(b) Which interaction allows flavour changing of quarks? Explain with an example. Draw the relevant Feynman diagram.

(c) What are the properties of colour force? What do you mean by colour confinement?

(d) State with reasons whether the following interactions or decays are possible or not :

$$\pi^- + p \rightarrow \Lambda^\circ + K^\circ$$
$$\Sigma^\circ \rightarrow \Lambda^\circ + \gamma$$

[2+3+3+4]

10. *(a)* Why baryons are fermions and mesons are bosons? Explain in the light of quark model.

(b) Why is mass of a proton much larger than the mass of the quarks that make up the proton?

(c) Write down Gell-Mann-Nishijima formula and explain each term. A non-strange baryon has charge-1. What is the third component of isospin (I_3) of the particle? Write down the quark structure of the particle and identify the possible particle.

(d) Which interaction binds quarks within the hadrons? Name the mediator particle (particles) of this interaction. Mention their colours and other.

(e) What do you mean by electro-weak unification?

[2+2+4+3+1]

★★★

M. Sc. EXAMINATION, 2024

(2nd Year, 1st Semester)

PHYSICS

PAPER : PHY/TH/110

(Nuclear & Particle Physics)

Time : *Two Hours* *Full Marks* : 40

GROUP—A

Answer ***any one*** question

1. *(a)* A nucleus ${}^{A}_{Z}X$ splits into two fragments in the scheme,

${}^{A}_{Z}X \rightarrow {}^{A_1}_{Z_1}Y + {}^{A_2}_{Z_2}Z$.

If the nucleus with $A = 235$ splits into two fragments with mass numbers in the ratio of 3 : 2, then find the separation between the fragments at the moment of splitting.

(b) Explain the working principle of a linear accelerator and show that the drift tube length is proportional to the square root of natural numbers. Discuss about the need for a circular accelerator. [3+(4+1)]

2. *(a)* What is electrical quadrupole moment of a nucleus? Explain its significance in nuclear Physics.

(b) Draw the pulse height versus applied voltage graph of a gas-filled detector clearly indicating its different regions of operation.

(c) Calculate the capacitance of a Si detector (Dielectric constant = 10) which has an area of $1{\cdot}5$ cm^2 and depletion layer of width 40 microns. If $3{\cdot}5$ eV energy is required to produce one ion pair, what potential must be developed across the detector by the absorption of $5{\cdot}0$ MeV α-particle? [$\varepsilon_0 = 8{\cdot}85 \times 10^{-12}$ F.m^{-1}]

[3+2+3]

GROUP—B

3. Without considering Coulomb interaction find the probability that an electron will be emitted from a beta active nucleus in the momentum range p_e and $p_e + dp_e$ per unit time for allowed beta decay. Discuss how the probability will change if one considers the Coulomb interaction (show it graphically also). [7+3]

OR

4. Mention two nuclear properties which can be explained in terms of the liquid drop model for the atomic nucleus. Derive the semi empirical nuclear mass formula using only the concept of liquid drop model for the atomic nucleus. Discuss how the importance of different terms change with the nuclear size. [2+5+3]

5. *(a)* An alpha emitter emits monoenergetic alpha particles of energy 5 MeV. Do you think all the alpha particles will have exactly same range in air? Explain your answer.

(b) Consider two alpha emitters (source A and source B) of ^{238}U series. Source A emits alpha of average range 5 cm and that of the other is 6 cm in air. Which source will have greater half-life and why? [2+2]

OR

6. *(a)* Lead is better photoelectric absorber of gamma rays than aluminium. — Explain.

(b) Find the spin and parity of ^{25}Mg nucleus using extreme single particle shell model. [2+2]

GROUP—C

(Answer ***any one*** question)

7. *(a)* What is nuclear reaction cross-section? Write down its physical significance.

(b) Name and explain the theory which was verified by Ghoshal's experiment and write down the expression for reaction cross-section from the theory. [2+4]

8. *(a)* Write down the deuteron wave functions inside and outside the well considering that proton and neutron are bound by a square well potential of depth 36 MeV and range $2{\cdot}1$ fm. Draw the wave functions.

(b) Define radius of a deuteron and explain why deuteron is a loosely bound state. [4+2]

GROUP—D

Answer ***any one*** question

9. *(a)* "Protons and neutrons are not elementary" — Explain the experimental observations in support of the statement.