Test Paper : **II**

Test Subject : **PHYSICAL SCIENCES**

Test Subject Code : **K-2518**

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

(Figures as per admission card)

OMR Sheet No. : ____________________

TEST 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) ಪಶ್ನೆಪುಸ್ತಿಕೆಗೆ 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 : Ⓐ Ⓑ ● Ⓓ

   (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 : Ⓐ Ⓑ ● Ⓓ

   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 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 SCIENCES
Paper – II

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

1. The eigenvalues of a 5×5 matrix B are 2, 1, 0, –1, –2. The determinant of e^B is

(A) e

(B) $1/e$

(C) 1

(D) 0

2. Given $\hat{A} = \exp\left(2\pi \frac{d}{dx}\right)$, $\hat{A}(e^{-x})$ is

(A) $-e^x$

(B) e^x

(C) $-e^{-x}$

(D) e^{-x}

3. The value of $\int_{-\infty}^{\infty} \sin x\, \delta'(x)\, dx$ is

(A) 1 (B) –1

(C) 0 (D) ∞

4. A solution of the differential equation $\frac{dy}{dx} = -\frac{y^3}{x^4}$ is

(A) y^2x^3 = const.

(B) $y^{3/2}/x^2 = \text{const}$.

(C) $\frac{3}{y^2} - \frac{2}{x^3} = \text{const}$.

(D) $\frac{3}{y^2} + \frac{2}{x^3} = \text{const}$.

5. If A^{ij}_k is a third rank mixed tensor, it transforms under the coordinate change $\{x^i\} \to \{\bar{x}^i\}$ as

(A) $\bar{A}^{ij}_k = \frac{\partial \bar{x}^i}{\partial x^m} \frac{\partial \bar{x}^j}{\partial x^n} \frac{\partial \bar{x}^k}{\partial x^l} A^{mn}_l$

(B) $\bar{A}^{ij}_k = \frac{\partial \bar{x}^i}{\partial x^m} \frac{\partial \bar{x}^j}{\partial x^n} \frac{\partial x^l}{\partial \bar{x}^k} A^{mn}_l$

(C) $\bar{A}^{ij}_k = \frac{\partial x^m}{\partial \bar{x}^i} \frac{\partial x^n}{\partial \bar{x}^j} \frac{\partial x^l}{\partial \bar{x}^k} A^{mn}_l$

(D) $\bar{A}^{ij}_k = \frac{\partial x^m}{\partial \bar{x}^i} \frac{\partial x^n}{\partial \bar{x}^j} \frac{\partial \bar{x}^k}{\partial x^l} A^{mn}_l$

6. Which of the following is <u>not</u> an su(2) matrix ?

(A) $\begin{pmatrix} e^{i\phi} & 0 \\ 0 & e^{-i\phi} \end{pmatrix}$ (B) $\begin{pmatrix} 0 & e^{i\theta} \\ -e^{-i\theta} & 0 \end{pmatrix}$

(C) $\begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$ (D) $\begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}$

7. Which of the following matrices are Hermitian ?

a. $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$ b. $\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$

c. $\begin{pmatrix} 0 & i \\ -i & 0 \end{pmatrix}$ d. $\begin{pmatrix} i & 1 \\ 1 & -i \end{pmatrix}$

(A) a, b, c

(B) b, c

(C) b, c, d

(D) a, d, c

8. The work done by the force $\vec{F} = x\hat{i} + y\hat{j}$ along a circular path from (1, 0) to (0, 1) is

(A) 0 (B) 1

(C) –2 (D) 2

9. The volume of the parallelopiped with edges $\vec{A} = \hat{i} + \hat{j}, \vec{B} = \hat{j} + \hat{k}$ and $\vec{C} = \hat{k} + \hat{i}$ is

(A) 8 (B) 6

(C) 4 (D) 2

10. f(z) is a function of complex variable z given by $f(z) = \frac{\sqrt{z-1}}{(z+1)^2}$

(A) z = –1 is a simple pole

(B) z = –1 is a branch point

(C) z = 1 is a branch point

(D) z = 1 is analytic in the region $\left| z - \frac{1}{2} \right| = 1$

11. Which differential equation has singularities at x = 1, –1, ∞ ?

(A) Legendre differential equation

(B) Bessel differential equation

(C) Hermite differential equation

(D) Laguerre differential equation

12. If F = ax + bv, where F, x, v are the magnitudes of force, position and velocity respectively, then $\frac{a}{b}$ has the dimensions

(A) T^{-2} (B) T^{-1}

(C) T (D) T^2

13. The physical quantity that has the same dimension as the action S in Hamilton's principle is

(A) Linear momentum

(B) Energy

(C) Orbital angular momentum

(D) Torque

14. q_k is said to be a cyclic coordinate if

(A) $\frac{\partial L}{\partial q_k} = 0$ (B) $\frac{\partial L}{\partial \dot{q}_k} = 0$

(C) $\frac{\partial L}{\partial q_k} = 2\pi n$ (D) $L(q_k) = L(q_k + 2\pi)$

15. If F = $\sum q_i Q_i$ is the generating function of a set of canonical transformations then

(A) $p_i = Q_i, P_i = -q_i$

(B) $p_i = q_i, P_i = -Q_i$

(C) $p_i = -Q_i, P_i = q_i$

(D) $p_i = -Q_i, P_i = -q_i$

16. Lagrangian equations of motion : $\frac{d}{dt}\frac{\partial L}{\partial \dot{q}_i} - \frac{\partial L}{\partial q_i} = 0$ are applicable to

(A) conservative, holonomic systems

(B) non-conservative, holonomic systems

(C) conservative, non-holonomic systems

(D) non-conservative, non-holonomic systems

17. Phase space trajectory of a one-dimensional simple harmonic oscillator is

(A) Hyperbola (B) Parabola

(C) Ellipse (D) Cycloid

18. The Lagrangian equations of motion will remain unchanged, if the Lagrangian L is replaced by L + L′ where L′ is a total time derivative of a function of

(A) Generalised coordinates and velocities

(B) Generalised velocities and time

(C) Generalised velocities

(D) Generalised coordinates and time

19. A planet moves in an orbit $r(\theta) = \frac{l}{1+\in\cos\theta}$ where l and $\in$ are constants, under the influence of a force $\vec{F}(\vec{r}) = -\frac{k\hat{r}}{r^2}$ (k > 0). The orbital speed of the planet is minimum when

(A) $\theta = 0$

(B) $\theta = \pi/3$

(C) $\theta = \pi/2$

(D) $\theta = \pi$

20. A particle of mass m moves in a central potential $V(r) = kmr^3$ (k > 0). The angular momentum for which the orbit will be a circle of radius a about the origin is

(A) $ma\sqrt{k}\ a$

(B) $ma^2\sqrt{3ka}$

(C) $ma^2\sqrt{ka}$

(D) $ma\sqrt{ka}$

21. If the Lagrangian of a system is $L(q,\dot{q},t) = \frac{1}{2}q^2(\dot{q})^2 - q^4$ the equation of motion is

(A) $q\ddot{q} + (\dot{q})^2 + 4q^2 = 0$

(B) $\ddot{q} + (\dot{q})^2 + 4q^3 = 0$

(C) $\ddot{q} + (\dot{q})^2 - 4q^3 = 0$

(D) $\ddot{q} + (\dot{q})^2 - 4q^2 = 0$

22. If the orbit of the equation in r – θ plane is $r = e^{k\theta}$, then the central force varies as

(A) $1/r^3$ (B) $1/r^2$

(C) $1/r$ (D) r

23. For which values of α and β is the following transformations

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

$P = q^\alpha \sin \beta q$

is a canonical transformation ?

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

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

(C) $\alpha = -1/2,\ \ \beta = 2$

(D) $\alpha = \frac{1}{4},\ \ \beta = 4$

24. If the spatial and temporal coordinates of two events in an inertial frame are : (x_1, y_1, z_1, t_1) and (x_2, y_2, z_2, t_2) then the following expression remains unchanged under Lorentz transformations

(A) $(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2$

(B) $(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 - c^2(t_1 - t_2)^2$

(C) $(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 + c^2(t_1 - t_2)^2$

(D) $(x_1 + x_2)^2 + (y_1 + y_2)^2 + (z_1 + z_2)^2 - c^2(t_1 + t_2)^2$

25. In the absence of an applied magnetic field, warm plasma can support both electron plasma waves and ion-plasma waves (ion-acoustic waves). The dispersion relations for these two waves indicate that, at large values of wave number k

(A) Electron plasma waves become constant velocity waves, whereas ion plasma waves become constant frequency waves

(B) Both waves become constant frequency waves

(C) Ion plasma waves become constant velocity waves, whereas electron plasma waves become constant frequency waves

(D) Both waves become constant velocity waves

26. The wave equation corresponding to a certain electromagnetic phenomenon occurring in a material medium is given by $(\nabla^2 + k_0^2)\,\vec{E}(\vec{r}, t) = \dfrac{1}{c^2}\dfrac{\partial^2 \vec{E}}{\partial t^2}$

where k_0^2 is a real constant of suitable dimensions. An electromagnetic wave whose electric field is given as $\vec{E}(\vec{r}, t) = \vec{E}_0\, e^{i(\vec{k}\cdot\vec{r} - \omega t)}$ propagates through the medium, where $\vec{E}_0$ is a constant vector. The relation between w and k is

(A) $\omega^2 = k^2c^2$

(B) $\omega^2 = (k + k_0)^2\, c^2$

(C) $\omega^2 = (k^2 - k_0^2)\, c^2$

(D) $\omega^2 = (k^2 + k_0^2)\, c^2$

27. Which of the following is the incorrect Maxwell's equation in free space, where both charges and currents are absent ?

(A) $\nabla \cdot \vec{E} = 0$

(B) $\nabla \cdot \vec{B} = 0$

(C) $\nabla \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$

(D) $\nabla \times \vec{B} = \dfrac{1}{\mu_0 \in_0}\dfrac{\partial \vec{E}}{\partial t}$

28. The electric field associated with a static charge distribution is given by $\vec{E} = -\dfrac{Qe^{-\mu r}}{4\pi \in_0 r^2}\,\hat{r}$. The value of the integral $\int \rho(\vec{r})\,d^3r$ over a spherical volume of radius R > 0 centered around the origin and $\rho(\vec{r})$ being the charge density is given by

(A) $Q\,e^{-\mu R}$ (B) $Q(1 - e^{-\mu R})$

(C) $4\pi Q$ (D) 0

29. The electric field in a source-free region is given by $\vec{E} = x\hat{i} + by\hat{j}$. The value of b is

(A) –1 (B) 0

(C) 1 (D) ∞

30. A co-axial cable of uniform cross section contains an insulating material of dielectric constant 3.5. The radius of the central wire is 0.01m and that of the sheath is 0.02 m. The capacitance per kilometer of a cable is

(A) 280.5 nF (B) 28.05 nF

(C) 56.10 nF (D) 2.805 nF

31. The electric field created by a charged sphere of radius R, having a charge density distribution given by $\rho = \rho_0 r$, is given by :

[Let $E_<$ represent the electric field for $r < R$ and $E_>$ represent the electric field for $r > R$]

(A) $E_< = \frac{\rho_0 r^2}{4 \epsilon_0}$, $E_> = \frac{\rho_0 R^4}{4 \epsilon_0 r^2}$

(B) $E_< = \frac{\rho_0 r}{3 \epsilon_0}$, $E_> = \frac{\rho_0 R^3}{3 \epsilon_0 r^2}$

(C) $E_< = \frac{\rho_0}{3 \epsilon_0}$, $E_> = \frac{\rho_0 R^3}{2 \epsilon_0 r^2}$

(D) $E_< = \frac{\rho_0 r}{4 \epsilon_0}$, $E_> = \frac{\rho_0 R^4}{4 \epsilon_0 r^2}$

32. A thin conducting wire is bent into a circular loop of radius r and placed in a time dependent magnetic field $\vec{B}(t) = B_0 e^{-\alpha t}\hat{k}$, ($B_0 > 0$ and $\alpha > 0$). Then the induced emf in the loop is

(A) $\pi r^2 \alpha B_0 e^{-\alpha t}$ (B) $\pi r^2 B_0 e^{-\alpha t}$

(C) $-\pi r^2 \alpha B_0 e^{-\alpha t}$ (D) $-\pi r^2 B_0 e^{-\alpha t}$

33. An infinite current sheet in the z = 0 plane carries a uniform constant current along the positive y-axis. According to Ampere's law in magnetostatics, the magnetic field vector generated by the current sheet in the region z > 0 is

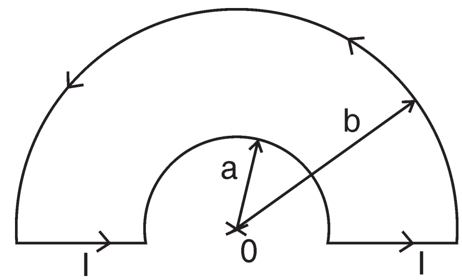
(A) Oriented perpendicular to the current sheet and points away from it

(B) Oriented parallel to the current sheet and points along the negative y-axis

(C) Oriented parallel to the current sheet and is parallel to the x-axis

(D) Oriented parallel to the current sheet and making an angle of 45° with y-axis

34. A loop made of copper wire is bent in the shape as shown in the figure below. The radius of the smaller semi-circular segment is 'a' and that of the larger semi-circular segment is 'b'. If a current I flows in the loop, the magnetic field at the centre '0' of the semi-circular segment is



(A) $\frac{\mu_0 I}{2}\left(\frac{1}{a}+\frac{1}{b}\right)$ (B) $\frac{\mu_0 I}{2}\left(\frac{1}{a}-\frac{1}{b}\right)$

(C) $2\mu_0 I\left(\frac{1}{a}+\frac{1}{b}\right)$ (D) $\frac{\mu_0 I}{2}\left(\frac{1}{a^2}-\frac{1}{b^2}\right)$

35. A particle of mass m and charge e moves in an electromagnetic field described by a scalar potential $\phi(\vec{r})$ and vector potential $\vec{A}(\vec{r})$. If c is the speed of light in vacuum, the momentum conjugate to the position $\vec{r}$ is

(A) $m\vec{v}$ (B) $m\vec{v} + e^2\vec{A}$

(C) $m\vec{v} - \frac{e\vec{A}}{c}$ (D) $m\vec{v} + \frac{e\vec{A}}{c}$

36. If light is incident at Brewster angle on a glass slab it results in

(A) The production of plane polarised light in reflection

(B) Total internal reflection of light

(C) The production of circularly polarised light in reflection

(D) The production of circularly polarised light in transmission

37. The product of the uncertainties Δx and Δp_x for the ground state of a one dimensional simple harmonic oscillator satisfies

(A) $\Delta x \ \Delta p_x > \frac{\hbar}{2}$ (B) $\Delta x \ \Delta p_x = \frac{\hbar}{2}$

(C) $\Delta x \ \Delta p_x < \frac{\hbar}{2}$ (D) $\Delta x \ \Delta p_x = 0$

38. If the Bohr radius is a_0, the most probable value of r in the ground state $\psi = \frac{1}{\sqrt{\pi a_0^3}} e^{-r/a_0}$ of Hydrogen atom is

(A) a_0 (B) $2a_0/3$

(C) $3a_0/2$ (D) $\sqrt{2}\, a_0$

39. The total number of energy eigen functions $\psi_{nlm}(r\,\theta\,\phi)$ corresponding to the same energy level E_n, without considering spin, according to non-relativistic quantum mechanics in the case of Hydrogen atom is

(A) $2l + 1$ (B) $2n^2$

(C) n^2 (D) $l(l + 1)$

40. The wave function of a particle is given by $\delta(x - x_0)$. The uncertainty in momentum Δp_x is

(A) zero (B) $\frac{\sqrt{\hbar}}{2}$

(C) $\sqrt{\hbar}$ (D) infinity

41. A particle of mass M is moving in a potential $V(x, y, z) = K(x^2 + y^2 + z^2)$ where K is a positive constant and $-\infty < x, y, z < \infty$. The degeneracy of the second excited state is

(A) zero (B) 3

(C) 6 (D) 9

42. The wave function of the second excited state of a particle in a box whose length is L, is proportional to

(A) $\sin\left(\frac{2\pi x}{L}\right)$ (B) $\sin\left(\frac{3\pi x}{L}\right)$

(C) $\sin\left(\frac{\pi x}{L}\right)$ (D) $\sin\left(\frac{\pi x}{3L}\right)$

43. The Klein-Gordon equation is used to describe a particle with spin

(A) zero (B) $\frac{\hbar}{2}$

(C) $\hbar$ (D) $2\hbar$

44. The relation between the partial cross section σ_l and the phase shift δ_l according to partial wave analysis is

(A) $\sigma_l = \frac{4\pi}{k^2}(2l+1)\sin^2\delta_l$

(B) $\sigma_l = \frac{4\pi}{k}(2l+1)\sin\delta_l$

(C) $\sigma_l = \frac{4\pi}{k^2}\sin^2\delta_l$

(D) $\sigma_l = \frac{4\pi}{k}\sin\delta_l$

45. Fine structure interaction involves coupling between

(A) Spin and orbital angular momentum of electron

(B) Spin and orbital angular momentum of nucleus

(C) Spin angular momentum of electron and spin angular momentum of nucleus

(D) Orbital angular momentum of the electron and spin angular momentum of the nucleus

46. Consider a quantum system described by a Hamiltonian H. Let $|\phi_1\rangle, |\phi_2\rangle$ denote the eigenvectors of H with respective eigenvalues E_1, E_2. The system is initially prepared in the state $|\psi_{in}\rangle = \frac{4}{5}|\phi_1\rangle + \frac{3}{5}|\phi_2\rangle$ and then it is allowed to evolve with time.

The state of the system is found to be $|\psi(t)\rangle = \frac{4}{5}|\phi_1\rangle - \frac{3}{5}|\phi_2\rangle$ at time t given by

(A) $h/4(E_2 - E_1)$ (B) $h/2(E_2 - E_1)$

(C) $2h/(E_2 - E_1)$ (D) $h/(E_2 - E_1)$

47. Which of the statements is NOT correct for the free particle Dirac Hamiltonian ?

(A) It commutes with the total angular momentum operator $\vec{J}$

(B) It commutes with the helicity operator

(C) It commutes with the spin operator $\vec{S}$

(D) It doesn't commute with the Dirac matrix β

48. If a system has the Hamiltonian operator $H = H_0 + H'$, where H' is a perturbation part and ψ_n are the eigen functions of the Hamiltonian H_0 such that $H_0 \psi_n = E_n \psi_n$, then the first order correction to E_n due to the perturbing Hamiltonian is given by

(A) $\dfrac{|\langle\psi_n|H'|\psi_n\rangle|}{\langle\psi_n|\psi_n\rangle}$

(B) $\dfrac{\langle\psi_n|H'|\psi_n\rangle}{\langle\psi_n|\psi_n\rangle}$

(C) $\left|\dfrac{\langle\psi_n|H'|\psi_n\rangle}{\langle\psi_n|\psi_n\rangle}\right|^{1/2}$

(D) $\dfrac{(\langle\psi_n|H'|\psi_n\rangle)^2}{\langle\psi_n|\psi_n\rangle}$

49. 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) $PV^{4/3}$ = constant

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

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

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

50. Blackbody radiation characterized by thermodynamic state variables T and V undergoes an adiabatic process. Which of the following describes this ?

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

(B) $TV^{\frac{2}{3}}$ = constant

(C) $TV^{1/3}$ = constant

(D) $TV^{1/2}$ = constant

51. One mole of oxygen gas undergoes isothermal expansion at a temperature of 310 K during which its volume increases from 12 litres to 19 litres. Assuming oxygen to be an ideal gas, the work done by the gas is (Given that gas constant R = 8.31 J/(mole. K))

(A) ~ 14,000 Joules

(B) ~ 2360 Joules

(C) ~ 1180 Joules

(D) ~ 7585 Joules

52. As T $\rightarrow$ 0, which combination of the following statements is correct ?

I. The entropy of every system vanishes.

II. The heat capacity of a system tends to infinity.

III. The thermal expansion coefficient approaches zero.

IV. The absolute temperature can never be reached.

(A) I, II and III are correct

(B) II, III and IV are correct

(C) III, IV and II are correct

(D) III, IV and I are correct

53. Ratio of the mean speed to the most probable speed of particles obeying Maxwell-Boltzmann distribution is given by

(A) $2/\sqrt{\pi}$ (B) 2

(C) $\pi/3$ (D) $\sqrt{3/2}$

54. The number of ways in which 5 identical Bosons can be distributed in 4 states is

(A) 5^4 (B) $\frac{8!}{5!\ 3!}$

(C) $\frac{9!}{5!\ 4!}$ (D) 4^5

55. A system consists of N weakly interacting subsystems, each with two internal states with energies O and E. The internal energy of the system at absolute temperature T is equal to

(A) $\frac{NE}{\exp(E/KT)+1}$

(B) NE exp ($-E/KT$)

(C) $\frac{3}{2}$NKT

(D) NE

56. The occupation probability for an electron of energy E in a metal is given by the Fermi function $f(E)=\frac{1}{e^{(E-E_F)/KT}+1}$. The energy of the state with an occupation probability of 1% is given by

(A) $E = E_F + 2.0$ KT

(B) $E = E_F - 4.6$ KT

(C) $E = E_F + 4.6$ KT

(D) $E = E_F - 2.0$ KT

57. With reference to thermal behaviour of any material the "Triple point" is

(A) the temperature at which the material exists in all the three phases, i.e. vapour, liquid and solid, at the same time

(B) the pressure at which the material exists in all the three phases, i.e. vapour, liquid and solid at the same time

(C) the temperature at which the material exists in only liquid and solid phase simultaneously

(D) the material exists in the solid phase only

58. The paramagnetic susceptibility (χ) for electrons is given by

(A) $\frac{N\mu^2}{KT}$ (B) $\frac{N^2\mu}{KT}$

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

where N = number of electrons per unit volume, K = Boltzmann constant and μ = electron magnetic moment

59. A walker travels along a one dimensional discrete lattice, labeled by points –N, –N + 1, ...0, ..., N – 1, N, by putting random left and/or right steps of length l with equal probability for every step. Suppose the random walker starts from the lattice position 0 and is found at the same lattice position after (i) 10 and (ii) 7 step walks. The corresponding probabilities are respectively given by

(A) 0.5, 0.5 (B) 0, 0.5

(C) 0.25, 0 (D) 0.25, 0.25

60. Liquid helium (He^4) undergoes a sudden transition to the superfluid state at a temperature of 2.18 K. This is called "Lambda Transition" and is an example of phase transition. This transition is characterised at the transition temperature by

(Given G is the Gibbs Free Energy and T is the temperature)

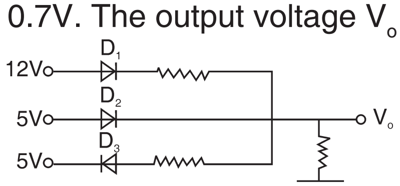
(A) Discontinuous change in $\frac{dG}{dT}$ but continuous behaviour of $\frac{d^2G}{dT^2}$

(B) Continuous behaviour of $\frac{dG}{dT}$ but discontinuous change in $\frac{d^2G}{dT^2}$

(C) Both $\left(\frac{dG}{dT}\right)$ and $\frac{d^2G}{dT^2}$ are continuous functions of temperature

(D) Both $\frac{dG}{dT}$ and $\frac{d^2G}{dT^2}$ show discontinuous change

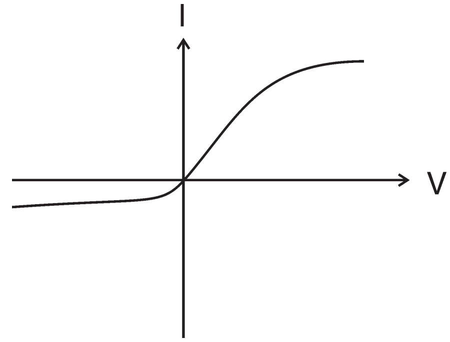
61. In the circuit given alongside, the silicon diodes used have a cut-in voltage of 0.7V. The output voltage V_o is close to

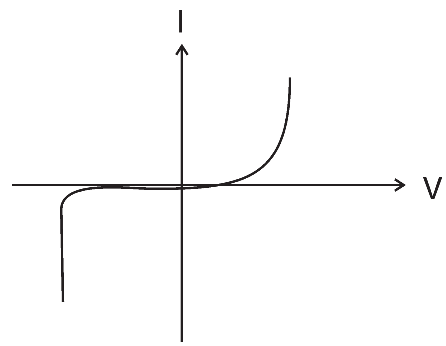


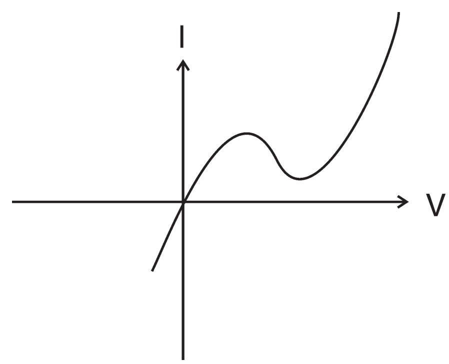
(A) 22 V (B) 10 V

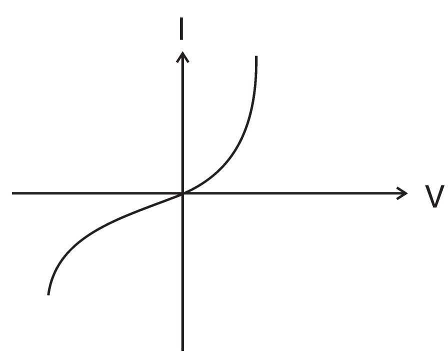
(C) 8.5 V (D) 17 V

62. I-V characteristic curve of a tunnel diode is given by

(A)


(B)


(C)


(D)


63. A differential amplifier takes two inputs V_+ and V_-. It produces an output $V_{out} = A_d (V_+ - V_-) + A_{CM}(V_+ + V_-)$. A good differential amplifier will have

(A) Low A_d and high A_{CM}

(B) High A_d and low A_{CM}

(C) $A_d = A_{CM}$

(D) $A_d = A_{CM}/2$

64. The maximum number of I/O ports that can be interfaced to Intel 8085 Microprocessor is

(A) 2 (B) 8

(C) 64 (D) 256

65. One gets percentage resolution of a 10 bit data converter as

(A) 0.024% (B) 0.39%

(C) 0.098% (D) 0.041%

66. The number 216 is represented in the binary number system as

(A) 1101100 (B) 11011000

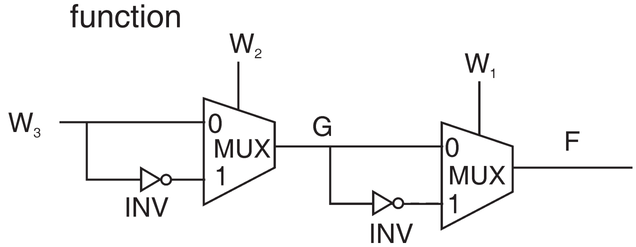
(C) 10011000 (D) 11001001

67. The number of NOR logic gates required to implement an AND function is

(A) 5 (B) 4

(C) 3 (D) 2

68. The following circuit carries out the function



(A) $F = W_1 \oplus W_2 \oplus W_3$

(B) $F = \overline{W_1}\ \overline{W_2}\ W_3$

(C) $F = W_1W_2 + W_2W_3 + W_1W_3$

(D) $F = W_1 + W_2 + W_3$

69. Least count of a voltmeter is 0.01V. It measures a voltage to be 2.38V, whereas the actual voltage is 2.50V in 20 trials. The voltmeter can be termed as

(A) Precise but not accurate

(B) Accurate but not precise

(C) Both accurate and precise

(D) Neither accurate nor precise

70. An experiment yields a set of data (x_i, y_i), $i = 1, 2, \ldots N$. It is required to fit the data to a straight line $y = mx + c$. Let $\overline{x}$ and $\overline{y}$ be the mean values. Then the best fit values of m and c as per least squares method are given by

(A) $$m = \frac{\sum_{i=1}^{N} (y_i - \overline{y})(x_i - \overline{x})^2}{\sum_{i=1}^{N} (x_i - \overline{x})^2}, \; c = \overline{y} - m\overline{x}$$

(B) $$m = \frac{\sum_{i=1}^{N} (x_i - \overline{x})(y_i - \overline{y})}{\sum_{i=1}^{N} (x_i - \overline{x})^2}, \; c = \overline{y} - m\overline{x}$$

(C) $$m = \frac{\sum_{i=1}^{N} (y_i - \overline{y})^2}{\sum_{i=1}^{N} (x_i - \overline{x})^2}, \; c = \overline{x} - m\overline{y}$$

(D) $$m = \frac{\sum_{i=1}^{N} (x_i - \overline{x})^2}{\sum_{i=1}^{N} (y_i - \overline{y})^2}, \; c = \overline{x} - m\overline{y}$$

71. For inter-atomic separation much larger than r_0 the equilibrium value, the radial form of potential energy between two spinless, identical atoms in ground state, is of the form $[1/r^n]$ where n is

(A) 3 (B) 4

(C) 5 (D) 6

72. Atoms with nuclear spin $J = \frac{1}{2}$ cannot have
(A) fine structure
(B) hyperfine structure coupling
(C) electric quadruple interactions
(D) magnetic interactions

73. The number of energy sublevels into which n = 2 level of a hydrogen atom splits into due to the linear Stark effect is
(A) 1 (B) 2
(C) 3 (D) 4

74. A molecule is formed from two undistinguishable atoms each of nuclear spin zero. It is known that such a molecule cannot have odd rotated states. The reason is
(A) the molecule cannot possess an electric dipole moment
(B) the total wave function must be antisymmetric with respect to the interchange of two nuclei
(C) the total wave function must be symmetric with respect to the interchange of two nuclei
(D) such a molecule does not have a definite parity

75. The coherence length of a laser beam is defined as optical path length difference which corresponds to x% of the fringe visibility, x is
(A) 10 (B) 27
(C) 50 (D) 37

76. Franck-Condon principle predicts large intensity spectral line for electronic transitions
(A) in monoatomic gases
(B) between the vibrational energy levels of any electronic state
(C) between vibrational levels of two electronic states at a constant inter-nuclear separation
(D) between the v = 0 vibrational levels of the two electronic states

77. The ground state energy of a positronium is
(A) –6.8 eV (B) +6.8 eV
(C) +13.6 eV (D) –13.6 eV

78. Nd-YAG Laser is an example of a 4-level laser whereas Ruby laser is a 3-level laser. Nd-YAG lasers have the special feature that
(A) They can generate laser light at different wavelengths since 4 different energy levels are involved
(B) The pump power required to achieve population inversion is less than that required for a 3-level laser
(C) The pump power required to achieve population inversion is more than that required for a 3-level laser
(D) It has two metastable states

79. For a sodium (Z = 11) atom, ten electrons are removed and only one last electron remains. The minimum energy that is required to remove the last remaining electron is
(A) 13.6 eV (B) 1.64 keV
(C) 136 eV (D) 1.64 eV

80. A_{ij}, the spontaneous transition probability between two states i and j is proportional to the stimulated transition probability B_{ij} as
(A) $A_{ij} \alpha \nu B_{ij}$ (B) $A_{ij} \alpha \nu^2 B_{ij}$
(C) $A_{ij} \alpha \nu^3 B_{ij}$ (D) $A_{ij} \alpha \nu^4 B_{ij}$

Where $h\nu$ is the energy difference between the two levels.

81. A lattice plane parallel to the X axis makes intercepts of 1 and 1 along Y and the Z axes. The Miller indices are
(A) (0, 1, 1) (B) (2, 0, 1)
(C) (1, 1, 1) (D) (1, 0, 1)

82. For a close packed BCC structure of hard spheres, the lattice constant 'a' is related to the sphere of radius R as

(A) $a = 4R/\sqrt{3}$

(B) $a = 2R/\sqrt{3}$

(C) $a = 4\sqrt{2}R$

(D) $a = 2\sqrt{2}R$

83. The packing fraction of a simple cubic lattice is

(A) 0.34 (B) 0.74

(C) 0.68 (D) 0.52

84. The diamond structure has a space filling factor that is ________ that of close packed structures.

(A) Approximately half

(B) Approximately $1/3^{rd}$

(C) Almost double

(D) Almost the same as

85. The binding energy of an ionic crystal depends on

a. attractive interaction between ions of opposite charge

b. repulsive interaction between ions of equal charge

c. van der Waals interaction

(A) mainly on (a) and (b) and marginally on (c)

(B) mainly (a) and marginally on (c)

(C) equally on (a), (b) and (c)

(D) only on (a)

86. Match the following descriptions with the corresponding values of energy.

i.	k_BT at room temperature	a. 2 eV
ii.	photon energy in crystallography	b. 9 eV
iii.	photon energy at the red end of the visible electromagnetic spectrum	c. 8 KeV
iv.	tripple covalent bond in Acetylene	d. 26 meV

(A) i – b, ii – d, iii – a, iv – c

(B) i – c, ii – a, iii – b, iv – d

(C) i – d, ii – b, iii – c, iv – a

(D) i – d, ii – c, iii – a, iv – b

87. Consider the free electron model of a divalent solid having a simple cubic lattice with lattice constant a. Let m be the mass of the electron.

(A) The electron energy at the face-center of the first Brillouin zone is given by $\hbar^2\pi^2/2ma^2$

(B) The electron energy is $\hbar^2\pi^2/2ma^2$ at the corner of the first Brillouin zone

(C) The volume of Fermi sphere is equal to the volume of first Brillouin zone

(D) The volume of Fermi sphere is smaller than the volume of first Brillouin zone

88. Type – II superconductors are characterised by two critical magnetic fields H_{c1} (<1000 Gauss) and H_{c2} (> 100 H_{c1}). These materials are used for making very high field electromagnets (> 100 kG). These materials show

(A) Meissner effect upto H_{c1} and constant magnetization between H_{c1} and H_{c2}

(B) Meissner effect upto H_{c1} and the magnetization reduces to zero between H_{c1} and H_{c2}

(C) Meissner effect upto H_{c2}

(D) Meissner effect only between H_{c1} and H_{c2}

89. Contact between a metal and semiconductor is

(A) always ohmic

(B) depends on the bandgap of the semiconductor alone

(C) depends on the relative work function of the metal and the semiconductor

(D) never ohmic

90. Match the following materials with their resistivity values at room temperature.

i. Deionised water	a. $1.80\times10^{5}\Omega m$
ii. Fused quartz	b. $1.68\times10^{-8}\Omega m$
iii. Copper	c. $2.0\times10^{-1}\Omega m$
iv. Sea water	d. $7.5\times10^{17}\Omega m$

(A) i – d, ii – b, iii – c, iv – a

(B) i – a, ii – d, iii – b, iv – c

(C) i – b, ii – a, iii – c, iv – d

(D) i – c, ii – d, iii – b, iv – a

91. The nucleus ^{16}O is assumed to be spherical with a charge radius R and volume $V = \frac{4}{3}\pi R^3$. Based on the empirical observation on the charge radius of the nucleus ^{128}Xe, one finds its volume as

(A) 2V (B) 8V

(C) 6.75V (D) 1.89V

92. The characteristic time of strong interactions is about

(A) 10^{-43}s (B) 10^{-2}s

(C) 10^{-10}s (D) 10^{-23}s

93. Choose the correct statement regarding the spin and isospin of Σ hyperon.

(A) spin = $\frac{1}{2}$, isospin = $\frac{1}{2}$

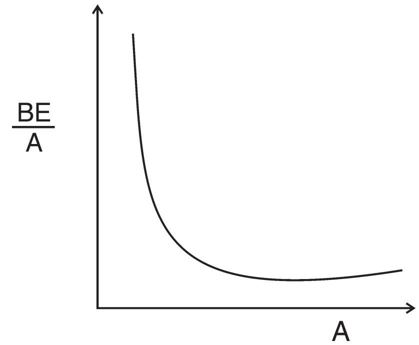
(B) spin = 1, isospin = $\frac{1}{2}$

(C) spin = $\frac{1}{2}$, isospin = 1

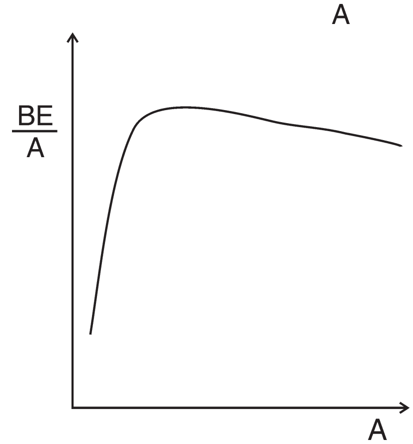
(D) spin = 1, isospin = 1

94. Which is the correct binding energy per nucleon curve ?

(A)



(B)



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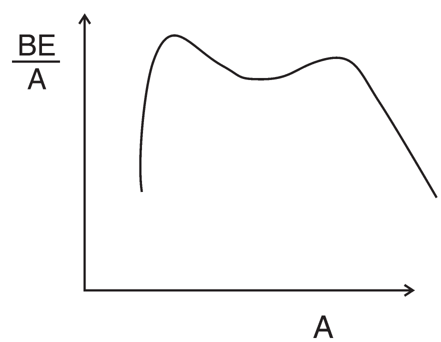

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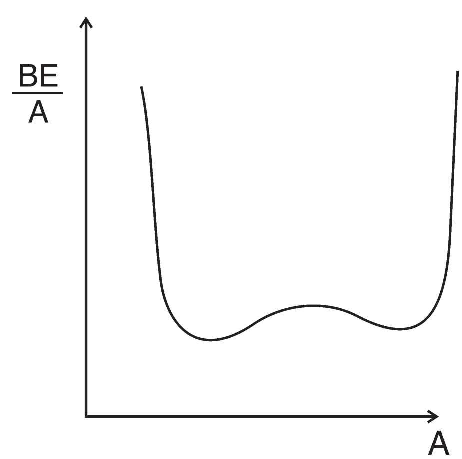

95. Let $|p\rangle$ and $|n\rangle$ denote the proton and neutron states, with the value of isospin quantum number I = $\frac{1}{2}$ and the third component of isospin $I_3 = \frac{1}{2}$ and $-\frac{1}{2}$ respectively. Which of the following two-nucleon state has isospin I = 0 and $I_3 = 0$?

(A) $\frac{1}{\sqrt{2}}\left(|n,p\rangle - |p,n\rangle\right)$

(B) $\frac{1}{\sqrt{2}}\left(|n,n\rangle - |p,p\rangle\right)$

(C) $\frac{1}{\sqrt{2}}\left(|n,n\rangle + |p,p\rangle\right)$

(D) $\frac{1}{\sqrt{2}}\left(|n,p\rangle + |p,n\rangle\right)$

96. According to the shell model, the ground state spin-parity of $^{11}_{5}B$ is

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

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

(C) $\frac{1^+}{2}$

(D) $\frac{1^-}{2}$

97. According to Fermi's theory of beta decay, the decay constant λ varies as the end-point energy E_0 of electrons as

(A) $\lambda \propto E_0^{3/2}$

(B) $\lambda \propto E_0^{3}$

(C) $\lambda \propto E_0^{4}$

(D) $\lambda \propto E_0^{5}$

98. The charge conjugation invariance does not allow the reaction

(A) $\pi^0 \rightarrow r + r$

(B) $e^+ + e^- \rightarrow r + r + r + r$

(C) $\pi^0 \rightarrow r + r + r$

(D) $r + r \rightarrow e^+ + e^-$

99. Which of the following is an antiparticle of itself ?

(A) eta meson

(B) neutrino

(C) neutral kaon

(D) neutron

100. Weak interactions respect the following conservation law

(A) strangeness

(B) parity

(C) charge

(D) combined charge conjugation and parity

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Space for Rough Work