TDC (CBCS) Odd Semester Exam., 2023

PHYSICS

(5th Semester)

Course No. : PHSDSE-502T

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

Candidates have to answer *either* Option—A or Option—B

OPTION—A

Course No. : PHSDSE-502T (A)

(Nuclear and Particle Physics)

SECTION—A

Answer *twenty* questions as directed, selecting *four* from each Unit : 1×20=20

Unit—I

1. Particles which can be added to the nucleus of an atom without changing its chemical properties are called

(a) proton

(b) electron

(c) neutron

(d) α-particle

(Choose the correct option)

2. Define the term mass defect of a nucleus.

3. What are the isotopes of hydrogen?

4. Density of a nucleus depends on

(a) atomic number

(b) mass number

(c) number of neutrons

(d) None of the above

(Choose the correct option)

5. "Increase of binding energy leads to release of energy."

(State True or False)

Unit—II

6. Which of the following best explains the nuclear fission?

(a) Liquid drop model

(b) Nuclear shell model

(c) Independent particle model

(d) Standard model

(Choose the correct option)

7. Name a doubly magic nuclei.

8. Meson is a particle with non-zero rest mass.

(State True or False)

9. Name the mediator particle responsible for carrying nuclear force between nucleons.

10. What do you mean by nuclear model?

Unit—III

11. How much is the mass of an α-particle in terms of amu?

12. What do you mean by range of an α-particle?

13. Like an excited atom, an excited nucleus can emit a photon.

(State True or False)

14. What is conversion electron?

15. What is end point energy?

Unit—IV

16. Name a phenomenon which describes corpuscular nature of light.

17. Write Einstein's photoelectric equation mentioning all the terms involved.

18. What is the origin of gamma radiation?

19. How much minimum energy is required for a photon to cause pair production?

20. Name a particle accelerator centre located in India.

Unit—V

21. Name the mediator of electromagnetic interaction.

22. Why are elementary particles called elementary?

23. What are strange particles?

24. The standard model of particle physics describes the universe in terms of matter and force.

(State True or False)

25. The hadrons, which are not strange particles, have the S-value

(a) 0

(b) + 1

(c) – 1

(d) + 2

(Choose the correct option)

SECTION—B

Answer *five* questions, selecting *one* from each Unit : 2×5=10

Unit—I

26. On what factors, does the stability of a nucleus depend?

27. Find the energy equivalent to 1 amu.

Unit—II

28. What are the basic assumptions of liquid drop model?

29. Find the ground state spin and parity of $^{27}_{13}Al$.

Unit—III

30. Explain Pauli's neutrino hypothesis.

31. Write the reactions corresponding to β^- and β^+ decay processes.

Unit—IV

32. What is Compton shift? Write its formula.

33. What are the two main types of particle accelerators?

Unit—V

34. Write the names of different leptons with their symbols.

35. What are Baryon number and Lepton number?

SECTION—C

Answer *five* questions, selecting *one* from each Unit : 8×5=40

Unit—I

36. *(a)* Explain the variation of binding energy per nucleon with mass number for light, medium and heavy nuclei in detail with necessary diagram. Why binding energy per nucleon decreases for nuclei with higher mass number? 4+1

(Continued)

(b) Calculate the binding energy of ^4_2He in MeV from the following data : 3

Mass of ^4_2He = 4·003875 amu

Mass of ^1_1H = 1·008145 amu

Mass of neutron = 1·008986 amu

37. *(a)* Briefly explain electrical quadrupole moment of a nucleus and nuclear spin. 3+3

(b) The radius of a nucleus is found to be 3·2 fm. Find the mass number. 2

Unit—II

38. *(a)* What do you mean by saturation property of nuclear force? 1

(b) Deduce semi-empirical mass formula. 7

39. *(a)* What are the basic assumptions of nuclear shell model? Write few merits and demerits of nuclear shell model. 2+2+2

(b) Nuclear forces are basically strong attractive forces but contain a small component of repulsive forces. Justify the statement. 2

(Turn Over)

Unit—III

40. *(a)* Show that during α-decay, most of the disintegration energy appears as kinetic energy of the emitted α-particle. 4

(b) Explain α-ray spectra in detail with necessary diagram. 4

41. Explain β-ray spectrum in detail. What are the theoretical inadequacies to explain β-ray spectrum? Explain. 4+4

Unit—IV

42. *(a)* Find the rest mass energy of electron in MeV. 2

(b) Explain the process of pair production. Show that electron positron pair cannot be created by a isolated photon. 3+3

43. Explain the construction of a Betatron. Derive the condition for its operation. Mention any two limitations of Betatron. 3+3+2

Unit—V

44. *(a)* Give the detailed list of classification of elementary particles, mentioning symbol, spin, Baryon number, lepton number and strangeness number of each particle. 5

(b) Which quantum numbers need to be conserved in a strong interaction? Show that the reaction $K^- + P \rightarrow \Xi^- + \pi^+$ is not allowed. 1+2

45. *(a)* What do you mean by quarks? Give the charge, baryon number and strangness number associated with each quark. 1+3

(b) Give the quark content of K^0, K^+, Σ^0 and Ξ^0. 4

OPTION—B

Course No. : PHSDSE–502T (B)

(Advance Mathematical Physics)

SECTION—A

Answer *twenty* questions as directed, selecting *four* from each Unit : 1×20=20

Unit—I

1. Define the concept of linear independence of vectors in a vector space.

2. What is dimension of a vector space?

3. Define symmetric relation.

4. When is a linear transformation said to be non-singular?

5. Define isomorphism.

Unit—II

6. Give definition of unitary matrix.

7. Give an example of function of a matrix.

8. Define the trace of a matrix.

9. Give example of a 2×2 orthogonal matrix.

10. Can an orthogonal matrix be a unitary matrix?

Unit—III

11. Identity element of a group is unique.

(State True or False)

12. Define coset.

13. Give definition of a subgroup of a group.

14. Order of a subgroup of a group of order 6 cannot be four. Explain.

15. What is the significance of the group multiplication table?

Unit—IV

16. What do you mean by dummy indices?

17. Give definition of Kronecker delta symbol.

18. $\delta^{\mu}_{\mu} = n$, where n is the dimension of space.

(State True or False)

19. Define Einstein summation convention.

20. Name a rank 2 symmetric tensor.

Unit—V

21. Define covariant 4-vector.

22. $\eta_{\mu\nu}\,\eta^{\nu\lambda} = \delta_{\mu}^{\lambda}$

(State True or False)

23. Product of rank-2 symmetric tensor $A^{\mu\nu}$ and anti-symmetric tensor $F_{\nu\lambda}$ is

$$A^{\mu\nu} F_{\nu\lambda} = 0$$

(State True or False)

24. If all the components of a tensor are zero in a frame, then these are zero in all other frames.

(State True or False)

25. Define Levi-Civita symbol in three-dimensions.

SECTION—B

Answer *five* questions, selecting *one* from each Unit : 2×5=10

Unit—I

26. Give definition of field.

27. Give definition of a vector space.

Unit—II

28. Prove that Tr(A) of a square matrix is the sum of its eigenvalues.

29. If both trace and determinant of a diagonalizable 2×2 matrix are zero, then comment on eigenvalues of that matrix.

Unit—III

30. Prove that cyclic groups are Abelian groups.

31. Explain the concept 'matrix representation of a group'.

Unit—IV

32. Prove that $x^{\mu} x_{\mu} = x^{\nu} x_{\nu}$.

33. Prove that total number of independent components of $g_{\mu\nu}$ is 10 in 4D.

Unit—V

34. Find metric tensor in spherical polar coordinate system.

35. Find inverse metric of two-dimensional flat metric in polar coordinate system.

SECTION—C

Answer *five* questions, selecting *one* from each Unit : 8×5=40

Unit—I

36. Show that a set of vectors is linearly dependent iff one vector in the set can be expressed as the linear combination of the others.

37. Let $s = \{(1, 0, 0), (0, 4, 0), (0, 0, -6), (1, 5, -3)\}$. Determine if s is linearly independent or dependent.

Unit—II

38. State and prove Cayley-Hamilton theorem.

39. Verify Cayley-Hamilton theorem with the following matrix :

$$\begin{bmatrix} 1 & 2 & 3 \\ 2 & -1 & 4 \\ 3 & 1 & 1 \end{bmatrix}$$

Unit—III

40. State and prove Schur's lemma.

41. Prove that groups of orders 2 and 3 are always cyclic but group of order 4 may or may not be cyclic.

Unit—IV

42. Prove that any rank-2 tensors can be uniquely written as sum of rank-2 symmetric and anti-symmetric tensors.

43. *(a)* Give transformation laws of rank-2 covariant, contra-variant and mixed tensors. 6

(b) How can you change a rank-2 mixed tensor into a covariant tensor? Show with an example. 2

Unit—V

44. *(a)* State and explain quotient law of tensors. 4

(b) Show that the anti-symmetric rank-2 tensor $F_{\mu\nu}$ of dimension n has $\frac{n(n-1)}{2}$ numbers of independent components. 4

45. *(a)* What is contraction of tensor? Show that $A_\mu B^{\mu\nu}$ transforms like a rank-1 contravariant tensor. 4

(b) If A^μ is an arbitrary contravariant vector and $C_{\mu\nu}A^\mu A^\nu$ is invariant, then prove that $(C_{\mu\nu} + C_{\nu\mu})$ is a rank-2 covariant tensor. 4

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