Set No. 1

18P/218/21

7231

Total No. of Printed Pages : 32

Question Booklet No....................

(To be filled up by the candidate by blue/black ball-point pen)

Roll No. | | | | | | | | | | |

Roll No. *(Write the digits in words)* ....

Serial No. of OMR Answer Sheet ....

Centre Code No. | | | | |

....

Day and Date .... (Signature of Invigilator)

INSTRUCTIONS TO CANDIDATES

(Use only **blue/black ball-point pen** in the space above and on both sides of the OMR Answer Sheet)

1. Within 30 minutes of the issue of the Question Booklet, check the Question Booklet to ensure that it contains all the pages in correct sequence and that no page/question is missing. In case of faulty Question Booklet bring it to the notice of the Superintendent/Invigilators immediately to obtain a fresh Question Booklet.
2. Do not bring any loose paper, written or blank, inside the Examination Hall *except the Admit Card.*
3. A separate OMR Answer Sheet is given. *It should not be folded or mutilated. A second OMR Answer Sheet shall not be provided. Only the OMR Answer Sheet will be evaluated.*
4. Write all the entries by blue/black ball pen in the space provided above.
5. **On the front page of the OMR Answer Sheet, write by pen your Roll Number in the space provided at the top, and by darkening the circles at the bottom. Also, write the Question Booklet Number, Centre Code Number and the Set Number (wherever applicable) in appropriate places.**
6. No overwriting is allowed in the entries of Roll No., Question Booklet No. and Set No. (if any) on OMR Answer Sheet and also Roll No. and OMR Answer Sheet Serial No. on the Question Booklet.
7. Any change in the aforesaid entries is to be verified by the Invigilator, otherwise it will be taken as unfair means.
8. Each question in this Booklet is followed by four alternative answers. *For each question, you are to record the correct option on the OMR Answer Sheet by darkening the appropriate circle* in the corresponding row of the OMR Answer Sheet, by ball-point pen as mentioned in the guidelines given on the first page of the OMR Answer Sheet.
9. For each question, darken only one circle on the OMR Answer Sheet. If you darken more than one circle or darken a circle partially, the answer will be treated as incorrect.
10. *Note that the answer once filled in ink cannot be changed.* If you *do not wish to attempt* a question, leave all the circles in the corresponding row blank (such question will be awarded zero mark).
11. For rough work, use the inner back page of the title cover and the blank page at the end of this Booklet.
12. On completion of the Test, the Candidate must handover the OMR Answer Sheet to the Invigilator in the examination room/hall. However, candidates are allowed to take away Text Booklet and copy of OMR Answer Sheet with them.
13. Candidates are not permitted to leave the Examination Hall until the end of the Test.
14. If a candidate attempts to use any form of unfair means, he/she shall be liable to such punishment as the University may determine and impose on him/her.

[उपर्युक्त निर्देश हिन्दी में अन्तिम आवरण-पृष्ठ पर दिये गए हैं।]

SPACE FOR ROUGH WORK

रफ़ कार्य के लिए जगह

No. of Questions : 120

Time : 2 Hours **Full Marks** : 360

Note : (1) Attempt as many questions as you can. Each question carries **3** marks. **One** mark will be deducted for each incorrect answer. Zero mark will be awarded for each unattempted question.

(2) If more than one alternative answers seem to be approximate to the correct answer, choose the closest one.

1. A rigid body is constrained to move on a plane. Number of degrees of freedom for it will be

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

2. Number of generalized coordinates required to describe the motion of a solid cylinder rolling without slipping on an inclined plane is

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

3. The constraints of a rigid body is

(1) conservative and scleronomic

(2) conservative and rheonomic

(3) holonomic and rheonomic

(4) non-holonomic and scleronomic

4. Which one of the following represents the equation of motion for the system described by the Hamiltonian $H(q, p)$?

(1) $\dot{q} = \frac{\partial H}{\partial p}, \; \dot{p} = \frac{\partial H}{\partial q}$

(2) $-\dot{q} = \frac{\partial H}{\partial p}, \; \dot{p} = \frac{\partial H}{\partial q}$

(3) $\dot{q} = \frac{\partial H}{\partial p}, \; \dot{p} = -\frac{\partial H}{\partial q}$

(4) $\dot{q} = \frac{\partial H}{\partial q}, \; -\dot{p} = \frac{\partial H}{\partial p}$

5. A particle of unit mass moves in a potential $V(x) = x^3 - 3x + 2$. The angular frequency of small oscillation about the minimum of the potential is

(1) $\sqrt{6}$

(2) $\sqrt{3}$

(3) $\frac{1}{\sqrt{6}}$

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

6. A system is described by the Lagrangian $L(r, \theta, \dot{r}\,\dot{\theta}) = \frac{1}{2}m\dot{r}^2 + \frac{1}{2}mr^2\dot{\theta}^2 + \frac{1}{r}$.

Which one of the following is not true?

(1) Total energy of the system is conserved

(2) Angular momentum of the system is conserved

(3) θ is cyclic coordinate

(4) Linear momentum of system is conserved

7. If q_1 and q_2 are generalized coordinates and p_1 and p_2 are corresponding generalized momenta, then the Poisson bracket $\{q_1^2 + q_2^2, 2p_1 + p_2\}$ is

(1) 0

(2) $(q_1 + 2q_2)\,2p_1$

(3) $3(q_1^2 + q_2^2)$

(4) $2(2q_1 + q_2)$

8. Lagrangian for simple harmonic oscillator with frequency ω, mass m in one dimension is given by

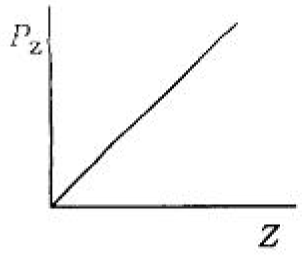
(1) $\frac{1}{2}m\,(\dot{x}^2 - \omega^2 x^2)$ (2) $\frac{1}{2}m\,(\dot{x}^2 + \omega^2 x^2)$

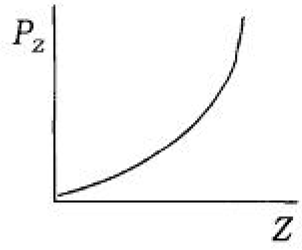
(3) $\frac{1}{2}m\,(\ddot{x} + \omega^2 x)$ (4) $\frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2$

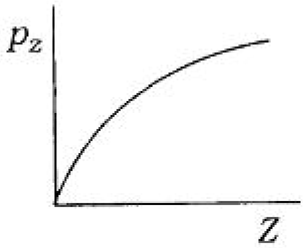
9. The probability distribution of a variable x in the range $-\infty$ to $+\infty$ is given by $P(x) = 10e^{-(2x^2-4x-6)}$. The maximum probability will correspond to

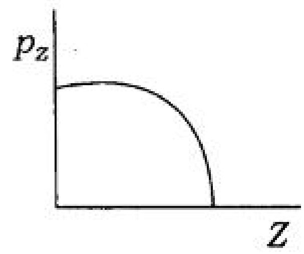
(1) $x = 1$ (2) $x = 0$ (3) $x = 3$ (4) $x = -1$

10. The phase space trajectory of a single particle, falling freely from a height will be

(1)


(2)


(3)


(4)


11. Number of microstates for a monoatomic ideal gas with N molecules in a volume V and with total energy E is proportional to

(1) E^N (2) $E^{3N/2}$ (3) $E^{N/2}$ (4) E^{3N}

12. If Q be the partition function of a system of particles in canonical ensemble, the average energy of the system is given by

(1) $\overline{E} = \frac{\partial Q}{\partial \beta}$ (2) $\overline{E} = -\frac{\partial Q}{\partial \beta}$ (3) $\overline{E} = \frac{\partial}{\partial \beta} \ln Q$ (4) $\overline{E} = -\frac{\partial}{\partial \beta} \ln Q$

13. Consider a system consisting of two particles each of which can be in any one of *three* quantum states $0, \varepsilon, 2\varepsilon$. The number of total configurations when the particles are identical bosons

(1) 9 (2) 6 (3) 5 (4) 3

14. Consider a gas of photons in a cubical container of edge length L and volume $V = L^3$. The mean pressure in terms of mean energy E is given by

(1) $\frac{E}{V}$ (2) $\frac{2}{3}\frac{E}{V}$ (3) $\frac{1}{3}\frac{E}{V}$ (4) 0

15. The statistical systems in which both energy and number of particles change are best described by

(1) micro-canonical ensemble theory

(2) canonical ensemble theory

(3) grand-canonical ensemble theory

(4) both canonical as well as grand-canonical ensemble theory

16. Relative root mean square fluctuation of energy in canonical ensemble theory is

(1) $\propto T^{1/2}$ (2) $\propto T$ (3) $\propto T^2$ (4) $\propto T^{3/2}$

17. Given three isobars, namely; ${}^{25}_{11}Na$, ${}^{25}_{12}Mg$ and ${}^{25}_{13}Al$

(1) ${}^{25}_{11}Na$ is stable and the other two are beta emitters

(2) ${}^{25}_{12}Mg$ is stable and the other two are beta emitters

(3) ${}^{25}_{13}Al$ is stable and the other two are beta emitters

(4) All nuclei are stable

18. Radiocarbon dating is done by estimating in the specimen

(1) the ratio of amount of ${}^{14}C$ to ${}^{12}C$ still present

(2) the ratio of amount of ${}^{13}C$ to ${}^{12}C$ still present

(3) the amount of radiocarbon still present

(4) the amount of ${}^{13}C$ still present

19. The rate of electron emission from 4 mg of ${}^{210}_{80}Pb$ with half-life 5 days is

(1) $1 \cdot 84 \times 10^{16}$ (2) $1 \cdot 84 \times 10^{13}$ (3) $9 \cdot 2 \times 10^{11}$ (4) $9 \cdot 2 \times 10^{16}$

20. A proton with 16 MeV energy is bombarded on ${}^{216}_{84}Po$ nucleus. The proton is

(1) scattered

(2) reflected back

(3) captured

(4) transmitted through the nucleus

21. The fission rate of ^{235}U to produce energy of 200 MW is

(1) $6 \cdot 25 \times 10^{15}$ fission/sec (2) $6 \cdot 25 \times 10^{16}$ fission/sec

(3) $6 \cdot 25 \times 10^{18}$ fission/sec (4) $3 \cdot 12 \times 10^{20}$ fission/sec

22. The minimum temperature required to initiate fusion of deuteron and triton is of the order of

(1) 10^9 K (2) 10^6 K (3) 10^{13} K (4) 10^{15} K

23. The average velocity of nucleons inside the nucleus is of the order of

(1) 3×10^8 m/s (2) 6×10^7 m/s (3) 3×10^6 m/s (4) 6×10^6 m/s

24. the magnetic dipole and electric quadrupole moment data of deuteron imply that the nuclear force is

(1) purely central

(2) central and spin dependent

(3) mixture of central and non-central components

(4) velocity dependent

25. In a crystal, a lattice plane cuts intercepts of $2a, 3b$ and $6c$ along the axes, where a, b, c are primitive vectors of the unit cell. The Miller indices of the given plane are

(1) (321) (2) (231) (3) (123) (4) (213)

26. The total number of Bravais lattices are

(1) 7 (2) 14 (3) 21 (4) 26

27. Origin of characteristic X-rays is

(1) photoelectric effect

(2) inverse photoelectric effect

(3) electronic transitions within atoms

(4) Compton effect

28. The K_α line from Molybdenum has a wavelength of 0·7078 Å. The wavelength of the K_α line of copper (given atomic number of Molybdenum = 42, atomic number of copper = 29)

(1) 1·517 Å (2) 1·157 Å (3) 1·175 Å (4) 1·715 Å

29. The relation of the reciprocal basis vector $\vec{A}$ to the direct basis vector $\vec{a}$ is given by

(1) $\vec{A}\cdot\vec{a}=0$ (2) $\vec{A}\cdot\vec{a}=2\pi$ (3) $\vec{A}\cdot\vec{a}=\pi$ (4) $\vec{A}\cdot\vec{a}=\frac{\pi}{2}$

30. If current carriers are electrons, the Hall coefficient R_H is

(1) $R_H=-\frac{1}{ne}$ (2) $R_H=\frac{1}{ne}$ (3) $R_H=\frac{n}{e}$ (4) $R_H=ne$

31. The electron velocity, v_F, at the Fermi surface is

(1) $\hbar\left(\frac{3\pi^2 N}{V}\right)^{1/3}$ (2) $\frac{\hbar}{m}\left(\frac{3\pi^2 N}{V}\right)^{1/3}$

(3) $\frac{\hbar}{m}\left(\frac{3\pi N}{V}\right)^{1/3}$ (4) $\frac{\hbar}{m}\left(\frac{\pi^2 N}{V}\right)^{1/3}$

32. The Langevin function, $L(\alpha)$ is represented by

(1) $L(\alpha) = \cot h\alpha$

(2) $L(\alpha) = \left[\cot h\alpha + \frac{1}{\alpha}\right]$

(3) $L(\alpha) = \left[\cot h\alpha - \frac{1}{\alpha}\right]$

(4) $L(\alpha) = (\cot h\alpha - \alpha)$

where the symbols have their usual meanings.

33. The curl of the electromagnetic intensity is

(1) conservative (2) rotational (3) divergent (4) static

34. The direction of propagation of electromagnetic wave is given by

(1) $\vec{E} \cdot \vec{B}$ (2) $\vec{E}$ (3) $\vec{E} \times \vec{B}$ (4) $\vec{B}$

35. For good conductors, the skin depth varies inversely with

(1) ω (2) ω^2 (3) $\sqrt{\omega}$ (4) ω^4

36. The divergence of the curl of a vector field is

(1) a scalar (2) a vector (3) zero (4) infinity

37. The charge build up in the capacitor is due to which quantity?

(1) Conduction current

(2) Displacement current

(3) Convection current

(4) Direct current

38. In conductors, which condition will be true?

(1) $\sigma\omega\varepsilon > 1$ (2) $\frac{\sigma}{(\omega\varepsilon)} > 1$ (3) $\frac{\sigma}{\omega\varepsilon} < 1$ (4) $\sigma\omega\varepsilon < 1$

39. the relation between the speed of light, permeability and permittivity is

(1) $c = \mu\varepsilon$ (2) $c = \frac{\mu}{\varepsilon}$ (3) $c = \frac{1}{\sqrt{\mu\varepsilon}}$ (4) $c = \frac{1}{\mu\varepsilon}$

40. The phenomenon employed in the waveguide operation is

(1) reflection (2) refraction

(3) total internal reflection (4) absorption

41. The metric of spherical polar coordinates are

(1) $h_{11} = r,\ h_{22} = 1,\ h_{33} = r \sin\theta$

(2) $h_{11} = 1,\ h_{22} = r,\ h_{33} = r \sin\theta$

(3) $h_{11} = r,\ h_{22} = r \sin\theta,\ h_{33} = 1$

(4) $h_{11} = r^2,\ h_{22} = r^2 \sin^2\theta,\ h_{33} = r^2 \sin^2\theta$

42. Given the transformation $u = x + y, v = x - y$ and $du\,dv = k dx\,dy$, the value of k is

(1) 1 (2) −1 (3) 2 (4) $\frac{1}{2}$

43. Given $A = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$, then $(aI + bA)^n$ is (where I is 2×2 unit vector)

(1) $a^n I + b^n A$

(2) $a^n I + nab^{n-1} A$

(3) $a^n I + nabA$

(4) $a^n I + na^{n-1} bA$

44. Eigenvectors of the matrix $\begin{pmatrix} 0 & i \\ -i & 0 \end{pmatrix}$ are

(1) $\begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

(2) $\frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ -i \end{pmatrix}, \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ i \end{pmatrix}$

(3) $\frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ 1 \end{pmatrix}, \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ 1 \end{pmatrix}$

(4) $\frac{1}{\sqrt{2}}\begin{pmatrix} i \\ 1 \end{pmatrix}, \frac{1}{\sqrt{2}}\begin{pmatrix} i \\ 1 \end{pmatrix}$

45. Given the matrix $\begin{pmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{pmatrix}$ with one of the eigenvalues equal to -3, the other two eigenvalues are

(1) 0, 1

(2) 0, −1

(3) 0, 2

(4) −3, 5

46. In the equation $x^2 \frac{d^2 y}{dx^2} + x \frac{dy}{dx} + (q^2 x^2 - m^2) y = 0$

(1) $x = 0$ and $x = \infty$ are ordinary points

(2) $x = 0$ and $x = \infty$ are regular singular points

(3) $x = 0$ is a regular singular point and $x = \infty$ is an irregular singular point

(4) $x = 0$ and $x = \infty$ are irregular singular points

47. One of the solutions of the equation $(1-x^2)\dfrac{d^2y}{dx^2}-2x\dfrac{dy}{dx}+12y=0$ is

(1) $H_4(x)$ (2) $P_3(x)$ (3) $L_4(x)$ (4) $J_4(x)$

48. The Delta function $\delta(x^2-a^2)$ is equal to

(1) $\delta(x+a)\delta(x-a)$

(2) $\delta(x+a)+\delta(x-a)$

(3) $\dfrac{1}{2|a|}[\delta(x+a)+\delta(x-a)]$

(4) $\delta(x+a)-\delta(x-a)$

49. The Fourier coefficients of the function

$$f(x)=\begin{cases}0 & \text{for } -L\le x\le 0\\ 1 & \text{for } 0\le x\le L\end{cases}$$

expanded in Fourier series are

(1) $a_0=1,\ a_n=0,\ b_n=\dfrac{1}{n\pi}[1-(-1)^n]$

(2) $a_0=1,\ a_n=[1-(-1)^n],\ b_n=0$

(3) $a_0=1,\ a_n=0,\ b_n=0$

(4) $a_0=1,\ a_n=1,\ b_n=\dfrac{1}{n\pi}[1-(-1)^n]$

50. The operator $i\hbar\dfrac{d}{d\hat{x}}-\hat{x}$ in momentum basis is

(1) $i\hbar\dfrac{d}{d\hat{p}}-\hat{p}$

(2) $-i\hbar\dfrac{d}{d\hat{p}}-\hat{p}$

(3) $-i\hbar\dfrac{d}{d\hat{p}}+\hat{p}$

(4) $i\hbar\dfrac{d}{d\hat{p}}+\hat{p}$

51. If a^+ and a are creation and annihilation operators for SHO, then which of the following is not a Hermitian operator

(1) $aa^+ + a^+a$ (2) $aa^+ - a^+a$ (3) $i(a^+ - a)$ (4) $i(a^+ + a)$

52. If the expectation value of the momentum operator in the normalized state $\psi(x)$ is $\langle p \rangle$, then expectation value of the momentum operator *in the state* $\psi_1(x) = e^{\frac{i}{\hbar}p_0 x}\psi(x)$ will be

(1) $\langle p \rangle + p_0$ (2) $\langle p \rangle - p_0$ (3) $\langle p \rangle$ (4) 0

53. The ground state wave function for a $1-d$ system described by the potential

$$V(x) = 0 \text{ for } -\frac{L}{2} \le x \le \frac{L}{2}$$
$$= \infty \quad \text{elsewhere}$$

is

(1) $A\cos\frac{\pi x}{L}$ (2) $A\sin\frac{\pi x}{2L}$ (3) $A\sin\frac{\pi x}{L}$ (4) $A\cos\frac{\pi x}{2L}$

54. A simple harmonic oscillator in one dimension has an eigenfunction (of the Hamiltonian) which vanishes 3 times in the interval $0 < x < \infty$ and is odd under parity. The energy eigenvalue for this state is

(1) $\frac{7}{2}\hbar\omega$ (2) $\frac{9}{2}\hbar\omega$ (3) $\frac{13}{2}\hbar\omega$ (4) $\frac{15}{2}\hbar\omega$

55. The raising and lowering of angular momentum operators are defined as $L_\pm = L_x \pm iL_y$. The commutator $[L_-, L_z]$ is equal to

(1) $-2\hbar L_-$ (2) $\hbar L_-$ (3) $\hbar L_+$ (4) $-\hbar L_-$

56. The bound state energy for the state $\psi_{5,4,2}(r, \theta, \phi)$ in a H-atom problem is given by

(1) $-\frac{13 \cdot 6}{5}$ eV   (2) $-\frac{13 \cdot 6}{25}$ eV

(3) $-13 \cdot 6 \times 5$ eV   (4) $-13 \cdot 6 \times 25$ eV

57. In a H-atom problem if $L_z \psi_{3,2,-2}(r, \theta, \phi) = a\hbar \psi_{3,2,-2}(r, \theta, \phi)$, then a is

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

58. ψ_1 and ψ_2 are the wave functions of two orthogonal states of a system belonging to the energy eigenvalues E and $-E$, respectively. In a measurement of energy of another state ψ of the system, the expectation value of energy is found to be $\frac{E}{2}$. ψ in terms of ψ_1 and ψ_2 is

(1) $\frac{\sqrt{3}}{2}\psi_1 + \frac{1}{2}\psi_2$ (2) $\frac{1}{2}(\psi_1 - \psi_2)$

(3) $\frac{1}{\sqrt{2}}(\psi_1 - \psi_2)$ (4) $\frac{3}{4}\psi_1 + \frac{1}{4}\psi_2$

59. In any Bohr orbit of hydrogen atom, the ratio of the kinetic energy to the potential energy of the electron is

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

60. Considering the nuclear mass finite, the Rydberg constant is maximum for

(1) hydrogen atom   (2) deuterium atom

(3) singly ionized helium atom   (4) doubly ionized lithium atom

61. In Sommerfeld's model of atom, the orbits characterized by a particular principal quantum number, n and different azimuthal quantum number $n_\theta = 1, 2, 3, \cdots, n$ have

(1) same energy

(2) energy in increasing order with n_θ

(3) energy in decreasing order with n_θ

(4) no associated energy

62. Stern-Gerlach experiment is important because it gives experimental verification of

(1) quantization of energy of atom

(2) orbital motion of electron

(3) electron spin

(4) Sommerfeld model of atom

63. The ratio of orbital magnetic dipole moment μ_l to the orbital angular momentum L of an electron in an orbit is given by

(1) $\frac{\mu_L}{L} = \frac{\mu_b}{\hbar}$ (2) $\frac{\mu_L}{L} = -\frac{\mu_b}{\hbar}$ (3) $\frac{\mu_L}{L} = -\frac{\mu_b}{2\hbar}$ (4) $\frac{\mu_L}{L} = \frac{\mu_b}{2\hbar}$

μ_b = Bohr magneton.

64. Larmor frequency is the frequency of precession of

(1) orbital angular momentum, L about the external magnetic field, B

(2) spin angular momentum, S about the external magnetic field, B

(3) total angular momentum, J about the external magnetic field, B

(4) orbital angular momentum, L about the total angular momentum, J

65. On application of weak **magnetic field** the sodium line arising due to the transition $^2P_{3/2} \rightarrow {}^2S_{1/2}$ will split ideally into

(1) 2 components

(2) 4 components

(3) 6 components

(4) 10 components

66. The half-width of gain profile of a He-Ne laser is 2×10^{-3} nm. If the length of the cavity is 30 cm, how many longitudinal modes can be excited? The emission *wavelength is* 6328 Å

(1) 1

(2) 2

(3) 3

(4) 4

67. At what temperature; pressure remaining unchanged, will the molecular velocity (root mean square velocity) of hydrogen will be double of its *value* at NTP ?

(1) 1092 °C

(2) 819 °C

(3) 1092 °F

(4) 819 °K

68. The mean square speed for the following group of particles (N_i represents the number of particles with speed v_i) will be

N_i	v_i (m/sec)
2	1·0
4	2·0
8	3·0

(1) 11·33 m/sec

(2) 16·43 m^2/sec^2

(3) 2·67 m/sec

(4) 3·36 m/sec

69. The ratio between most probable speed and root mean square speed of a gas molecule is

(1) $\sqrt{\frac{3}{2}}$ (2) $\sqrt{\frac{3}{8\pi}}$ (3) $\sqrt{\frac{2}{3}}$ (4) $\sqrt{\frac{8}{3\pi}}$

70. The mean free path of molecules of a gas at pressure p and temperature T is 2×10^{-5} cm. The mean free path at pressure $\frac{p}{2}$ and temperature $2T$ will be

(1) 10^{-5} cm (2) 8×10^{-5} cm (3) 10^{-5} m (4) 8×10^{-5} m

71. For the adiabatic expansion of a blackbody radiation enclosure, which of the following is correct?

(1) $V^{1/3}T$ = constant

(2) $V\cdot T$ = constant

(3) $V^{4/3}T$ = constant

(4) $\frac{V}{T}$ = constant

where V is the volume and T is the temperature of the enclosure.

72. In throttling process,

(1) the enthalpy remains constant

(2) temperature remains constant

(3) Gibbs' free energy remains constant

(4) entropy remains constant

73. Which one of the following is correct?

(1) $\frac{E_\lambda}{T^4}$ = constant (2) $\frac{E_\lambda}{T^5}$ = constant

(3) $\frac{E_\lambda}{T^2}$ = constant (4) $\frac{E_\lambda}{T}$ = constant

where E_λ is spectral emissive power.

74. The numerical value of the slope of an isenthalpic curve at any point on a TP-diagram is called

(1) Joule coefficient (2) Joule-Kelvin coefficient

(3) Van der Waals' constant (4) Virial coefficient

75. Which of the following can be used to produce lowest temperature?

(1) Liquefaction of N_2

(2) Liquid He

(3) Adiabatic demagnetization of paramagnetic salts

(4) None of these

76. A mass m of water at T_1K is isobarically and adiabatically mixed with an equal mass of water at T_2K, the entropy change of the universe is

(1) $2mC_p \ln \frac{(T_1 + T_2)/2}{\sqrt{T_1 T_2}}$ (2) $2m \ln \frac{(T_1 + T_2)/2}{\sqrt{T_1 T_2}}$

(3) $2C_p \ln \frac{(T_1 + T_2)/2}{\sqrt{T_1 T_2}}$ (4) $2mC_P$

where C_P is specific heat at constant pressure.

77. Thermodynamic equation

$$TdS = C_V dT + \frac{\beta T}{k} dV$$

is called

(1) 2nd TdS equation
(2) 1st TdS equation
(3) 3rd TdS equation
(4) None of these

where terms have their usual meanings.

78. Which of the following is correct?

(1) $C_P = \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial T}\right)_S$
(2) $C_P = T\left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial T}\right)_S$
(3) $C_P = \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial P}{\partial T}\right)_S$
(4) $C_P = T\left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial P}{\partial T}\right)_S$

79. In one-dimensional elastic collision of two particles, the ratio of velocities of separation and approach is equal to :

(1) coefficient of restitution
(2) negative of coefficient of restitution
(3) zero, if collision is perfectly elastic
(4) infinite

80. If in an elastic collision, a massive particle collides against a lighter one at rest :

(1) it can never bounce back along its original path
(2) it may bounce back along its original path
(3) the two particles move at right angles to each other after collision
(4) None of the above

81. In which of the following conditions, the total linear momentum of the system remains constant?

(1) If the resultant external force acting on the system of particles is zero

(2) If the resultant external force acting on the system of particles is positive

(3) If the resultant external force acting on the system of particles is –ve

(4) None of these

82. From the nozzle of a rocket, 100 kg of gases are exhausted per sec with a velocity of 1000 m/sec. What force (thrust) does the gas exert on the rocket?

(1) 100 kg/sec (2) 10^5 Newton (3) 10^3 Newton (4) 100 Newton

83. If a particle is at rest relative to an observer at rest at the centre of a rotating frame of reference

(1) centrifugal and Coriolis forces both act

(2) only centrifugal force acts

(3) only Coriolis force acts

(4) None of these

84. The length of a rod, of length 5 m in a frame of reference which is moving with $0 \cdot 6c$ velocity in a direction making 30° angle with the rod is nearly

(1) 4·3 m (2) 3·4 m (3) 2·43 m (4) 2·34 m

85. π^+ meson decays into a μ^+ meson and a neutrino with a mean lifetime of abou $2 \cdot 5 \times 10^{-8}$ sec in a frame in which it is at rest. If the velocity of the π^+ mesons i the laboratory frame be $0 \cdot 9c$, then the expected lifetime in this frame is

(1) $5 \cdot 7 \times 10^{-8}$ sec
(2) $2 \cdot 5 \times 10^{-8}$ sec
(3) $3 \cdot 1 \times 10^{-8}$ sec
(4) None of these

86. The speed of an electron having kinetic energy 2 MeV will be

(1) $2 \cdot 93 \times 10^{8}$ m/sec
(2) 3×10^{8} m/sec
(3) 10^{8} m/sec
(4) $1 \cdot 5 \times 10^{8}$ m/sec

87. Which of the following relations is correct for modulus of rigidity η, bu modulus K and Poisson's ratio σ ?

(1) $\sigma = \frac{K - 2\eta}{6K + 2\eta}$
(2) $\sigma = \frac{3K - 2\eta}{K + 2\eta}$
(3) $\sigma = \frac{3K - 2\eta}{6K + 2\eta}$
(4) $\sigma = \frac{K - 2\eta}{K + 2\eta}$

88. Two wires A and B of the same material and equal lengths but of radii r and are soldered coaxially. The free end of B is twisted by an angle Φ. The ratio of t twist at the junction and angle Φ is

(1) $\frac{16}{1}$
(2) $\frac{17}{16}$
(3) $\frac{16}{17}$
(4) $\frac{1}{16}$

89. Which of the following is true about liquid flow through a capillary tube?

(1) The velocity of the liquid layer in contact with the capillary tube is lea
(2) The velocity of the liquid layer in contact with the capillary tube maximum
(3) The velocity of the liquid layer at the centre of the capillary tube is minimu
(4) None of these

90. The depletion region is created by

(1) ionization (2) diffusion

(3) recombination (4) (1), (2) and (3)

91. A silicon diode is in series with a 1 kΩ resistor and a 5 V battery. If the anode is connected to the +ve battery terminal, the cathode voltage with respect to the negative battery terminal is

(1) 0·7 V (2) 0·3 V (3) 5·7 V (4) 4·3 V

92. Where will be the position of the Fermi level of the *n*-type material when $N_D = N_A$?

(1) E_C (2) E_V

(3) $\frac{E_C + E_V}{2}$ (4) None of the above

where terms have their usual meanings.

93. The mobility of electrons in a material is expressed in unit of

(1) V/s (2) $\left(\frac{m^2}{V\ sec}\right)$ (3) m^2/s (4) J/K

94. A silicon sample is uniformly doped with 10^{16} phosphorus atoms/cm^3 and 2×10^{16} boron atoms/cm^3. If all the dopants are fully ionized, the material is

(1) n-type with carrier concentration of $3 \times 10^{16}/\text{cm}^3$

(2) p-type with carrier concentration of $10^{16}/\text{cm}^3$

(3) p-type with carrier concentration of $4 \times 10^{16}/\text{cm}^3$

(4) intrinsic

95. The bias condition for a transistor to be used as a linear amplifier is called

(1) forward-reverse
(2) forward-forward
(3) reverse-reverse
(4) collector bias

96. Wien-bridge oscillators are based on

(1) positive feedback
(2) negative feedback
(3) the piezoelectric effect
(4) high gain

97. Which of the following is a universal gate?

(1) OR gate
(2) NOR gate
(3) AND gate
(4) NOT gate

98. For an ideal dielectric, polarization $\vec{P}$ is given by

(1) $\vec{P} = \varepsilon_0 \vec{E}$
(2) $\vec{P} = (K-1)\,\varepsilon_0 \vec{E}$
(3) $\vec{P} = (K+1)\,\varepsilon_0 \vec{E}$
(4) $\vec{P} = \dfrac{\varepsilon_0}{K-1} \vec{E}$

99. Clausius-Mossotti relation is represented by the equation

(1) $\alpha = \frac{3\varepsilon_0}{n} \frac{K-1}{K+2}$

(2) $\alpha = \frac{\varepsilon_0}{n} \frac{K-1}{K+2}$

(3) $\alpha = \frac{\varepsilon_0}{3n} \frac{K-1}{K+2}$

(4) $\alpha = \frac{3\varepsilon_0}{n} \frac{K+2}{K-1}$

where symbols have their usual meanings.

100. The dipole moment of water molecule is $6 \cdot 2 \times 10^{-30}$ C-m at 20 °C. The polarizability α is

(1) $3 \cdot 17 \times 10^{-39}$ C-m^2/V

(2) $3 \cdot 17 \times 10^{-37}$ C-m^2/V

(3) $3 \cdot 17 \times 10^{-35}$ C-m^2/V

(4) $3 \cdot 17 \times 10^{-33}$ C-m^2/V

101. Three magnetic vectors are related as

(1) $\vec{B} = \mu_0 (\vec{M} - \vec{H})$

(2) $\vec{B} = \mu_0 (\vec{M} + \vec{H})$

(3) $\vec{B} = \mu_0^{-1} (\vec{M} + \vec{H})$

(4) $\vec{B} = \mu_0^{-1} (\vec{M} - \vec{H})$

102. For higher values of temperature, the susceptibility of paramagnetic substances is proportional to

(1) T

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

(3) T^2

(4) $\frac{1}{T^2}$

103. The loss of energy per hour in the iron core of a transformer, the hysteresis loop of which is equivalent in area to 2500 ergs/cm^3, is (given frequency = 50 Hz, density of iron = $7 \cdot 5$ g/cm^3, weight of the iron core = 10 kg)

(1) $5 \cdot 985 \times 10^2$ J
(2) $5 \cdot 985 \times 10^3$ J
(3) $5 \cdot 985 \times 10^4$ J
(4) $5 \cdot 985 \times 10^5$ J

104. A current i is flowing in a toroidal coil of circular cross-section of radius R with N number of turns distributed uniformly over its circumference. If A is the cross-sectional area of the toroid, its self-inductance will be

(1) $L = \frac{\mu_0 N^2 A}{2\pi R}$
(2) $L = \frac{\mu_0 N^2 A}{\pi R}$
(3) $L = \frac{\mu_0 N^2 A}{4\pi R}$
(4) $L = \frac{\mu_0 N^2 A}{2R}$

105. Two inductors L_1 and L_2 are connected in series. The total inductance L will be

(1) $L = L_1 + L_2$
(2) $L = L_1 + L_2 + 2M$
(3) $L = L_1 + L_2 + M$
(4) $L = L_1 + L_2 - M$

where M is mutual inductance of two coils.

106. A circuit containing resistor R_1, inductor L_1 and capacitor C_1 connected in series gives resonance at the same frequency f as the second similar combination R_2, L_2 and C_2. If the two circuits are connected in series, the whole circuit will resonate at the frequency

(1) $2f$
(2) $\frac{f}{2}$
(3) f
(4) $\frac{f}{4}$

107. A capacitor of 250 pF is connected in parallel with a coil having inductance of 16 mH and effective resistance 20 Ω. The circuit impedance at resonance is

(1) $3 \cdot 2 \times 10^4$ Ω (2) $3 \cdot 2 \times 10^3$ Ω

(3) $3 \cdot 2 \times 10^2$ Ω (4) $3 \cdot 2 \times 10^5$ Ω

108. For dispersive medium, group velocity (v_g) and phase velocity (v_p) are related as

(1) $v_g = v_p + \lambda \frac{dv_p}{d\lambda}$ (2) $v_g = v_p - \lambda \frac{dv_p}{d\lambda}$

(3) $v_g = v_p + \frac{1}{\lambda} \frac{dv_p}{d\lambda}$ (4) $v_g = v_p - \frac{1}{\lambda} \frac{dv_p}{d\lambda}$

109. Photon of energy 1·02 MeV undergoes Compton scattering through 180°. The energy of the scattered photon is

(1) 1·02 MeV (2) 0·204 MeV (3) 0·402 MeV (4) 0·240 MeV

110. In Newton's ring experiment, the diameters of the bright rings are proportional to the

(1) natural number

(2) square root of natural numbers

(3) square root of odd numbers

(4) odd numbers

111. A thin sheet of a transparent material of refractive index, $\mu = 1 \cdot 50$ is placed in the path of one of the interfering beams in a biprism experiment with a monochromatic source of wavelength, $\lambda = 5000$ Å. The central fringe shifts to a position originally occupied by 10th bright fringe. the thickness of the sheet is

(1) 1×10^{-5} m
(2) $1 \cdot 5 \times 10^{-5}$ m
(3) 2×10^{-5} m
(4) $2 \cdot 5 \times 10^{-5}$ m

112. Interference pattern is produced by two point sources S_1 and S_2 on a plane perpendicular to the line joining S_1 and S_2. What will be the shape of interference fringes?

(1) Straight line
(2) Circular
(3) Parabolic
(4) Hyperbolic

113. In order to make a glass plate of refractive index, μ_g non-reflecting over a wide wavelength range around λ, a thin film is deposited on it. The refractive index μ_f and the thickness d of the film should be

(1) $\mu_f = \sqrt{\mu_g \mu_a}$, $d = \frac{3\lambda}{4\mu_f}$
(2) $\mu_f = \sqrt{\mu_g \mu_a}$, $d = \frac{\lambda}{4\mu_f}$
(3) $\mu_f = \sqrt{\mu_g / \mu_a}$, $d = \frac{\lambda}{4\mu_f}$
(4) $\mu_f = \sqrt{\mu_g / \mu_a}$, $d = \frac{3\lambda}{4\mu_f}$

where μ_a is the refractive index of air.

114. When the distance between two mirrors in Michelson interferometer is decreased

(1) the fringe pattern appears to collapse at the centre
(2) the fringe pattern expands
(3) the fringe pattern remains stable
(4) the shape of the fringe changes

115. The spread of the central maximum in the Fraunhofer diffraction by a single slit is approximately given by

(1) $\frac{\lambda}{b} \leq \theta \leq \frac{\lambda}{b}$ (2) $\frac{2\lambda}{b} \leq \theta \leq \frac{2\lambda}{b}$ (3) $\frac{\lambda}{2b} \leq \theta \leq \frac{\lambda}{2b}$ (4) $\frac{\lambda}{b} \leq \theta \leq \frac{\lambda}{2b}$

where θ is diffraction angle, b is width of the slit and λ is the wavelength of the light used.

116. A 2 mW laser beams of wavelength $\lambda = 6 \times 10^{-5}$ cm is focussed on the retina by a human eye lens of focal length $f = 2 \cdot 5$ cm and pupil diameter 2 mm. The intensity on the retina will be of the order of

(1) 10^4 W/m^2 (2) 10^6 W/m^2 (3) 10^8 W/m^2 (4) 10^2 W/m^2

117. To increase the resolving power of a grating total number of lines on the grating is increased such that the grating element becomes $2 \cdot 5\,\lambda$. How many orders will be seen on the screen?

(1) First order only

(2) First and second orders only

(3) First, second and third orders only

(4) First, second, third and fourth orders only

118. The radii of the circles of a zone plate is given by $r_n = 0 \cdot 1\sqrt{n}$ cm. The most intense focal point for wavelength $\lambda = 5 \times 10^{-5}$ cm will be at a distance

(1) 50 cm (2) 100 cm (3) 150 cm (4) 200 cm

119. What is the minimum thickness of the base of a prism that can just resolve the two lines of sodium light centred at 5890 Å and 5896 Å. The given value of refractive index of prism material is 1·6545 at wavelength 6563 Å and 1·6635 at wavelength 5270 Å ?

(1) 8 mm (2) 10 mm (3) 12 mm (4) 14 mm

120. An unpolarized light is incident on a glass plate placed in air at polarizing angle. The reflected light is

(1) plane polarized with electric vector perpendicular to the plane of incidence

(2) plane polarized with electric vector parallel to the plane of incidence

(3) partially polarized having more electric field vectors perpendicular to the plane of incidence

(4) partially polarized having more electric field vectors parallel to the plane of incidence

★★★

SPACE FOR ROUGH WORK

रफ़ कार्य के लिए जगह

अभ्यर्थियों के लिए निर्देश

(इस पुस्तिका के प्रथम आवरण-पृष्ठ पर तथा ओ०एम०आर० उत्तर-पत्र के दोनों पृष्ठों पर केवल नीली/काली बाल-प्वाइंट पेन से ही लिखें)

1. प्रश्न-पुस्तिका मिलने के 30 मिनट के अन्दर ही देख लें कि प्रश्नपत्र में सभी पृष्ठ मौजूद हैं और कोई पृष्ठ या प्रश्न छूटा नहीं है। पुस्तिका दोषयुक्त पाये जाने पर इसकी सूचना तत्काल कक्ष-निरीक्षक को देकर सम्पूर्ण प्रश्नपत्र की दूसरी पुस्तिका प्राप्त कर लें।

2. परीक्षा भवन में *प्रवेश-पत्र के अतिरिक्त*, लिखा या सादा कोई भी खुला कागज साथ में न लायें।

3. ओ०एम०आर० उत्तर-पत्र अलग से दिया गया है। ***इसे न तो मोड़ें और न ही विकृत करें। दूसरा ओ०एम०आर० उत्तर-पत्र नहीं दिया जायेगा। केवल ओ०एम०आर० उत्तर-पत्र का ही मूल्यांकन किया जायेगा।***

4. सभी प्रविष्टियाँ प्रथम आवरण-पृष्ठ पर नीली/काली बाल पेन से निर्धारित स्थान पर लिखें।

5. **ओ०एम०आर० उत्तर-पत्र के प्रथम पृष्ठ पर पेन से अपना अनुक्रमांक निर्धारित स्थान पर लिखें तथा नीचे दिये वृत्तों को गाढ़ा कर दें। जहाँ-जहाँ आवश्यक हो वहाँ प्रश्न-पुस्तिका का क्रमांक एवं केन्द्र कोड नम्बर तथा सेट का नम्बर उचित स्थानों पर लिखें।**

6. ओ०एम०आर० उत्तर-पत्र पर अनुक्रमांक संख्या, प्रश्न-पुस्तिका संख्या व सेट संख्या (यदि कोई हो) तथा प्रश्न-पुस्तिका पर अनुक्रमांक सं० और ओ०एम०आर० उत्तर-पत्र सं० की प्रविष्टियों में उपरिलेखन की अनुमति नहीं है।

7. उपर्युक्त प्रविष्टियों में कोई भी परिवर्तन कक्ष निरीक्षक द्वारा प्रमाणित होना चाहिये अन्यथा यह एक अनुचित साधन का प्रयोग माना जायेगा।

8. प्रश्न-पुस्तिका में प्रत्येक प्रश्न के चार वैकल्पिक उत्तर दिये गये हैं। ***प्रत्येक प्रश्न के वैकल्पिक उत्तर के लिये आपको ओ०एम०आर० उत्तर-पत्र की सम्बन्धित पंक्ति के सामने दिये गये वृत्त को ओ०एम०आर० उत्तर-पत्र के प्रथम पृष्ठ पर दिये गये निर्देशों के अनुसार पेन से गाढ़ा करना है।***

9. प्रत्येक प्रश्न के उत्तर के लिये केवल एक ही वृत्त को गाढ़ा करें। एक से अधिक वृत्तों को गाढ़ा करने पर अथवा एक वृत्त को अपूर्ण भरने पर वह उत्तर गलत माना जायेगा।

10. ध्यान दें कि एक बार स्याही द्वारा अंकित उत्तर बदला नहीं जा सकता है। यदि आप किसी प्रश्न का *उत्तर नहीं देना चाहते हैं*, तो सम्बन्धित पंक्ति के सामने दिये गये सभी वृत्तों को खाली छोड़ दें। ऐसे प्रश्नों पर शून्य अंक दिये जायेंगे।

11. रफ कार्य के लिये प्रश्न-पुस्तिका के मुखपृष्ठ के अन्दर वाले पृष्ठ तथा अंतिम पृष्ठ का प्रयोग करें।

12. परीक्षा की समाप्ति के बाद अभ्यर्थी अपना ओ०एम०आर० उत्तर-पत्र परीक्षा कक्ष/हाल में कक्ष निरीक्षक को सौंप दें। अभ्यर्थी अपने साथ प्रश्न-पुस्तिका तथा ओ०एम०आर० उत्तर-पत्र की प्रति ले जा सकते हैं।

13. परीक्षा समाप्त होने से पहले परीक्षा भवन से बाहर जाने की अनुमति नहीं होगी।

14. यदि कोई अभ्यर्थी परीक्षा में अनुचित साधनों का प्रयोग करता है, तो वह विश्वविद्यालय द्वारा निर्धारित दंड का/की, भागी होगा/होगी।