

(8 pages)

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M.Sc. (CBCS) DEGREE EXAMINATION, APRIL 2025.

Fourth Semester

Physics — Core

NUCLEAR AND PARTICLE PHYSICS

(For those who joined in July 2023 onwards)

Time : Three hours

Maximum : 75 marks

PART A — ($15 \times 1 = 15$ marks)

Answer ALL questions.

Choose the correct answer :

1. The Liquid Drop Model assumes that nucleons in a nucleus behave like molecules in a liquid drop. Which of the following forces is primarily responsible for the 'surface tension' effect in this model?
 - (a) Strong nuclear force
 - (b) Coulomb force
 - (c) Weak nuclear force
 - (d) Gravitational force

2. Which of the following contributes to the magnetic moment of an atom?
 - (a) The orbital motion of electrons
 - (b) The spin of electrons
 - (c) The nuclear spin
 - (d) All of the above
3. The nuclear shell model is based on the assumption that
 - (a) Nucleons move independently in a spherically symmetric potential
 - (b) The nucleus is a uniformly dense sphere of protons and neutrons
 - (c) Nucleons interact strongly with each other, forming clusters within the nucleus
 - (d) The nucleus has a complex shape with many deformations
4. Which of the following statements is true about nuclear exchange forces?
 - (a) They are responsible for the radioactive decay of atoms
 - (b) They are short-range forces that hold protons and neutrons together in the nucleus
 - (c) They are long-range forces that act between atoms in a molecule
 - (d) They are the same as electromagnetic forces

5. Which of the following is NOT a characteristic of tensor forces?
 - (a) They are central forces
 - (b) They depend on the spin of the particles
 - (c) They are important in the structure of light nuclei
 - (d) They contribute to the quadrupole moment of the deuteron
6. The Yukawa potential describes a force that is
 - (a) Long-ranged and attractive
 - (b) Short-ranged and attractive
 - (c) Long-ranged and repulsive
 - (d) Short-ranged and repulsive
7. Which isotope is most commonly used in nuclear reactors due to its ability to sustain a chain reaction?
 - (a) Uranium-238
 - (b) Uranium-235
 - (c) Plutonium-239
 - (d) Thorium-232

8. What is the role of neutrons in a nuclear chain reaction?
 - (a) They initiate the fission process
 - (b) They sustain the chain reaction by causing further fissions
 - (c) They carry away excess energy from the reaction
 - (d) Both (a) and (b)
9. Which of the following is true about the Q value of a nuclear reaction?
 - (a) It is always positive
 - (b) It is always negative
 - (c) It can be positive, negative, or zero
 - (d) It depends on the temperature of the reaction
10. What force is responsible for beta decay?
 - (a) Strong nuclear force
 - (b) Electromagnetic force
 - (c) Weak nuclear force
 - (d) Gravitational force

11. Which type of beta decay involves the emission of a positron?
 - (a) Beta-minus decay
 - (b) Beta-plus decay
 - (c) Both beta-minus and beta-plus decay
 - (d) Neither beta-minus nor beta-plus decay
12. Which of the following fundamental forces violates parity symmetry?
 - (a) Strong force
 - (b) Electromagnetic force
 - (c) Weak force
 - (d) Gravitational force
13. Which of the following is NOT a fundamental particle?
 - (a) Quark
 - (b) Lepton
 - (c) Hadron
 - (d) Boson
14. Hadrons are particles made of quarks. Which of the following is a type of hadron?
 - (a) Lepton
 - (b) Meson
 - (c) Photon
 - (d) Neutrino

15. Which of the following is NOT a fundamental particle in the Standard Model?
 - (a) Up quark
 - (b) Electron
 - (c) Proton
 - (d) Down quark

PART B — ($5 \times 4 = 20$ marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 250 words.

16. (a) Discuss the Bohr and Mottelson collective model.
 Or
 (b) Give an account of Schmidt model.
17. (a) What do you mean by tensor forces? Comment on the experimental evidence of the existence of tensor forces.
 Or
 (b) Give a brief account of spin dependence and saturation character of nuclear forces.
18. (a) Explain nuclear chain reaction and deduce the four factor formula.
 Or
 (b) State and discuss reciprocity theorem.

19. (a) Analyse the continuous Beta Spectrum.

Or

- (b) Find the expected type of gamma ray transitions between the following states of odd A nuclei.

20. (a) Explain the concept of isospin and isospin quantum number.

Or

- (b) What are quarks? Give their properties.

PART C — ($5 \times 8 = 40$ marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 600 words.

21. (a) Deduce the Weizsacker's semi empirical mass formula.

Or

- (b) Describe the important phenomena of the liquid drop model of the nucleus.

22. (a) Give a simple theory of deuteron obtain and plot the wave function for the deuteron ground state taken as an s-state.

Or

- (b) Analyse the nucleon-nucleon scattering. What information does it give about the nature of nuclear forces.

23. (a) Give an account of Bohr's compound nucleus formation hypothesis for nuclear reactions.

Or

- (b) Explain Q value of a reaction. How is related to threshold energy of a particle?

24. (a) Define parity. Explain the violation of parity conservation during β decay. How has this been experimentally verified.

Or

- (b) Give Fermi theory of Beta decay. Discuss the selection rules for allowed transitions. What are the forbidden transitions?

25. (a) Give an detailed account of SU(3) symmetry scheme of elementary particles.

Or

- (b) Explain the types of interaction and conservation laws in elementary particles.