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CPG-EE-2019 (Physics)-(SET-Y)

A

Sr. No. 10381

Time : 1½ **Hours** | Total Questions : **100** | Max. Marks : **100**

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SEAL

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1. A body, initially at rest, explodes into two pieces of mass $2M$ and $3M$, respectively, having a total kinetic energy E. The kinetic energy of the piece of mass $2M$ after the explosion is :
(1) $E/3$ (2) $E/5$ (3) $2E/5$ (4) $3E/5$

2. If a generalized coordinate has the dimension of momentum, the generalized velocity will have the dimension of :
(1) Velocity (2) Acceleration (3) Torque (4) Force

3. If a constant force acts on a particle, its acceleration will :
(1) Remain constant (2) Gradually decrease
(3) Gradually increase (4) Become undefined after some time

4. The law of conservation of linear momentum has its origin in :
(1) Translational symmetry of space (2) Isotropy of space
(3) Time invariance of space (4) Lagrange's equation

5. The Lagrange's equation for simple pendulum is (symbols have their usual meaning) :
(1) $\ddot{\theta}+\frac{g}{l}\sin\theta=0$ (2) $\ddot{\theta}+\frac{g}{l\sin\theta}=0$ (3) $\ddot{\theta}-\frac{g}{l}\sin\theta=0$ (4) $\ddot{\theta}+\frac{l}{g}\sin\theta=0$

6. A particle is constrained to move along the inner surface of a fixed hemispherical bowl. The number of degrees of freedom of the particle is :
(1) One (2) Two (3) Three (4) Four

7. If a linear harmonic oscillator has frequency f, the frequency of oscillation of the kinetic energy of oscillator is :
(1) f (2) $f/2$ (3) $2f$ (4) $4f$

8. The electric potential at point r inside a uniformly charged thin spherical shell with surface charge density σ and radius R is equal to (q is the total charge on the spherical shell) :
(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ (3) $\frac{1}{4\pi\varepsilon_0}\frac{\sigma}{r}$ (4) Zero

9. The induced electric field in the Maxwell equation $\oint \vec{E}.\, d\vec{l} = -\frac{d\Phi_B}{dt}$, is called a non-conservative field as the line integral of the electric field in electrostatics $\oint \vec{E}.\, d\vec{l}$ is always :
(1) Zero (2) 2π (3) $\frac{d\Phi_B}{dt}$ (4) $2\pi\vec{E}$

10. In electromagnetic wave in free space, the phase difference between electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ is :
(1) Zero (2) $\pi/2$ (3) π (4) $3\pi/2$

11. The vector potential in a region is given as $\vec{A}(x,y,z) = -\hat{x}y + \hat{y}2x$. The associated magnetic induction $\vec{B}$ is :

(1) $\hat{x}+\hat{z}$ (2) $-\hat{x}+2\hat{y}$ (3) $-\hat{x}+2\hat{y}+\hat{z}$ (4) $3\hat{z}$

12. A paramagnetic substance is placed in an external homogeneous and static magnetic field. The resulting magnetic susceptibility contains :

(1) Paramagnetic contribution
(2) Paramagnetic and diamagnetic contributions
(3) Diamagnetic contribution
(4) Paramagnetic, ferromagnetic and diamagnetic contributions

13. Suppose that you hold a diamond up to a street lamp which emits yellow light of frequency 5.09×10^{14} Hz. Given that diamond has permittivity 5.84 and permeability 1.00, the speed of wave propagation and wavelength of yellow light in diamond would, respectively, be equal to :

(1) 1.24×10^{8} m/s and 589 nm (2) 3.0×10^{8} m/s and 589 nm
(3) 1.24×10^{8} m/s and 244 nm (4) 3.0×10^{8} m/s and 244 nm

14. The potential field of an electric field $\vec{E} = (y\hat{i} + x\hat{j})$ is :

(1) $V = -xy$ + constant (2) $V = -y + x$ + constant
(3) $V = -(y^2 + x^2)$ + constant (4) V = constant

15. In an elastic material the force that tends to hold atoms back to their equilibrium positions, has its origin in :

(1) Electrostatic force (2) Electromagnetic force
(3) Weak force (4) Gravitational force

16. Consider an ideal gas made up of point-like particles in thermal equilibrium at temperature T. The most probable value of energy is :

(1) $k_BT/2$ (2) $3k_BT/2$ (3) k_BT (4) $2k_BT$

17. Suppose an atomic gas in a container is at thermal equilibrium. Atoms are continuously colliding with each other and the walls of the container. The nature of these collisions is :

(1) Inelastic (2) Elastic
(3) Inelastic at extremely low temperatures (4) None of the above

18. For an ideal gas of diatomic molecules in thermal equilibrium at temperature T, the average energy per molecule is :

(1) $\frac{1}{2}k_BT$ (2) $\frac{3}{2}k_BT$ (3) $3k_BT$ (4) $6k_BT$

19. At what temperature is the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47°C ?

(1) 80 K (2) –73 K (3) 3 K (4) 20 K

20. A cube has a volume of 1000 cm^3. Its volume as observed by an observer Q moving at a velocity of 0.8c relative to the cube in a direction parallel to one edge is :

(1) 500 cm^3 (2) 1000 cm^3 (3) 900 cm^3 (4) 600 cm^3

21. If the speed of a particle moving at 0.4c is doubled, its momentum will :

(1) Become double (2) Become more than double

(3) Remain unchanged (4) Become slightly less than double

22. Which of the following is invariant in special theory of relativity ?

(1) Mass (2) Charge

(3) Speed of light (4) Charge as well as speed of light

23. A capacitor with capacitance $25\times10^{-6}\,F$ is charged by connecting it to a 300 V dc power supply. The capacitor is disconnected from the supply and connected across an inductor with $L = 10^{-2}\,H$. What is the frequency and period of oscillation in the circuit ?

(1) 320 Hz; 3.1 ms (2) 220 Hz; 4.5 ms (3) 50 Hz; 0.02 s (4) 100 Hz; 0.01 s

24. A 200 Ω resistor and a 5 μF capacitor are connected in series with an alternating voltage source. The voltage across the resistor is $v_R = (1.20\ V)\cos(2500\ \text{rad}/s)t$. The voltage across the capacitor will be :

(1) $(0.48\ V)\cos[(2500\ \text{rad}/s)t + \pi/2\ \text{rad}]$ (2) $(1.20\ V)\cos[(2500\ \text{rad}/s)t - \pi/2\ \text{rad}]$

(3) $(1.20\ V)\cos[(2500\ \text{rad}/s)t]$ (4) $(0.48\ V)\cos[(2500\ \text{rad}/s)t - \pi/2\ \text{rad}]$

25. When a forward bias is applied to a *pn* junction, the drift current ?

(1) Increases (2) Decreases to zero

(3) Decreases, but not to zero (4) Remains unchanged

26. Which of the following is true about Hall effect in a semiconductor substance ? The Hall coefficient :

(I) Changes with doping concentration

(II) Depends on temperature

(III) Varies with probe current and magnetic field

(IV) Independent of probe current and magnetic field

(1) I, II and III (2) II and III (3) I, II and IV (4) IV and I

27. The color of the bright spot on the screen of a CRO is the characteristic of the :

(1) Signal being viewed

(2) Primary electrons emitted from the cathode

(3) Final speed with which the electrons strike the screen

(4) Coating material of the display screen

28. The maximum wavelength of electromagnetic radiation which can create a hole-electron pair in germanium (given that the band gap of germanium is 0.65 eV) is :

(1) 6×10^{-6} m (2) 1.6×10^{-6} m (3) 1.9×10^{-6} m (4) 1.9×10^{-5} m

29. If the load resistance of a CE amplifier increases, then its current gain :

(1) Decreases (2) Increases

(3) Increases followed by an initial decrease (4) Remains unchanged

30. A transistor has $\alpha = 0.98$, IB = 100 μA and ICO = 6 μA. The value of IE will be :

(1) 5.3 mA (2) 6 mA (3) 4.6 mA (4) 9 mA

31. The value of M after the following set of FORTRAN statements are executed is :

```
M = 0
Do 10 I = 1.2
Do 20 J = 1.2
M = M + I + J
20 Continue
10 Continue
Stop
End
```

(1) 11 (2) 12 (3) 4 (4) 10

32. In FORTRAN language, the statement, $p = 1/x * a + 1/y + b - 1/z ** 3 * c$ will compute the expression :

(1) $p = \frac{1}{xa} + \frac{1}{y} + b - \frac{1}{z^{3c}}$ (2) $p = \frac{a}{x} + \frac{1}{y} + b - \frac{c}{z^3}$

(3) $p = \frac{a}{x} + \frac{1}{y+b} - \frac{c}{z^3}$ (4) $p = \frac{1}{xa} + \frac{1}{y+b} - \frac{1}{z^3 c}$

33. The change in entropy is zero for :

(1) Irreversible processes (2) Reversible adiabatic processes

(3) Reversible isothermal processes (4) All adiabatic processes

34. When changes occur within a closed system, which of the following is true for change in entropy ΔS of the system ?

(1) $\Delta S = 0$ (2) $\Delta S < 0$ (3) $\Delta S \geq 0$ (4) $\Delta S > 0$

35. Let us take two sub-systems A_1 and A_2 in general contact. The most general thermodynamic equilibrium relation for the change in internal energy is :

(1) $dE = TdS - PdV + \mu dN$ (2) $dE = TdQ - PdV + \mu dN$

(3) $dE = TdS + PdV + \mu dN$ (4) $dE = TdS + PdV - \mu dN$

36. A Carnot engine absorbs 1 MJ of heat from a reservoir at 300°C and exhausts heat to a reservoir at 150°C. The work done by the engine is :

(1) 2.6×10^6J (2) 2.6×10^5J (3) 1×10^6J (4) 1.6×10^5J

37. Consider that an amount of heat dQ is added to a substance at temperature T keeping its volume constant at V. As a result, its temperature changes by dT, while the internal energy by dE. The heat capacity C of the substance is given by :

(1) $\frac{dE}{dT}$ (2) $\frac{1}{T}\frac{dE}{dT}$ (3) $\frac{1}{T}\frac{dQ}{dT}$ (4) $\frac{1}{V}\frac{dQ}{dT}$

38. The Fourier transform $f(q)$ of the function $f(x) = e^{-x^2/2}$ is :

(1) e^{-q^2} (2) $e^{-q^2/2}$ (3) e^{q^2} (4) $e^{q^2/2}$

39. A real, periodic and continuous function $n(x)$ can be expanded in the Fourier series as : $n(x) = \sum_{p=-\infty}^{\infty} C_p e^{ipx}$. The Fourier coefficient C_p must satisfy the condition :

(1) $C_p = C_p^*$ (2) $C_{-p} = C_p^*$ (3) $C_{-p} = C_p$ (4) $C_0 = 0$

40. If $f(q)$ is the Fourier transform of $f(x)$, the Fourier transform of $f(ax)$ is :

(1) $f(q/\alpha)$ (2) $f(q\alpha)$ (3) $\alpha^{-1} f(q/\alpha)$ (4) $\alpha f(q/\alpha)$

41. If amplitudes of two waves producing interference is 'a' each, then intensity of light at maxima is :

(1) $4a^2$ (2) $2a^2$ (3) $2a$ (4) $4a$

42. If in a Young's double slit experiment being performed with white light, one of the slits is covered with the red filter, while the other slit with the blue filter.

(1) There shall be no interference fringes

(2) There shall be an alternate interference pattern of red and blue

(3) There shall be an interference pattern of mixed color of red and blue

(4) None of the above

43. What is the shape of interference fringes in the Lloyd's mirror experiment ?

(1) Dark and bright straight fringes of equal width

(2) Dark and bright straight fringes of unequal width

(3) Dark and bright straight fringes of equal width with central fringe a dark one

(4) Dark and bright straight fringes of unequal width with central fringe a dark one

44. When light travels from rare to denser medium, it loses some speed. As a result :

(1) Energy carried by light decreases (2) Energy carried by light stays constant

(3) Frequency of light reduces (4) Energy carried by light increases

45. Consider the distribution of N molecules in two halves of a box partitioned by an imaginary wall. The most probable mode of distribution is the one for which the randomness (i.e. the degree of non-predictability) is :

(1) Maximum (2) Minimum

(3) Absolute zero (4) Either maximum or minimum

46. A real gas behaves like an ideal gas if its :

(1) Pressure and temperature are both high (2) Pressure and temperature are both low

(3) Pressure is high and temperature is low (4) Pressure is low and temperature is high

47. N distinguishable particles in a statistical system are somehow restricted to move in a plane. The dimensionality of its phase space will be :

(1) 4^N (2) 6^N (3) 4N (4) 2N

48. Two macroscopic systems, say A_1 and A_2, are allowed to have thermal contact. Obviously, there will be exchange of energy if A_1 and A_2 were at different temperatures. According to the postulates of statistical physics, the condition of equilibrium is (Ω denotes the number of microstates for a system) :

(1) $\frac{\partial}{\partial E} ln\Omega_1 = \frac{\partial}{\partial E} ln\Omega_2$ (2) $\frac{\partial}{\partial E}\Omega_1 = \frac{\partial}{\partial E}\Omega_2$

(3) $\frac{\partial}{\partial E}\Omega_1\Omega_2 = 0$ (4) $\frac{\partial}{\partial E}(\Omega_1 + \Omega_2) = 0$

49. The electronic heat capacity of a metal within the framework of Fermi-Dirac statistics depends on temperature as :

(1) AT^3 (2) AT (3) $AT^{3/2}$ (4) $AT^{1/2}$

50. The phenomenon of Bose-Einstein condensation may occur for a class of particles which are ?

(1) Indistinguishable and have half-integral spin

(2) Distinguishable and have integral spin

(3) Distinguishable and have half-integral spin

(4) Indistinguishable and have integral spin

51. The gas of electrons in a metal possesses tremendous internal energy even at absolute zero temperature. The origin of this energy lies in the :

(1) Maxwell-Boltzmann Law (2) Negative charge on electrons

(3) Pauli exclusion principle (4) Small mass of electrons

52. For a gas of electrons in thermal equilibrium at room temperature, the probability of finding an electron in the single-electron states $\varepsilon_F + \varepsilon$ and $\varepsilon_F - \varepsilon$ is (where ε_F is the Fermi energy) :

(1) Equal (2) Not equal

(3) Equal if ε is positive (4) Equal if ε is negative

53. The diameter of n^{th} dark ring in Newton's ring arrangement changes from 1.2 to 1.0 cm when air is replaced by a transparent liquid. What is the refractive index of liquid ?

(1) 1.44 (2) 1.20 (3) 4.10 (4) 1.50

54. Three plane-waves viz. $y_1 = A_1\,\hat{y}\cos(kx-\omega t+\delta_1), y_2 = A_2\,\hat{z}\cos(kx-\omega t+\delta_2)$ and $y_3 = A_3\,\hat{y}\cos(kx-\omega t+\delta_3)$ are superposed pairwise. Which superposition can lead to interference ? (here $A_1, A_2, A_3, \delta_1, \delta_2, \delta_3$ are constants)

(1) y_1 and y_2 (2) y_1 and y_3

(3) y_2 and y_3 (4) No interference in any pair

55. In a Young's double slit experiment the intensity at a point where the path difference is $\lambda/6$ (λ being the wavelength of light used) is I. If I_0 denotes the maximum intensity, I/I_0 is equal to :

(1) 3/4 (2) 1/2 (3) 3/2 (4) 1/6

56. Illuminated normally, a diffracting grating produces second order bright images with an angle of 60° between them. The light is monochromatic and has a wavelength of 300 nm. The spacing of the grating in mm is :

(1) 3.6×10^{-3} (2) 2.4×10^{-3} (3) 2.0×10^{-3} (4) 1.5×10^{-3}

57. Electromagnetic waves are transverse in nature, is evident by :

(1) Polarization (2) Interference (3) Reflection (4) Diffraction

58. A beam of transverse waves whose vibrations occur in all directions perpendicular to their direction of motion is :

(1) Polarized (2) Unpolarized (3) Resolved (4) Diffracted

59. The state of polarization of light with the electric field vector $\vec{E} = \hat{x}E_0\cos(kz-\omega t) - \hat{y}E_0\cos(kz-\omega t)$ is :

(1) Linearly polarized along z-direction

(2) Linearly polarized at -45° to x-axis

(3) Circularly polarized

(4) Elliptically polarized with the major axis along x-axis

60. If the electric field vector in a polarized electromagnetic wave is $\vec{E}(\vec{r},t) = \hat{n}E_0 e^{i(\vec{k}.\vec{r}-\omega t)}$ (with $\hat{n}$ being the polarization vector and $\vec{k}$ the propagation vector), its magnetic field vector is given by :

(1) $\frac{1}{c}\hat{k}\times\vec{E}$ (2) $\hat{k}\times\vec{E}$ (3) $\frac{1}{c^2}\hat{k}\times\vec{E}$ (4) $\frac{1}{c}\hat{k}.\vec{E}$

61. A crystalline solid can be distinguished from a glassy solid on the basis of their :

(1) Distinct physical and chemical properties

(2) X-ray diffraction pattern

(3) Lattice and unit cells

(4) Lattice, basis and unit cells

62. Which of the following is true about the Wigner-Seitz unit cell ?

(1) It contains always one lattice point at the center of the cell

(2) In contains always one atom at the center of the unit cell

(3) It contains one lattice point, with each corner making a contribution of 1/8

(4) It contains two lattice points, one at the center and other at one of the eight corners

63. If $\vec{R} = u_1\vec{a}_1 + u_2\vec{a}_2 + u_3\vec{a}_3$ is a vector in direct lattice, while $\vec{G} = v_1\vec{b}_1 + v_2\vec{b}_2 + v_3\vec{b}_3$ is a vector in the corresponding reciprocal lattice, then $\vec{R}.\vec{G}$ has the from :

(1) $2\pi/(\vec{a}_1.\vec{a}_2 \times \vec{a}_3)$ (2) 2π/Integer (3) $2\pi \times$ integer (4) $2\pi/(\vec{b}_1.\vec{b}_2 \times \vec{b}_3)$

64. At low temperature T, the specific heat of insulating crystals varies as :

(1) $AT + BT^3$ (2) BT^3

(3) Will not change with temperature (4) Aexp $(-T)$

65. Consider a cubical lattice. A lattice plane that bisects the bottom face of the cube diagonally, has Miller indices :

(1) (100) (2) (010) (3) (111) (4) (110)

66. The structure of diamond crystal can be described by :

(1) A simple cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$

(2) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{2}\frac{1}{2}\frac{1}{2}$

(3) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$

(4) A simple cubic lattice, with carbon atoms positioned at corners and face centers of the cubic cell

67. If the first-order diffraction from a set of lattice planes in a crystal occurs at $\theta = 45°$, then the second-order diffraction from the same set of planes may occur at θ equal to :

(1) $\theta = 60°$ (2) $\theta = 90°$ (3) $\theta = 22.5°$ (4) None of the above

68. Consider that the structure of a simple cubic solid can be described by three different sets of lattice planes having Miller indices (100), (110) and (111). The inter-planar spacing for these planes has the ratio :

(1) $\sqrt{6} : \sqrt{3} : \sqrt{2}$ (2) $\sqrt{2} : \sqrt{3} : \sqrt{6}$ (3) 1 : 2 : 3 (4) 3 : 2 : 1

69. The reciprocal lattice of the reciprocal lattice of simple cubic lattice is :
(1) A simple cubic lattice
(2) An expanded simple cubic lattice
(3) A simple cubic lattice rotated by an angle of 45°
(4) A compressed simple cubic lattice

70. According to Einstein's model, the average energy of an atomic oscillator in a one-dimensional crystalline solid in thermal equilibrium at temperature T is given by :
(1) $\dfrac{h\nu}{\left[\exp\left(\dfrac{h\nu}{k_B T}\right)+1\right]}$
(2) $\dfrac{k_B T}{2}$
(3) $k_B T$
(4) $\dfrac{h\nu}{\left[\exp\left(\dfrac{h\nu}{k_B T}\right)-1\right]}$

71. Light of wavelength 500 nanometers is incident on sodium with work function 2.28 eV. What is the maximum kinetic energy of the ejected photoelectrons ?
(1) 0.03 eV (2) 0.2 eV (3) 1.3 eV (4) 2.1 eV

72. A particle moving freely in x-direction is described by the wave function $\psi(x, t) = Ce^{i(kx-\omega t)}$. Uncertainty in its momentum is equal to :
(1) Zero (2) $\hbar$ (3) ∞ (4) $\hbar/2$

73. Which of the following wave functions can describe a physical state ?
(1) $\psi(x) = |x|$ (2) $\psi(x) = \exp(x^2)$ (3) $\psi(x) = \tan(x)$ (4) $\psi(x) = \exp(-x^2)$

74. A particle restricted to the x-axis has the wave function $\psi(x) = ax$ between $x = 0$ and $x = 1$; $\psi(x) = 0$ elsewere. The probability that the particle can be found between $x = 0.45$ and $x = 0.55$ is :
(1) a^2 (2) $0.0251\,a^2$ (3) $0.3025\,a^2$ (4) $0.2025\,a^2$

75. X-rays of wavelength 10.0 pm are scattered from a target via Compton scattering. The maximum wavelength present in the scattered X-rays is (given that Compton wavelength is 2.426 pm) :
(1) 14.9 pm
(2) 1.49 pm
(3) 2.426 pm
(4) 2426 pm

76. The wave function describing a de-Broglie wave associated with a material particle of linear momentum $p = mv$ may be represented as : $\psi(x, t) = e^{i(kx-\omega t)}$. The phase velocity v_p of de-Broglie wave is related to the particle velocity v as :
(1) $v_p = v$
(2) $v_p = v/2$
(3) $v_p = v + c$
(4) $v_p = \pm v$

77. Consider a particle described by the time-dependent Schrodinger wave equation : $i\hbar\frac{\partial}{\partial t}\psi(x,t)=\left[-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}+V(x,t)\right]\psi(x,t)$. If $\psi(x,t)$ is one solution of this equation, then which of the following statements is true for $\psi^*(x,t)$:

(1) $\psi^*(x,t)$ is also a solution of the same Schrodinger wave equation.

(2) $\psi^*(x,t)$ cannot in general be a solution of the same Schrodinger wave equation.

(3) $\psi^*(x,t)$ can be a solution of the same Schrodinger wave equation provided that $V(x,t)$ is zero.

(4) $\psi^*(x,t)$ can be a solution of the same Schrodinger wave equation provided that $V(x,t)$ is independent of x.

78. Zero-point energy of an oscillator has its origin in :

(1) Pauli exclusion principle

(2) Experimental non-realization of absolute zero temperature

(3) Quantization of energy

(4) Heisenberg uncertainty principle

79. Quantum mechanically an electron of energy 2.0 eV incident on a barrier 10.0 eV high and 0.50 nm wide has a finite probability of tunneling through it. If electron is replaced by a proton, the tunneling probability :

(1) Increases by a factor of 2
(2) Decreases
(3) Remains unchanged
(4) Decrease by a factor of 2

80. Eigen value of the operator $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ operating on the wave function $\psi(x)=\sqrt{\frac{2}{L}}\sin\left(\frac{9\pi x}{L}\right)$ is given by :

(1) $\frac{\pi^2\hbar^2}{2mL^2}$
(2) $\frac{9\pi^2\hbar^2}{2mL^2}$
(3) $\frac{81\pi^2\hbar^2}{2mL^2}$
(4) $\frac{3\pi^2\hbar^2}{2mL^2}$

81. For $j = 5/2$ the allowed values of l are :

(1) 1, 2
(2) 2, 3
(3) 3, 4
(4) 4, 5

82. An atom having one electron in its valence shell is placed in a weak magnetic field oriented along the z-axis. The allowed angles of spin angular momentum with z-axis are :

(1) $\cos^{-1}\left(\pm\frac{1}{\sqrt{3}}\right)$
(2) $\cos^{-1}\left(\pm\frac{1}{\sqrt{2}}\right)$
(3) $\cos^{-1}\left(\pm\frac{\sqrt{3}}{2}\right)$
(4) $\cos^{-1}\left(\pm\frac{1}{2}\right)$

83. The effect of spin-orbit splitting on the ground state level of hydrogen atom is to split it into :

(1) Two sub-levels
(2) Three sub-levels
(3) Five sub-levels
(4) None of the above

84. The spin angular momentum of an electron can be described as :

(1) Electron spinning about an axis passing through its center

(2) Electron spinning clockwise or anti-clockwise about an axis passing through its center

(3) Electron spinning at speed of light clockwise or anti-clockwise about an axis passing through its center

(4) None of the above

85. The maximum degeneracy of an atomic energy level with principal quantum number n is :

(1) n (2) n^2 (3) $2n^2$ (4) $2n$

86. Suppose that an isolated hydrogen atom in its ground state is placed in an external weak electric field (weak field Stark effect). The ground state would split into :

(1) Two sub-levels (2) Four sub-levels (3) Three sub-levels (4) None of the above

87. An electron is in a magnetic field of strength B = 100 Gauss. The magnetic dipole moment $(\vec{\mu})$ of the electron is initially anti-parallel to the direction of $\vec{B}$. How much external work must be done to reverse the direction of magnetic moment of the electron ?

(1) $-2\mu B$ (2) $+2\mu B$ (3) $-\mu B$ (4) $+\mu B$

88. The rotational, vibrational and molecular electronic spectra of diatomic molecules lie, respectively, in the :

(1) Microwave, infrared and visible-ultraviolet regions

(2) Infrared, microwave and visible-ultraviolet regions

(3) Visible-ultraviolet, microwave and infrared regions

(4) Infrared, visible-ultraviolet and microwave regions

89. For laser action to occur, what is the minimum number of energy levels the lasing medium should have ?

(1) Two (2) Four (3) Three (4) Five

90. A certain ruby LASER emits 1.0 J pulses of light whose wavelength is 694 nm. What is the minimum number of Cr^{3+} ions in the ruby ?

(1) 1.0×10^{22} (2) 3.5×10^{23} (3) Avogadro number (4) 3.5×10^{18}

91. The fact that the binding energy per nucleon is roughly a constant over most of the range of stable nuclei is a consequence of the fact that the nuclear force is :

(1) Strong (2) Short range

(3) Charge-independent (4) Always attractive

92. Alpha particles produced during alpha-decay have kinetic energy of the order of :

(1) MeV (2) KeV (3) GeV (4) eV

93. What limits the size of a stable nucleus ?

(1) Limited number of nucleons (2) Limited range of the strong nuclear force

(3) Large surface to volume ratio (4) None of the above

94. Which of the following is ***true*** ?

I. A neutron can transform into a proton in free space

II. A proton can transform into a neutron in free space

III. A neutron can transform into a proton inside nucleus

IV. A proton can transform into a neutron inside nucleus

(1) I, III and IV (2) I, II, III and IV (3) II, III and IV (4) III and IV

95. Tritium has a half-life of 12.5 y against beta decay. What fraction of a sample of tritium will remain un-decayed after 25 y ?

(1) 1/4 (2) 1/2 (3) 1/10 (4) 1/3

96. How many neutrons are released in the following nuclear reaction ?

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{88}_{38}Sr + ^{136}_{54}Xe + ?\ ^{1}_{0}n$$

(1) 11 (2) 12 (3) 10 (4) 14

97. When the nuclear reaction takes place, which of the following is true about the reaction ?

I. The energy is conserved

II. The electric charge is conserved

III. The mass is conserved

IV. The number of nucleons is conserved

(1) I, II, III and IV (2) I and II only (3) I, II and III only (4) I, II and IV only

98. Which of the following statements is not ***true*** about γ-radiation ?

I. It is produced by unstable nuclei

II. It can penetrate several centimeters of lead

III. It can ionize gasses

IV. It can be deflected by a magnetic field

V. It is a short wavelength electromagnetic photon

(1) IV and V (2) III and IV (3) IV (4) V

99. The photoelectric cross-section depends on Z (target atomic number) and E_γ (energy of incident photon) through the expression :

(1) $Z^5 / E_\gamma^{3/2}$ (2) $Z^2 / E_\gamma^{7/2}$ (3) $Z^5 / E_\gamma^{7/2}$ (4) Z / E_γ

100. Positive ions and electrons produced in the Geiger-Mueller tube as a result of interaction of incident radiation with the gas medium are drifted, respectively, towards cathode and anode. On an average :

(1) Ion has more kinetic energy, but smaller speed than electron

(2) Ion has smaller kinetic energy and speed than electron

(3) Ion and electron have equal kinetic energy and speed

(4) Ion and electron have equal kinetic energy, but speed of electron is more than that of ion

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CPG-EE-2019 (Physics)-(SET-Y)

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10382

Sr. No. ....

Time : **1½ Hours** | Total Questions : **100** | Max. Marks : **100**

Roll No. (in figures) ____________ (in words) ____________

Candidate's Name ____________ Date of Birth ____________

Father's Name ____________ Mother's Name ____________

Date of Exam : ____________

(Signature of the Candidate) (Signature of the Invigilator)

SEAL

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1. All questions are ***compulsory*** and carry equal marks. The candidates are required to attempt all questions.
2. The candidate ***must return*** this question booklet and the OMR Answer-Sheet to the Invigilator concerned before leaving the Examination Hall, failing which a case of use of unfair-means / misbehaviour will be registered against him / her, in addition to lodging of an FIR with the police. Further the answer-sheet of such a candidate will not be evaluated.
3. Keeping in view the transparency of the examination system, carbonless OMR Sheet is provided to the candidate so that a copy of OMR Sheet may be kept by the candidate.
4. Question Booklet along-with answer key of all the A, B, C and D code shall be got uploaded on the University Website immediately after the conduct of Entrance Examination. Candidates may raise valid objection/complaint if any, with regard to discrepancy in the question booklet/answer key within 24 hours of uploading the same on the University website. The complaint be sent by the students to the Controller of Examinations by hand or through email. Thereafter, no complaint in any case will be considered.
5. The candidate ***must not*** do any rough work or writing in the OMR Answer-Sheet. Rough work, if any, may be done in the question booklet itself. Answers ***must not*** be ticked in the question booklet.
6. ***Use only black or blue ball point pen of good quality in the OMR Answer-Sheet.***
7. There will be ***negative*** marking. Each correct answer will be awarded ***one*** full mark and each incorrect answer will be negatively marked for which the candidate will get ¼ Mark (0.25 Mark) discredit. Cutting, erasing, overwriting and more than one answer in OMR Answer-Sheet will be treated as incorrect answer.
8. *Before answering the questions, the candidates should ensure that they have been supplied correct & complete question booklet. Complaints, if any, regarding misprinting etc. will not be entertained* **30** *minutes after starting of the examination.*

1. The vector potential in a region is given as $\vec{A}(x,y,z) = -\hat{x}y + \hat{y}2x$. The associated magnetic induction $\vec{B}$ is :

(1) $\hat{x}+\hat{z}$ (2) $-\hat{x}+2\hat{y}$ (3) $-\hat{x}+2\hat{y}+\hat{z}$ (4) $3\hat{z}$

2. A paramagnetic substance is placed in an external homogeneous and static magnetic field. The resulting magnetic susceptibility contains :

(1) Paramagnetic contribution
(2) Paramagnetic and diamagnetic contributions
(3) Diamagnetic contribution
(4) Paramagnetic, ferromagnetic and diamagnetic contributions

3. Suppose that you hold a diamond up to a street lamp which emits yellow light of frequency 5.09×10^{14} Hz. Given that diamond has permittivity 5.84 and permeability 1.00, the speed of wave propagation and wavelength of yellow light in diamond would, respectively, be equal to :

(1) 1.24×10^{8} m/s and 589 nm (2) 3.0×10^{8} m/s and 589 nm
(3) 1.24×10^{8} m/s and 244 nm (4) 3.0×10^{8} m/s and 244 nm

4. The potential field of an electric field $\vec{E} = (y\hat{i} + x\hat{j})$ is :

(1) $V = -xy$ + constant (2) $V = -y + x$ + constant
(3) $V = -(y^2 + x^2)$ + constant (4) V = constant

5. In an elastic material the force that tends to hold atoms back to their equilibrium positions, has its origin in :

(1) Electrostatic force (2) Electromagnetic force
(3) Weak force (4) Gravitational force

6. Consider an ideal gas made up of point-like particles in thermal equilibrium at temperature T. The most probable value of energy is :

(1) $k_BT/2$ (2) $3k_BT/2$ (3) k_BT (4) $2k_BT$

7. Suppose an atomic gas in a container is at thermal equilibrium. Atoms are continuously colliding with each other and the walls of the container. The nature of these collisions is :

(1) Inelastic (2) Elastic
(3) Inelastic at extremely low temperatures (4) None of the above

8. For an ideal gas of diatomic molecules in thermal equilibrium at temperature T, the average energy per molecule is :

(1) $\frac{1}{2}k_BT$ (2) $\frac{3}{2}k_BT$ (3) $3k_BT$ (4) $6k_BT$

9. At what temperature is the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47°C ?

(1) 80 K (2) –73 K (3) 3 K (4) 20 K

10. A cube has a volume of 1000 cm^3. Its volume as observed by an observer Q moving at a velocity of 0.8c relative to the cube in a direction parallel to one edge is :

(1) 500 cm^3 (2) 1000 cm^3 (3) 900 cm^3 (4) 600 cm^3

11. The fact that the binding energy per nucleon is roughly a constant over most of the range of stable nuclei is a consequence of the fact that the nuclear force is :

(1) Strong (2) Short range

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12. Alpha particles produced during alpha-decay have kinetic energy of the order of :

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(1) I, III and IV (2) I, II, III and IV (3) II, III and IV (4) III and IV

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17. When the nuclear reaction takes place, which of the following is true about the reaction ?

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III. The mass is conserved

IV. The number of nucleons is conserved

(1) I, II, III and IV (2) I and II only (3) I, II and III only (4) I, II and IV only

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(1) IV and V (2) III and IV (3) IV (4) V

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(3) $Z^5 / E_\gamma^{7/2}$ (4) Z / E_γ

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(2) Ion has smaller kinetic energy and speed than electron

(3) Ion and electron have equal kinetic energy and speed

(4) Ion and electron have equal kinetic energy, but speed of electron is more than that of ion

21. Light of wavelength 500 nanometers is incident on sodium with work function 2.28 eV. What is the maximum kinetic energy of the ejected photoelectrons ?

(1) 0.03 eV (2) 0.2 eV

(3) 1.3 eV (4) 2.1 eV

22. A particle moving freely in x-direction is described by the wave function $\psi(x, t) = Ce^{i(kx-\omega t)}$. Uncertainty in its momentum is equal to :

(1) Zero (2) $\hbar$ (3) ∞ (4) $\hbar/2$

23. Which of the following wave functions can describe a physical state ?

(1) $\psi(x) = |x|$ (2) $\psi(x) = \exp(x^2)$

(3) $\psi(x) = \tan(x)$ (4) $\psi(x) = \exp(-x^2)$

24. A particle restricted to the x-axis has the wave function $\psi(x) = ax$ between $x = 0$ and $x = 1$; $\psi(x) = 0$ elsewere. The probability that the particle can be found between $x = 0.45$ and $x = 0.55$ is :

(1) a^2 (2) $0.0251\,a^2$ (3) $0.3025\,a^2$ (4) $0.2025\,a^2$

25. X-rays of wavelength 10.0 pm are scattered from a target via Compton scattering. The maximum wavelength present in the scattered X-rays is (given that Compton wavelength is 2.426 pm) :

(1) 14.9 pm (2) 1.49 pm

(3) 2.426 pm (4) 2426 pm

26. The wave function describing a de-Broglie wave associated with a material particle of linear momentum $p = mv$ may be represented as : $\psi(x, t) = e^{i(kx-\omega t)}$. The phase velocity v_p of de-Broglie wave is related to the particle velocity v as :

(1) $v_p = v$ (2) $v_p = v/2$

(3) $v_p = v + c$ (4) $v_p = \pm v$

27. Consider a particle described by the time-dependent Schrodinger wave equation : $i\hbar\frac{\partial}{\partial t}\psi(x,t) = \left[-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x,t)\right]\psi(x,t)$. If $\psi(x, t)$ is one solution of this equation, then which of the following statements is true for $\psi^*(x, t)$:

(1) $\psi^*(x, t)$ is also a solution of the same Schrodinger wave equation.

(2) $\psi^*(x, t)$ cannot in general be a solution of the same Schrodinger wave equation.

(3) $\psi^*(x, t)$ can be a solution of the same Schrodinger wave equation provided that $V(x, t)$ is zero.

(4) $\psi^*(x, t)$ can be a solution of the same Schrodinger wave equation provided that $V(x, t)$ is independent of x.

28. Zero-point energy of an oscillator has its origin in :

(1) Pauli exclusion principle

(2) Experimental non-realization of absolute zero temperature

(3) Quantization of energy

(4) Heisenberg uncertainty principle

29. Quantum mechanically an electron of energy 2.0 eV incident on a barrier 10.0 eV high and 0.50 nm wide has a finite probability of tunneling through it. If electron is replaced by a proton, the tunneling probability :

(1) Increases by a factor of 2 (2) Decreases

(3) Remains unchanged (4) Decrease by a factor of 2

30. Eigen value of the operator $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ operating on the wave function $\psi(x) = \sqrt{\frac{2}{L}}\sin\left(\frac{9\pi x}{L}\right)$ is given by :

(1) $\frac{\pi^2\hbar^2}{2mL^2}$ (2) $\frac{9\pi^2\hbar^2}{2mL^2}$ (3) $\frac{81\pi^2\hbar^2}{2mL^2}$ (4) $\frac{3\pi^2\hbar^2}{2mL^2}$

31. The gas of electrons in a metal possesses tremendous internal energy even at absolute zero temperature. The origin of this energy lies in the :

(1) Maxwell-Boltzmann Law (2) Negative charge on electrons

(3) Pauli exclusion principle (4) Small mass of electrons

32. For a gas of electrons in thermal equilibrium at room temperature, the probability of finding an electron in the single-electron states $\varepsilon_F + \varepsilon$ and $\varepsilon_F - \varepsilon$ is (where ε_F is the Fermi energy) :

(1) Equal (2) Not equal

(3) Equal if ε is positive (4) Equal if ε is negative

33. The diameter of n^{th} dark ring in Newton's ring arrangement changes from 1.2 to 1.0 cm when air is replaced by a transparent liquid. What is the refractive index of liquid ?

(1) 1.44 (2) 1.20 (3) 4.10 (4) 1.50

34. Three plane-waves viz. $y_1 = A_1\,\hat{y}\cos(kx-\omega t+\delta_1), y_2 = A_2\,\hat{z}\cos(kx-\omega t+\delta_2)$ and $y_3 = A_3\,\hat{y}\cos(kx-\omega t+\delta_3)$ are superposed pairwise. Which superposition can lead to interference ? (here A_1, A_2, A_3, δ_1, δ_2, δ_3 are constants)

(1) y_1 and y_2 (2) y_1 and y_3

(3) y_2 and y_3 (4) No interference in any pair

35. In a Young's double slit experiment the intensity at a point where the path difference is $\lambda/6$ (λ being the wavelength of light used) is I. If I_0 denotes the maximum intensity, I/I_0 is equal to :

(1) 3/4 (2) 1/2 (3) 3/2 (4) 1/6

36. Illuminated normally, a diffracting grating produces second order bright images with an angle of 60° between them. The light is monochromatic and has a wavelength of 300 nm. The spacing of the grating in mm is :

(1) 3.6×10^{-3} (2) 2.4×10^{-3} (3) 2.0×10^{-3} (4) 1.5×10^{-3}

37. Electromagnetic waves are transverse in nature, is evident by :

(1) Polarization (2) Interference (3) Reflection (4) Diffraction

38. A beam of transverse waves whose vibrations occur in all directions perpendicular to their direction of motion is :

(1) Polarized (2) Unpolarized (3) Resolved (4) Diffracted

39. The state of polarization of light with the electric field vector $\vec{E} = \hat{x}E_0\cos(kz-\omega t) - \hat{y}E_0\cos(kz-\omega t)$ is :

(1) Linearly polarized along z-direction

(2) Linearly polarized at -45° to x-axis

(3) Circularly polarized

(4) Elliptically polarized with the major axis along x-axis

40. If the electric field vector in a polarized electromagnetic wave is $\vec{E}(\vec{r},t) = \hat{n}E_0 e^{i(\vec{k}.\vec{r}-\omega t)}$ (with $\hat{n}$ being the polarization vector and $\vec{k}$ the propagation vector), its magnetic field vector is given by :

(1) $\frac{1}{c}\hat{k}\times\vec{E}$ (2) $\hat{k}\times\vec{E}$

(3) $\frac{1}{c^2}\hat{k}\times\vec{E}$ (4) $\frac{1}{c}\hat{k}.\vec{E}$

41. The value of M after the following set of FORTRAN statements are executed is :

```
M = 0
Do 10 I = 1.2
Do 20 J = 1.2
M = M + I + J
20 Continue
10 Continue
Stop
End
```

(1) 11 (2) 12 (3) 4 (4) 10

42. In FORTRAN language, the statement, $p = 1/x * a + 1/y + b - 1/z ** 3 * c$ will compute the expression :

(1) $p = \frac{1}{xa} + \frac{1}{y} + b - \frac{1}{z^{3c}}$ (2) $p = \frac{a}{x} + \frac{1}{y} + b - \frac{c}{z^3}$

(3) $p = \frac{a}{x} + \frac{1}{y+b} - \frac{c}{z^3}$ (4) $p = \frac{1}{xa} + \frac{1}{y+b} - \frac{1}{z^3 c}$

43. The change in entropy is zero for :

(1) Irreversible processes (2) Reversible adiabatic processes

(3) Reversible isothermal processes (4) All adiabatic processes

44. When changes occur within a closed system, which of the following is true for change in entropy ΔS of the system ?

(1) $\Delta S = 0$ (2) $\Delta S < 0$ (3) $\Delta S \geq 0$ (4) $\Delta S > 0$

45. Let us take two sub-systems A_1 and A_2 in general contact. The most general thermodynamic equilibrium relation for the change in internal energy is :

(1) $dE = TdS - PdV + \mu dN$ (2) $dE = TdQ - PdV + \mu dN$

(3) $dE = TdS + PdV + \mu dN$ (4) $dE = TdS + PdV - \mu dN$

46. A Carnot engine absorbs 1 MJ of heat from a reservoir at 300°C and exhausts heat to a reservoir at 150°C. The work done by the engine is :

(1) 2.6×10^6J (2) 2.6×10^5J (3) 1×10^6J (4) 1.6×10^5J

47. Consider that an amount of heat dQ is added to a substance at temperature T keeping its volume constant at V. As a result, its temperature changes by dT, while the internal energy by dE. The heat capacity C of the substance is given by :

(1) $\frac{dE}{dT}$ (2) $\frac{1}{T}\frac{dE}{dT}$ (3) $\frac{1}{T}\frac{dQ}{dT}$ (4) $\frac{1}{V}\frac{dQ}{dT}$

48. The Fourier transform $f(q)$ of the function $f(x) = e^{-x^2/2}$ is :

(1) e^{-q^2} (2) $e^{-q^2/2}$ (3) e^{q^2} (4) $e^{q^2/2}$

49. A real, periodic and continuous function $n(x)$ can be expanded in the Fourier series as : $n(x) = \sum_{p=-\infty}^{\infty} C_p e^{ipx}$. The Fourier coefficient C_p must satisfy the condition :

(1) $C_p = C_p^*$ (2) $C_{-p} = C_p^*$ (3) $C_{-p} = C_p$ (4) $C_0 = 0$

50. If $f(q)$ is the Fourier transform of $f(x)$, the Fourier transform of $f(ax)$ is :

(1) $f(q/\alpha)$ (2) $f(q\alpha)$ (3) $\alpha^{-1} f(q/\alpha)$ (4) $\alpha f(q/\alpha)$

51. If the speed of a particle moving at 0.4c is doubled, its momentum will :

(1) Become double
(2) Become more than double
(3) Remain unchanged
(4) Become slightly less than double

52. Which of the following is invariant in special theory of relativity ?

(1) Mass
(2) Charge
(3) Speed of light
(4) Charge as well as speed of light

53. A capacitor with capacitance 25×10^{-6} F is charged by connecting it to a 300 V dc power supply. The capacitor is disconnected from the supply and connected across an inductor with $L = 10^{-2}$ H. What is the frequency and period of oscillation in the circuit ?

(1) 320 Hz; 3.1 ms (2) 220 Hz; 4.5 ms (3) 50 Hz; 0.02 s (4) 100 Hz; 0.01 s

54. A 200 Ω resistor and a 5 μF capacitor are connected in series with an alternating voltage source. The voltage across the resistor is $v_R = (1.20\ V) \cos (2500\ \text{rad}/s)t$. The voltage across the capacitor will be :

(1) $(0.48\ V) \cos [(2500\ \text{rad}/s)t + \pi/2\ \text{rad}]$

(2) $(1.20\ V) \cos [(2500\ \text{rad}/s)t - \pi/2\ \text{rad}]$

(3) $(1.20\ V) \cos [(2500\ \text{rad}/s)t]$

(4) $(0.48\ V) \cos [(2500\ \text{rad}/s)t - \pi/2\ \text{rad}]$

55. When a forward bias is applied to a *pn* junction, the drift current ?

(1) Increases
(2) Decreases to zero
(3) Decreases, but not to zero
(4) Remains unchanged

56. Which of the following is true about Hall effect in a semiconductor substance ? The Hall coefficient :

(I) Changes with doping concentration

(II) Depends on temperature

(III) Varies with probe current and magnetic field

(IV) Independent of probe current and magnetic field

(1) I, II and III (2) II and III (3) I, II and IV (4) IV and I

57. The color of the bright spot on the screen of a CRO is the characteristic of the :
(1) Signal being viewed
(2) Primary electrons emitted from the cathode
(3) Final speed with which the electrons strike the screen
(4) Coating material of the display screen

58. The maximum wavelength of electromagnetic radiation which can create a hole-electron pair in germanium (given that the band gap of germanium is 0.65 eV) is :
(1) 6×10^{-6} m (2) 1.6×10^{-6} m (3) 1.9×10^{-6} m (4) 1.9×10^{-5} m

59. If the load resistance of a CE amplifier increases, then its current gain :
(1) Decreases (2) Increases
(3) Increases followed by an initial decrease (4) Remains unchanged

60. A transistor has $\alpha = 0.98$, IB = 100 μA and ICO = 6 μA. The value of IE will be :
(1) 5.3 mA (2) 6 mA (3) 4.6 mA (4) 9 mA

61. If amplitudes of two waves producing interference is 'a' each, then intensity of light at maxima is :
(1) $4a^2$ (2) $2a^2$ (3) $2a$ (4) $4a$

62. If in a Young's double slit experiment being performed with white light, one of the slits is covered with the red filter, while the other slit with the blue filter.
(1) There shall be no interference fringes
(2) There shall be an alternate interference pattern of red and blue
(3) There shall be an interference pattern of mixed color of red and blue
(4) None of the above

63. What is the shape of interference fringes in the Lloyd's mirror experiment ?
(1) Dark and bright straight fringes of equal width
(2) Dark and bright straight fringes of unequal width
(3) Dark and bright straight fringes of equal width with central fringe a dark one
(4) Dark and bright straight fringes of unequal width with central fringe a dark one

64. When light travels from rare to denser medium, it loses some speed. As a result :
(1) Energy carried by light decreases (2) Energy carried by light stays constant
(3) Frequency of light reduces (4) Energy carried by light increases

65. Consider the distribution of N molecules in two halves of a box partitioned by an imaginary wall. The most probable mode of distribution is the one for which the randomness (i.e. the degree of non-predictability) is :
(1) Maximum (2) Minimum
(3) Absolute zero (4) Either maximum or minimum

66. A real gas behaves like an ideal gas if its :
(1) Pressure and temperature are both high (2) Pressure and temperature are both low
(3) Pressure is high and temperature is low (4) Pressure is low and temperature is high

67. N distinguishable particles in a statistical system are somehow restricted to move in a plane. The dimensionality of its phase space will be :

(1) 4^N (2) 6^N (3) 4N (4) 2N

68. Two macroscopic systems, say A_1 and A_2, are allowed to have thermal contact. Obviously, there will be exchange of energy if A_1 and A_2 were at different temperatures. According to the postulates of statistical physics, the condition of equilibrium is (Ω denotes the number of microstates for a system) :

(1) $\frac{\partial}{\partial E} ln\,\Omega_1 = \frac{\partial}{\partial E} ln\,\Omega_2$ (2) $\frac{\partial}{\partial E}\Omega_1 = \frac{\partial}{\partial E}\Omega_2$

(3) $\frac{\partial}{\partial E}\Omega_1\Omega_2 = 0$ (4) $\frac{\partial}{\partial E}(\Omega_1 + \Omega_2) = 0$

69. The electronic heat capacity of a metal within the framework of Fermi-Dirac statistics depends on temperature as :

(1) AT^3 (2) AT (3) $AT^{3/2}$ (4) $AT^{1/2}$

70. The phenomenon of Bose-Einstein condensation may occur for a class of particles which are ?

(1) Indistinguishable and have half-integral spin
(2) Distinguishable and have integral spin
(3) Distinguishable and have half-integral spin
(4) Indistinguishable and have integral spin

71. A crystalline solid can be distinguished from a glassy solid on the basis of their :

(1) Distinct physical and chemical properties
(2) X-ray diffraction pattern
(3) Lattice and unit cells
(4) Lattice, basis and unit cells

72. Which of the following is true about the Wigner-Seitz unit cell ?

(1) It contains always one lattice point at the center of the cell
(2) In contains always one atom at the center of the unit cell
(3) It contains one lattice point, with each corner making a contribution of 1/8
(4) It contains two lattice points, one at the center and other at one of the eight corners

73. If $\vec{R} = u_1\vec{a}_1 + u_2\vec{a}_2 + u_3\vec{a}_3$ is a vector in direct lattice, while $\vec{G} = v_1\vec{b}_1 + v_2\vec{b}_2 + v_3\vec{b}_3$ is a vector in the corresponding reciprocal lattice, then $\vec{R}.\vec{G}$ has the from :

(1) $2\pi/(\vec{a}_1.\vec{a}_2 \times \vec{a}_3)$ (2) 2π/Integer (3) $2\pi \times$ integer (4) $2\pi/(\vec{b}_1.\vec{b}_2 \times \vec{b}_3)$

74. At low temperature T, the specific heat of insulating crystals varies as :

(1) $AT + BT^3$ (2) BT^3

(3) Will not change with temperature (4) Aexp $(-T)$

75. Consider a cubical lattice. A lattice plane that bisects the bottom face of the cube diagonally, has Miller indices :

(1) (100) (2) (010) (3) (111) (4) (110)

76. The structure of diamond crystal can be described by :

(1) A simple cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$

(2) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{2}\frac{1}{2}\frac{1}{2}$

(3) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$

(4) A simple cubic lattice, with carbon atoms positioned at corners and face centers of the cubic cell

77. If the first-order diffraction from a set of lattice planes in a crystal occurs at $\theta = 45°$, then the second-order diffraction from the same set of planes may occur at θ equal to :

(1) $\theta = 60°$ (2) $\theta = 90°$ (3) $\theta = 22.5°$ (4) None of the above

78. Consider that the structure of a simple cubic solid can be described by three different sets of lattice planes having Miller indices (100), (110) and (111). The inter-planar spacing for these planes has the ratio :

(1) $\sqrt{6}:\sqrt{3}:\sqrt{2}$ (2) $\sqrt{2}:\sqrt{3}:\sqrt{6}$ (3) 1 : 2 : 3 (4) 3 : 2 : 1

79. The reciprocal lattice of the reciprocal lattice of simple cubic lattice is :

(1) A simple cubic lattice

(2) An expanded simple cubic lattice

(3) A simple cubic lattice rotated by an angle of 45°

(4) A compressed simple cubic lattice

80. According to Einstein's model, the average energy of an atomic oscillator in a one-dimensional crystalline solid in thermal equilibrium at temperature T is given by :

(1) $\frac{h\nu}{\left[\exp\left(\frac{h\nu}{k_B T}\right)+1\right]}$ (2) $\frac{k_B T}{2}$ (3) $k_B T$ (4) $\frac{h\nu}{\left[\exp\left(\frac{h\nu}{k_B T}\right)-1\right]}$

81. A body, initially at rest, explodes into two pieces of mass $2M$ and $3M$, respectively, having a total kinetic energy E. The kinetic energy of the piece of mass $2M$ after the explosion is :

(1) $E/3$ (2) $E/5$ (3) $2E/5$ (4) $3E/5$

82. If a generalized coordinate has the dimension of momentum, the generalized velocity will have the dimension of :

(1) Velocity (2) Acceleration (3) Torque (4) Force

83. If a constant force acts on a particle, its acceleration will :

(1) Remain constant (2) Gradually decrease
(3) Gradually increase (4) Become undefined after some time

84. The law of conservation of linear momentum has its origin in :

(1) Translational symmetry of space (2) Isotropy of space
(3) Time invariance of space (4) Lagrange's equation

85. The Lagrange's equation for simple pendulum is (symbols have their usual meaning) :

(1) $\ddot{\theta}+\frac{g}{l}\sin\theta=0$ (2) $\ddot{\theta}+\frac{g}{l\sin\theta}=0$ (3) $\ddot{\theta}-\frac{g}{l}\sin\theta=0$ (4) $\ddot{\theta}+\frac{l}{g}\sin\theta=0$

86. A particle is constrained to move along the inner surface of a fixed hemispherical bowl. The number of degrees of freedom of the particle is :

(1) One (2) Two (3) Three (4) Four

87. If a linear harmonic oscillator has frequency *f*, the frequency of oscillation of the kinetic energy of oscillator is :

(1) f (2) $f/2$ (3) $2f$ (4) $4f$

88. The electric potential at point *r* inside a uniformly charged thin spherical shell with surface charge density σ and radius *R* is equal to (*q* is the total charge on the spherical shell) :

(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ (3) $\frac{1}{4\pi\varepsilon_0}\frac{\sigma}{r}$ (4) Zero

89. The induced electric field in the Maxwell equation $\oint \vec{E}.\,d\vec{l}=-\frac{d\Phi_B}{dt}$, is called a non-conservative field as the line integral of the electric field in electrostatics $\oint \vec{E}.\,d\vec{l}$ is always :

(1) Zero (2) 2π (3) $\frac{d\Phi_B}{dt}$ (4) $2\pi\vec{E}$

90. In electromagnetic wave in free space, the phase difference between electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ is :

(1) Zero (2) $\pi/2$ (3) π (4) $3\pi/2$

91. For $j = 5/2$ the allowed values of l are :

(1) 1, 2 (2) 2, 3 (3) 3, 4 (4) 4, 5

92. An atom having one electron in its valence shell is placed in a weak magnetic field oriented along the *z*-axis. The allowed angles of spin angular momentum with *z*-axis are :

(1) $\cos^{-1}\left(\pm\frac{1}{\sqrt{3}}\right)$ (2) $\cos^{-1}\left(\pm\frac{1}{\sqrt{2}}\right)$ (3) $\cos^{-1}\left(\pm\frac{\sqrt{3}}{2}\right)$ (4) $\cos^{-1}\left(\pm\frac{1}{2}\right)$

93. The effect of spin-orbit splitting on the ground state level of hydrogen atom is to split it into :

(1) Two sub-levels (2) Three sub-levels

(3) Five sub-levels (4) None of the above

94. The spin angular momentum of an electron can be described as :

(1) Electron spinning about an axis passing through its center

(2) Electron spinning clockwise or anti-clockwise about an axis passing through its center

(3) Electron spinning at speed of light clockwise or anti-clockwise about an axis passing through its center

(4) None of the above

95. The maximum degeneracy of an atomic energy level with principal quantum number n is :

(1) n (2) n^2

(3) $2n^2$ (4) $2n$

96. Suppose that an isolated hydrogen atom in its ground state is placed in an external weak electric field (weak field Stark effect). The ground state would split into :

(1) Two sub-levels (2) Four sub-levels (3) Three sub-levels (4) None of the above

97. An electron is in a magnetic field of strength B = 100 Gauss. The magnetic dipole moment $(\vec{\mu})$ of the electron is initially anti-parallel to the direction of $\vec{B}$. How much external work must be done to reverse the direction of magnetic moment of the electron ?

(1) $-2\mu B$ (2) $+2\mu B$ (3) $-\mu B$ (4) $+\mu B$

98. The rotational, vibrational and molecular electronic spectra of diatomic molecules lie, respectively, in the :

(1) Microwave, infrared and visible-ultraviolet regions

(2) Infrared, microwave and visible-ultraviolet regions

(3) Visible-ultraviolet, microwave and infrared regions

(4) Infrared, visible-ultraviolet and microwave regions

99. For laser action to occur, what is the minimum number of energy levels the lasing medium should have ?

(1) Two (2) Four

(3) Three (4) Five

100. A certain ruby LASER emits 1.0 J pulses of light whose wavelength is 694 nm. What is the minimum number of Cr^{3+} ions in the ruby ?

(1) 1.0×10^{22} (2) 3.5×10^{23}

(3) Avogadro number (4) 3.5×10^{18}

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CPG-EE-2019 (Physics)-(SET-Y)

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Candidate's Name ____________ Date of Birth ____________

Father's Name ____________ Mother's Name ____________

Date of Exam : ____________

____________ ____________

(Signature of the Candidate) (Signature of the Invigilator)

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1. All questions are ***compulsory*** and carry equal marks. The candidates are required to attempt all questions.
2. The candidate ***must return*** this question booklet and the OMR Answer-Sheet to the Invigilator concerned before leaving the Examination Hall, failing which a case of use of unfair-means / misbehaviour will be registered against him / her, in addition to lodging of an FIR with the police. Further the answer-sheet of such a candidate will not be evaluated.
3. Keeping in view the transparency of the examination system, carbonless OMR Sheet is provided to the candidate so that a copy of OMR Sheet may be kept by the candidate.
4. Question Booklet along-with answer key of all the A, B, C and D code shall be got uploaded on the University Website immediately after the conduct of Entrance Examination. Candidates may raise valid objection/complaint if any, with regard to discrepancy in the question booklet/answer key within 24 hours of uploading the same on the University website. The complaint be sent by the students to the Controller of Examinations by hand or through email. Thereafter, no complaint in any case will be considered.
5. The candidate ***must not*** do any rough work or writing in the OMR Answer-Sheet. Rough work, if any, may be done in the question booklet itself. Answers ***must not*** be ticked in the question booklet.
6. ***Use only black or blue ball point pen of good quality in the OMR Answer-Sheet.***
7. There will be ***negative*** marking. Each correct answer will be awarded ***one*** full mark and each incorrect answer will be negatively marked for which the candidate will get ¼ Mark (0.25 Mark) discredit. Cutting, erasing, overwriting and more than one answer in OMR Answer-Sheet will be treated as incorrect answer.
8. *Before answering the questions, the candidates should ensure that they have been supplied correct & complete question booklet. Complaints, if any, regarding misprinting etc. will not be entertained* **30** *minutes after starting of the examination.*

1. If amplitudes of two waves producing interference is 'a' each, then intensity of light at maxima is :

(1) $4a^2$ (2) $2a^2$ (3) $2a$ (4) $4a$

2. If in a Young's double slit experiment being performed with white light, one of the slits is covered with the red filter, while the other slit with the blue filter.

(1) There shall be no interference fringes

(2) There shall be an alternate interference pattern of red and blue

(3) There shall be an interference pattern of mixed color of red and blue

(4) None of the above

3. What is the shape of interference fringes in the Lloyd's mirror experiment ?

(1) Dark and bright straight fringes of equal width

(2) Dark and bright straight fringes of unequal width

(3) Dark and bright straight fringes of equal width with central fringe a dark one

(4) Dark and bright straight fringes of unequal width with central fringe a dark one

4. When light travels from rare to denser medium, it loses some speed. As a result :

(1) Energy carried by light decreases (2) Energy carried by light stays constant

(3) Frequency of light reduces (4) Energy carried by light increases

5. Consider the distribution of N molecules in two halves of a box partitioned by an imaginary wall. The most probable mode of distribution is the one for which the randomness (i.e. the degree of non-predictability) is :

(1) Maximum (2) Minimum

(3) Absolute zero (4) Either maximum or minimum

6. A real gas behaves like an ideal gas if its :

(1) Pressure and temperature are both high (2) Pressure and temperature are both low

(3) Pressure is high and temperature is low (4) Pressure is low and temperature is high

7. N distinguishable particles in a statistical system are somehow restricted to move in a plane. The dimensionality of its phase space will be :

(1) 4^N (2) 6^N (3) 4N (4) 2N

8. Two macroscopic systems, say A_1 and A_2, are allowed to have thermal contact. Obviously, there will be exchange of energy if A_1 and A_2 were at different temperatures. According to the postulates of statistical physics, the condition of equilibrium is (Ω denotes the number of microstates for a system) :

(1) $\frac{\partial}{\partial E} ln\,\Omega_1 = \frac{\partial}{\partial E} ln\,\Omega_2$ (2) $\frac{\partial}{\partial E}\Omega_1 = \frac{\partial}{\partial E}\Omega_2$

(3) $\frac{\partial}{\partial E}\Omega_1\Omega_2 = 0$ (4) $\frac{\partial}{\partial E}(\Omega_1 + \Omega_2) = 0$

9. The electronic heat capacity of a metal within the framework of Fermi-Dirac statistics depends on temperature as :

(1) AT^3 (2) AT (3) $AT^{3/2}$ (4) $AT^{1/2}$

10. The phenomenon of Bose-Einstein condensation may occur for a class of particles which are ?

(1) Indistinguishable and have half-integral spin

(2) Distinguishable and have integral spin

(3) Distinguishable and have half-integral spin

(4) Indistinguishable and have integral spin

11. If the speed of a particle moving at 0.4c is doubled, its momentum will :

(1) Become double (2) Become more than double

(3) Remain unchanged (4) Become slightly less than double

12. Which of the following is invariant in special theory of relativity ?

(1) Mass (2) Charge

(3) Speed of light (4) Charge as well as speed of light

13. A capacitor with capacitance $25\times10^{-6}\ F$ is charged by connecting it to a 300 V dc power supply. The capacitor is disconnected from the supply and connected across an inductor with $L = 10^{-2}\ H$. What is the frequency and period of oscillation in the circuit ?

(1) 320 Hz; 3.1 ms (2) 220 Hz; 4.5 ms

(3) 50 Hz; 0.02 s (4) 100 Hz; 0.01 s

14. A 200 Ω resistor and a 5 μF capacitor are connected in series with an alternating voltage source. The voltage across the resistor is $v_R = (1.20\ V)\cos(2500\ \text{rad}/s)t$. The voltage across the capacitor will be :

(1) $(0.48\ V)\cos[(2500\ \text{rad}/s)t + \pi/2\ \text{rad}]$ (2) $(1.20\ V)\cos[(2500\ \text{rad}/s)t - \pi/2\ \text{rad}]$

(3) $(1.20\ V)\cos[(2500\ \text{rad}/s)t]$ (4) $(0.48\ V)\cos[(2500\ \text{rad}/s)t - \pi/2\ \text{rad}]$

15. When a forward bias is applied to a *pn* junction, the drift current ?

(1) Increases (2) Decreases to zero

(3) Decreases, but not to zero (4) Remains unchanged

16. Which of the following is true about Hall effect in a semiconductor substance ? The Hall coefficient :

(I) Changes with doping concentration

(II) Depends on temperature

(III) Varies with probe current and magnetic field

(IV) Independent of probe current and magnetic field

(1) I, II and III (2) II and III (3) I, II and IV (4) IV and I

17. The color of the bright spot on the screen of a CRO is the characteristic of the :

(1) Signal being viewed

(2) Primary electrons emitted from the cathode

(3) Final speed with which the electrons strike the screen

(4) Coating material of the display screen

18. The maximum wavelength of electromagnetic radiation which can create a hole-electron pair in germanium (given that the band gap of germanium is 0.65 eV) is :

(1) 6×10^{-6} m (2) 1.6×10^{-6} m (3) 1.9×10^{-6} m (4) 1.9×10^{-5} m

19. If the load resistance of a CE amplifier increases, then its current gain :

(1) Decreases (2) Increases

(3) Increases followed by an initial decrease (4) Remains unchanged

20. A transistor has $\alpha = 0.98$, IB = 100 μA and ICO = 6 μA. The value of IE will be :

(1) 5.3 mA (2) 6 mA (3) 4.6 mA (4) 9 mA

21. A body, initially at rest, explodes into two pieces of mass $2M$ and $3M$, respectively, having a total kinetic energy E. The kinetic energy of the piece of mass $2M$ after the explosion is :

(1) $E/3$ (2) $E/5$ (3) $2E/5$ (4) $3E/5$

22. If a generalized coordinate has the dimension of momentum, the generalized velocity will have the dimension of :

(1) Velocity (2) Acceleration (3) Torque (4) Force

23. If a constant force acts on a particle, its acceleration will :

(1) Remain constant (2) Gradually decrease

(3) Gradually increase (4) Become undefined after some time

24. The law of conservation of linear momentum has its origin in :

(1) Translational symmetry of space (2) Isotropy of space

(3) Time invariance of space (4) Lagrange's equation

25. The Lagrange's equation for simple pendulum is (symbols have their usual meaning) :

(1) $\ddot{\theta} + \frac{g}{l}\sin\theta = 0$ (2) $\ddot{\theta} + \frac{g}{l\sin\theta} = 0$ (3) $\ddot{\theta} - \frac{g}{l}\sin\theta = 0$ (4) $\ddot{\theta} + \frac{l}{g}\sin\theta = 0$

26. A particle is constrained to move along the inner surface of a fixed hemispherical bowl. The number of degrees of freedom of the particle is :

(1) One (2) Two (3) Three (4) Four

27. If a linear harmonic oscillator has frequency f, the frequency of oscillation of the kinetic energy of oscillator is :

(1) f (2) $f/2$ (3) $2f$ (4) $4f$

28. The electric potential at point r inside a uniformly charged thin spherical shell with surface charge density σ and radius R is equal to (q is the total charge on the spherical shell) :

(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ (3) $\frac{1}{4\pi\varepsilon_0}\frac{\sigma}{r}$ (4) Zero

29. The induced electric field in the Maxwell equation $\oint \vec{E}.\,d\vec{l} = -\frac{d\Phi_B}{dt}$, is called a non-conservative field as the line integral of the electric field in electrostatics $\oint \vec{E}.\,d\vec{l}$ is always :

(1) Zero (2) 2π (3) $\frac{d\Phi_B}{dt}$ (4) $2\pi\vec{E}$

30. In electromagnetic wave in free space, the phase difference between electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ is :

(1) Zero (2) $\pi/2$ (3) π (4) $3\pi/2$

31. The fact that the binding energy per nucleon is roughly a constant over most of the range of stable nuclei is a consequence of the fact that the nuclear force is :

(1) Strong (2) Short range
(3) Charge-independent (4) Always attractive

32. Alpha particles produced during alpha-decay have kinetic energy of the order of :

(1) MeV (2) KeV (3) GeV (4) eV

33. What limits the size of a stable nucleus ?

(1) Limited number of nucleons (2) Limited range of the strong nuclear force
(3) Large surface to volume ratio (4) None of the above

34. Which of the following is ***true*** ?

I. A neutron can transform into a proton in free space
II. A proton can transform into a neutron in free space
III. A neutron can transform into a proton inside nucleus
IV. A proton can transform into a neutron inside nucleus

(1) I, III and IV (2) I, II, III and IV (3) II, III and IV (4) III and IV

35. Tritium has a half-life of 12.5 y against beta decay. What fraction of a sample of tritium will remain un-decayed after 25 y ?

(1) 1/4 (2) 1/2 (3) 1/10 (4) 1/3

36. How many neutrons are released in the following nuclear reaction ?

$${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{88}_{38}Sr + {}^{136}_{54}Xe + ?\,{}^{1}_{0}n$$

(1) 11 (2) 12 (3) 10 (4) 14

37. When the nuclear reaction takes place, which of the following is true about the reaction ?

I. The energy is conserved

II. The electric charge is conserved

III. The mass is conserved

IV. The number of nucleons is conserved

(1) I, II, III and IV (2) I and II only (3) I, II and III only (4) I, II and IV only

38. Which of the following statements is not ***true*** about γ-radiation ?

I. It is produced by unstable nuclei

II. It can penetrate several centimeters of lead

III. It can ionize gasses

IV. It can be deflected by a magnetic field

V. It is a short wavelength electromagnetic photon

(1) IV and V (2) III and IV (3) IV (4) V

39. The photoelectric cross-section depends on Z (target atomic number) and E_γ (energy of incident photon) through the expression :

(1) $Z^5 / E_\gamma^{3/2}$ (2) $Z^2 / E_\gamma^{7/2}$ (3) $Z^5 / E_\gamma^{7/2}$ (4) Z / E_γ

40. Positive ions and electrons produced in the Geiger-Mueller tube as a result of interaction of incident radiation with the gas medium are drifted, respectively, towards cathode and anode. On an average :

(1) Ion has more kinetic energy, but smaller speed than electron

(2) Ion has smaller kinetic energy and speed than electron

(3) Ion and electron have equal kinetic energy and speed

(4) Ion and electron have equal kinetic energy, but speed of electron is more than that of ion

41. A crystalline solid can be distinguished from a glassy solid on the basis of their :

(1) Distinct physical and chemical properties

(2) X-ray diffraction pattern

(3) Lattice and unit cells

(4) Lattice, basis and unit cells

42. Which of the following is true about the Wigner-Seitz unit cell ?

(1) It contains always one lattice point at the center of the cell

(2) In contains always one atom at the center of the unit cell

(3) It contains one lattice point, with each corner making a contribution of 1/8

(4) It contains two lattice points, one at the center and other at one of the eight corners

43. If $\vec{R} = u_1\vec{a}_1 + u_2\vec{a}_2 + u_3\vec{a}_3$ is a vector in direct lattice, while $\vec{G} = v_1\vec{b}_1 + v_2\vec{b}_2 + v_3\vec{b}_3$ is a vector in the corresponding reciprocal lattice, then $\vec{R}.\vec{G}$ has the from :

(1) $2\pi/(\vec{a}_1.\vec{a}_2 \times \vec{a}_3)$ (2) 2π/Integer (3) 2π × integer (4) $2\pi/(\vec{b}_1.\vec{b}_2 \times \vec{b}_3)$

44. At low temperature T, the specific heat of insulating crystals varies as :

(1) $AT+BT^3$ (2) BT^3

(3) Will not change with temperature (4) Aexp $(-T)$

45. Consider a cubical lattice. A lattice plane that bisects the bottom face of the cube diagonally, has Miller indices :

(1) (100) (2) (010) (3) (111) (4) (110)

46. The structure of diamond crystal can be described by :

(1) A simple cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$

(2) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{2}\frac{1}{2}\frac{1}{2}$

(3) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$

(4) A simple cubic lattice, with carbon atoms positioned at corners and face centers of the cubic cell

47. If the first-order diffraction from a set of lattice planes in a crystal occurs at $\theta = 45°$, then the second-order diffraction from the same set of planes may occur at θ equal to :

(1) $\theta = 60°$ (2) $\theta = 90°$ (3) $\theta = 22.5°$ (4) None of the above

48. Consider that the structure of a simple cubic solid can be described by three different sets of lattice planes having Miller indices (100), (110) and (111). The inter-planar spacing for these planes has the ratio :

(1) $\sqrt{6}:\sqrt{3}:\sqrt{2}$ (2) $\sqrt{2}:\sqrt{3}:\sqrt{6}$ (3) 1 : 2 : 3 (4) 3 : 2 : 1

49. The reciprocal lattice of the reciprocal lattice of simple cubic lattice is :

(1) A simple cubic lattice

(2) An expanded simple cubic lattice

(3) A simple cubic lattice rotated by an angle of 45°

(4) A compressed simple cubic lattice

50. According to Einstein's model, the average energy of an atomic oscillator in a one-dimensional crystalline solid in thermal equilibrium at temperature T is given by :

(1) $\frac{h\nu}{\left[\exp\left(\frac{h\nu}{k_BT}\right)+1\right]}$ (2) $\frac{k_BT}{2}$ (3) k_BT (4) $\frac{h\nu}{\left[\exp\left(\frac{h\nu}{k_BT}\right)-1\right]}$

51. The value of M after the following set of FORTRAN statements are executed is :

```
M = 0
Do 10 I = 1.2
Do 20 J = 1.2
M = M + I + J
20 Continue
10 Continue
Stop
End
```

(1) 11 (2) 12 (3) 4 (4) 10

52. In FORTRAN language, the statement, $p = 1/x*a + 1/y + b - 1/z**3*c$ will compute the expression :

(1) $p = \frac{1}{xa} + \frac{1}{y} + b - \frac{1}{z^{3c}}$ (2) $p = \frac{a}{x} + \frac{1}{y} + b - \frac{c}{z^3}$

(3) $p = \frac{a}{x} + \frac{1}{y+b} - \frac{c}{z^3}$ (4) $p = \frac{1}{xa} + \frac{1}{y+b} - \frac{1}{z^3 c}$

53. The change in entropy is zero for :

(1) Irreversible processes (2) Reversible adiabatic processes

(3) Reversible isothermal processes (4) All adiabatic processes

54. When changes occur within a closed system, which of the following is true for change in entropy ΔS of the system ?

(1) $\Delta S = 0$ (2) $\Delta S < 0$ (3) $\Delta S \geq 0$ (4) $\Delta S > 0$

55. Let us take two sub-systems A_1 and A_2 in general contact. The most general thermodynamic equilibrium relation for the change in internal energy is :

(1) $dE = TdS - PdV + \mu dN$ (2) $dE = TdQ - PdV + \mu dN$

(3) $dE = TdS + PdV + \mu dN$ (4) $dE = TdS + PdV - \mu dN$

56. A Carnot engine absorbs 1 MJ of heat from a reservoir at 300°C and exhausts heat to a reservoir at 150°C. The work done by the engine is :

(1) 2.6×10^6J (2) 2.6×10^5J (3) 1×10^6J (4) 1.6×10^5J

57. Consider that an amount of heat dQ is added to a substance at temperature T keeping its volume constant at V. As a result, its temperature changes by dT, while the internal energy by dE. The heat capacity C of the substance is given by :

(1) $\frac{dE}{dT}$ (2) $\frac{1}{T}\frac{dE}{dT}$ (3) $\frac{1}{T}\frac{dQ}{dT}$ (4) $\frac{1}{V}\frac{dQ}{dT}$

58. The Fourier transform $f(q)$ of the function $f(x) = e^{-x^2/2}$ is :

(1) e^{-q^2} (2) $e^{-q^2/2}$ (3) e^{q^2} (4) $e^{q^2/2}$

59. A real, periodic and continuous function $n(x)$ can be expanded in the Fourier series as : $n(x) = \sum_{p=-\infty}^{\infty} C_p e^{ipx}$. The Fourier coefficient C_p must satisfy the condition :

(1) $C_p = C_p^*$ (2) $C_{-p} = C_p^*$

(3) $C_{-p} = C_p$ (4) $C_0 = 0$

60. If $f(q)$ is the Fourier transform of $f(x)$, the Fourier transform of $f(ax)$ is :

(1) $f(q/\alpha)$ (2) $f(q\alpha)$

(3) $\alpha^{-1} f(q/\alpha)$ (4) $\alpha f(q/\alpha)$

61. Light of wavelength 500 nanometers is incident on sodium with work function 2.28 eV. What is the maximum kinetic energy of the ejected photoelectrons ?

(1) 0.03 eV (2) 0.2 eV

(3) 1.3 eV (4) 2.1 eV

62. A particle moving freely in x-direction is described by the wave function $\psi(x, t) = Ce^{i(kx-\omega t)}$. Uncertainty in its momentum is equal to :

(1) Zero (2) $\hbar$ (3) ∞ (4) $\hbar/2$

63. Which of the following wave functions can describe a physical state ?

(1) $\psi(x) = |x|$ (2) $\psi(x) = \exp(x^2)$

(3) $\psi(x) = \tan(x)$ (4) $\psi(x) = \exp(-x^2)$

64. A particle restricted to the x-axis has the wave function $\psi(x) = ax$ between $x = 0$ and $x = 1$; $\psi(x) = 0$ elsewere. The probability that the particle can be found between $x = 0.45$ and $x = 0.55$ is :

(1) a^2 (2) $0.0251\,a^2$

(3) $0.3025\,a^2$ (4) $0.2025\,a^2$

65. X-rays of wavelength 10.0 pm are scattered from a target via Compton scattering. The maximum wavelength present in the scattered X-rays is (given that Compton wavelength is 2.426 pm) :

(1) 14.9 pm (2) 1.49 pm

(3) 2.426 pm (4) 2426 pm

66. The wave function describing a de-Broglie wave associated with a material particle of linear momentum $p = mv$ may be represented as : $\psi(x, t) = e^{i(kx-\omega t)}$. The phase velocity v_p of de-Broglie wave is related to the particle velocity v as :

(1) $v_p = v$ (2) $v_p = v/2$

(3) $v_p = v + c$ (4) $v_p = \pm v$

67. Consider a particle described by the time-dependent Schrodinger wave equation : $i\hbar\frac{\partial}{\partial t}\psi(x,t)=\left[-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}+V(x,t)\right]\psi(x,t)$. If $\psi(x, t)$ is one solution of this equation, then which of the following statements is true for $\psi^*(x, t)$:

(1) $\psi^*(x, t)$ is also a solution of the same Schrodinger wave equation.

(2) $\psi^*(x, t)$ cannot in general be a solution of the same Schrodinger wave equation.

(3) $\psi^*(x, t)$ can be a solution of the same Schrodinger wave equation provided that $V(x, t)$ is zero.

(4) $\psi^*(x, t)$ can be a solution of the same Schrodinger wave equation provided that $V(x, t)$ is independent of x.

68. Zero-point energy of an oscillator has its origin in :

(1) Pauli exclusion principle

(2) Experimental non-realization of absolute zero temperature

(3) Quantization of energy

(4) Heisenberg uncertainty principle

69. Quantum mechanically an electron of energy 2.0 eV incident on a barrier 10.0 eV high and 0.50 nm wide has a finite probability of tunneling through it. If electron is replaced by a proton, the tunneling probability :

(1) Increases by a factor of 2 (2) Decreases

(3) Remains unchanged (4) Decrease by a factor of 2

70. Eigen value of the operator $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ operating on the wave function $\psi(x)=\sqrt{\frac{2}{L}}\sin\left(\frac{9\pi x}{L}\right)$ is given by :

(1) $\frac{\pi^2\hbar^2}{2mL^2}$ (2) $\frac{9\pi^2\hbar^2}{2mL^2}$ (3) $\frac{81\pi^2\hbar^2}{2mL^2}$ (4) $\frac{3\pi^2\hbar^2}{2mL^2}$

71. For $j = 5/2$ the allowed values of l are :

(1) 1, 2 (2) 2, 3 (3) 3, 4 (4) 4, 5

72. An atom having one electron in its valence shell is placed in a weak magnetic field oriented along the z-axis. The allowed angles of spin angular momentum with z-axis are :

(1) $\cos^{-1}\left(\pm\frac{1}{\sqrt{3}}\right)$ (2) $\cos^{-1}\left(\pm\frac{1}{\sqrt{2}}\right)$ (3) $\cos^{-1}\left(\pm\frac{\sqrt{3}}{2}\right)$ (4) $\cos^{-1}\left(\pm\frac{1}{2}\right)$

73. The effect of spin-orbit splitting on the ground state level of hydrogen atom is to split it into :

(1) Two sub-levels (2) Three sub-levels (3) Five sub-levels (4) None of the above

74. The spin angular momentum of an electron can be described as :

(1) Electron spinning about an axis passing through its center

(2) Electron spinning clockwise or anti-clockwise about an axis passing through its center

(3) Electron spinning at speed of light clockwise or anti-clockwise about an axis passing through its center

(4) None of the above

75. The maximum degeneracy of an atomic energy level with principal quantum number n is :

(1) n (2) n^2 (3) $2n^2$ (4) $2n$

76. Suppose that an isolated hydrogen atom in its ground state is placed in an external weak electric field (weak field Stark effect). The ground state would split into :

(1) Two sub-levels (2) Four sub-levels (3) Three sub-levels (4) None of the above

77. An electron is in a magnetic field of strength B = 100 Gauss. The magnetic dipole moment ($\vec{\mu}$) of the electron is initially anti-parallel to the direction of $\vec{B}$. How much external work must be done to reverse the direction of magnetic moment of the electron ?

(1) $-2\mu B$ (2) $+2\mu B$ (3) $-\mu B$ (4) $+\mu B$

78. The rotational, vibrational and molecular electronic spectra of diatomic molecules lie, respectively, in the :

(1) Microwave, infrared and visible-ultraviolet regions

(2) Infrared, microwave and visible-ultraviolet regions

(3) Visible-ultraviolet, microwave and infrared regions

(4) Infrared, visible-ultraviolet and microwave regions

79. For laser action to occur, what is the minimum number of energy levels the lasing medium should have ?

(1) Two (2) Four (3) Three (4) Five

80. A certain ruby LASER emits 1.0 J pulses of light whose wavelength is 694 nm. What is the minimum number of Cr^{3+} ions in the ruby ?

(1) 1.0×10^{22} (2) 3.5×10^{23} (3) Avogadro number (4) 3.5×10^{18}

81. The vector potential in a region is given as $\vec{A}(x, y, z) = -\hat{x}y + \hat{y}2x$. The associated magnetic induction $\vec{B}$ is :

(1) $\hat{x} + \hat{z}$ (2) $-\hat{x} + 2\hat{y}$ (3) $-\hat{x} + 2\hat{y} + \hat{z}$ (4) $3\hat{z}$

82. A paramagnetic substance is placed in an external homogeneous and static magnetic field. The resulting magnetic susceptibility contains :

(1) Paramagnetic contribution

(2) Paramagnetic and diamagnetic contributions

(3) Diamagnetic contribution

(4) Paramagnetic, ferromagnetic and diamagnetic contributions

83. Suppose that you hold a diamond up to a street lamp which emits yellow light of frequency 5.09×10^{14} Hz. Given that diamond has permittivity 5.84 and permeability 1.00, the speed of wave propagation and wavelength of yellow light in diamond would, respectively, be equal to :

(1) 1.24×10^8 m/s and 589 nm

(2) 3.0×10^8 m/s and 589 nm

(3) 1.24×10^8 m/s and 244 nm

(4) 3.0×10^8 m/s and 244 nm

84. The potential field of an electric field $\vec{E} = (y\hat{i} + x\hat{j})$ is :

(1) $V = -xy +$ constant
(2) $V = -y + x +$ constant
(3) $V = -(y^2 + x^2) +$ constant
(4) $V =$ constant

85. In an elastic material the force that tends to hold atoms back to their equilibrium positions, has its origin in :

(1) Electrostatic force
(2) Electromagnetic force
(3) Weak force
(4) Gravitational force

86. Consider an ideal gas made up of point-like particles in thermal equilibrium at temperature T. The most probable value of energy is :

(1) $k_BT/2$
(2) $3k_BT/2$
(3) k_BT
(4) $2k_BT$

87. Suppose an atomic gas in a container is at thermal equilibrium. Atoms are continuously colliding with each other and the walls of the container. The nature of these collisions is :

(1) Inelastic
(2) Elastic
(3) Inelastic at extremely low temperatures
(4) None of the above

88. For an ideal gas of diatomic molecules in thermal equilibrium at temperature T, the average energy per molecule is :

(1) $\frac{1}{2}k_BT$
(2) $\frac{3}{2}k_BT$
(3) $3k_BT$
(4) $6k_BT$

89. At what temperature is the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47°C ?

(1) 80 K
(2) –73 K
(3) 3 K
(4) 20 K

90. A cube has a volume of $1000\ cm^3$. Its volume as observed by an observer Q moving at a velocity of 0.8c relative to the cube in a direction parallel to one edge is :

(1) $500\ cm^3$
(2) $1000\ cm^3$
(3) $900\ cm^3$
(4) $600\ cm^3$

91. The gas of electrons in a metal possesses tremendous internal energy even at absolute zero temperature. The origin of this energy lies in the :

(1) Maxwell-Boltzmann Law
(2) Negative charge on electrons
(3) Pauli exclusion principle
(4) Small mass of electrons

92. For a gas of electrons in thermal equilibrium at room temperature, the probability of finding an electron in the single-electron states $\varepsilon_F + \varepsilon$ and $\varepsilon_F - \varepsilon$ is (where ε_F is the Fermi energy) :

(1) Equal
(2) Not equal
(3) Equal if ε is positive
(4) Equal if ε is negative

93. The diameter of n^{th} dark ring in Newton's ring arrangement changes from 1.2 to 1.0 cm when air is replaced by a transparent liquid. What is the refractive index of liquid ?

(1) 1.44
(2) 1.20
(3) 4.10
(4) 1.50

94. Three plane-waves viz. $y_1 = A_1\, \hat{y} \cos(kx - \omega t + \delta_1), y_2 = A_2\, \hat{z} \cos(kx - \omega t + \delta_2)$ and $y_3 = A_3\, \hat{y} \cos(kx - \omega t + \delta_3)$ are superposed pairwise. Which superposition can lead to interference ? (here $A_1, A_2, A_3, \delta_1, \delta_2, \delta_3$ are constants)

(1) y_1 and y_2
(2) y_1 and y_3
(3) y_2 and y_3
(4) No interference in any pair

95. In a Young's double slit experiment the intensity at a point where the path difference is $\lambda/6$ (λ being the wavelength of light used) is I. If I_0 denotes the maximum intensity, I/I_0 is equal to :

(1) 3/4
(2) 1/2
(3) 3/2
(4) 1/6

96. Illuminated normally, a diffracting grating produces second order bright images with an angle of 60° between them. The light is monochromatic and has a wavelength of 300 nm. The spacing of the grating in mm is :

(1) 3.6×10^{-3}
(2) 2.4×10^{-3}
(3) 2.0×10^{-3}
(4) 1.5×10^{-3}

97. Electromagnetic waves are transverse in nature, is evident by :

(1) Polarization
(2) Interference
(3) Reflection
(4) Diffraction

98. A beam of transverse waves whose vibrations occur in all directions perpendicular tc their direction of motion is :

(1) Polarized
(2) Unpolarized
(3) Resolved
(4) Diffracted

99. The state of polarization of light with the electric field vector $\vec{E} = \hat{x}E_0 \cos(kz - \omega t) - \hat{y}E_0 \cos(kz - \omega t)$ is :

(1) Linearly polarized along z-direction
(2) Linearly polarized at -45° to x-axis
(3) Circularly polarized
(4) Elliptically polarized with the major axis along x-axis

100. If the electric field vector in a polarized electromagnetic wave is $\vec{E}(\vec{r},t) = \hat{n}E_0 e^{i(\vec{k}.\vec{r}-\omega t}$ (with $\hat{n}$ being the polarization vector and $\vec{k}$ the propagation vector), its magnetic fiel vector is given by :

(1) $\frac{1}{c}\hat{k} \times \vec{E}$
(2) $\hat{k} \times \vec{E}$
(3) $\frac{1}{c^2}\hat{k} \times \vec{E}$
(4) $\frac{1}{c}\hat{k}.\vec{E}$

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Father's Name ____________ Mother's Name ____________

Date of Exam : ____________

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____________ (Signature of the Invigilator)

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1. All questions are ***compulsory*** and carry equal marks. The candidates are required to attempt all questions.
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4. Question Booklet along-with answer key of all the A, B, C and D code shall be got uploaded on the University Website immediately after the conduct of Entrance Examination. Candidates may raise valid objection/complaint if any, with regard to discrepancy in the question booklet/answer key within 24 hours of uploading the same on the University website. The complaint be sent by the students to the Controller of Examinations by hand or through email. Thereafter, no complaint in any case will be considered.
5. The candidate ***must not*** do any rough work or writing in the OMR Answer-Sheet. Rough work, if any, may be done in the question booklet itself. Answers ***must not*** be ticked in the question booklet.
6. ***Use only black or blue ball point pen of good quality in the OMR Answer-Sheet.***
7. There will be ***negative*** marking. Each correct answer will be awarded ***one*** full mark and each incorrect answer will be negatively marked for which the candidate will get ¼ Mark (0.25 Mark) discredit. Cutting, erasing, overwriting and more than one answer in OMR Answer-Sheet will be treated as incorrect answer.
8. *Before answering the questions, the candidates should ensure that they have been supplied correct & complete question booklet. Complaints, if any, regarding misprinting etc. will not be entertained* **30** *minutes after starting of the examination.*

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1. Light of wavelength 500 nanometers is incident on sodium with work function 2.28 eV. What is the maximum kinetic energy of the ejected photoelectrons ?
(1) 0.03 eV (2) 0.2 eV (3) 1.3 eV (4) 2.1 eV

2. A particle moving freely in x-direction is described by the wave function $\psi(x, t) = Ce^{i(kx-\omega t)}$. Uncertainty in its momentum is equal to :
(1) Zero (2) $\hbar$ (3) ∞ (4) $\hbar/2$

3. Which of the following wave functions can describe a physical state ?
(1) $\psi(x) = |x|$ (2) $\psi(x) = \exp(x^2)$ (3) $\psi(x) = \tan(x)$ (4) $\psi(x) = \exp(-x^2)$

4. A particle restricted to the x-axis has the wave function $\psi(x) = ax$ between $x = 0$ and $x = 1$; $\psi(x) = 0$ elsewere. The probability that the particle can be found between $x = 0.45$ and $x = 0.55$ is :
(1) a^2 (2) $0.0251\,a^2$ (3) $0.3025\,a^2$ (4) $0.2025\,a^2$

5. X-rays of wavelength 10.0 pm are scattered from a target via Compton scattering. The maximum wavelength present in the scattered X-rays is (given that Compton wavelength is 2.426 pm) :
(1) 14.9 pm (2) 1.49 pm
(3) 2.426 pm (4) 2426 pm

6. The wave function describing a de-Broglie wave associated with a material particle of linear momentum $p = mv$ may be represented as : $\psi(x, t) = e^{i(kx-\omega t)}$. The phase velocity v_p of de-Broglie wave is related to the particle velocity v as :
(1) $v_p = v$ (2) $v_p = v/2$
(3) $v_p = v + c$ (4) $v_p = \pm v$

7. Consider a particle described by the time-dependent Schrodinger wave equation : $i\hbar\frac{\partial}{\partial t}\psi(x,t) = \left[-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x,t)\right]\psi(x,t)$. If $\psi(x, t)$ is one solution of this equation, then which of the following statements is true for $\psi^*(x, t)$:
(1) $\psi^*(x, t)$ is also a solution of the same Schrodinger wave equation.
(2) $\psi^*(x, t)$ cannot in general be a solution of the same Schrodinger wave equation.
(3) $\psi^*(x, t)$ can be a solution of the same Schrodinger wave equation provided that $V(x, t)$ is zero.
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8. Zero-point energy of an oscillator has its origin in :
(1) Pauli exclusion principle
(2) Experimental non-realization of absolute zero temperature
(3) Quantization of energy
(4) Heisenberg uncertainty principle

9. Quantum mechanically an electron of energy 2.0 eV incident on a barrier 10.0 eV high and 0.50 nm wide has a finite probability of tunneling through it. If electron is replaced by a proton, the tunneling probability :

(1) Increases by a factor of 2 (2) Decreases

(3) Remains unchanged (4) Decrease by a factor of 2

10. Eigen value of the operator $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ operating on the wave function $\psi(x) = \sqrt{\frac{2}{L}}\sin\left(\frac{9\pi x}{L}\right)$ is given by :

(1) $\frac{\pi^2\hbar^2}{2mL^2}$ (2) $\frac{9\pi^2\hbar^2}{2mL^2}$ (3) $\frac{81\pi^2\hbar^2}{2mL^2}$ (4) $\frac{3\pi^2\hbar^2}{2mL^2}$

11. The gas of electrons in a metal possesses tremendous internal energy even at absolute zero temperature. The origin of this energy lies in the :

(1) Maxwell-Boltzmann Law (2) Negative charge on electrons

(3) Pauli exclusion principle (4) Small mass of electrons

12. For a gas of electrons in thermal equilibrium at room temperature, the probability of finding an electron in the single-electron states $\varepsilon_F + \varepsilon$ and $\varepsilon_F - \varepsilon$ is (where ε_F is the Fermi energy) :

(1) Equal (2) Not equal

(3) Equal if ε is positive (4) Equal if ε is negative

13. The diameter of n^{th} dark ring in Newton's ring arrangement changes from 1.2 to 1.0 cm when air is replaced by a transparent liquid. What is the refractive index of liquid ?

(1) 1.44 (2) 1.20 (3) 4.10 (4) 1.50

14. Three plane-waves viz. $y_1 = A_1\,\hat{y}\cos(kx - \omega t + \delta_1), y_2 = A_2\,\hat{z}\cos(kx - \omega t + \delta_2)$ and $y_3 = A_3\,\hat{y}\cos(kx - \omega t + \delta_3)$ are superposed pairwise. Which superposition can lead to interference ? (here $A_1, A_2, A_3, \delta_1, \delta_2, \delta_3$ are constants)

(1) y_1 and y_2 (2) y_1 and y_3

(3) y_2 and y_3 (4) No interference in any pair

15. In a Young's double slit experiment the intensity at a point where the path difference is $\lambda/6$ (λ being the wavelength of light used) is I. If I_0 denotes the maximum intensity, I/I_0 is equal to :

(1) 3/4 (2) 1/2 (3) 3/2 (4) 1/6

16. Illuminated normally, a diffracting grating produces second order bright images with an angle of 60° between them. The light is monochromatic and has a wavelength of 300 nm. The spacing of the grating in mm is :

(1) 3.6×10^{-3} (2) 2.4×10^{-3} (3) 2.0×10^{-3} (4) 1.5×10^{-3}

17. Electromagnetic waves are transverse in nature, is evident by :
(1) Polarization (2) Interference (3) Reflection (4) Diffraction

18. A beam of transverse waves whose vibrations occur in all directions perpendicular to their direction of motion is :
(1) Polarized (2) Unpolarized (3) Resolved (4) Diffracted

19. The state of polarization of light with the electric field vector $\vec{E} = \hat{x}E_0 \cos(kz - \omega t) - \hat{y}E_0 \cos(kz - \omega t)$ is :
(1) Linearly polarized along z-direction
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20. If the electric field vector in a polarized electromagnetic wave is $\vec{E}(\vec{r},t) = \hat{n}E_0 e^{i(\vec{k}.\vec{r}-\omega t)}$ (with $\hat{n}$ being the polarization vector and $\vec{k}$ the propagation vector), its magnetic field vector is given by :
(1) $\frac{1}{c}\hat{k}\times\vec{E}$ (2) $\hat{k}\times\vec{E}$ (3) $\frac{1}{c^2}\hat{k}\times\vec{E}$ (4) $\frac{1}{c}\hat{k}.\vec{E}$

21. The value of M after the following set of FORTRAN statements are executed is :
```
M = 0
Do 10 I = 1.2
Do 20 J = 1.2
M = M + I + J
20 Continue
10 Continue
Stop
End
```
(1) 11 (2) 12 (3) 4 (4) 10

22. In FORTRAN language, the statement, $p = 1/x * a + 1/y + b - 1/z ** 3 * c$ will compute the expression :
(1) $p = \frac{1}{xa} + \frac{1}{y} + b - \frac{1}{z^{3c}}$ (2) $p = \frac{a}{x} + \frac{1}{y} + b - \frac{c}{z^3}$
(3) $p = \frac{a}{x} + \frac{1}{y+b} - \frac{c}{z^3}$ (4) $p = \frac{1}{xa} + \frac{1}{y+b} - \frac{1}{z^3 c}$

23. The change in entropy is zero for :
(1) Irreversible processes (2) Reversible adiabatic processes
(3) Reversible isothermal processes (4) All adiabatic processes

24. When changes occur within a closed system, which of the following is true for change in entropy ΔS of the system ?

(1) $\Delta S = 0$ (2) $\Delta S < 0$ (3) $\Delta S \geq 0$ (4) $\Delta S > 0$

25. Let us take two sub-systems A_1 and A_2 in general contact. The most general thermodynamic equilibrium relation for the change in internal energy is :

(1) $dE = TdS - PdV + \mu dN$ (2) $dE = TdQ - PdV + \mu dN$

(3) $dE = TdS + PdV + \mu dN$ (4) $dE = TdS + PdV - \mu dN$

26. A Carnot engine absorbs 1 MJ of heat from a reservoir at 300°C and exhausts heat to a reservoir at 150°C. The work done by the engine is :

(1) 2.6×10^6J (2) 2.6×10^5J (3) 1×10^6J (4) 1.6×10^5J

27. Consider that an amount of heat dQ is added to a substance at temperature T keeping its volume constant at V. As a result, its temperature changes by dT, while the internal energy by dE. The heat capacity C of the substance is given by :

(1) $\frac{dE}{dT}$ (2) $\frac{1}{T}\frac{dE}{dT}$

(3) $\frac{1}{T}\frac{dQ}{dT}$ (4) $\frac{1}{V}\frac{dQ}{dT}$

28. The Fourier transform $f(q)$ of the function $f(x) = e^{-x^2/2}$ is :

(1) e^{-q^2} (2) $e^{-q^2/2}$ (3) e^{q^2} (4) $e^{q^2/2}$

29. A real, periodic and continuous function $n(x)$ can be expanded in the Fourier series as : $n(x) = \sum_{p=-\infty}^{\infty} C_p e^{ipx}$. The Fourier coefficient C_p must satisfy the condition :

(1) $C_p = C_p^*$ (2) $C_{-p} = C_p^*$ (3) $C_{-p} = C_p$ (4) $C_0 = 0$

30. If $f(q)$ is the Fourier transform of $f(x)$, the Fourier transform of $f(ax)$ is :

(1) $f(q/\alpha)$ (2) $f(q\alpha)$ (3) $\alpha^{-1} f(q/\alpha)$ (4) $\alpha f(q/\alpha)$

31. The vector potential in a region is given as $\vec{A}(x, y, z) = -\hat{x}y + \hat{y}2x$. The associated magnetic induction $\vec{B}$ is :

(1) $\hat{x} + \hat{z}$ (2) $-\hat{x} + 2\hat{y}$ (3) $-\hat{x} + 2\hat{y} + \hat{z}$ (4) $3\hat{z}$

32. A paramagnetic substance is placed in an external homogeneous and static magnetic field. The resulting magnetic susceptibility contains :

(1) Paramagnetic contribution

(2) Paramagnetic and diamagnetic contributions

(3) Diamagnetic contribution

(4) Paramagnetic, ferromagnetic and diamagnetic contributions

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(1) 1.24×10^8 m/s and 589 nm (2) 3.0×10^8 m/s and 589 nm

(3) 1.24×10^8 m/s and 244 nm (4) 3.0×10^8 m/s and 244 nm

34. The potential field of an electric field $\vec{E} = (y\hat{i} + x\hat{j})$ is :

(1) $V = -xy$ + constant (2) $V = -y + x$ + constant

(3) $V = -(y^2 + x^2)$ + constant (4) V = constant

35. In an elastic material the force that tends to hold atoms back to their equilibrium positions, has its origin in :

(1) Electrostatic force (2) Electromagnetic force

(3) Weak force (4) Gravitational force

36. Consider an ideal gas made up of point-like particles in thermal equilibrium at temperature T. The most probable value of energy is :

(1) $k_BT/2$ (2) $3k_BT/2$ (3) k_BT (4) $2k_BT$

37. Suppose an atomic gas in a container is at thermal equilibrium. Atoms are continuously colliding with each other and the walls of the container. The nature of these collisions is :

(1) Inelastic (2) Elastic

(3) Inelastic at extremely low temperatures (4) None of the above

38. For an ideal gas of diatomic molecules in thermal equilibrium at temperature T, the average energy per molecule is :

(1) $\frac{1}{2}k_BT$ (2) $\frac{3}{2}k_BT$ (3) $3k_BT$ (4) $6k_BT$

39. At what temperature is the r.m.s. velocity of a hydrogen molecule equal to that of an oxygen molecule at 47°C ?

(1) 80 K (2) –73 K (3) 3 K (4) 20 K

40. A cube has a volume of 1000 cm^3. Its volume as observed by an observer Q moving at a velocity of 0.8c relative to the cube in a direction parallel to one edge is :

(1) 500 cm^3 (2) 1000 cm^3 (3) 900 cm^3 (4) 600 cm^3

41. The fact that the binding energy per nucleon is roughly a constant over most of the range of stable nuclei is a consequence of the fact that the nuclear force is :

(1) Strong (2) Short range

(3) Charge-independent (4) Always attractive

42. Alpha particles produced during alpha-decay have kinetic energy of the order of :

(1) MeV (2) KeV (3) GeV (4) eV

43. What limits the size of a stable nucleus ?
(1) Limited number of nucleons (2) Limited range of the strong nuclear force
(3) Large surface to volume ratio (4) None of the above

44. Which of the following is ***true*** ?
I. A neutron can transform into a proton in free space
II. A proton can transform into a neutron in free space
III. A neutron can transform into a proton inside nucleus
IV. A proton can transform into a neutron inside nucleus
(1) I, III and IV (2) I, II, III and IV (3) II, III and IV (4) III and IV

45. Tritium has a half-life of 12.5 y against beta decay. What fraction of a sample of tritium will remain un-decayed after 25 y ?
(1) 1/4 (2) 1/2 (3) 1/10 (4) 1/3

46. How many neutrons are released in the following nuclear reaction ?

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{88}_{38}Sr + ^{136}_{54}Xe + ?\, ^{1}_{0}n$$

(1) 11 (2) 12 (3) 10 (4) 14

47. When the nuclear reaction takes place, which of the following is true about the reaction ?
I. The energy is conserved
II. The electric charge is conserved
III. The mass is conserved
IV. The number of nucleons is conserved
(1) I, II, III and IV (2) I and II only (3) I, II and III only (4) I, II and IV only

48. Which of the following statements is not ***true*** about γ-radiation ?
I. It is produced by unstable nuclei
II. It can penetrate several centimeters of lead
III. It can ionize gasses
IV. It can be deflected by a magnetic field
V. It is a short wavelength electromagnetic photon
(1) IV and V (2) III and IV (3) IV (4) V

49. The photoelectric cross-section depends on Z (target atomic number) and E_γ (energy of incident photon) through the expression :
(1) $Z^5 / E_\gamma^{3/2}$ (2) $Z^2 / E_\gamma^{7/2}$ (3) $Z^5 / E_\gamma^{7/2}$ (4) Z / E_γ

50. Positive ions and electrons produced in the Geiger-Mueller tube as a result of interaction of incident radiation with the gas medium are drifted, respectively, towards cathode and anode. On an average :
(1) Ion has more kinetic energy, but smaller speed than electron
(2) Ion has smaller kinetic energy and speed than electron
(3) Ion and electron have equal kinetic energy and speed
(4) Ion and electron have equal kinetic energy, but speed of electron is more than that of ion

51. A crystalline solid can be distinguished from a glassy solid on the basis of their :
(1) Distinct physical and chemical properties
(2) X-ray diffraction pattern
(3) Lattice and unit cells
(4) Lattice, basis and unit cells

52. Which of the following is true about the Wigner-Seitz unit cell ?
(1) It contains always one lattice point at the center of the cell
(2) In contains always one atom at the center of the unit cell
(3) It contains one lattice point, with each corner making a contribution of 1/8
(4) It contains two lattice points, one at the center and other at one of the eight corners

53. If $\vec{R} = u_1\vec{a}_1 + u_2\vec{a}_2 + u_3\vec{a}_3$ is a vector in direct lattice, while $\vec{G} = v_1\vec{b}_1 + v_2\vec{b}_2 + v_3\vec{b}_3$ is a vector in the corresponding reciprocal lattice, then $\vec{R}.\vec{G}$ has the from :

(1) $2\pi/(\vec{a}_1.\vec{a}_2 \times \vec{a}_3)$ (2) 2π/Integer (3) $2\pi \times$ integer (4) $2\pi/(\vec{b}_1.\vec{b}_2 \times \vec{b}_3)$

54. At low temperature *T*, the specific heat of insulating crystals varies as :
(1) $AT + BT^3$ (2) BT^3
(3) Will not change with temperature (4) $A\exp(-T)$

55. Consider a cubical lattice. A lattice plane that bisects the bottom face of the cube diagonally, has Miller indices :
(1) (100) (2) (010) (3) (111) (4) (110)

56. The structure of diamond crystal can be described by :
(1) A simple cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$
(2) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{2}\frac{1}{2}\frac{1}{2}$
(3) A face centered cubic lattice and a basis of two carbon atoms, with atoms positioned at 000 and $\frac{1}{4}\frac{1}{4}\frac{1}{4}$
(4) A simple cubic lattice, with carbon atoms positioned at corners and face centers of the cubic cell

57. If the first-order diffraction from a set of lattice planes in a crystal occurs at $\theta = 45°$, then the second-order diffraction from the same set of planes may occur at θ equal to :
(1) $\theta = 60°$ (2) $\theta = 90°$ (3) $\theta = 22.5°$ (4) None of the above

58. Consider that the structure of a simple cubic solid can be described by three different sets of lattice planes having Miller indices (100), (110) and (111). The inter-planar spacing for these planes has the ratio :

(1) $\sqrt{6}:\sqrt{3}:\sqrt{2}$ (2) $\sqrt{2}:\sqrt{3}:\sqrt{6}$ (3) 1 : 2 : 3 (4) 3 : 2 : 1

59. The reciprocal lattice of the reciprocal lattice of simple cubic lattice is :

(1) A simple cubic lattice

(2) An expanded simple cubic lattice

(3) A simple cubic lattice rotated by an angle of 45°

(4) A compressed simple cubic lattice

60. According to Einstein's model, the average energy of an atomic oscillator in a one-dimensional crystalline solid in thermal equilibrium at temperature T is given by :

(1) $\dfrac{h\nu}{\left[\exp\left(\dfrac{h\nu}{k_BT}\right)+1\right]}$ (2) $\dfrac{k_BT}{2}$ (3) k_BT (4) $\dfrac{h\nu}{\left[\exp\left(\dfrac{h\nu}{k_BT}\right)-1\right]}$

61. For $j = 5/2$ the allowed values of l are :

(1) 1, 2 (2) 2, 3 (3) 3, 4 (4) 4, 5

62. An atom having one electron in its valence shell is placed in a weak magnetic field oriented along the z-axis. The allowed angles of spin angular momentum with z-axis are :

(1) $\cos^{-1}\left(\pm\dfrac{1}{\sqrt{3}}\right)$ (2) $\cos^{-1}\left(\pm\dfrac{1}{\sqrt{2}}\right)$ (3) $\cos^{-1}\left(\pm\dfrac{\sqrt{3}}{2}\right)$ (4) $\cos^{-1}\left(\pm\dfrac{1}{2}\right)$

63. The effect of spin-orbit splitting on the ground state level of hydrogen atom is to split it into :

(1) Two sub-levels (2) Three sub-levels (3) Five sub-levels (4) None of the above

64. The spin angular momentum of an electron can be described as :

(1) Electron spinning about an axis passing through its center

(2) Electron spinning clockwise or anti-clockwise about an axis passing through its center

(3) Electron spinning at speed of light clockwise or anti-clockwise about an axis passing through its center

(4) None of the above

65. The maximum degeneracy of an atomic energy level with principal quantum number n is :

(1) n (2) n^2 (3) $2n^2$ (4) $2n$

66. Suppose that an isolated hydrogen atom in its ground state is placed in an external weak electric field (weak field Stark effect). The ground state would split into :

(1) Two sub-levels (2) Four sub-levels (3) Three sub-levels (4) None of the above

67. An electron is in a magnetic field of strength $B = 100$ Gauss. The magnetic dipole moment $(\vec{\mu})$ of the electron is initially anti-parallel to the direction of $\vec{B}$. How much external work must be done to reverse the direction of magnetic moment of the electron ?

(1) $-2\mu B$ (2) $+2\mu B$ (3) $-\mu B$ (4) $+\mu B$

68. The rotational, vibrational and molecular electronic spectra of diatomic molecules lie, respectively, in the :

(1) Microwave, infrared and visible-ultraviolet regions

(2) Infrared, microwave and visible-ultraviolet regions

(3) Visible-ultraviolet, microwave and infrared regions

(4) Infrared, visible-ultraviolet and microwave regions

69. For laser action to occur, what is the minimum number of energy levels the lasing medium should have ?

(1) Two (2) Four (3) Three (4) Five

70. A certain ruby LASER emits 1.0 J pulses of light whose wavelength is 694 nm. What is the minimum number of Cr^{3+} ions in the ruby ?

(1) 1.0×10^{22} (2) 3.5×10^{23} (3) Avogadro number (4) 3.5×10^{18}

71. If amplitudes of two waves producing interference is 'a' each, then intensity of light at maxima is :

(1) $4a^2$ (2) $2a^2$ (3) $2a$ (4) $4a$

72. If in a Young's double slit experiment being performed with white light, one of the slits is covered with the red filter, while the other slit with the blue filter.

(1) There shall be no interference fringes

(2) There shall be an alternate interference pattern of red and blue

(3) There shall be an interference pattern of mixed color of red and blue

(4) None of the above

73. What is the shape of interference fringes in the Lloyd's mirror experiment ?

(1) Dark and bright straight fringes of equal width

(2) Dark and bright straight fringes of unequal width

(3) Dark and bright straight fringes of equal width with central fringe a dark one

(4) Dark and bright straight fringes of unequal width with central fringe a dark one

74. When light travels from rare to denser medium, it loses some speed. As a result :

(1) Energy carried by light decreases

(2) Energy carried by light stays constant

(3) Frequency of light reduces

(4) Energy carried by light increases

75. Consider the distribution of N molecules in two halves of a box partitioned by an imaginary wall. The most probable mode of distribution is the one for which the randomness (i.e. the degree of non-predictability) is :

(1) Maximum (2) Minimum

(3) Absolute zero (4) Either maximum or minimum

76. A real gas behaves like an ideal gas if its :

(1) Pressure and temperature are both high (2) Pressure and temperature are both low

(3) Pressure is high and temperature is low (4) Pressure is low and temperature is high

77. *N* distinguishable particles in a statistical system are somehow restricted to move in a plane. The dimensionality of its phase space will be :

(1) 4^N (2) 6^N (3) 4N (4) 2N

78. Two macroscopic systems, say A_1 and A_2, are allowed to have thermal contact. Obviously, there will be exchange of energy if A_1 and A_2 were at different temperatures. According to the postulates of statistical physics, the condition of equilibrium is (Ω denotes the number of microstates for a system) :

(1) $\frac{\partial}{\partial E} ln\Omega_1 = \frac{\partial}{\partial E} ln\Omega_2$ (2) $\frac{\partial}{\partial E}\Omega_1 = \frac{\partial}{\partial E}\Omega_2$

(3) $\frac{\partial}{\partial E}\Omega_1\Omega_2 = 0$ (4) $\frac{\partial}{\partial E}(\Omega_1 + \Omega_2) = 0$

79. The electronic heat capacity of a metal within the framework of Fermi-Dirac statistics depends on temperature as :

(1) AT^3 (2) AT (3) $AT^{3/2}$ (4) $AT^{1/2}$

80. The phenomenon of Bose-Einstein condensation may occur for a class of particles which are ?

(1) Indistinguishable and have half-integral spin

(2) Distinguishable and have integral spin

(3) Distinguishable and have half-integral spin

(4) Indistinguishable and have integral spin

81. If the speed of a particle moving at 0.4c is doubled, its momentum will :

(1) Become double

(2) Become more than double

(3) Remain unchanged

(4) Become slightly less than double

82. Which of the following is invariant in special theory of relativity ?

(1) Mass (2) Charge

(3) Speed of light (4) Charge as well as speed of light

83. A capacitor with capacitance $25\times10^{-6}\,F$ is charged by connecting it to a 300 V dc power supply. The capacitor is disconnected from the supply and connected across an inductor with $L=10^{-2}\,H$. What is the frequency and period of oscillation in the circuit ?

(1) 320 Hz; 3.1 ms (2) 220 Hz; 4.5 ms (3) 50 Hz; 0.02 s (4) 100 Hz; 0.01 s

84. A 200 Ω resistor and a 5 μF capacitor are connected in series with an alternating voltage source. The voltage across the resistor is v_R = (1.20 *V*) cos (2500 rad/*s*)*t*. The voltage across the capacitor will be :

(1) (0.48 *V*) cos [(2500 rad/*s*)*t* + π/2 rad] (2) (1.20 *V*) cos [(2500 rad/*s*)*t* – π/2 rad]

(3) (1.20 *V*) cos [(2500 rad/*s*)*t*] (4) (0.48 *V*) cos [(2500 rad/*s*)*t* – π/2 rad]

85. When a forward bias is applied to a *pn* junction, the drift current ?

(1) Increases (2) Decreases to zero

(3) Decreases, but not to zero (4) Remains unchanged

86. Which of the following is true about Hall effect in a semiconductor substance ? The Hall coefficient :

(I) Changes with doping concentration

(II) Depends on temperature

(III) Varies with probe current and magnetic field

(IV) Independent of probe current and magnetic field

(1) I, II and III (2) II and III (3) I, II and IV (4) IV and I

87. The color of the bright spot on the screen of a CRO is the characteristic of the :

(1) Signal being viewed

(2) Primary electrons emitted from the cathode

(3) Final speed with which the electrons strike the screen

(4) Coating material of the display screen

88. The maximum wavelength of electromagnetic radiation which can create a hole-electron pair in germanium (given that the band gap of germanium is 0.65 eV) is :

(1) 6×10^{-6} m (2) 1.6×10^{-6} m (3) 1.9×10^{-6} m (4) 1.9×10^{-5} m

89. If the load resistance of a CE amplifier increases, then its current gain :

(1) Decreases (2) Increases

(3) Increases followed by an initial decrease (4) Remains unchanged

90. A transistor has α = 0.98, IB = 100 μA and ICO = 6 μA. The value of IE will be :

(1) 5.3 mA (2) 6 mA (3) 4.6 mA (4) 9 mA

91. A body, initially at rest, explodes into two pieces of mass 2*M* and 3*M*, respectively, having a total kinetic energy *E*. The kinetic energy of the piece of mass 2*M* after the explosion is :

(1) *E*/3 (2) *E*/5 (3) 2*E*/5 (4) 3*E*/5

92. If a generalized coordinate has the dimension of momentum, the generalized velocity will have the dimension of :

(1) Velocity (2) Acceleration (3) Torque (4) Force

93. If a constant force acts on a particle, its acceleration will :

(1) Remain constant (2) Gradually decrease

(3) Gradually increase (4) Become undefined after some time

94. The law of conservation of linear momentum has its origin in :

(1) Translational symmetry of space (2) Isotropy of space

(3) Time invariance of space (4) Lagrange's equation

95. The Lagrange's equation for simple pendulum is (symbols have their usual meaning) :

(1) $\ddot{\theta}+\frac{g}{l}\sin\theta=0$ (2) $\ddot{\theta}+\frac{g}{l\sin\theta}=0$

(3) $\ddot{\theta}-\frac{g}{l}\sin\theta=0$ (4) $\ddot{\theta}+\frac{l}{g}\sin\theta=0$

96. A particle is constrained to move along the inner surface of a fixed hemispherical bowl. The number of degrees of freedom of the particle is :

(1) One (2) Two (3) Three (4) Four

97. If a linear harmonic oscillator has frequency f, the frequency of oscillation of the kinetic energy of oscillator is :

(1) f (2) $f/2$ (3) $2f$ (4) $4f$

98. The electric potential at point r inside a uniformly charged thin spherical shell with surface charge density σ and radius R is equal to (q is the total charge on the spherical shell) :

(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ (3) $\frac{1}{4\pi\varepsilon_0}\frac{\sigma}{r}$ (4) Zero

99. The induced electric field in the Maxwell equation $\oint\vec{E}.\,d\vec{l}=-\frac{d\Phi_B}{dt}$, is called a non-conservative field as the line integral of the electric field in electrostatics $\oint\vec{E}.\,d\vec{l}$ is always :

(1) Zero (2) 2π

(3) $\frac{d\Phi_B}{dt}$ (4) $2\pi\vec{E}$

100. In electromagnetic wave in free space, the phase difference between electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ is :

(1) Zero (2) $\pi/2$

(3) π (4) $3\pi/2$

Centralized entrance Exam 2019 Answer Key of Physics				
Question No.	A	B	C	D
1	4	4	1	2
2	4	2	1	1
3	2	3	3	4
4	1	1	2	2
5	1	2	1	1
6	2	1	4	2
7	3	2	3	2
8	2	3	1	4
9	1	4	2	2
10	1	4	4	3
11	4	2	2	3
12	2	1	4	2
13	3	2	1	1
14	1	1	4	2
15	2	1	4	1
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17	2	4	4	1
18	3	3	3	2
19	4	3	1	2
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43	3	2	3	2
44	2	3	2	1
45	1	1	4	1
46	4	2	3	2
47	3	1	4	4
48	1	2	1	3
49	2	2	1	3
50	4	3	4	4

Checked from original key & jumble chart

5/7/19 5/7/19 05/7/19

Centralized entrance Exam 2019 Answer Key of Physics				
Question No.	A	B	C	D
51	3	2	2	2
52	2	4	2	1
53	1	1	2	3
54	2	4	3	2
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97	4	1	1	3
98	3	1	2	2
99	3	3	2	1
100	4	4	1	1