 MeV betatron has a stable orbit of radius 1m. The electrons acquire energy at the rate of 500 eV per revolution, The magnet of the betatron is energised at 100 Hz and produces pulses of 1 μs duration, each containing $10^{10}$ electrons. Calculate total distance covered by the electrons and the peak beam current they produce.                                                                    [5+(4+3)]