2021/TDC/CBCS/ODD/ PHSDSE–502T(A/B)/158

TDC (CBCS) Odd Semester Exam., 2021 held in March, 2022

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_ from Option—A _or_ Option—B

OPTION—A

Course No. : PHSDSE–502T (A)

(Nuclear and Particle Physics)

SECTION—A

Answer any _twenty_ of the following as directed :

1×20=20

1. The size of the nucleus is estimated to be of the order of

   (a) few picometer

   (b) few femtometer

   (c) few nanometer

   (d) few micrometer

   (Choose the correct answer)

   (Turn Over)

(2)

2. Define packing fraction of a nucleus.

3. Which parameter describes the deviation of charge distribution of a nucleus from spherical symmetry?

4. What will be the ratio of the radii of two nuclei of mass numbers A_1 and A_2?

5. Define binding energy of a nucleus.

6. The nuclear shell model can explain the process of nuclear fission.

(State True or False)

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

8. Nuclear force is

(a) spin independent

(b) charge dependent

(c) spin dependent but charge independent

(d) both charge and spin independent

(Choose the correct answer)

(Continued)

(3)

9. Name doubly magic nuclei.

10. What do you mean by saturation property of nuclear force?

11. Emission of β-rays in radioactive decay results in the change of either mass or charge.

(State True or False)

12. Particles that are helium nuclei are called

(a) alpha particle

(b) beta particle

(c) god particle

(d) gamma particle

(Choose the correct answer)

13. How is β-particle different from α-particle?

14. Radioactivity is

(a) spontaneous

(b) self-disintegration process

(c) irreversible process

(d) All of the above

(Choose the correct answer)

(Turn Over)

15. Define exoergic reaction.

16. What is Compton shift?

17. Compton effect can be explained on the basis of corpuscular nature of light.

    (State True or False)

18. The work function ϕ of a material in a photoelectric effect

    (a) is different for different materials

    (b) is same for all materials

    (c) depends upon the frequency of incident light

    (d) depends upon the intensity of incident light

    (Choose the correct answer)

19. What are the processes by which γ-radiation loses energy on passing through matter?

20. What is the minimum energy required for pair production to occur?

21. What do you mean by elementary particle?

22. Why are elementary particles considered to be fundamental?

23. What are strange particles?

24. What is the s value of hadrons which is not strange?

25. What are the electric charges of up and down quark?

SECTION—B

Answer any *five* of the following questions : 2×5=10

26. What are isotopes? Name different isotopes of hydrogen.

27. Calculate the mass number of a nucleus whose radius is $4 \cdot 8 \times 10^{-15}$ m.

28. What are the usefulness and limitations of liquid drop model of nucleus?

29. What is the basic point of difference between liquid drop model and shell model of nucleus?

30. What do you mean by range of an α-particle? How is it related to energy?

31. Briefly explain the process of internal conversion.

(6)

32. The stopping potential for a photoelectric emission process is 10 V. Find the maximum kinetic energy of the emitted electrons in joule.

33. What is Cerenkov radiation?

34. What are leptons? How many leptons are there?

35. Write a short note on time reversal.

SECTION—C

Answer any *five* of the following questions : 8×5=40

36. *(a)* What is the shape of a nucleus if its electrical quadrupole moment is zero? In which unit nuclear magnetic moment is measured? What are the measured values of magnetic moments of proton and neutron? 1+1+2=4

(b) Explain the term nuclear spin in detail. 4

37. *(a)* What do you mean by mass defect of a nucleus? With necessary diagram, discuss how binding energy per nucleon varies with mass number for light, medium and heavy nuclei. 1+4=5

(b) Why do stable medium nuclei contain excess neutrons? 3

(7)

38. *(a)* State the main assumptions of the nuclear shell model. What are the evidences in favour of shell model? 3+3=6

(b) Mention two limitations of shell model of nucleus. 2

39. *(a)* What are the properties of nuclear force? 3

(b) Discuss meson theory of nuclear force in detail. 5

40. *(a)* Write four properties of α-particle. Explain α-ray spectra in detail. 2+4=6

(b) Explain Geiger-Nuttall law. 2

41. *(a)* Discuss the apparent non-conservation of energy and momentum in β-decay. Explain how the neutrino hypothesis restores the conservation laws. 2+4=6

(b) Name various physical quantities that remain conserved in a nuclear reaction. 2

42. *(a)* Explain photoelectric effect. What are the pertinent experimental observations of photoelectric effect? 2+3=5

(b) In an experiment, tungsten cathode which has a threshold wavelength 2300 Å is irradiated by ultraviolet light of wavelength 1800 Å. Calculate the maximum energy of the emitted photo-electrons. 3

43. *(a)* Prove that it is not possible for a photon to transfer its entire energy to the recoil electron in Compton effect. 3

(b) Discuss the theory of betatron and obtain the betatron condition. 5

44. *(a)* What do you mean by quarks? How many possible quarks are there? Give the charge and quantum number associated with each quark. 1+1+2=4

(b) How do the quarks combine to form baryons and mesons? Discuss citing an example in each case. 2+2=4

45. *(a)* Check whether the following reaction is allowed : 2

$$\Pi^- + P \rightarrow \wedge^\circ + \Pi^\circ$$
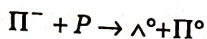
(b) Write short notes on standard model and CPT theorem. 3+3=6

OPTION—B

Course No. : PHSDSE–502T (B)

(Advance Mathematical Physics)

SECTION—A

Answer any *twenty* of the following as directed : 1×20=20

1. Define binary operation.

2. Explain the term 'basis'.

3. What do you mean by isomorphism?

4. What is linear independence of vectors?

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

6. Define trace of a square matrix.

7. What is the relation between trace and eigenvalues of a matrix?

8. Give an example of 2×2 unitary matrix.

(10)

9. A real orthogonal matrix is a unitary matrix.

(Write True or False)

10. How is determinant of a matrix related to its eigenvalues?

11. Identity element of a group is unique.

(Write True or False)

12. Define coset.

13. Explain the term 'proper subgroup'.

14. Give an example of an Abelian group.

15. All Abelian groups are cyclic groups.

(Write True or False)

16. Give an example of rank-2 antisymmetric tensor.

17. State True or False :

$$\delta^{\mu}_{\mu} = dimension$$

(11)

18. Define rank of a tensor.

19. Define covariant vector.

20. Define contravariant vector.

21. Metric tensor can be used to raise or lower an index.

(Write True or False)

22. Contraction reduces rank.

(Write True or False)

23. Write down transformation law of metric tensor $g_{\mu\nu}$.

24. Number of independent components of $g_{\mu\nu}$ in flat space-time is _____.

(Fill in the blank)

25. State True or False :

$$g^{\mu\nu} g_{\nu\lambda} = \delta^{\mu}_{\lambda}$$

(12)

SECTION—B

Answer any *five* of the following questions : 2×5=10

26. Explain the term 'equivalence relation'.

27. Give definition of field.

28. What do you mean by similarity transformation?

29. Show that similarity transformation does not change the value of determinant.

30. Define group.

31. What do you mean by normal subgroup?

32. Explain Einstein's summation conversion with an example.

33. Find number of independent components of $F^{\mu\nu}$, if it is an antisymmetric tensor in four-dimension.

(Continued)

(13)

34. Find metric tensor for Minkowski space-time.

35. Show that metric tensor and its inverse have same component values for Minkowski space-time.

SECTION—C

Answer any *five* of the following questions : 8×5=40

36. (a) Show that the vectors
$$\vec{X} = (\hat{i} + \hat{j}) / \sqrt{2}, \quad \vec{Y} = (\hat{i} - \hat{j}) / \sqrt{2} \text{ and } \vec{Z} = \hat{k}$$
are linearly independent in $\mathbf{R}^3$. 4

(b) Let F is a relation on the set $\mathbf{R}$ of real numbers defined by xFy, if and only if, $(x - y)$ is an integer. Prove that F is an equivalent relation on $\mathbf{R}$. 4

37. (a) Prove that the set of real numbers $\mathbf{R}$ together with regular addition (+) and multiplication (×) is a field. 4

(b) Show that the vectors
$$V_1 = (1, 1, 2, 4), \quad V_2 = (2, -1, 5, 2),$$
$$V_3 = (1, -1, -4, 0), \quad V_4 = (2, 1, 1, 6)$$
are linearly dependent in $\mathbf{R}^4$. 4

(Turn Over)

(14)

38. State and prove Cayley-Hamilton theorem. 8

39. Solve

$$\frac{dX}{dt} = AX$$

where $X = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$ and $A = \begin{pmatrix} 1 & 1 \\ 4 & 1 \end{pmatrix}$. 8

40. State and prove Lagrange's theorem for finite groups. Prove that the group of order two is always cyclic. 6+2=8

41. Prove that the set $G = \{1, -1, i, -i\}$ forms a group under ordinary multiplications. Find all the subgroups of it with the help of Lagrange's theorem. 5+3=8

42. (a) Show that any rank-2 tensor can be uniquely written as sum of symmetric and antisymmetric rank-2 tensors. 4

(b) Show that $\delta^{ik}\varepsilon_{ijk} = 0$. 4

43. (a) Prove that $F^{\mu\nu}A_\mu B_\nu = 0$ for any anti-symmetric tensor $F^{\mu\nu}$ and vectors A_μ and B_ν. 4

(b) Write a short note on Levi-Civita symbol. 4

(15)

44. (a) Find metric tensor in spherical polar coordinate. 4

(b) Hence find inverse of it. 4

45. (a) If A_α, B_β and $C^{\alpha\beta}\gamma$ are tensors, then show that $A_\alpha B_\beta C^{\alpha\beta}\gamma$ is a vector. 4

(b) State and explain quotient law of tensors. 4

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