Test Paper : **III**	Test Booklet Serial No. : ______________
Test Subject : **PHYSICAL SCIENCE**	OMR Sheet No. : ______________
Test Subject Code : **K-2517**	Roll No. [ ] (Figures as per admission card)

Name & Signature of Invigilator/s

Signature : ______________________

Name : ______________________

Paper : III

Subject : PHYSICAL SCIENCE

Time : 2 Hours 30 Minutes | Maximum Marks : 150

Number of Pages in this Booklet : **16** | Number of Questions in this Booklet : **75**

ಅಭ್ಯರ್ಥಿಗಳಿಗೆ ಸೂಚನೆಗಳು

1. ಈ ಪುಟದ ಮೇಲ್ತುದಿಯಲ್ಲಿ ಒದಗಿಸಿದ ಸ್ಥಳದಲ್ಲಿ ನಿಮ್ಮ ರೋಲ್ ನಂಬರನ್ನು ಬರೆಯಿರಿ.
2. ಈ ಪತ್ರಿಕೆಯು ಬಹು ಆಯ್ಕೆ ವಿಧದ ಎಪ್ಪತ್ತೈದು ಪ್ರಶ್ನೆಗಳನ್ನು ಒಳಗೊಂಡಿದೆ.
3. ಪರೀಕ್ಷೆಯ ಪ್ರಾರಂಭದಲ್ಲಿ, ಪ್ರಶ್ನೆಪುಸ್ತಿಕೆಯನ್ನು ನಿಮಗೆ ನೀಡಲಾಗುವುದು. ಮೊದಲ 5 ನಿಮಿಷಗಳಲ್ಲಿ ನೀವು ಪುಸ್ತಿಕೆಯನ್ನು ತೆರೆಯಲು ಮತ್ತು ಕೆಳಗಿನಂತೆ ಕಡ್ಡಾಯವಾಗಿ ಪರೀಕ್ಷಿಸಲು ಕೋರಲಾಗಿದೆ.
   (i) ಪ್ರಶ್ನೆ ಪುಸ್ತಿಕೆಗೆ 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 ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆಯನ್ನು 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. ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಗಳನ್ನು, **ಪತ್ರಿಕೆ III ಪುಸ್ತಿಕೆಯೊಳಗೆ ಕೊಟ್ಟಿರುವ OMR ಉತ್ತರ ಹಾಳೆಯಲ್ಲಿ ಮಾತ್ರವೇ ಸೂಚಿಸತಕ್ಕದ್ದು.** OMR ಹಾಳೆಯಲ್ಲಿನ ಅಂಡಾಕೃತಿ ಹೊರತುಪಡಿಸಿ ಬೇರೆ ಯಾವುದೇ ಸ್ಥಳದಲ್ಲಿ 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 ಬಾಧ್ಯರಾಗಿರುತ್ತೀರಿ.
9. ಪರೀಕ್ಷೆಯು ಮುಗಿದನಂತರ, ಕಡ್ಡಾಯವಾಗಿ OMR ಉತ್ತರ ಹಾಳೆಯನ್ನು ಸಂವೀಕ್ಷಕರಿಗೆ ನೀವು ಹಿಂತಿರುಗಿಸಬೇಕು ಮತ್ತು ಪರೀಕ್ಷಾ ಕೊಠಡಿಯ ಹೊರಗೆ OMR ನ್ನು ನಿಮ್ಮೊಂದಿಗೆ ಕೊಂಡೊಯ್ಯಕೂಡದು.
10. ಪರೀಕ್ಷೆಯ ನಂತರ, ಪರೀಕ್ಷಾ ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆಯನ್ನು 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 ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆಗಳಲ್ಲಿ 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 seventy five 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 question of Paper III are to be indicated in the **OMR Sheet kept inside the Booklet**. If you mark at any place other than in the circles in 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 test 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 – III

Note : This paper contains **seventy-five (75)** objective type questions. **Each** question carries **two (2)** marks. **All** questions are **compulsory**.

1. A solution of the differential equation

$\frac{dy}{dx} = -\frac{y^2}{x^2}$ is

(A) xy = constant

(B) y/x = constant

(C) $\frac{1}{y} - \frac{1}{x} = \text{constant}$

(D) $\frac{1}{y} + \frac{1}{x} = \text{constant}$

2. The general solution of the equation

$\frac{\partial^2 y}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 y}{\partial t^2}$ is

(A) $y = F(x + ct) + G\left(x/c + t\right)$

(B) $y = F(x + ct) + G(x - ct)$

(C) $y = F(xc + t) + G(xc - t)$

(D) $y = F\left(x/c + t\right) + G\left(x/c + t\right)$

Where F and G are arbitrary differentiable functions.

3. The general solution of the Laplace equation in cylindrical co-ordinates

$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2} + \frac{\partial^2 u}{\partial z^2} = 0$ is

(A) $u = \sum_m \left[e^{kz}(A_m \cos m\theta + B_m \sin m\theta) + e^{-kz} \times (C_m \cos m\theta + D_m \sin m\theta)\right] J_m(kr)$

(B) $u = \sum_m \left[e^{kz}(A_m \cosh m\theta + B_m \sinh m\theta) + e^{-kz} \times (C_m \cosh m\theta + D_m \sinh m\theta)\right] J_m(kr)$

(C) $u = \sum_m \{A_m \cosh m\theta\,(\cos kz + \sin kz) + B_m \sinh m\theta\,(\cos kz - \sin kz)\} J_m(kr)$

(D) $u = \sum_m \{A_m \cos kz\, e^{-im\theta} + B_m \sin kz\, e^{+im\theta}\} J_m(kr)$

Where A_m, B_m, C_m, D_m and k are constants and $J_m(kr)$ is Bessel function of order m.

4. The Green's function for the Poisson equation

$$\nabla^2\phi(\bar{r}) = -\frac{\rho(\bar{r})}{\epsilon_0} \text{ is}$$

(A) $G(\vec{r}_1, \vec{r}_2) = \dfrac{4\pi}{\left|\vec{r}_2 - \vec{r}_1\right|^2}$

(B) $G(\vec{r}_1, \vec{r}_2) = \dfrac{4\pi}{\sqrt{\left|\vec{r}_2 - \vec{r}_1\right|}}$

(C) $G(\vec{r}_1, \vec{r}_2) = \dfrac{1}{4\pi\left|\vec{r}_2 - \vec{r}_1\right|}$

(D) $G(\vec{r}_1, \vec{r}_2) = \dfrac{1}{4\pi} e^{-\left|\vec{r}_2 - \vec{r}_1\right|}$

5. The Lagrange polynomial passing through the two points (x_0, y_0) and (x_1, y_1) is

(A) $\dfrac{x - x_1}{x_0 - x_1} y_0 + \dfrac{x - x_0}{x_1 - x_0} y_1$

(B) $\dfrac{x - x_1}{x_1 - x_0} y_0 + \dfrac{x - x_0}{x_1 - x_0} y_1$

(C) $\dfrac{x - x_1}{x_0 - x_1} y_1 + \dfrac{x - x_0}{x_1 - x_0} y_0$

(D) $\dfrac{x_1 - x}{x_0 - x_1} y_0 + \dfrac{x_0 - x}{x_1 - x_0} y_1$

6. If T^i_j is a second rank mixed tensor, it transforms under the co-ordinate change $\{x^i\} \to \{\bar{x}^i\}$ as

(A) $\bar{T}^\alpha_\beta = \dfrac{\partial \bar{x}^\alpha}{\partial x^i} \dfrac{\partial \bar{x}^\beta}{\partial x^j} T^i_j$

(B) $\bar{T}^\alpha_\beta = \dfrac{\partial \bar{x}^\alpha}{\partial x^i} \dfrac{\partial x^j}{\partial \bar{x}^\beta} T^i_j$

(C) $\bar{T}^\alpha_\beta = \dfrac{\partial x^i}{\partial \bar{x}^\alpha} \cdot \dfrac{\partial x^j}{\partial \bar{x}^\beta} T^i_j$

(D) $\bar{T}^\alpha_\beta = \dfrac{\partial \bar{x}^\alpha}{\partial x^i} \cdot \dfrac{\partial \bar{x}^j}{\partial x^\beta} T^i_j$

7. Let $(x_0, y_0), (x_1, y_1), \ldots. (x_n, y_n)$ be n points in the x – y plane then integral $\int_{x_0}^{x_n} y\,dx$ by the Simpson's rule is given by

(A) $\dfrac{h}{3}\left[(y_0 + y_n) + 2(y_1 + y_3 + y_5 + \ldots + y_{n-1}) + 4\,(y_2 + y_4 + \ldots y_{n-2})\right]$

(B) $\dfrac{h}{3}\left[(y_0 + y_n) + 3(y_1 + y_3 + y_5 + \ldots + y_{n-1}) + 4\,(y_2 + \ldots + y_{n-2})\right]$

(C) $\dfrac{h}{3}\left[(y_0 + y_n) + 4(y_1 + y_3 + \ldots + y_{n-1}) + 2\,(y_2 + y_4 + \ldots + y_{n-2})\right]$

(D) $\dfrac{h}{3}\left[(y_0 + y_n) + 2(y_1 + y_3 + \ldots + y_{n-1}) + 3\,(y_2 + y_4 + \ldots + y_{n-2})\right]$

Where h is the equal interval between the points $x_0, x_1, x_2 \ldots$ and n is even.

8. In the modified Euler's method, solution to the differential equation $\frac{dy}{dx} = f(x, y)$ is obtained by using the algorithm

(A) $y_{n+1}^{(r+1)} = y_n + \frac{h}{2}\left[f(x_n, y_n) + f(x_{n+1}, y_{n+1}^{(r)})\right]$

(B) $y_{n+1}^{(r+1)} = y_n + h\left[f(x_n, y_n) + f(x_{n+1}, y_{n+1}^{(r)})\right]$

(C) $y_{n+1}^{(r+1)} = y_n + \frac{h}{2}\left[f(x_n, y_n) + 2f(x_{n+1}, y_{n+1}^{(r)})\right]$

(D) $y_{n+1}^{(r+1)} = y_n + \frac{h}{2}\left[2f(x_n, y_n) + f(x_{n+1}, y_{n+1}^{(r)})\right]$

Where $y_{n+1}^{(r+1)}$ is the $(r + 1)^{th}$ approximation to the value of y at x_{n+1}.

9. If the line element of a space is given as $ds^2 = 2dq^2 + 4dq_1dq_2 + 3dq_2^2$, the metric tensor is given by

(A) $\begin{pmatrix} 2 & 4 \\ 4 & 3 \end{pmatrix}$

(B) $\begin{pmatrix} \sqrt{2} & 2 \\ 2 & \sqrt{3} \end{pmatrix}$

(C) $\begin{pmatrix} 2 & 2 \\ 2 & 3 \end{pmatrix}$

(D) $\begin{pmatrix} \sqrt{2} & 4 \\ 4 & \sqrt{3} \end{pmatrix}$

10. The phase space of a simple harmonic oscillator with mass 'm' and force constant 'k' with energy 'E' is given by the curve

(A) $\frac{P^2}{2m} - \frac{1}{2}kx^2 = E$

(B) $\frac{P^2}{2m} + \frac{1}{2}kx^2 = E$

(C) $\frac{P^2}{\sqrt{2m}} + \sqrt{\frac{k}{2}}\,x^2 = \sqrt{E}$

(D) $\frac{P^2}{2m} + \frac{1}{2}kx^2 = E^2$

11. Assuming the fundamental Poisson bracket [q, p] = 1, evaluate the Poisson bracket $[p^2, q^2]$.

(A) 0 (B) 2pq

(C) 4pq (D) – 4pq

12. The transformation from (q_i, p_i) to $(Q_i, \mathbb{P}_i)$ is canonical when the following condition is satisfied.

(A) $\sum_i (\mathbb{P}_i dQ_i + p_i dq_i)$ is an exact differential

(B) $\sum_i (\mathbb{P}_i dQ_i - p_i dq_i)$ is an exact differential

(C) $\sum_i (\mathbb{P}_i dq_i - p_i dQ_i)$ is an exact differential

(D) $\sum_i (\mathbb{P}_i dp_i - Q_i dq_i)$ is an exact differential

13. For what values of α and β is the following transformation canonical ?

$Q = q^{\alpha} \cos\beta q$

$\mathbb{P} = q^{\alpha} \sin\beta q$

(A) $\alpha = \frac{1}{2}, \beta = 2$

(B) $\alpha = 2, \beta = \frac{1}{2}$

(C) $\alpha = \frac{1}{3}, \beta = 3$

(D) $\alpha = 3, \beta = \frac{1}{3}$

14. If $F = \sum q_i \mathbb{P}_i$ is the generating function for a canonical transformation, then under the transformation we are lead to

(A) $Q_i = q_i, \ \mathbb{P}_i = p_i$

(B) $Q_i = -q_i, \ \mathbb{P}_i = -p_i$

(C) $Q_i = -q_i, \ \mathbb{P}_i = p_i$

(D) $Q_i = q_i, \ \mathbb{P}_i = -p_i$

15. The number of independent components of a four dimensional second rank symmetric tensor is

(A) 4

(B) 6

(C) 10

(D) 16

16. Find the generator of the following canonical transformation :

$Q = p \tan t$

$\mathbb{P} = -q \cot t$

Where t = time,

(A) F = qQ cot t

(B) F = qQ tan t

(C) $F = \frac{Q}{q} \cot t$

(D) $F = \frac{Q}{q} \tan t$

17. If the Lagrangian of a system does not depend on time explicitly then

(A) The Lagrangian is conserved

(B) The total momentum is conserved

(C) The Hamiltonian is conserved

(D) The total angular momentum is conserved

18. The Hamilton-Jacobi equation for a mass thrown up vertically from the surface of the earth is given by

(A) $\frac{1}{2m}\left(\frac{\partial s}{\partial z}\right)^2 - mgz = \alpha$

(B) $-\frac{1}{2m}\left(\frac{\partial s}{\partial z}\right)^2 + mgz = \alpha$

(C) $\frac{1}{2m}\left(\frac{\partial s}{\partial z}\right)^2 + mgz = \alpha$

(D) $\frac{1}{2m}\left(\frac{\partial s}{\partial z}\right) + mgz = \alpha$

Where m = mass of the object, α is a constant and s is the action. z = height above the ground.

19. The cut-off frequencies of TE_{II} mode in a rectangular metal wave guide with dimensions 2 cm × 1 cm is

(A) 15.88 GHz

(B) 16.16 GHz

(C) 18.2 GHz

(D) 16.77 GHz

20. The operator

$$\frac{\partial^2}{\partial x_\mu^2} = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2} = \Box^2,$$

a four dimensional operator is known as

(A) Laplace operator

(B) Lorentz operator

(C) Hermitian operator

(D) d'Alembertian operator

21. If x_μ are four vector co-ordinates then match the correct options from Columns I and II.

Column I	Column II
(a_1) x_μ	(b_1) $x_\mu + x_\mu$
(a_2) Square of length of four vector s^2	(b_2) $x_1 \cdot x_2 \cdot x_3 \cdot x_4$
	(b_3) x_1, x_2, x_3, x_4
	(b_4) $x_\mu\, x_\mu$

(A) $a_1 \to b_1$; $a_2 \to b_2$

(B) $a_1 \to b_3$; $a_2 \to b_4$

(C) $a_1 \to b_3$; $a_2 \to b_1$

(D) $a_1 \to b_4$; $a_2 \to b_1$

22. If $F_{\mu\gamma}$ with $\mu = 1, 2, 3, 4$ and $\gamma = 1, 2, 3, 4$ are the components of the electromagnetic field tensor {F} then the component $\left(\bar{\nabla} \times \bar{E}\right)_1 + \frac{\partial B_1}{\partial t} = 0$ of the Maxwell's equation can be obtained from equation $\frac{\partial F_{\lambda\mu}}{\partial x_\gamma} + \frac{\partial F_{\mu\gamma}}{\partial x_\lambda} + \frac{\partial F_{\gamma\lambda}}{\partial x_\mu} = 0$ with the following values of λ, μ and γ.

(A) $\lambda=2,\ \mu=3,\ \gamma=4$

(B) $\lambda=3,\ \mu=4,\ \gamma=3$

(C) $\lambda=4,\ \mu=1,\ \gamma=2$

(D) $\lambda=1,\ \mu=2,\ \gamma=1$

23. Potential $\vec{A}(r) = \frac{\mu_0}{4\pi}\int \frac{\vec{j}(r)}{|\bar{r} - \bar{r}'|} d\tau$, the solution of differential equation $\bar{\nabla}^2\vec{A} = -\mu_0\vec{J}$ is valid if

(A) The charge density ρ and currents on the body are changing with time

(B) The charge density ρ and currents on the body are homogeneous

(C) The charges are at rest and currents are steady

(D) Currents keep changing with time

24. In case of an oscillating dipole, the radiation resistance R_r is

(A) Directly proportional to dipole length

(B) Directly proportional to square of the wavelength emitted by the dipole

(C) Inversely proportional to the wavelength radiated by the dipole

(D) Inversely proportional to the square of the wavelength radiated by the dipole

25. In a rectangular wave guide, for dominant mode propagation

(A) The operating frequency must be 2 times the cut-off frequency of the guide

(B) The operating frequency must be same as cut-off frequency of the guide

(C) The cut-off frequency must be reciprocal of the operating frequency of the guide

(D) The cut-off frequency must be 2 times the operating frequency of the guide

26. In a wave guide with conducting walls, let $E_{||}$ and $B_{||}$ be the components of the electric and magnetic fields parallel to the inner walls while $E_{\perp}$ and $B_{\perp}$ be the components normal to the inner walls. Then the correct boundary conditions are

(A) $E_{||}$ and $B_{||}$ are both zero

(B) $E_{||} = 0$ and $B_{\perp} = 0$

(C) $E_{\perp} = 0$ and $B_{||} = 0$

(D) $E_{\perp} = 0$ and $B_{\perp} = 0$

27. The Poynting vector of an electric dipole oscillating along z-axis is proportional to

(A) $(\cos^2\theta)\,\hat{r}$

(B) $\hat{r}\sin^2\theta$

(C) $2\hat{r}\sin\theta\cos\theta$

(D) $\hat{r}\sin^2\theta\cos^2\theta$

Where $\hat{r}$ is a unit vector along the radial direction. The dipole is located at the origin.

28. In the dipole approximation, the induced transition rate between two quantum states $|n\rangle$ and $|m\rangle$ is proportional to

(A) $\langle m|\bar{r}|n\rangle$

(B) $|\langle m|\bar{r}|n\rangle|$

(C) $|\langle m|\bar{r}|n\rangle|^2$

(D) $|\langle m|\bar{r}|n\rangle|^{3/2}$

29. The scattering amplitude in quantum mechanics has the dimension of

(A) Length

(B) Area

(C) $(\text{Length})^{1/2}$

(D) Dimensionless

30. In partial waves method, the total cross section is given by

(A) $\sigma = \frac{4\pi}{K^2}\sum_{l=0}^{\infty}(2l+1)\sin^2\delta_l$

(B) $\sigma = \frac{4\pi}{K^2}\sum_{l=0}^{\infty}(2l+1)\cos^2\delta_l$

(C) $\sigma = \frac{4\pi}{K^2}\sum_{l=0}^{\infty}(2l+3)\sin^2\delta_l$

(D) $\sigma = \frac{4\pi}{K^2}\sum_{l=0}^{\infty}(l+\tfrac{1}{2})\sin\delta_l\cos\delta_l$

31. The Dirac Hamiltonian is represented as

(A) $\hat{H} = C(\hat{\alpha}\cdot\hat{p}) + \hat{\beta}\, m_0 C^2$

(B) $\hat{H} = C(\hat{\alpha}\cdot\hat{p}) - \hat{\beta}\, m_0 C^2$

(C) $\hat{H} = C^2(\hat{\alpha}\cdot\hat{p}) + \hat{\beta}\, C$

(D) $\hat{H} = C^2(\hat{\beta}\cdot\hat{p}) + \hat{\alpha}\, m_0 C^2$

Where $\hat{\alpha}$ and $\hat{\beta}$ are Dirac matrics.

32. Consider scattering of neutrons by a nuclear potential of range 1.2 fm. If the energy of the neutron beam is 100 MeV, the partial waves that will contribute to scattering cross-section are

(A) $l = 0$ (s-wave)

(B) $l = 0, 1$ (s and p waves)

(C) $l = 0, 1, 2$ (s, p and d-waves)

(D) $l = 0, 1, 2, 3$ (s, p, d and f waves)

33. In scattering experiments, the differential cross-section for spherically symmetric potential V(r) using Born approximation is given by

(A) $\frac{d\sigma(\theta)}{d\Omega} = \left(\frac{2\mu}{\hbar^2}\right)^2 \left| \int_0^\infty V(r) \left[\frac{\sin qr}{qr}\right] r^2 dr \right|^2$

(B) $\frac{d\sigma(\theta)}{d\Omega} = \left(\frac{2\mu}{\hbar^2}\right)^2 \left| \int_0^\infty V(r) \left[\frac{\cos qr}{qr}\right] r^2 dr \right|^2$

(C) $\frac{d\sigma(\theta)}{d\Omega} = \left(\frac{2\mu}{\hbar^2}\right)^2 \left| \int_0^\infty V(r) \left[\frac{1}{qr}\right] r^2 dr \right|^2$

(D) $\frac{d\sigma(\theta)}{d\Omega} = \left(\frac{2\mu}{\hbar^2}\right)^2 \left| \int_0^\infty V(r)\, r^2 dr' \right|^2$

34. If $\alpha_x, \alpha_y, \alpha_z$ and β denote the Dirac matrices, then which of the following is correct ?

(A) $\alpha_i^2 = 1,\ \beta^2 = -1$, trace $\beta = +1$

(B) $\alpha_i^2 = -1,\ \beta^2 = 1$, trace $\beta = 0$

(C) $\alpha_i^2 = 1,\ \beta^2 = 1$, trace $\beta = 0$

(D) $\alpha_i^2 = 1,\ \beta^2 = 1$, trace $\beta = -1$

Where α_i is any one of α_x, α_y and α_z.

35. The Klein-Gordon equation for a free particle of rest mass 'm' is given by

(A) $\hbar^2 \frac{\partial^2\psi}{\partial t^2} = \hbar^2 c^2 \nabla^2 \psi + m^2 c^4 \psi$

(B) $-\hbar^2 \frac{\partial^2\psi}{\partial t^2} = \hbar^2 c^2 \nabla^2 \psi + m^2 c^4 \psi$

(C) $-\hbar^2 \frac{\partial^2\psi}{\partial t^2} = -\hbar^2 c^2 \nabla^2 \psi + m^2 c^4 \psi$

(D) $\hbar^2 \frac{\partial^2\psi}{\partial t^2} = -\hbar^2 c^2 \nabla^2 \psi - m^2 c^4 \psi$

36. The transition rate between two quantum states $|m\rangle$ and $|n\rangle$ due to spontaneous emission is proportional to

(A) $W_{mn}^3 |\langle m|\,\bar{r}\,|n\rangle|^2$

(B) $W_{mn}^2 |\langle m|\,\bar{r}\,|n\rangle|^2$

(C) $W_{mn} |\langle m|\,\bar{r}\,|n\rangle|^2$

(D) $\frac{1}{W_{mn}^2} |\langle m|\,\bar{r}\,|n\rangle|^2$

Where $W_{mn} = (E_m - E_n)/\hbar$

37. The ratio of Einstein coefficients A and B for laser is proportional to

(A) γ

(B) γ^2

(C) γ^3

(D) γ^4

38. The energy separation between two consecutive stokes lines in Raman scattering depends on

(A) Energy separation between vibrational levels in the excited state

(B) Wavelength of the incident light

(C) Energy separation between vibrational levels in the ground state

(D) Intensity of the incident light

39. Which of the following molecules does not exhibit a rotational spectrum ?

(A) H

(B) CO

(C) HCl

(D) HBr

40. Wavelength of $\lambda = 1.064\ \mu m$ is emitted by

(A) He – Ne laser

(B) CO_2 laser

(C) Ruby laser

(D) Nd-YAG laser

41. The typical energy of the rotational modes in a polyatomic molecule like NH_3 is

(A) 10^6 eV

(B) 10^{-3} eV

(C) 10^{-1} eV

(D) 1 eV

42. The alternation of intensities observed in the pure rotational Raman spectrum of homonuclear diatomic molecules is due to

(A) Isotope effect

(B) Nuclear spin

(C) Electron spin

(D) Doppler effect

43. Ionization energy for hydrogen atom, initially at n = 3 excited state is

(A) – 13.6 eV

(B) + 13.6 eV

(C) – 3.4 eV

(D) + 1.51 eV

44. Selection rule for Raman spectrum is

(A) $\Delta J = 0$

(B) $\Delta J = \pm 1$

(C) $\Delta J = \pm 2$

(D) $\Delta J = \pm 3$

45. The Red light emitted by a He-Ne laser is due to transition between

(A) He energy levels

(B) He and Ne energy levels

(C) Ne energy levels

(D) Impurity energy levels

46. The proton and neutron have almost same mass because

(A) Up and down quarks have the same spin

(B) Masses of the up and down quarks are similar

(C) Both are colorless

(D) Both are part of nucleus

47. If two nuclei of masses m_1 and m_2 are fused to form a nucleus of mass m and some energy is released, then

(A) $(m_1 + m_2) > m$

(B) $(m_1 + m_2) < m$

(C) $(m_1 + m_2) = m$

(D) $m_1 - m_2 = m$

48. The property of "strangeness" was proposed by

(A) Gamow and Teller

(B) Weisskopf

(C) Wigner

(D) Gellmann and Nishijima

49. If the mass of the exchanged particle is m, then the range of the force is approximately equal to

(A) $\frac{\hbar c}{m}$

(B) $\frac{\hbar}{mc}$

(C) $\frac{\hbar m}{c}$

(D) $\hbar mc$

50. The following reaction is not allowed by strong interaction :

$d + d \rightarrow {}^4He + \pi^\circ$

That is because, in the reaction

(A) Parity is not conserved

(B) Angular momentum is not conserved

(C) Isospin is not conserved

(D) Strangeness is not conserved

51. In the shell model with harmonic oscillator potential, closed shells occur for N or Z equal to

(A) $\sum_l (2l + 1)$

(B) $\sum_l 2(2l + 1)$

(C) $\sum_l 2(l + 1)$

(D) $\sum 2(2l + 1)^2$

Where $l = 0, 1, 2, ...$

52. The ratio of the cross sections $\frac{\sigma(n + p \rightarrow \pi^\circ + d)}{\sigma(p + p \rightarrow \pi^+ + d)}$ is equal to

(A) 1

(B) $3/4$

(C) $1/2$

(D) $1/4$

53. Which of the following is not a moderator in an atomic pile ?

(A) Heavy water

(B) Graphite

(C) Beryllium

(D) Boron

54. Match the quark-antiquark composition of the following particles.

Particle	**Quark-antiquark composition**
1. K^+	a. $u\bar{d}$
2. K°	b. $u\bar{s}$
3. π^+	c. $\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$
4. π°	d. $d\bar{s}$

(A) 1 – b, 2 – a, 3 – c, 4 – d

(B) 1 – d, 2 – c, 3 – a, 4 – b

(C) 1 – b, 2 – d, 3 – a, 4 – c

(D) 1 – c, 2 – b, 3 – d, 4 – a

55. The orientational polarizability per molecule in a polyatomic gas is given by

(A) $\frac{\mu_m}{3\,k_B T}$

(B) $\frac{\mu_m^2}{3\,k_B T}$

(C) $\frac{\mu_m^3}{3\,k_B T}$

(D) $\frac{\mu_m^2}{3\,k_B T^2}$

56. In an allowed band of semiconductor, the effective mass m^* of the electron is infinite

(A) at the bottom of energy band

(B) at the top of the energy band

(C) in the middle of the energy band

(D) never

57. The Fermi level of an n-type semiconductor is

(A) Close to the valence band

(B) At the middle of the band gap

(C) Inside the conduction band

(D) Close to the conduction band

58. Magnetic susceptibility of a perfect diamagnet in CGS units is

(A) 0

(B) $\frac{+1}{4\pi}$

(C) $\frac{-1}{4\pi}$

(D) Infinity

59. In Bose-Einstein condensation at critical temperature, the de Broglie wavelength of particles constituting the medium should be equal to

(A) Average particles distance

(B) Critical volume of particles

(C) Planck's constant

(D) Chemical potential

60. Bose-Einstein condensation temperature T_c refers to the temperature below which

(A) An assembly of Bose gas condenses to the liquid state

(B) There is an appreciable occupation of the ground state in an electron system

(C) There is a significantly large occupancy of the ground state in a system of bosons

(D) The bosons essentially behave like fermions

61. The total number of $(Na^{+} + Cl^{-})$ ions per unit cell is
(A) 2
(B) 4
(C) 6
(D) 8

62. Dielectric function $\in (w)$ at frequency w for free electron gas is equal to

(A) $1 - \frac{4\pi ne^2}{mw^2}$

(B) $1 + \frac{4\pi ne^2}{mw^2}$

(C) $\sqrt{\frac{4\pi ne^2}{mw^2}}$

(D) $\sqrt{\frac{mw^2}{4\pi ne^2}}$

63. Which of the following gauge can measure the pressure in the range of 10^{-3} to 10^{-10} Torr. ?
(A) McLeod Gauge
(B) Pirani Gauge
(C) Penning Gauge
(D) Ionization Gauge

64. An analog transducer has range of 0 – 10 V. How many bits of A/D converter is required to get the resolution of 5 mV ?
(A) 10
(B) 9
(C) 11
(D) 8

65. Which of the following radiation detectors has poor energy resolution ?
(A) G. M. Counter
(B) Scintillation detector
(C) Si(Li)/Ge(Li)
(D) Si at room temperature

66. The Johnson Noise in resistor R is given by

(A) $\overline{v}^2_{rms} = (4KTR\Delta f)$

(B) $\overline{v}_m = (2qI\Delta f)^{1/2} R$

(C) $\overline{v}_{rms} = A/f^2$

(D) $\overline{v}_{rms} = A/f$

67. Floating voltage signals should be amplified by
(A) OP-AMP in inverting configuration
(B) OP-AMP in non-inverting configuration
(C) Instrumentation amplifier
(D) Buffer amplifier

68. A certain op-amp has an open loop gain of 200000 and a common mode gain of 2. The common mode rejection ratio (CMMR) of the op-amp is
(A) 20 dB
(B) 40 dB
(C) 60 dB
(D) 100 dB

69. Which of the following amplifier is used to extract signal one million times smaller than noise component ?

(A) Instrumentation amplifier

(B) Buffer amplifier

(C) Pre-amplifier

(D) Lock-in-amplifier

70. The number of atoms per unit cell of the reciprocal of bcc structure is

(A) 1

(B) 2

(C) 3

(D) 4

71. Einstein's relation connecting the coefficient of diffusion with mobility is

(A) $\frac{KT}{e}\mu$

(B) $\frac{KP}{e}\mu$

(C) $\frac{eT}{K}\mu$

(D) $\frac{KT^2}{e}\mu$

72. Which of the following radiation has the most penetrating power ?

(A) α particles

(B) β particles

(C) γ rays

(D) Neutrons

73. A transient response of a control system can be checked by using

(A) Sinusoidal wave form

(B) Square wave form

(C) Triangular wave form

(D) Ramp wave form

74. To eliminate noise due to building vibrations, one of the following filters is used. Tick the right answer.

(A) Low pass filter

(B) High pass filter

(C) Band pass filter

(D) Band stop filter

75. The crystal unit cell with parameters a = 3.1 Å, b = 3.1 Å, c = 5.2 Å and $\alpha = \beta = \gamma = 90^\circ$ belongs to

(A) Cubic

(B) Triclinic

(C) Monoclinic

(D) Tetragonal

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Space for Rough Work

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