DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

23-0009-AU TEST BOOKLET

PHYSICS

PAPER – II

Time Allowed: 3 hours | **Maximum Marks: 300**

INSTRUCTIONS TO CANDIDATES

***Read the instructions carefully before answering the questions*: -**

1. This Test Booklet consists of 16(sixteen) pages and has 75 (seventy-five) items (questions).
2. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
3. **Please note that it is the candidate's responsibility to fill in the Roll Number and other required details carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet and the Separate Answer Booklet. Any omission/discrepancy will render the OMR Answer Sheet and the Separate Answer Booklet liable for rejection.**
4. Do not write anything else on the OMR Answer Sheet except the required information. Before you proceed to mark in the OMR Answer Sheet, please ensure that you have filled in the required particulars as per given instructions.
5. Use **only Black Ball Point Pen** to fill the OMR Answer Sheet.
6. This Test Booklet is divided into 4 (four) parts – **Part – I, Part – II, Part - III and Part – IV**.
7. **All three parts are Compulsory.**
8. **Part-I consists of Multiple Choice-based Questions.** The answers to these questions have to be marked in the **OMR Answer Sheet** provided to you.
9. **Part-II, Part-III and Part-IV consist of Conventional Essay-type Questions.** The answers to these questions have to be written in the separate **Answer Booklet** provided to you.
10. In Part-I, each item (question) comprises of 04 (four) responses (answers). You are required to select the response which you want to mark on the OMR Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose *ONLY ONE* response for each item.
11. After you have completed filling in all your responses on the OMR Answer Sheet and the Answer Booklet(s) and the examination has concluded, you should hand over to the Invigilator ***only the OMR Answer Sheet and the Answer Booklet(s)***. You are permitted to take the Test Booklet with you.
12. **Penalty for wrong answers in Multiple Choice-based Questions:**

THERE WIL BE **PENALTY** FOR WRONG ANSWERS MARKED BY A CANDIDATE.

(i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, one-third of the marks assigned to the question will be deducted as penalty.

(ii) If a candidate gives more than one answer, it will be treated as a wrong answer even if one of the given answers happens to be correct and there will be same penalty as above to the question.

(iii) If a question is left blank. i.e., no answer is given by the candidate, there will be no penalty for that question.

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PART-I
(Multiple Choice-based Questions)

Instructions for Questions 1 to 50:

- *Attempt all questions. Each question carries 3 marks.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[3x50=150]

1. The de Broglie wavelength of an electron having a kinetic energy of $\mathbf{50}\ \boldsymbol{eV}$ is equal to:
   (a) 1.735 Å
   (b) 0.245 Å
   (c) 0.870 Å
   (d) 0.123 Å

2. What is the speed of an electron whose de Broglie wavelength is equal to its Compton wavelength ($\boldsymbol{c}$ is the speed of light)?
   (a) c
   (b) $c/2$
   (c) $c/\sqrt{2}$
   (d) $c/3$

3. The duration of a radar pulse is $\mathbf{0.25}\ \boldsymbol{\mu s}$. Calculate the uncertainty in the energy of the photon.
   (a) $1.32 \times 10^{-9}\ eV$
   (b) $1.32 \times 10^{9}\ eV$
   (c) $1.32 \times 10^{-10}\ eV$
   (d) $1.32 \times 10^{10}\ eV$

4. What is the minimum uncertainty in the position of ball of mass $\mathbf{200}\ \boldsymbol{gm}$, if the uncertainty in the speed of the ball is $\mathbf{5}\ \boldsymbol{km/h}$ (let $\boldsymbol{h/2\pi = 0.5\ Js}$)?
   (a) 14.3 cm
   (b) 28.6 cm
   (c) 90.0 cm
   (d) 1.8 m

5. The total energy operator in quantum mechanics is given by:
   (a) $E = i\hbar\frac{\delta}{\delta t}$
   (b) $E = -i\hbar\frac{\delta}{\delta t}$
   (c) $E = i\hbar\frac{\delta}{\delta x}$
   (d) $E = -i\hbar\frac{\delta}{\delta x}$

6. The momentum operator $\hat{\boldsymbol{p}}$ is given by:
   (a) $-i\hbar\nabla$
   (b) $i\hbar\nabla$
   (c) $-\hbar\nabla$
   (d) $\hbar\nabla$

7. The time dependent wave function of a particle has to be:
   (a) real
   (b) imaginary
   (c) complex
   (d) square integral

8. The energy of a particle in its lowest Eigen state ($\boldsymbol{n = 1}$) in a one-dimensional box is $\boldsymbol{E}$. Its energy in $\boldsymbol{n = 4}$ state is equal to:
   (a) $2E$
   (b) $4E$
   (c) $16E$
   (d) $64E$

9. The radial wave function of the hydrogen atom is given in terms of the associated _____.
   (a) Hermite Polynomials
   (b) Legendre Polynomials
   (c) Laguerre Polynomials
   (d) Laplace Polynomials

10. What according to quantum mechanics is the average distance of electron from nucleus in the $\boldsymbol{1s}$ orbitalof a hydrogen atom? ($\boldsymbol{a}$ is the radius of the first Bohr orbit)
   (a) $a/2$
   (b) $a/\sqrt{2}$
   (c) a
   (d) $3a/2$

11. The Eigen values of the Hermitian operator are _____
   (a) real
   (b) imaginary
   (c) real or imaginary
   (d) depends on operator

12. Eigen value(s) of the parity operator is/are equal to:
   (a) 1
   (b) -1
   (c) 0
   (d) ± 1

13. The magnetic field in Stern Gerlach experiment atoms are moving along x-direction enter in the region between magnetic poles, must
    (a) be constant
    (b) have a gradient along x-direction
    (c) have a gradient in the perpendicular x-direction
    (d) be oscillating with time

14. What gives rise to the fine structure of atomic spectral lines?
    (a) Electron spin-orbit coupling.
    (b) Nuclear spin.
    (c) Interaction between electron and nucleus.
    (d) Interaction between atom.

15. The dimension of $\boldsymbol{\mu} \cdot \vec{\boldsymbol{B}}$ and _____ are the same.
    (a) Force
    (b) Energy
    (c) Linear momentum
    (d) Angular momentum

16. Which of the following statements is correct?
    (a) The value of orbital angular momentum quantum number ($\boldsymbol{l}$)is always non-$\boldsymbol{zero}$.
    (b) The number of possible values of orbital angular momentum quantum number ($\boldsymbol{l}$) is equal to the value of principal quantum number ($\boldsymbol{n}$).
    (c) The value of orbital angular momentum quantum number ($\boldsymbol{l}$) is equal to the value of principal quantum number ($\boldsymbol{n}$).
    (d) The value of orbital angular momentum quantum number ($\boldsymbol{l}$) is equal to $\boldsymbol{infinity}$.

17. The period of a linear harmonic oscillator is $\mathbf{1}\ \boldsymbol{second}$. What is its zero-point energy?
    (a) 0
    (b) $3.3 \times 10^{-31}\ J$
    (c) $3.3 \times 10^{-34}\ J$
    (d) $3.3 \times 10^{-30}\ J$

18. Fermi energy level in an intrinsic semiconductor is situated _____
    (a) near conduction band
    (b) near valence band
    (c) between conduction and valence band
    (d) none of the above

19. The conductivity of intrinsic semiconductor increases when _____
    (a) temperature is increased
    (b) temperature is decreased
    (c) area is increased
    (d) area is decreased

20. Which of the following is the thinnest part of a transistor?
    (a) Emitter
    (b) Base
    (c) Collector
    (d) None of the above

21. Which of the following is the correct relation between the α and βparameters of current gain for a transistor?
    (a) $\alpha = \beta$
    (b) $\alpha = \beta/(1+\beta)$
    (c) $\beta = \alpha/(1+\alpha)$
    (d) $\alpha = 1/\beta$

22. In an NPN transistor, the majority carriers in the base region are _____
    (a) free electrons
    (b) holes
    (c) both electrons and holes
    (d) protons

23. What is the ideal value of the bias stability factor (S) of a transistor amplifier?
    (a) 0
    (b) ∞
    (c) -1
    (d) 1

24. In which configuration is the value of forward current transfer ratio maximum for a transistor?
    (a) Common base.
    (b) Common emitter.
    (c) Common collector.
    (d) All configurations have the same forward current transfer ratio for a given transistor.

25. In a feedback amplifier, constant amplitude oscillations are obtained when loop gain ($A\beta$) is equal to _____
    (a) 0
    (b) -1
    (c) 1
    (d) ∞

26. The resonant frequency (ω) of a crystal oscillator in series resonance mode is equal to:
    (a) $\omega = \frac{\sqrt{L}}{C}$
    (b) $\omega = \frac{1}{\sqrt{LC}}$
    (c) $\omega = \frac{\sqrt{C}}{L}$
    (d) $\omega = \sqrt{LC}$

27. Since the input resistance of an ideal op-amp is infinite, therefore _____
    (a) its output resistance is zero
    (b) its output voltage is independent of load resistance
    (c) its input current is zero
    (d) it works as a current controlled device

28. What are the majority charge carriers in a p-channel JFET?
    (a) Holes
    (b) Electrons
    (c) Protons
    (d) Neutrinos

29. The capacitance effect of MOSFET is _____the capacitance effect of JFET.
    (a) higher than
    (b) lower than
    (c) equal to
    (d) none of the above

30. Under which of the following conditions is the output state of an **OR gate**equal to**1**?
    (a) Only when both inputs are zero.
    (b) When either one or both inputs are one.
    (c) Only when both inputs are one.
    (d) None of the above.

31. A nucleus has a size of $10^{-15}m$. Consider an electron bound within a nucleus. The estimated energy of this electron is of the order of _____
    (a) $1\ MeV$
    (b) $100\ MeV$
    (c) $1000\ MeV$
    (d) $100000\ MeV$

32. Which one of the following is a correct set of magic numbers?
    (a) 1, 2, 8, 16, 20, 28
    (b) 2, 8, 16, 20, 28, 50
    (c) 8, 28, 50, 82, 100, 126
    (d) 2, 8, 20, 28, 50, 82, 126

33. For the even-odd or odd-even nuclei, the pairing energy is _____
    (a) always positive
    (b) always negative
    (c) always zero
    (d) either negative or positive

34. Which of the following nuclei has the largest binding energy per nucleon?
    (a) ^{4}He
    (b) ^{56}Fe
    (c) ^{12}C
    (d) ^{238}U

35. Energy equivalent of $\mathbf{1\ a.m.u.}$ is equal to -
    (a) 931 KeV
    (b) 931 MeV
    (c) 931 GeV
    (d) 1000 MeV

36. Which of the following property is not explained by the Nuclear Shell model?
    (a) Stability of closed shell nuclei.
    (b) Spin and parities of nuclear ground state.
    (c) Electric quadrupole moment of nuclei.
    (d) Nuclear isomerism.

37. Which is the electric charge of a neutrino?
    (a) 1
    (b) -1
    (c) 0
    (d) Depends on the nature of neutrino.

38. What happens in an internal pair conversion?
    (a) A neutron decays to a proton.
    (b) Only one electron is emitted.
    (c) No particle is emitted.
    (d) A particle and its anti-particle are emitted.

39. Consider the reaction $^{54}_{25}Mn + e^- \longrightarrow {}^{54}_{24}Cr + X$.The particle X is:
    (a) γ
    (b) ν_e
    (c) π°
    (d) N

40. For critical mass in a nuclear chain reaction, the value of the multiplication factor k is:
    (a) greater than 1.
    (b) less than 1.
    (c) equal to 1.
    (d) none of the above.

41. Quark structure of neutron is:
    (a) uuu
    (b) uud
    (c) udd
    (d) ddd

42. The total charge of the particle ***dds*** is:
    (a) e
    (b) $(1/3)e$
    (c) $(-2/3)\ e$
    (d) $-e$

43. What is the maximum number of hydrogen bond(s)formed by a molecule of water?
    (a) 1
    (b) 2
    (c) 3
    (d) 4

44. Which crystal system requires only three lattice parameters to fully specify its unit cell?
    (a) Tetragonal
    (b) Orthorhombic
    (c) Monoclinic
    (d) Triclinic

45. The miller indices of the fifth reflection in an FCC crystal is:
    (a) (331)
    (b) (222)
    (c) (311)
    (d) (400)

46. The atomic packing factor of BCC structure is:
    (a) 52%
    (b) 68%
    (c) 74%
    (d) 81%

47. What is the number of possible quantum states in an energyband?
    (a) 2N
    (b) N
    (c) 5N
    (d) None of the above

48. The relation between the energy of an electron (E_e) and energy of a hole (E_h) is given by:
    (a) $E_h = E_e$
    (b) $E_h = -E_e$
    (c) $E_e/E_h = 1$
    (d) None of the above

49. Which of the following are associated with soft superconductors?
    (a) Meissner effect
    (b) Silsbee's rule
    (c) both (a) and (b)
    (d) none of the above

50. If the mobility of electrons in a metal increase, the resistivity
    (a) decreases
    (b) increases
    (c) remains constant
    (d) first decreases&then increases

PART-II
(Short Answer-type Questions)

Instructions for Questions 51 to 63:

- ***Write the answers in short for any 10 (TEN)out of the thirteen questions.***
- ***Each question carries 5 marks.***
- ***Candidates are required to give their answers in their own words as far as practicable.***
- ***No Data Books/Tables are allowed; assume the data if required anywhere.***
- ***Unless otherwise mentioned, symbols and notations have their usual meaning.***

[5 x 10 = 50]

51. State the ***Uncertainty Principle*** and calculate the ground state energy of Hydrogen atom with the help of uncertainty principal.
52. What do you understand by the concept of ***density of states***?
53. Explain the properties of ***Pauli spin matrices***.
54. Briefly explain the phenomenon of ***Lamb shift***.
55. Describe briefly the concept and significance of ***j-j coupling*** scheme.
56. Discuss the results of the ***Stern-Gerlach experiment***.
57. What are the applications of ***EPR***?
58. Define C***entral and Non-central Forces*** with the help of two examples each.
59. What is a nuclear reactor? Describe in short, each of the main components of a nuclear reactor?
60. What is meant by ***weak and strong interaction***? Explain with the help of an example each.
61. Explain Meissner effect in ***superconductivity.***
62. State ***De Morgan's theorem***. And prove that $(\bar{A} + B) + CD = (\bar{A} + B)\,CD$ with the help of it.
63. Draw the symbols for ***OR, AND*** and ***NOT gates***. Explain the functioning of each gate with the help of a truth table and a circuit diagram.

PART-III
(Long Answer-type Questions)

Instructions for Questions 64 to 71:

- *Answer any 5 (FIVE)out of the eight questions.*
- *Each question carries 10 marks.*
- *Candidates are required to give their answers in their own words as far as practicable.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[10 x 5 = 50]

64. Explain in the detail the working of an ***n-p-n*** transistor. A transistor has a base current I_B= 100 μA and the collector current is I_C is 0.5mA. Determine the value of α, β and emitter current.
65. Distinguish between ***dia-magnetism, para-magnetism*** and ***ferro-magnetism***.
66. State the any five conservations laws for elementary particles reactions. Explain $\pi^0 \rightarrow \gamma\gamma$ is allowed but $\pi^0 \rightarrow \gamma\gamma\gamma$ is forbiddon.
67. How is energy produced in stars? Explain in detail.
68. Explain the ***Raman effect*** in detail. What are its applications?
69. What is a ***neutral hydrogen atom***? Discuss in detail the significance of ***neutral hydrogen atom***.
70. What is the free electron theory of metals? Discuss in detail the basic postulates of this theory.
71. Derive the expression to determine the zero-point energy of a linear harmonic oscillator?

PART-IV
(Essay-type Questions)

Instructions for Questions 72 to 75:

- *Answer any 2 (TWO) out of the four questions.*
- *Each question carries 25 marks.*
- *Candidates are required to give their answers in their own words as far as practicable.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[25 x 2 = 50]

72. State the time-independent Schrödinger equation for a particle moving in a one-dimensional box. For a particle scattered by a potential step, show that the sum of the reflection and transmission coefficient is 1 (one).

73. What do you understand by *Spectral Terms*? Evaluate the spectral terms for a two-electron system (**4p** and**4d**) considering the L-S coupling. Also drawn the relevant energy diagrams.

74. (a)Explain in brief the following properties of *nuclear force*:
    i. Charge symmetry and charge independence.
    ii. Saturation.
    iii. Non-central components.

    (b) Derive the *semi-empirical mass formula*. Explain its significance also.

75. (a)According to band theory of solids, how would you distinguish between a conductor, an insulator and a semi-conductor? Discuss in detail.

    (b) What are the fundamental components of a microprocessor?
    (c) The electron energy in the band is described by the equation $E = A + BK + CK^2$. Determine the effective mass of the electron.

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