Paper : II

Subject : **PHYSICAL SCIENCE**

Subject Code : **25**

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

(Figures as per admission card)

OMR Sheet No. : ________________

BOOKLET SERIAL NO.

Name & Signature of Invigilator/s

Signature : ______________________________

Name : ______________________________

Time : 2 Hours

Maximum Marks : 200

Number of Pages in this Booklet : **16**

Number of Questions in this Booklet : **100**

ಅಭ್ಯರ್ಥಿಗಳಿಗೆ ಸೂಚನೆಗಳು

1. ಈ ಪುಟದ ಮೇಲ್ತುದಿಯಲ್ಲಿ ಒದಗಿಸಿದ ಸ್ಥಳದಲ್ಲಿ ನಿಮ್ಮ ರೋಲ್ ನಂಬರನ್ನು ಬರೆಯಿರಿ.
2. ಈ ಪತ್ರಿಕೆಯು ಬಹು ಆಯ್ಕೆ ವಿಧದ ನೂರು (100) ಪ್ರಶ್ನೆಗಳನ್ನು ಒಳಗೊಂಡಿದೆ.
3. ಪರೀಕ್ಷೆಯ ಪ್ರಾರಂಭದಲ್ಲಿ, ಪ್ರಶ್ನೆ ಪುಸ್ತಿಕೆಯನ್ನು ನಿಮಗೆ ನೀಡಲಾಗುವುದು. ಮೊದಲ 5 ನಿಮಿಷಗಳಲ್ಲಿ ನೀವು ಪುಸ್ತಿಕೆಯನ್ನು ತೆರೆಯಲು ಮತ್ತು ಕೆಳಗಿನಂತೆ ಕಡ್ಡಾಯವಾಗಿ ಪರೀಕ್ಷಿಸಲು ಕೋರಲಾಗಿದೆ.
   (i) ಪ್ರಶ್ನೆಪುಸ್ತಿಕೆಗೆ ಪ್ರವೇಶಾವಕಾಶ ಪಡೆಯಲು, ಈ ಹೊದಿಕೆ ಪುಟದ ಅಂಚಿನ ಮೇಲಿರುವ ಪೇಪರ್ ಸೀಲನ್ನು ಹರಿಯಿರಿ. ಸ್ಟಿಕ್ಕರ್ ಸೀಲ್ ಇಲ್ಲದ ಅಥವಾ ತೆರೆದ ಪುಸ್ತಿಕೆಯನ್ನು ಸ್ವೀಕರಿಸಬೇಡಿ.
   (ii) **ಪುಸ್ತಿಕೆಯಲ್ಲಿನ ಪ್ರಶ್ನೆಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ಪುಟಗಳ ಸಂಖ್ಯೆಯನ್ನು ಮುಖಪುಟದ ಮೇಲೆ ಮುದ್ರಿಸಿದ ಮಾಹಿತಿಯೊಂದಿಗೆ ತಾಳೆ ನೋಡಿರಿ. ಪುಟಗಳು/ಪ್ರಶ್ನೆಗಳು ಕಾಣೆಯಾದ ಅಥವಾ ದ್ವಿಪ್ರತಿ ಅಥವಾ ಅನುಕ್ರಮವಾಗಿಲ್ಲದ ಅಥವಾ ಇತರ ಯಾವುದೇ ವ್ಯತ್ಯಾಸದ ದೋಷಪೂರಿತ ಪುಸ್ತಿಕೆಯನ್ನು ಕೂಡಲೆ 5 ನಿಮಿಷದ ಅವಧಿ ಒಳಗೆ, ಸಂವೀಕ್ಷಕರಿಂದ ಸರಿ ಇರುವ ಪುಸ್ತಿಕೆಗೆ ಬದಲಾಯಿಸಿಕೊಳ್ಳಬೇಕು. ಆ ಬಳಿಕ ಪ್ರಶ್ನೆಪತ್ರಿಕೆಯನ್ನು ಬದಲಾಯಿಸಲಾಗುವುದಿಲ್ಲ, ಯಾವುದೇ ಹೆಚ್ಚು ಸಮಯವನ್ನೂ ಕೊಡಲಾಗುವುದಿಲ್ಲ.**
4. ಪ್ರತಿಯೊಂದು ಪ್ರಶ್ನೆಗೂ (A), (B), (C) ಮತ್ತು (D) ಎಂದು ಗುರುತಿಸಿದ ನಾಲ್ಕು ಪರ್ಯಾಯ ಉತ್ತರಗಳಿವೆ. ನೀವು ಪ್ರಶ್ನೆಯ ಎದುರು ಸರಿಯಾದ ಉತ್ತರದ ಮೇಲೆ, ಕೆಳಗೆ ಕಾಣಿಸಿದಂತೆ ಅಂಡಾಕೃತಿಯನ್ನು ಕಪ್ಪಾಗಿಸಬೇಕು.

   ಉದಾಹರಣೆ : (A) (B) ● (D)

   (C) ಸರಿಯಾದ ಉತ್ತರವಾಗಿದ್ದಾಗ.
5. ಈ ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆಯ ಜೊತೆಯಲ್ಲಿ **ಕೊಟ್ಟಿರುವ OMR ಉತ್ತರ ಹಾಳೆಯಲ್ಲಿ ನಿಮ್ಮ ಉತ್ತರಗಳನ್ನು ಸೂಚಿಸತಕ್ಕದ್ದು**. OMR ಹಾಳೆಯಲ್ಲಿ ಅಂಡಾಕೃತಿಯಲ್ಲದೆ ಬೇರೆ ಯಾವುದೇ ಸ್ಥಳದಲ್ಲಿ ಉತ್ತರವನ್ನು ಗುರುತಿಸಿದರೆ, ಅದರ ಮೌಲ್ಯಮಾಪನ ಮಾಡಲಾಗುವುದಿಲ್ಲ.
6. OMR ಉತ್ತರ ಹಾಳೆಯಲ್ಲಿ ಕೊಟ್ಟ ಸೂಚನೆಗಳನ್ನು ಜಾಗರೂಕತೆಯಿಂದ ಓದಿರಿ.
7. ಎಲ್ಲಾ ಕರಡು ಕೆಲಸವನ್ನು ಪುಸ್ತಿಕೆಯ ಕೊನೆಯಲ್ಲಿ ಮಾಡತಕ್ಕದ್ದು.
8. ನಿಮ್ಮ ಗುರುತನ್ನು ಬಹಿರಂಗಪಡಿಸಬಹುದಾದ ನಿಮ್ಮ ಹೆಸರು ಅಥವಾ ಯಾವುದೇ ಚಿಹ್ನೆಯನ್ನು, ಸಂಗತವಾದ ಸ್ಥಳ ಹೊರತು ಪಡಿಸಿ, OMR ಉತ್ತರ ಹಾಳೆಯ ಯಾವುದೇ ಭಾಗದಲ್ಲಿ ಬರೆದರೆ, ನೀವು ಅನರ್ಹತೆಗೆ ಬಾಧ್ಯರಾಗುತ್ತೀರಿ.
9. ಪರೀಕ್ಷೆಯು ಮುಗಿದನಂತರ, ಕಡ್ಡಾಯವಾಗಿ OMR ಉತ್ತರ ಹಾಳೆಯನ್ನು ಸಂವೀಕ್ಷಕರಿಗೆ ನೀವು ಹಿಂತಿರುಗಿಸಬೇಕು ಮತ್ತು ಪರೀಕ್ಷಾ ಕೊಠಡಿಯ ಹೊರಗೆ OMRನ್ನು ನಿಮ್ಮೊಂದಿಗೆ ಕೊಂಡೊಯ್ಯಕೂಡದು.
10. ಪರೀಕ್ಷೆಯ ನಂತರ, ಪರೀಕ್ಷಾ ಪ್ರಶ್ನೆಪತ್ರಿಕೆಯನ್ನು ಮತ್ತು ನಕಲು OMR ಉತ್ತರ ಹಾಳೆಯನ್ನು ನಿಮ್ಮೊಂದಿಗೆ ತೆಗೆದುಕೊಂಡು ಹೋಗಬಹುದು.
11. **ನೀಲಿ/ಕಪ್ಪು ಬಾಲ್‌ಪಾಯಿಂಟ್ ಪೆನ್ ಮಾತ್ರವೇ ಉಪಯೋಗಿಸಿರಿ.**
12. **ಕ್ಯಾಲ್ಕುಲೇಟರ್, ವಿದ್ಯುನ್ಮಾನ ಉಪಕರಣ ಅಥವಾ ಲಾಗ್ ಟೇಬಲ್ ಇತ್ಯಾದಿಯ ಉಪಯೋಗವನ್ನು ನಿಷೇಧಿಸಲಾಗಿದೆ.**
13. **ಸರಿ ಅಲ್ಲದ ಉತ್ತರಗಳಿಗೆ ಋಣ ಅಂಕ ಇರುವುದಿಲ್ಲ.**
14. **ಕನ್ನಡ ಮತ್ತು ಇಂಗ್ಲೀಷ್ ಆವೃತ್ತಿಗಳ ಪ್ರಶ್ನೆಪತ್ರಿಕೆಗಳಲ್ಲಿ ಯಾವುದೇ ರೀತಿಯ ವ್ಯತ್ಯಾಸಗಳು ಕಂಡುಬಂದಲ್ಲಿ, ಇಂಗ್ಲೀಷ್ ಆವೃತ್ತಿಗಳಲ್ಲಿರುವುದೇ ಅಂತಿಮವೆಂದು ಪರಿಗಣಿಸಬೇಕು.**

Instructions for the Candidates

1. Write your roll number in the space provided on the top of this page.
2. This paper consists of Hundred multiple-choice type of questions.
3. At the commencement of examination, the question booklet will be given to you. In the first 5 minutes, you are requested to open the booklet and compulsorily examine it as below :
   (i) To have access to the Question Booklet, tear off the paper seal on the edge of the cover page. Do not accept a booklet without sticker seal or open booklet.
   (ii) **Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faulty booklets due to pages/questions missing or duplicate or not in serial order or any other discrepancy should be got replaced immediately by a correct booklet from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given.**
4. Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.

   Example : (A) (B) ● (D)

   where (C) is the correct response.
5. Your responses to the questions are to be indicated in the **OMR Sheet kept inside this Booklet.** If you mark at any place other than in the circles in the OMR Sheet, it will not be evaluated.
6. Read the instructions given in OMR carefully.
7. Rough Work is to be done in the end of this booklet.
8. If you write your name or put any mark on any part of the OMR Answer Sheet, except for the space allotted for the relevant entries, which may disclose your identity, you will render yourself liable to disqualification.
9. You have to return the OMR Answer Sheet to the invigilators at the end of the examination compulsorily and must NOT carry it with you outside the Examination Hall.
10. You can take away question booklet and carbon copy of OMR Answer Sheet after the examination.
11. **Use only Blue/Black Ball point pen.**
12. **Use of any calculator, electronic gadgets or log table etc., is prohibited.**
13. **There is no negative marks for incorrect answers.**
14. **In case of any discrepancy found in the Kannada translation of a question booklet the question in English version shall be taken as final.**

PHYSICAL SCIENCE
Paper – II

Note : This paper contains **hundred (100)** objective type questions. **Each** question carries **two (2)** marks. **All** questions are **compulsory**.

1. Identify the vector that is perpendicular to both $(\hat{i}+2\hat{j}-3\hat{k})$ and $(-\hat{i}+\hat{j}-2\hat{k})$ from the following.

(A) $\hat{i}+3\hat{j}+2\hat{k}$ (B) $2\hat{i}+3\hat{j}+\hat{k}$

(C) $-\hat{i}+5\hat{j}+3\hat{k}$ (D) $\hat{i}+\hat{j}+\hat{k}$

2. If $\vec{A}=2y\hat{i}-x^2y\hat{j}$ and $\phi=2x^2y$, then $\vec{A}.\vec{\nabla}\phi$ at (1, 1) is

(A) $1/2$ (B) –2

(C) 6 (D) 12

3. The value of the integral $\int_{-\infty}^{\infty}\frac{d}{dx}(\delta(x))\,e^{ikx}dx$ where k is a constant and $\delta(x)$ is the Dirac delta function is given by

(A) zero (B) sin k

(C) cos k (D) – ik

4. The two independent solutions of the following differential equation $\frac{d^2y}{dx^2}+3\frac{dy}{dx}+2y=0$ are

(A) e^{-x}, e^{-2x} (B) e^{x}, e^{3x}

(C) e^{2x}, e^{3x} (D) e^{x}, e^{-2x}

5. The number of independent components of a real antisymmetric tensor of rank two in 4 dimensions is

(A) 4 (B) 6

(C) 8 (D) 10

6. If $v(x, y)=2xy+3$, $f(z)=u(x, y)+iv(x, y)$ is analytic and further f(z = 0) = 2 + 3i, then the function u(x, y) is

(A) x^2-y^2+2xy

(B) x^2-y^2+y

(C) x^2-y^2+2

(D) x^2-y^2+2x

7. The value of $\oint_c \frac{dz}{z}$ where c is a unit circle with origin as its center and the integration is done in a clockwise path is

(A) $2\pi i$ (B) $-2\pi i$

(C) zero (D) $i/2\pi$

8. The number of independent parameters of the group O(3) and SU(2) are respectively

(A) 3, 3 (B) 3, 2

(C) 2, 3 (D) 2, 2

9. Any Hermitian 2 × 2 matrix H can be expressed in terms of the 2 × 2 identity matrix I and three Pauli sigma matrices σ_x, σ_y, σ_z as $H = a_0I + \sum_{j=x,y,z} a_j\sigma_j$ where

(A) a_0 is real and a_x, a_y, a_z are pure imaginary

(B) a_0, a_x, a_y, a_z are all pure imaginary

(C) a_0 is pure imaginary and a_x, a_y, a_z are all real

(D) a_0, a_x, a_y, a_z are all real

10. One of the eigen values of the matrix e^A is e^α, where $A = \begin{pmatrix} \alpha & 0 & 0 \\ 0 & 0 & -i\alpha \\ 0 & i\alpha & 0 \end{pmatrix}$, the product of the other two eigen values is

(A) 1 (B) e^α

(C) $e^{2\alpha}$ (D) $e^{-\alpha}$

11. Three fair coins are tossed together. Find the probability of getting one head and two tails.

(A) $\frac{1}{4}$ (B) $\frac{1}{3}$

(C) $\frac{3}{8}$ (D) $\frac{1}{2}$

12. Given the matrix $A = \frac{1}{3}\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$ what is the value of Det (e^A) ?

(A) $e^{1/3}$ (B) e

(C) e^2 (D) e^3

13. A particle thrown upwards from earth's surface reaches a height of 100 m and returns back. The acceleration of the particle at its highest point of reach has the value

(A) zero

(B) $g/4$

(C) $g/2$

(D) g

14. Suppose the radius of the earth were to shrink by 1%, its mass remaining the same, the acceleration due to gravity would

(A) increase by 4%

(B) decrease by 1%

(C) not change at all

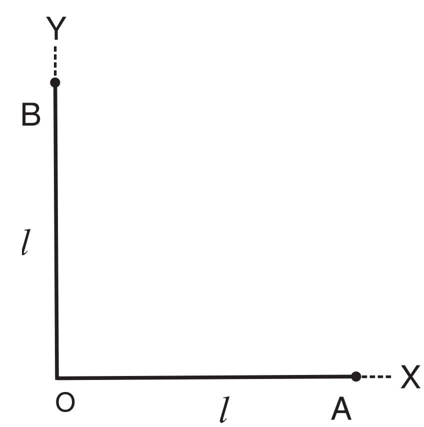
(D) increase by 2%

15. If the differential cross-section in scattering is equal to a^2, where a is a constant, then the total cross-section will be

(A) $\frac{a^2}{2}$ (B) πa^2

(C) $2\pi a^2$ (D) $4\pi a^2$

16. The center of mass of an L-shaped uniform wire as shown in the figure, with OA = OB = l, is at



(A) $\left(\frac{l}{2}, \frac{l}{2}\right)$ (B) $\left(\frac{l}{4}, \frac{l}{4}\right)$

(C) $\left(\frac{l}{3}, \frac{l}{3}\right)$ (D) $\left(\frac{2l}{3}, \frac{2l}{3}\right)$

17. If the Lagrangian of a mass m is given by $L = \frac{1}{2}m\dot{x}^2 + xf$, f being a constant, then x(t) can be obtained in terms of the constants c_1, c_2 as

(A) $c_1 + c_2 t$

(B) $c_1 + \frac{f}{2m}t$

(C) $c_1 + c_2 t + \frac{f}{2m}t^2$

(D) $c_1 + c_2 t + ft^2$

18. A body of mass m moves in a circular orbit of radius R in a potential :

$V_{(r)} = -\frac{K}{r}$, where K is a constant, then its orbital angular momentum about the centre of the circle is

(A) 2RKm

(B) $\sqrt{2RKm}$

(C) $\sqrt{RKm}$

(D) RKm

19. Identify the correct Hamilton's equations of motion from the following.

(A) $\dot{q}_i = \frac{\partial H}{\partial p_i}$ and $\dot{p}_i = \frac{\partial H}{\partial q_i}$

(B) $\dot{q}_i = -\frac{\partial H}{\partial p_i}$ and $\dot{p}_i = \frac{\partial H}{\partial q_i}$

(C) $\dot{q}_i = \frac{\partial H}{\partial p_i}$ and $\dot{p}_i = \frac{-\partial H}{\partial q_i}$

(D) $\dot{q}_i = \frac{-\partial H}{\partial p_i}$ and $\dot{p}_i = \frac{-\partial H}{\partial q_i}$

20. If the potential energy of a body is $V(x) = (x^2 - 4x + 4)$, the point of stable equilibrium is given by

(A) $x = 4$

(B) $x = 2$

(C) $x = -2$

(D) $x = 0$

21. A rigid body consisting of three particles A, B, C is constrained such that A, B are rigidly fixed to be at rest. Which of the following statements correctly describes the behaviour of C ?

(A) C can move on the surface of a sphere of constant radius

(B) C can move on the circumference of a circle of constant radius with line joining A, B passing normally through the centre of the circle

(C) C can move along the line joining A, B

(D) C can move parallel to the line joining A, B

22. If the motion of planet (of mass m) around sun (of mass M) is treated as a two body problem, T the period of revolution, a, the semimajor axis and G, the gravitational constant, then the exact form of the third law of Kepler is

(A) $\frac{T^2}{a^3} = \frac{4\pi}{GM}$

(B) $\frac{T^2}{a^3} = \frac{4\pi^2}{GMm}$

(C) $\frac{T^2}{a^3} = \frac{4\pi^2}{G(M+m)}$

(D) $\frac{T^2}{a^3} = \frac{4\pi^2(M+m)}{GMm}$

23. The eigen frequencies of small oscillations of a system having the Lagrangian given by

$L = \frac{m}{2}(\dot{x}^2 + \dot{y}^2) - \frac{m}{2}\left(\omega_1^2 x^2 + \omega_2^2 y^2\right)$ are

(A) $\omega_x = \omega_1$ and $\omega_y = \omega_2$

(B) $\omega_x = \frac{\omega_1}{\sqrt{2}}$ and $\omega_y = \frac{\omega_2}{\sqrt{2}}$

(C) $\omega_x = \frac{\omega_1}{2}$ and $\omega_y = \frac{\omega_2}{2}$

(D) $\omega_x = \sqrt{\omega_1}$ and $\omega_y = \sqrt{\omega_2}$

24. Two masses of value m that are moving towards each other with equal speeds of value 0.6 c collide head on and sticking together form a bigger particle of mass M. Then the value of M is equal to

(A) 2m

(B) $\frac{5}{2}$m

(C) $\frac{9}{4}$m

(D) $\frac{25}{8}$m

25. Charge Q is uniformly distributed in a sphere of radius R. The divergence of an electric field $\vec{E}$ inside the sphere is (in Gaussian units)

(A) $\frac{4\pi Q}{R^3}$

(B) $\frac{3Q}{R^3}$

(C) $\frac{4\pi R^3}{3}$

(D) $4\pi Q$

26. Given below are two vectors. Find out which of them can be a magnetic field vector.

I. $x\hat{i} - z\hat{j}$

II. $2x\hat{i} + y\hat{j} - 3z\hat{k}$

Codes :

(A) I is true and II is false

(B) II is true and I is false

(C) I and II are both true

(D) I and II are both false

27. At the interface between two dielectrics, the normal components of the electric field satisfy

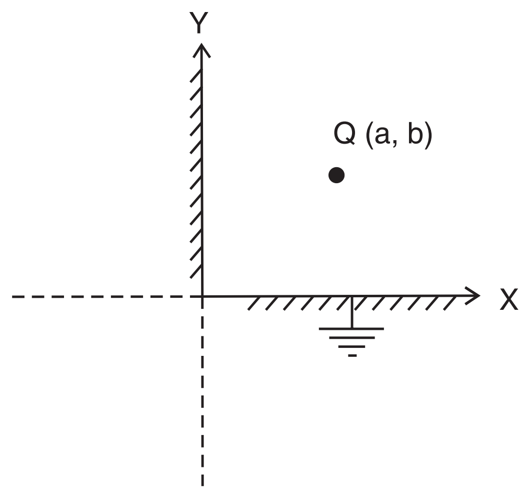
(A) $\epsilon_2 E_{2n} - \epsilon_1 E_{1n} = \sigma$

(B) $E_{2n} - E_{1n} = \sigma$

(C) $\frac{E_{2n}}{\epsilon_2} - \frac{E_{1n}}{\epsilon_1} = \sigma$

(D) $E_{2n} = E_{1n}$

28. A charge Q is placed at (a, b) between two right angled grounded conducting planes. Then the image charges and their locations are



(A) – Q(a, –b), – Q(–a, –b), – Q(–a, b)

(B) – Q(a, –b), – Q(–a, b), + Q(–a, –b)

(C) – Q(a, –b), + Q(–a, b), – Q(–a, – b)

(D) + Q(a, –b), + Q(–a, b), – Q(–a, –b)

29. Electric dipole moment of HCl molecule is 1.0 debye. The electric field due to this dipole at a distance of 100 Å from the centre of the HCl molecule on the line joining H and Cl ions is
(1 debye = 3.3×10^{-30} Cm)

(A) 3.3×10^{-6} Cm^{-2}

(B) 3.3×10^{-6} Cm^{2}

(C) 6.6 μCm^{-2}

(D) 6.6 μCm^{2}

30. Lienard – Wiechert potentials are the

(A) Vector potentials due to a moving point charge

(B) Scalar potentials due to a moving point charge

(C) Vector and scalar potentials due to a static point charge

(D) Vector and scalar potentials due to a moving point charge

31. Electric fields associated with the two electro magnetic waves are in the ratio 3 : 2. Then the energy transported per unit area per unit time by these waves are in the ratio

(A) 3 : 2 (B) 9 : 4

(C) 4 : 9 (D) 2 : 3

32. If the electric and magnetic vectors of a plane electromagnetic wave are along $\left(\frac{\sqrt{3}}{2}\hat{i}+\frac{1}{2}\hat{j}\right)$ and $\left(-\frac{1}{2}\hat{i}+\frac{\sqrt{3}}{2}\hat{j}\right)$, respectively, then the propagation takes place along

(A) $\hat{i}+\hat{j}+\hat{k}$ (B) $\hat{i}-\hat{j}$

(C) $\hat{k}$ (D) $\frac{\sqrt{3}}{2}\hat{k}+\frac{1}{2}\hat{j}$

33. A dipole of moment $\vec{p}$ is placed in an electric field $\vec{E} = E_0 x\hat{i}$. Then the force experienced by the dipole is equal to

(A) Zero

(B) $P_x E_0 \hat{i}$

(C) $|\vec{p}| E_0 \hat{i}$

(D) $(\vec{p} \times \vec{E})$

34. The magnetic field at the center of a square loop of wire having side 'a' and carrying a current I is given by

(A) $\frac{\mu_0 I}{a}$

(B) $\frac{\mu_0 I\sqrt{2}}{a}$

(C) $\frac{\mu_0 I\, 2\sqrt{2}}{a}$

(D) $\frac{4\mu_0 I}{a}$

35. Energy eigen values of a particle of mass m, confined inside a one-dimensional box of length L are given by

(A) $\frac{\hbar^2\pi^2 n}{2mL^2}$

(B) $\frac{\hbar^2\pi^2 L^2}{2mn^2}$

(C) $\frac{\hbar^2\pi^2 n^2}{2mL^2}$

(D) $\frac{\hbar^2\pi^2}{2mn^2L^2}$

36. The ratio of the wave numbers of the first Balmer spectral line of Hydrogen to that of the second Balmer line is

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

(B) $\frac{27}{32}$

(C) $\frac{32}{27}$

(D) $\frac{3}{4}$

37. The probability current density for $\psi(\vec{r}) = \frac{e^{ikr}}{r}$, k is a real constant, has the magnitude

(A) $\frac{1}{r}\frac{\hbar k}{m}$

(B) $\frac{1}{r^2}\frac{\hbar k}{m}$

(C) $\frac{1}{r^2}\frac{mk}{\hbar}$

(D) $\frac{1}{r^2}\frac{m\hbar}{k}$

38. If $\{|1\rangle, |2\rangle, |3\rangle\}$ denote a set of mutually orthonormal states, the norm of the state : $|\psi\rangle = a|1\rangle + (b+ic)|2\rangle - id|3\rangle$ is

(A) $\sqrt{a+b+c+d}$

(B) $\sqrt{a^2+b^2-c^2+d^2}$

(C) $\sqrt{a^2+b^2+c^2-d^2}$

(D) $\sqrt{a^2+b^2+c^2+d^2}$

39. The commutator $[\hat{x}^2, \hat{p}_x^2]$ is equal to

(A) Zero

(B) $4i\hbar\,\hat{x}\hat{p}_x$

(C) $2i\hbar\,(\hat{x}\hat{p}_x + \hat{p}_x\hat{x})$

(D) $i\hbar\,(\hat{x}\hat{p}_x + \hat{p}_x\hat{x})$

40. Trace of the matrix $(\alpha_x\beta\alpha_x)$, where α_x and β denote Dirac matrices, is given by

(A) 0

(B) 2

(C) –1

(D) 1

41. Let $\psi(x)$ be an arbitrary wave function of a physical system and let $\hat{H}$ be the Hamiltonian of the system, with its lowest eigen value denoted by E_0. Then,

(A) $\frac{\langle\psi|\hat{H}|\psi\rangle}{\langle\psi|\psi\rangle} \le E_0$

(B) $\left|\frac{\langle\psi|H|\psi\rangle}{\langle\psi|\psi\rangle}\right|^2 \ge E_0$

(C) $\sqrt{\frac{|\langle\psi|H|\psi\rangle|}{\langle\psi|\psi\rangle}} \le E_0$

(D) $\frac{\langle\psi|H|\psi\rangle}{\langle\psi|\psi\rangle} \ge E_0$

42. A quantum system is in the state $\frac{1}{2}|\phi_1\rangle + \frac{1}{\sqrt{2}}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$, where $|\phi_i\rangle, i = 1, 2, 3$ are orthonormal states. The probability amplitude for the system to be in the state $\frac{1}{\sqrt{2}}\left(|\phi_1\rangle + |\phi_3\rangle\right)$ is

(A) $\frac{1}{2}$ (B) $\frac{1}{\sqrt{2}}$

(C) 1 (D) 0

43. Which of the following is a possible eigen value of the operator $\hat{L}_x^2 + 3\hat{L}_y^2 + \sqrt{3}(\hat{L}_x\hat{L}_y + \hat{L}_y\hat{L}_x)$?
($\hat{L}_x, \hat{L}_y$ are components of the orbital angular momentum operator)

(A) $\hbar^2$ (B) $4\hbar^2$

(C) $\sqrt{3}\hbar^2$ (D) $3\hbar^2$

44. A two-level quantum system has energy eigen values $E_\pm = \pm\sqrt{E_0^2 + E_1^2}$. In terms of the Pauli matrices

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

and the identity matrix $I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$, identify which of the following does not correspond to the Hamiltonian of the system.

(A) $H = E_0\,\sigma_x - E_1\,\sigma_z$

(B) $H = E_0\,\sigma_y + E_1\,\sigma_z$

(C) $H = E_0\,\sigma_y + E_1\,\sigma_x$

(D) $H = E_0 I + E_1\,\sigma_z$

45. A 3-dimensional harmonic oscillator is in thermal equilibrium with a heat bath at temperature T. The average total energy of the oscillator is

(A) $\frac{1}{2}$ KT

(B) 3 KT

(C) KT

(D) $\frac{3}{2}$ KT

46. The number of ways in which 5 identical bosons can be distributed in 4 states is

(A) $\frac{9!}{5!\,4!}$

(B) $\frac{9!}{4!\,4!}$

(C) $\frac{8!}{4!\,4!}$

(D) $\frac{8!}{5!\,3!}$

47. The equation of state of a gas with internal energy U is given by $PV = \frac{1}{3}U$. Then the corresponding equation for an adiabatic process is

(A) $PV^{2/3}$ = constant

(B) $PV^{1/3}$ = constant

(C) $PV^{4/3}$ = constant

(D) $PV^{3/5}$ = constant

48. Suppose we have two non-interacting identical bosons both of mass m in a 1-dimensional infinite square well potential in the range, $0 \le x \le a$. The wave function when one of them is in the ground state and the other is in the first excited state is given by

(A) $\psi(x_1, x_2) = \frac{2}{a} \sin\left(\frac{\pi x_1}{a}\right) \sin\left(\frac{\pi x_2}{a}\right)$

(B) $\psi(x_1, x_2) = \frac{2}{a} \sin\left(\frac{2\pi x_1}{a}\right) \sin\left(\frac{2\pi x_2}{a}\right)$

(C) $\psi(x_1, x_2) = \frac{\sqrt{2}}{a}\left[\sin\left(\frac{\pi x_1}{a}\right) \sin\left(\frac{2\pi x_2}{a}\right) + \sin\left(\frac{2\pi x_1}{a}\right) \sin\left(\frac{\pi x_2}{a}\right)\right]$

(D) $\psi(x_1, x_2) = \frac{\sqrt{2}}{a}\left[\sin\left(\frac{\pi x_1}{a}\right) \sin\left(\frac{2\pi x_2}{a}\right) - \sin\left(\frac{2\pi x_1}{a}\right) \sin\left(\frac{\pi x_2}{a}\right)\right]$

49. The partition function for a photon gas is given by $ln\ z = \frac{\pi^2}{45} \frac{V(KT)^3}{\hbar^3 c^3}$. The internal energy is

(A) $\frac{\pi^2 V(KT)}{45\, \hbar^2 c^3}$ (B) $\frac{\pi^2 V}{45\, \hbar^2 c^3\ KT}$

(C) $\frac{\pi^2 V(KT)^2}{45\, \hbar^2 c^3}$ (D) $\frac{\pi^2 V(KT)^4}{15\, \hbar^2 c^3}$

50. Average energy of an ensemble of gas molecules in equilibrium is given, in terms of the partition function z, by

(A) $-\frac{\partial \ln z}{\partial \beta}$ (B) $-\frac{1}{z}\frac{\partial z}{\partial T}$

(C) $-\frac{\partial z}{\partial \beta}$ (D) $-\frac{\partial \ln z}{\partial T}$

51. A random walker travels along a one-dimensional discrete lattice (labelled by points –N, –N+1, ..., 0, ... N – 1, N) by putting random steps of length 1 unit towards left or right. If the initial position is zero, the probability of finding the walker at the 0^{th} position in a 6 step walk is

(A) $\frac{9}{256}$ (B) $\frac{5}{18}$

(C) $\frac{1}{9}$ (D) $\frac{5}{16}$

52. Which of the following gives statistical definition of temperature in terms of number of microstates Ω ?

(A) $\frac{1}{T} = k \frac{\partial \ln \Omega}{\partial U}$

(B) $\frac{1}{T} = k \frac{\partial \Omega}{\partial P}$

(C) $\frac{1}{T} = k \frac{\partial \Omega}{\partial V}$

(D) $\frac{1}{T} = k \frac{\ln \Omega}{PV}$

53. If Ω denotes the number of microstates, V, U are volume and internal energy respectively, which of the following gives statistical definition of pressure P ?

(A) $\left(KT \frac{\partial \ln \Omega}{\partial V}\right)^{-1}$

(B) $K \frac{\partial \ln \Omega}{\partial V}$

(C) $K \left(\frac{\partial \ln \Omega}{\partial V}\right)^{-1}$

(D) $KT \frac{\partial \ln \Omega}{\partial V}$

54. A photon gas with internal energy U is described by the following equation of state

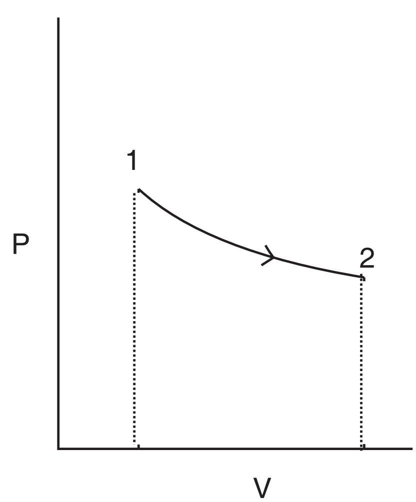
(A) $PV = \frac{1}{3}U$

(B) $PV = \frac{2}{3}U$

(C) $PV = \frac{2}{5}U$

(D) $PV = U$

55. An ideal gas undergoes isothermal expansion (see the PV diagram). Entropy of the system is given by



(A) $\frac{P_1V_1 - P_2V_2}{T}$

(B) $nR \ln\left(\frac{P_2}{P_1}\right)$

(C) $nR \ln\left(\frac{V_2}{V_1}\right)$

(D) $nRT (V_2 - V_1)$

56. If a PN junction is formed having a junction potential V_J and a depletion region width W, then

(A) $V_J \propto W$

(B) $V_J \propto W^{1/2}$

(C) $V_J \propto W^2$

(D) $V_J \propto W^{3/2}$

57. An op-amp amplifier has a gain of 10 in the inverting configuration and a bandwidth of 1 MHz. At what gain will it have a bandwidth of 10 MHz ?

(A) 1 (B) 20

(C) 100 (D) 10^5

58. A square wave of peak to peak amplitude of 500 mV has to be amplified to a peak to peak amplitude of 4V with a rise time of 3 μs or less. The op-amp used should have a minimum slew rate of

(A) 0.5 V/μs

(B) 0.75 V/μs

(C) 0.8 V/μs

(D) 1.1 V/μs

59. A first order low pass filter has a pass band gain of 10 and a cutoff of 10 KHz. The gain of the circuit at 100 KHz in db is

(A) 17 db (B) 1.0 db

(C) – 20 db (D) – 3 db

60. An ideal differentiator using an op-amp has a high frequency gain above its maximum frequency varying as

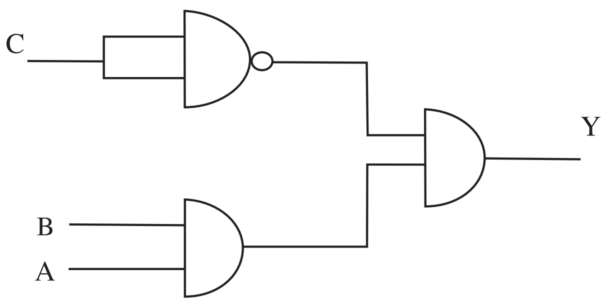
(A) + 20 db/decade

(B) – 20 db/decade

(C) 10 db/decade

(D) – 10 db/decade

61. To get an output of 1 from the circuit given below, ABC should be



(A) 000 (B) 110
(C) 010 (D) 001

62. A weighted resistor network is used as a 4 bit D/A converter. If the current through the LSB resistor is 10 μA, what is the maximum current through the MSB resistor ?

(A) 40 μA (B) 2.5 μA
(C) 160 μA (D) 80 μA

63. A mod 12 counter whose output is DCBA is to be made using a ripple counter. The decoding gate for this will have the input as

(A) $\overline{D}\overline{C}\overline{B}\overline{A}$
(B) $D\overline{C}B\overline{A}$
(C) $DC\overline{B}\overline{A}$
(D) $DC\overline{B}A$

64. Most metals used for temperature measurements in the form of a resistance thermometer have

(A) Negative resistance characteristic
(B) Positive temperature coefficient of resistance
(C) A non-linear resistance variation
(D) Negative temperature co-efficient of resistance

65. Which of the following is not part of a lock-in amplifier ?

(A) Phase sensitive detector
(B) Integrator
(C) Differentiator
(D) Small signal amplifier

66. Heterojunction devices are made up of GaAs and AlGaAs because they have

(A) Different bandgap but similar crystal structure
(B) Same bandgap and similar crystal structure
(C) Same bandgap but different crystal structure
(D) Different bandgap and different crystal structure

67. The output of a driver is 75 Ω. Maximum power is transferred when

I. It is connected to a load of 75 Ω by a 75 Ω cable
II. It is connected to a load of 75 Ω by single wires
III. It is connected to a load of 75 Ω by a 50 Ω cable
IV. It is connected to a load of 50 Ω by a 50 Ω cable

Codes :

(A) I, II, III are correct and IV is wrong
(B) I, III are correct and II, IV are wrong
(C) I, IV are correct and II, III are wrong
(D) I, II are correct and III, IV are wrong

68. The ground state of the caesium atom is

(A) $^1S_{1/2}$ (B) $^2S_{1/2}$

(C) $^3S_{1/2}$ (D) $^2S_{3/2}$

69. To demonstrate the stark effect experimentally in one-electron atoms, the electric fields should be of the order of

(A) 10^5 V/cm

(B) 10^2 V/cm

(C) 1 V/cm

(D) Less than 1 V/cm

70. In the normal Zeeman effect, the middle spectral line is

(A) Circularly polarized

(B) Elliptically polarized

(C) Not polarized

(D) Plane polarised

71. One of the following elements shows the doublet spectral features like the alkalies. Identify it from the following.

(A) Singly ionised Boron

(B) Singly ionised Aluminum

(C) Singly ionised Barium

(D) Singly ionised Oxygen

72. A proton having magnetogyric ratio of 3×10^8 rad/Ts is precessing in a magnetic field of strength 5T. Its NMR frequency will be nearer to

(A) 250 MHz (B) 175 MHz

(C) 500 MHz (D) 750 MHz

73. In the Born-Oppenheimer approximation, the following assumption is made

(A) The nuclei also move in relation to the more fast moving electrons

(B) The nuclei move with the same velocity as the fast-moving electrons

(C) The nuclei move faster than the fast moving electrons

(D) The nuclei remain stationary in relation to the fast-moving electrons

74. For molecules, the state $^1\Sigma$ refers to

(A) Spin of the electrons being zero

(B) Orbital angular momentum of electrons being zero

(C) Both the spin and orbital angular momentum of the electrons being zero

(D) The angular momentum of nuclear rotation being zero

75. If the average separation between the adjacent lines in the rotational IR spectrum of CO molecule is 3.844 cm^{-1}, then the value of the rotational constant is

(A) 1.922 cm^{-1} (B) 3.844 cm^{-1}

(C) 5.766 cm^{-1} (D) 7.688 cm^{-1}

76. For the vibrational transition $1 \leftarrow 0$, if the band is referred to as fundamental, then for the transition $2 \leftarrow 0$, the band is called

(A) Second overtone

(B) First overtone

(C) First harmonic

(D) Third harmonic

77. The ratio of spontaneous emission process probability to the stimulated emission probability is proportional to

(A) Square root of the transition frequency

(B) Reciprocal of the transition frequency

(C) Square of the transition frequency

(D) Cube of the transition frequency

78. For an electron configuration in which there is one S-electron and one d-electron, the resultant spectral terms are

(A) $^2D, ^3D$ (B) $^1D, ^2D$

(C) $^1D, ^3D$ (D) $^2D, ^4D$

79. In a b.c.c. lattice with lattice constant 'a', the body centered position from the origin is at a distance of

(A) $\sqrt{2}\,a$ (B) $\frac{\sqrt{3a}}{2}$

(C) $\frac{\sqrt{3}}{2}a$ (D) $\frac{\sqrt{3}}{4}a$

80. In a cubic crystal, the interplanar spacing of (hkl) planes is represented by d_{hkl}. Which of the following is true ?

(A) $d_{111} > d_{100}$

(B) $d_{110} > d_{111}$

(C) $d_{111} < d_{210}$

(D) $d_{200} > d_{111}$

81. Madelung energy is calculated in

(A) Inert gas crystals

(B) Covalent crystals

(C) Hydrogen bonded crystals

(D) Ionic crystals

82. The total potential energy of a pair of inert gas atoms at separation r is given by

$$V(r) = -\frac{A}{r^6} + \frac{B}{r^{12}}$$

Where A and B are positive constants. The repulsive force between the two atoms is

(A) $\frac{6A}{r^7}$ (B) $\frac{12B}{r^{13}}$

(C) $-\frac{6A}{r^7} + \frac{12B}{r^{13}}$ (D) $\frac{6A}{r^7} - \frac{12B}{r^{13}}$

83. In a crystalline solid with N number of unit cells, the number of allowed independent phonon modes of a branch is

(A) N (B) 2N

(C) $\frac{N}{2}$ (D) N^2

84. Heat capacity C_v of a metal is measured as a function of temperature T in the low temperature region. Assume that the measured C_v is due to both electrons and lattice. Then, the plot of $\frac{C_v}{T}$ vs T is

(A) Linear in T

(B) Linear in T^2

(C) Linear in T^3

(D) Decreases with increase of T

85. In metals A and B, the electron densities are n_A and n_B, respectively. Their respective Fermi wave vectors are k_{FA} and k_{FB}. Then, $k_{FA} = 2k_{FB}$ if

(A) $n_A = 4n_B$

(B) $n_A = \frac{n_B}{4}$

(C) $n_A = 2n_B$

(D) $n_A = 8n_B$

86. A metal wire of radius r and electron density n is carrying a current I. Then, the drift velocity V_d of the electrons in this wire is given by

(A) $\frac{I\pi r^2}{ne}$

(B) $\frac{I}{\pi r^2 ne}$

(C) $\frac{Ine}{\pi r^2}$

(D) $\frac{I}{2\pi r\, ne}$

Here e is the charge of electron.

87. Application of Hall effect are

I. To find the type of charge carriers in a sample.

II. To find the density of charge in a sample.

III. To find the unknown magnetic field.

Codes :

(A) I, II are true and III is false

(B) I, II are false and III is true

(C) I, III are true and II is false

(D) I, II and III are true

88. Which of the following is not true ? A superconductor is characterized by

(A) Persistent current

(B) Perfect diamagnetism

(C) Existence of energy gap

(D) Heat capacity linear in temperature

89. Given below are two lists of statements. Match the items in List – I with those in List – II.

List – I	List – II
I. Point defects	1. Meissner effect
II. Superfluidity	2. Fountain effect
III. Liquid crystals	3. Increase with increase of temperature
IV. Insulators	4. Large energy gap
	5. Orientational order

Codes :

	I	II	III	IV
(A)	4	1	2	5
(B)	3	1	4	5
(C)	3	4	2	5
(D)	3	2	5	4

90. $\mu^+ \rightarrow e^+ + \nu_e$ is forbidden because

(A) Charge is not conserved

(B) Lepton number is not conserved

(C) Iso-spin is not conserved

(D) Baryon number is not conserved

91. The half life of a radio active sample is 20 days. This means that

(A) The substance completely disintegrates in 40 days

(B) The substance completely disintegrates in 80 days

(C) 1/8 part of the substance disintegrates in 60 days

(D) 7/8 part of the substance disintegrates in 60 days

92. The decay of $P \rightarrow e^{+} + \gamma$ is
(A) Weak interaction
(B) Not allowed
(C) Strong interaction
(D) Electro magnetic interaction

93. The function of a moderator in a nuclear reactor is
(A) To absorb unwanted neutrons
(B) To slowdown the fast neutrons to secure more effective hits on other nuclei
(C) To decrease the number of fissile nuclei
(D) To increase the number of fissile nuclei

94. The quark contents of Δ^{+} and proton are respectively
(A) uud, uus (B) uus, uds
(C) uud, uud (D) ssu, uds

95. The ground state of a deuteron is an admixture of the following states.
(A) $^1S_0 - {}^3S_1$ (B) $^1S_0 - {}^3P_1$
(C) $^3S_1 - 3D_1$ (D) $^1S_0 - {}^3D_1$

96. The energy dependence of the cross-section of a reaction between two particles close to the resonance energy E is described by
(A) Bethe-Bloch formula
(B) Breit-Wigner formula
(C) Gamow-Teller formula
(D) Weizsaker formula

97. The mass defect of an atom divided by its mass number is known as
(A) Binding energy
(B) Packing fraction
(C) Asymmetric energy
(D) Surface energy

98. For deuteron packing fraction is (given $M_H = 1.007825$ amu; Mn = 1.008665 amu and $M_d = 2.014102$ amu; 1amu = 931.5 MeV)
(A) 2.342 MeV/nucleon
(B) 2.86 MeV/nucleon
(C) 1.112 MeV/nucleon
(D) 3.456 MeV/nucleon

99. The radius of the nuclei whose mass number is 216 is
(given $r_0 = 1.2 \times 10^{-15}$ m)
(A) 7.2×10^{-15} m
(B) 12×10^{-15} m
(C) 6.7×10^{-15} m
(D) 9.9×10^{-15} m

100. For the magnetic multiple transition, the parity is
(A) Odd for even L and even for odd L
(B) Odd for both even and odd L
(C) Even for even L and odd for odd L
(D) Even for both even and odd L

Space for Rough Work