Total Printed Pages : **20** **Booklet No. 11904**

M.Phil./Ph.D. ADMISSION TEST, 2019 & 2020

Paper II

Subject : 136 - PHYSICS

Roll No. (In figures) ....**(In words)** ....

OMR Sheet Barcode No. ....

Signature of Invigilators 1...2. ....

Names of Invigilators 1...2. ....

Time : 2 Hours **Max. Marks : 200**

GENERAL INSTRUCTIONS

1. Read the instructions given on the Question Booklet and OMR Sheet before starting the answers. All the entries should be filled by **blue or black ball point pen.**

2. The Question Booklet contains **100** questions and all questions are compulsory.

3. Each question is of 2 marks. There is **no negative marking.**

4. Candidates must ensure that the Question Booklet issued to them has all the questions. Defective Question Booklet can be got changed within **10** minutes.

1. प्रश्नों के उत्तर लिखने से पूर्व प्रश्न–पुस्तिका और ओ. एम.आर.शीट पर दिये हुए निर्देश पढ़ें। सभी प्रविष्टियाँ **नीले अथवा काले बॉल पॉइन्ट पेन** से भरें।

2. प्रश्न – पुस्तिका में **100** प्रश्न हैं और सभी प्रश्न अनिवार्य हैं।

3. प्रत्येक प्रश्न **2** अंक का है। कोई नकारात्मक अंकन **(negative marking)** नहीं होगा।

4. परीक्षार्थी सुनिश्चित कर लें कि उन्हें जो प्रश्न–पुस्तिका दी गई है उसमें सभी अंकित हैं। त्रुटिपूर्ण प्रश्न–पुस्तिका **10** मिनट की अवधि में बदलवाई जा सकती है।

1. An object is dropped on a cushion. from a height 10 m above it. On being hit. the cushion is depressed by 0.1 m. Assuming that the cushion provides a constant resistive force, the deceleration of the object after hiting the cushion, in terms of the acceleration due to gravity g. is

(A) 10 g (B) 50 g

(C) 100 g (D) g

2. The differential equation of the orbit for planetry motion is given as :-

(A) $\frac{d^2\mu}{d\theta^2} = \mu - \frac{m}{l^2\mu^2} f\left(\frac{1}{\mu}\right)$

(B) $\frac{d^2\mu}{d\theta^2} = \mu + \frac{m}{l^2\mu^2} f\left(\frac{1}{\mu}\right)$

(C) $\frac{d^2\mu}{d\theta^2} = -\mu - \frac{m}{l^2\mu^2} f\left(\frac{1}{\mu}\right)$

(D) $\frac{d^2\mu}{d\theta^2} = -\mu + \frac{m}{l^2\mu^2} f\left(\frac{1}{\mu}\right)$

(Here symbols carry their usual meaning)

3. What is the maximum angle of scattering for equal masses in an elastic collision laboratory system : -

(A) $\pi/2$ (B) π

(C) $3\pi/2$ (D) 2π

4. The relationship between the impact parameter (b) and the scattering angle (θ) in Rutherford experiment is : -

(A) $b = \frac{zz'e^2 \operatorname{cosec}\theta\ 2}{mv^2}$

(B) $b = \frac{ZZ'e^2 \cot\theta\ 2}{mv^2}$

(C) $b = \frac{ZZ'e^2 \cos\theta\ 2}{mv^2}$

(D) $b = \frac{mv^2}{ZZ'e^2} \sin\theta/2$

5. A bead slides on a wire in the shape of a cycloid described by equations $x = a(\theta - \sin\theta)$ and $y = a(1 + \cos\theta)$ where $0 \le \theta \le 2\pi$. The lagrangian function is :-

(A) $L = ma^2\dot{\theta}^2(1-\cos\theta)$

(B) $L = mga(1+\cos\theta)$

(C) $L = ma^2\dot{\theta}^2(1+\cos\theta) + mga(1-\cos\theta)$

(D) $L = ma^2\dot{\theta}^2(1-\cos\theta) - mga(1+\cos\theta)$

6. The Hamiltoman corresponding to the Lagrangian $L = a\dot{x}^2 + b\dot{y}^2 - kxy$ is

(A) $\frac{p_x^2}{2a} - \frac{p_y^2}{2b}$

(B) $\frac{p_x^2 + p_y^2}{4ab}$

(C) $\frac{p_x^2}{4a} + \frac{p_y^2}{4b} + kxy$

(D) $\left(\frac{p_x^2 + p_y^2}{4ab}\right) kxy$

7. The Poisson bracket $\{x, xp_y - yp_x + ax^2 + by^2\}$ with a and b as constants is equal to

(A) P_y (B) x

(C) y (D) P_x

8. Hamiltoman canonical equation of motion for a conservative system are

(A) $\frac{-dq_i}{dt} = \frac{\partial H}{\partial p_i}$; $\frac{-dp_i}{dt} = \frac{\partial H}{\partial q_i}$

(B) $\frac{dp_i}{dt} = \frac{\partial H}{\partial p_i}$; $\frac{dp_i}{dt} = \frac{\partial H}{\partial q_i}$

(C) $\frac{-dq_i}{dt} = \frac{\partial H}{\partial p_i}$; $\frac{dp_i}{\partial t} = \frac{\partial H}{\partial q_i}$

(D) $\frac{dq_i}{dt} = \frac{\partial H}{\partial p_i}$; $\frac{-dp_i}{dt} = \frac{\partial H}{\partial q_i}$

21. Laplace transform of sin at is :

(A) $\frac{a}{s^2-a^2}$ (B) $\frac{a}{s^2+a^2}$

(C) $\frac{-a}{s^2+a^2}$ (D) $\frac{a^2}{s^2+a^2}$

22. Which of the following statement is not true:-

(A) The rank of the resultant tensor of the product of the two tensors is product of ranks of both tensors

(B) Two tensors are said to be reciprocal to each other if their inner product is equal to unit tensor

(C) Two tensors are called conjugate tensors if they are symmetric as well as reciprocal.

(D) Scalars are tensors of rank zero.

23. A silicon diode is in series with a 0.1 kΩ resistor and a 5V battery. If the anode is connected to the positive battery terminal, the cathode voltage with respect to the negative battery terminal is -

(A) 0.7 V (B) 0.3 V

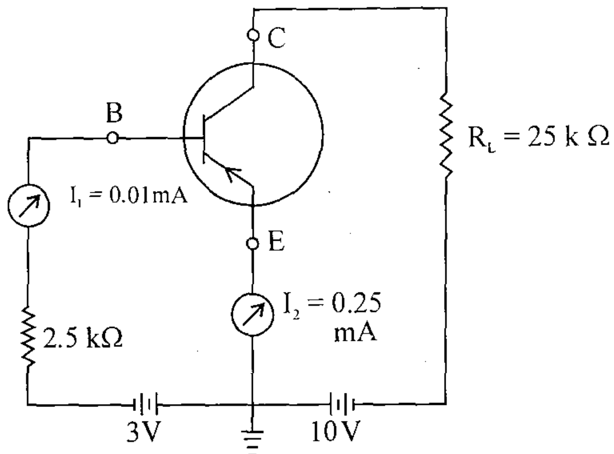
(C) 5.7 V (D) 4.3 V

24. The change in collector current in a transistor in its common emitter mode is _____, when a change of 4mA is done in base current. Given current amplification $\alpha = 0.9$

(A) 16 mA (B) 26 mA

(C) 36 mA (D) 46 mA

25. The value of voltages across load resistance V_L, V_{CE} and V_{BE} for the given transistor are :-



(A) $V_L = 6V$; $V_{CE} = 4V$; $V_{BE} = 2.975V$

(B) $V_L = 3V$; $V_{CE} = 2V$; $V_{BE} = 2.975V$

(C) $V_L = 4V$; $V_{CE} = 2.975V$; $V_{BE} = 6V$

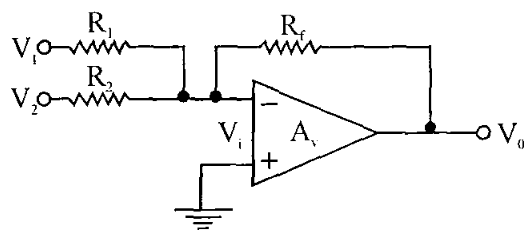
(D) $V_L = 2V$; $V_{CE} = 2.975V$; $V_{BE} = 3V$

26. A FET has $I_{DSS} = 3mA$, $V_p = -4.25V$. Find I_D for $V_{GS} = -2.5V$

(A) 0.169 mA (B) 0.508 mA

(C) 0.34 mA (D) 0.676 mA

27. When $R_1 = R_2 = R_f = R$, the output voltage of an OP-Amp circuit as shown in figure is



(A) $V_0 = -(V_1 + V_2)$ (B) $V_0 = V_1 V_2$

(C) $V_0 = \frac{V_1 V_2}{V_1 + V_2}$ (D) $V_0 = \frac{V_1}{V_2}$

38. In a grand canonical ensemble, a system A of fixed volume is in contact with a large reservoir B. Then-

(A) A can exchange energy only with B.

(B) A can exchange only particles with B.

(C) A can exchange neither energy nor particles with B.

(D) A can exchange both energy and particles with B.

39. Which of the following relation between internal energy U and the canonical partition function z. is true?

(A) $U = -\frac{\partial}{\partial T}[\log z]$ (B) $U = k_B T^2 \frac{\partial}{\partial T}[\log z]$

(C) $U = -k_B T \log z$ (D) $U = k_B T \frac{\partial}{\partial T}[\log z]$

40. A second order phase transition is characterised by -

(A) A latent heat

(B) A discontinuous change in its specific heat

(C) A change in volume

(D) Irreversible behaviour during warning and cooling

41. In an ideal gas obeying Maxwell-Boltzmann statistics there are N number of particles at temperature T. The heat capacity at constant volume is equal to -

(A) Nk_B (B) $3Nk_B$

(C) $3/2\ Nk_B$ (D) $1/2\ Nk_B$

42. Consider black body radiation contained in a cavity whose walls are at temperature T. The radiation is in equilibrium with the walls of the cavity. If the temperature of the walls is increased to 2T and the radiation is allowed to come to equilibrium at the new temperature, the entropy of the radiation increases by a factor of -

(A) 2 (B) 4

(C) 8 (D) 16

43. Consider the Fermi - Dirac distribution function $f(E)$ at 300k where E refers to Energy. If E_F is the Fermi energy, which of the following statement is true-

(A) $f(E_F)$ is zero

(B) $f(E_F)$ is equal to 1/2

(C) $f(E_F)$ is infinite as E decreases below E_F

(D) States with $E < E_F$ are filled completely.

44. A system consists of three spin half particles, the z component of whose spins $S_z(1)$, $S_z(2)$ and $S_z(3)$ can take any value +1/2 and -1/2. The total spin of the system is $S_z = S_z(1) + S_z(2) + S_z(3)$. The total number of possible micro states for this system is -

(A) 3 (B) 6

(C) 2 (D) 8

45. Consider a system of 2 identical particles each of which can be in any one of 3 single particle states. The number of states of the system are possible in Bose Einstein statistics.

(A) 9 (B) 3

(C) 6 (D) 1

55. For a type I super conductor, the surface energy is -

(A) always positive

(B) always negative

(C) depends on its T_c

(D) does not depend on its T_c

56. The Hall effect in solid state physics is used to measure -

(A) ratio of change of mass

(B) magnetic susceptibility

(C) The sign of the charge carrier

(D) Fermi energy

57. The differential form of Gauss's law in CGS system is -

(A) $\vec{\nabla}.\vec{E} = \frac{\rho}{\epsilon_0}$ (B) $\vec{\nabla} \times \vec{E} = \frac{\rho}{\epsilon_0}$

(C) $\vec{\nabla}.\vec{E} = -\frac{\partial B}{\partial t}$ (D) $\vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial B}{\partial t}$

58. For a plane electromagnetic wave given by

$E_z = a \cos \omega x \cos \omega ct$;

$H_y = -a \sin \omega x \sin \omega ct$

The instantaneous value of Poynting vector will be -

(A) $a^2 \sin 2\omega x \sin 2\omega ct$

(B) $a^2/4 \sin 2\omega x \sin 2\omega ct$

(C) $-a^2 \sin 2\omega x \sin 2\omega ct$

(D) $-a^2/4 \sin 2\omega x \sin 2\omega ct$

59. The potential which exhibit the dependence of the potentials on the velocity of the particle is known as -

(A) Electric potential

(B) Magnetic vector potential

(C) Lienard - Wiechert potentials

(D) Electromagnetic scattering potentials

60. Consider the reflection and refraction of a plane wave at a dielectric interface. Which of the following is true -

(A) The frequency of the wave does not change.

(B) The energy of the wave does not change.

(C) The polarization does not change

(D) The momentum of the wave does not change.

61. Larmour formula for the power radiated by a non-relativistically accelerated charged particle is given by -

(A) $\frac{1}{4\pi \epsilon_0}\left[\frac{2}{3}\frac{e^2a^2}{c^3}\right]$ (B) $\frac{2}{3}\frac{e^2a^2}{c^3}$

(C) $\frac{1}{4\pi \epsilon_0}\left[\frac{2}{3}\frac{e^2a}{c^2}\right]$ (D) $\frac{1}{4\pi \epsilon_0}\left[\frac{2}{3}\frac{e^2a^2}{c^2}\right]$

62. The electrostatic energy of a system of sphere of radius r with uniform charge density q within it is given by -

(A) $\frac{q^2}{2r}$ (B) $\frac{q}{2r^2}$

(C) $\frac{3}{5}\frac{q^2}{r}$ (D) $\frac{2q}{r^2}$

63. Which one of the Maxwell's equation implies the absence of magnetic monopoles?

(A) $div \vec{E} = \frac{\rho}{\epsilon_0}$ (B) $\nabla.\vec{B} = 0$

(C) $curl \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ (D) $curl \vec{B} = \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t} + \mu_0 \vec{J}$

68. A Hermitian operator is represented by the matrix $\hat{\Omega} = \begin{pmatrix} 2 & i \\ -i & 2 \end{pmatrix}$

Which of the following are eigenvalues?

(A) 1, 2

(B) 1, -1

(C) 1, 3

(D) 1, i

69. Suppose put a delta-function bumb in the center of the infinite square well:

$$H' = \alpha\,\delta\left(x - \frac{a}{2}\right)$$

Where α is a constant. [Consider the unpertubed wave function $\psi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$]

The first - order correction to the allowed energies is:

(A) $\frac{2\alpha}{a} n$

(B) $\frac{2\alpha}{a} \sin^2\left(\frac{n\pi}{2}\right)$

(C) $\frac{\alpha}{a}(2n+1)$

(D) $\frac{2\alpha}{a} n^2$

70. Let a spin $-\frac{1}{2}$ particle is in the state represented by the normalized spinor $\psi = \frac{1}{\sqrt{6}}\begin{pmatrix} 1+i \\ 2 \end{pmatrix}$ in the eigenbasis of $\hat{S}^2$ and $\hat{S}_z$. If we measure the z - component of the spin, what is the probability of getting $-\frac{1}{2}\hbar$?

(A) $\frac{2}{\sqrt{6}}$

(B) $\frac{2}{3}$

(C) $\frac{1}{3}$

(D) $\sqrt{\frac{1}{3}}$

71. A free particle with initial kinetic energy E and de Broglie wavelength λ enters a region in which it has potential V. What is the particle's new de Broglie wavelength?

(A) $\lambda\left(1 - \frac{E}{V}\right)^{1/2}$

(B) $\lambda(E - V)^{1/2}$

(C) $\lambda\left(1 - \frac{E}{V}\right)^{-1/2}$

(D) $\lambda\left(\frac{E}{(E-V)}\right)^{1/2}$

72. A system which is initially in the state

$$|\psi(t=0)\rangle = \left(\sqrt{2}|\phi_1\rangle + \sqrt{3}|\phi_2\rangle + |\phi_3\rangle + |\phi_4\rangle\right)/\sqrt{7}$$

where $|\phi_n\rangle$ are eigenstates of the system's Hamiltonian such that $\hat{H}|\phi_n\rangle = n^2\varepsilon_0|\phi_n\rangle$, wher n = 1,2,3 and 4.

The state $|\psi(t)\rangle$ at any later time t is :

(A) $|\psi(t)\rangle = n^2\varepsilon_0\left(\sqrt{2}|\phi_1\rangle + \sqrt{3}|\phi_2\rangle + |\phi_3\rangle|\phi_4\rangle\right) e^{-itn^2\varepsilon_0/h}/\sqrt{7}$

(B) $|\psi(t)\rangle = \left(\sqrt{2}|\phi_1\rangle e^{i\varepsilon_0 t/h} + \sqrt{3}|\phi_2\rangle e^{-i4\varepsilon_0 t/h} + |\phi_3\rangle e^{-i9\varepsilon_0 t/h} + |\phi_4\rangle e^{-i16\varepsilon_0 t/h}\right)/\sqrt{7}$

(C) $|\psi(t)\rangle = \left(\sqrt{2}|\phi_1\rangle e^{-i\varepsilon_0 t/h} + \sqrt{3}|\phi_2\rangle e^{-i2\varepsilon_0 t/h} + |\phi_3\rangle e^{-i3\varepsilon_0 t/h} + |\phi_4\rangle e^{-i4\varepsilon_0 t/h}\right)/\sqrt{7}$

(D) $|\psi(t)\rangle = \varepsilon_0\left(\sqrt{2}|\phi_1\rangle + 4\sqrt{3}|\phi_2\rangle + 9|\phi_3\rangle + 16|\phi_4\rangle\right)e^{iHt/h}$

77. Consider the following statements for the spin-orbit interaction:

(I) Spin - orbit interaction becomes stronger with increasing Z.

(II) In the spin-orbit interaction for hydrogen atom, the magnitude of the internal magnetic field magnetic field B acting on the spin magnetic dipole moment of the electron is of the order of ~1 Tesla.

(III) Spin-orbit interaction is responsible for splitting of the ground state energy level of the hydrogen atom.

Which of the above statements are TRUE?

(A) I and II only

(B) I and III only

(C) III only

(D) II and III only

78. Consider a system of four nonidentical spin 1/2 particles. The possible values of the total spin. S of this system and the total number of angular momentum eigenstate is :

(A) S = 0,1,2; and total there are 8 angular momentum eigenstates.

(B) S = 0,2: and there are total 8 angular momentum eigenstates.

(C) S = 2; and there are total 5 angular momentum eigenstates.

(D) S = 0,1,2; and total there are 16 angular momentum eigenstates.

79. Which of the following orbital angular momentum eigenfunctions, $Y_l^m(\theta,\phi)$, corresponds to a state in which the operators $\hat{L}^2$ and $\hat{L}_z$ have eigenvalues $6h^2$ and -h respectively?

(A) $Y_2^1(\theta,\phi)$

(B) $Y_2^{-1}(\theta,\phi)$

(C) $[Y_3^{-1}(\theta,\phi) + Y_2^{-1}(\theta,\phi)]/2$

(D) $Y_3^{-1}(\theta,\phi)$

80. Consider a nuclide whose radius is 1/3 (one third) of the radius of nucleus of osmium isotope $^{189}_{76}Os$. The mass number, A of the nuclide is :

(A) 21

(B) 9

(C) 63

(D) 7

86. Which of the following is not a desirable property of an ideal scintillation material for detector applications.

(A) It should convert the kinetic energy of charged particles into detectable light with a high scintillation efficiency.

(B) The light yield should be proportional to deposited energy over as wide a range as possible.

(C) The material should be transparent to the wavelength of its own emission for good light collection.

(D) The decay time of induced luminescence should be large so that large signal pulse can be generated.

87. A cyclotron is operated at an oscillator frequency of 15.2 MHz. What is the magnitude of magnetic field B (in Tesla) to accelerate a proton (Mass of proton $M_p = 1.67 x 10^{-27}$ kg)?

(A) 8.2

(B) 10.3

(C) 1.0

(D) 2.3

88. The magnitude of binding energy of the last neutron in ${}^{15}_{7}N$ is :

[The values of atomic Masses: M(${}^{1}_{0}n$) = 1.0087amu. M(${}^{14}_{7}N$) = 14.0031 amu, M(${}^{15}_{7}N$=15.0001amu].

(A) 10.8985 MeV

(B) 0.0117 MeV

(C) 1.0204 MeV

(D) 7.5678 MeV

89. The following terms may be contribute to the expression for binding energy of a nucleus:

(I) Volume energy

(II) Asymmetric energy

(III) Pairing energy

(IV) Surface energy

(V) Coulomb energy

The contribution of terms to the mean binding energy, in the liquid drop model of nucleus is :

(A) All, I, II, III, IV, and V

(B) I, III, IV, and V

(C) I, IV and V only

(D) I, II, III, and IV only

95. Spectroscopic measurements at very high resolution show that the ground state level of the hydrogen atom is split into two levels (i.e., the frequency of the photon emitted in the transition = 1420 MHz). This splitting of the level takes place because of:

(A) Lamb shift

(B) Hyperfine splitting

(C) Spin - Orbit Coupling

(D) Weak - Field Zeeman Effect

96. If a hydrogen atom is placed in a magnetic field which is very strong compared to its internal field, its orbital and spin magnetic dipole moments precess independently about the external field, and its energy depends on the quantum numbers m_l and m_s which specify their components along the external field direction. The strength of the external magnetic field that would produce an energy difference between the most widely separated n = 2 levels which equals the difference between the energies of the n=1 and n=2 levels in the absence of the field is :

(Use : $E_n = -13.6/n^2$ eV and $\mu_B = 9.27 \times 10^{-24}$ JT^{-1})

(A) 4.4×10^{4} T

(B) 8.8×10^{3} T

(C) 8×10^{6} T

(D) 4.4×10^{10} T

97. In the nuclear magnetic resonance (NMR) spectrum of CH_3OH, the hydrogen nuclei in the OH and CH_3 groups have slightly different resonant frequencies in the same magnetic field. What is the possible reason for the separation between resonance peaks?

(A) Carbon and oxygen have nuclei with spin.

(B) Scalar Coupling

(C) Carbon and oxygen have a different number of protons in their nuclei.

(D) Chemical shift

98. Which of the following statements is TRUE for a Stern-Gerlach experiment?

(A) If a beam of free electrons is sent through a Stern-Gerlach magnet, then the beam will be splits into two components according to the two spin orientations.

(B) In the Stern-Gerlach experiment, the average force acting on the magnetic dipole is proportional to $\partial B_z/\partial z$, where z is the coordinate axis in the direction of increase of the field strength, and $\partial B_z/\partial z$ is the rate at which it increases.

SPACE FOR ROUGH WORK/ रफ कार्य के लिए जगह