Booklet Serial No. : 0430

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

TEST BOOKLET

AP(CC)PHYSICS-2016

Time Allowed : 2 Hours] [Maximum Marks : 100

All questions carry equal marks.

INSTRUCTIONS

1. Immediately after the commencement of the examination, you should check that test booklet does not have any unprinted or torn or missing pages or items, etc. If so, get it replaced by a complete test booklet.
2. Write your Roll Number only in the box provided alongside. Do not write anything else on the Test Booklet.
3. This Test Booklet contains **100** items (questions). Each item comprises four responses (answers). Choose only one response for each item which you consider the best.
4. After the candidate has read each item in the Test Booklet and decided which of the given responses is correct or the best, he has to mark the circle containing the letter of the selected response by blackening it completely with Black or Blue ball pen. In the following example, response "C" is so marked :

   (A) (B) ● (D)

5. Do the encoding carefully as given in the illustrations. While encoding your particulars or marking the answers on answer sheet, you should blacken the circle corresponding to the choice in full and no part of the circle should be left unfilled. After the response has been marked in the ANSWER SHEET, no erasing/fluid is allowed.
6. You have to mark all your responses ONLY on the ANSWER SHEET separately given according to 'INSTRUCTIONS FOR CANDIDATES' already supplied to you. *Responses marked on the Test Booklet or in any paper other than the answer sheet shall not be examined.*
7. All items carry equal marks. Attempt all items. Your total marks will depend only on the number of correct responses marked by you in the Answer Sheet. There will be no negative marking.
8. Before you proceed to mark responses in the Answer Sheet fill in the particulars in the front portion of the Answer Sheet as per the instructions sent to you.
9. If a candidate gives more than one answer, it will be treated as a wrong answer even if one of the given answers happens to be correct.
10. After you have completed the test, hand over the Answer Sheet only, to the Invigilator.

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P.T.O.

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1. The ratio of thermal (k) and electrical (σ) conductivity at a given temperature (T) for all metals is given by :

(A) $\frac{k}{\sigma} \propto T$ (B) $\frac{k}{\sigma} \propto T^{\frac{2}{3}}$

(C) $\frac{k}{\sigma} \propto T^{\frac{1}{2}}$ (D) $\frac{k}{\sigma} = T^{\frac{2}{3}}$

2. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. Find the band gap of the semiconductor.

(A) 0.3 eV (B) 0.4 eV

(C) 0.5 eV (D) 0.6 eV

3. A varactor diode has a capacitance of 20 pF when a reverse bias voltage of 4.0 V is applied across it. Find the diode capacitance when reverse bias voltage is increased to 9.0 V.

(A) 13 pF (B) 20 pF

(C) 24 pF (D) 32 pF

4. A half wave rectifier uses a transformer of turns ratio 8 : 1. If the primary (rms) voltage is 230 V, find the d.c. output voltage.

(A) 23.2 V (B) 19.6 V

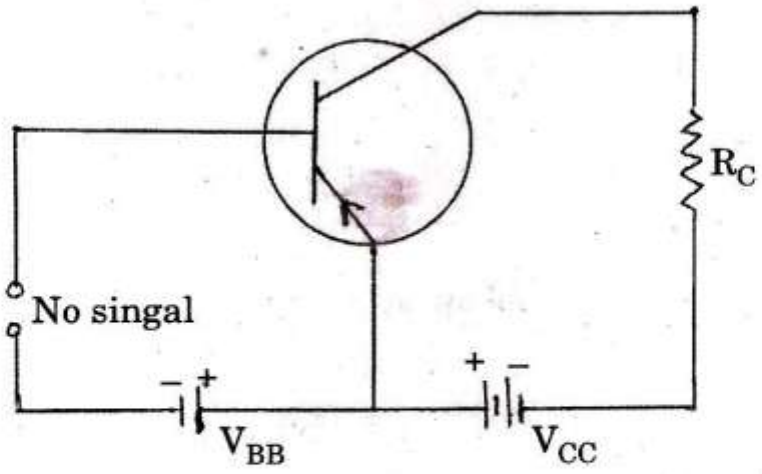
(C) 12.9 V (D) 8.3 V

5. The constant α of a transistor is 0.9. What would be the change in the collector current corresponding to a change of 4.0 mA in the base current in a common emitter arrangement ?

(A) 4.0 mA (B) 16.4 mA

(C) 22.9 mA (D) 36.0 mA

6. In the circuit diagram (shown), V_{CC} = 12.0 V and R_C = 6.0 kΩ. What will be the Q-point if zero signal base current is 20.0 μA and = 50 ?



(A) 6 V, 1.0 mA (B) 12 V, 1.5 mA

(C) 18 V, 1.8 mA (D) 24 V, 2.4 mA

7. A complementary class B power amplifier uses a 15 V dc supply. With a sinusoidal input, a maximum peak to peak of 24 V is desired across a load of 100 Ω. Find the power dissipated by each transistor.

(A) 213 mW (B) 127 mW

(C) 59 mW (D) 23 mW

8. In an astable multivibrator, the value of $R_1 = R_2 = 15$ kΩ and $C_1 = C_2 = 0.005$ μF. Calculate the frequency of oscillation.

(A) 19.6 kHz (B) 12.5 kHz

(C) 9.7 kHz (D) 3.4 kHz

9. Convert $(0.4375)_{10}$ to binary.

(A) $(0.0111)_{10}$ (B) $(0.1000)_{10}$

(C) $(0.0011)_{10}$ (D) $(0.1010)_{10}$

10. Find the value of X in the following :

$$(10010)_2 = (X)_{10}$$

(A) 4 (B) 5

(C) 12 (D) 18

11. Find X when $429_{10} = X_{16}$.

(A) DA1 (B) AD1

(C) 1AD (D) D1A

12. Demorganise the expression $\overline{(\bar{A} + B + \bar{C})(\bar{A} + B + C)}$.

(A) $A\bar{B}C + A\bar{B}\bar{C}$ (B) $\bar{A}BC + \bar{A}\bar{B}C$

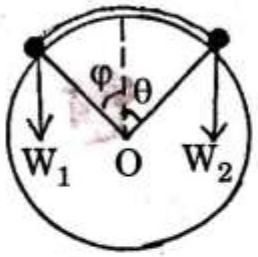
(C) $AB\bar{C} + \bar{A}B\bar{C}$ (D) $\bar{A}\bar{B}\bar{C} + ABC$

13. Find the degrees of freedom for a rigid body moving in space with one point fixed.

(A) 3 (B) 6

(C) 9 (D) 12

14. Two heavy particles of weights W_1 and W_2 are connected by a light inextensible string and hang over a fixed smooth circular cylinder of radius R, the axis of which is horizontal (as shown). Find the condition of equilibrium.



(A) $\frac{W_1}{W_2} = \frac{\sin\varphi}{\sin\theta}$ (B) $\frac{W_1}{W_2} = \frac{\sin\theta}{\sin\varphi}$

(C) $\frac{W_1}{W_2} = \frac{\cos\varphi}{\cos\theta}$ (D) $\frac{W_1}{W_2} = \frac{\cos\theta}{\cos\varphi}$

15. The Lagrangian for a charged particle in moving in an electromagnetic field is :

(A) $L = T + q\phi + q\left(\vec{v}.\vec{A}\right)$ (B) $L = T - q\phi - q\left(\vec{v}.\vec{A}\right)$

(C) $L = T - q\phi + q\left(\vec{v}.\vec{A}\right)$ (D) $L = T + q\phi - q\left(\vec{v}.\vec{A}\right)$

16. Find the Routhian for the following Lagrangian :

$$L = \frac{1}{2}\mu\left(\dot{r}^2 + r^2\dot{\theta}^2\right) + \frac{GMm}{r},$$

where $\mu = \dfrac{mM}{m+M}$.

(A) $\frac{1}{2}\mu\dot{r}^2 - \frac{p_\theta^2}{2\mu r^2} + \frac{GmM}{r}$ (B) $-\frac{1}{2}\mu\dot{r}^2 + \frac{p_\theta^2}{2\mu r^2} - \frac{GmM}{r}$

(C) $-\frac{1}{2}\mu\dot{r}^2 - \frac{p_\theta^2}{2\mu r^2} - \frac{GmM}{r}$ (D) $\frac{1}{2}\mu\dot{r}^2 + \frac{p_\theta^2}{2\mu r^2} - \frac{GmM}{r}$

17. A particle, moving in a central force field located at $r = 0$, describes a spiral $r = e^{-\theta}$. The magnitude of the force is :

(A) proportional to r

(B) proportional to r^3

(C) inversely proportional to r

(D) inversely proportional to r^3

18. In Rutherford experiment, 10^5 α-particles are scattered at an angle of 2°. Find the number of α-particles scattered at an angle of 20°.

(A) 10^3 (B) 10^2

(C) 10 (D) 5

19. The differential scattering cross-section for the scattering of a particle by a rigid sphere of radius R is given by :

(A) $\frac{R^2}{4}$ (B) $\frac{\pi R^2}{4}$

(C) πR^2 (D) None of these

20. A meson has a speed of 0.8 c relative to the ground. Find how far the meson travels relative to the ground, if its speed remains constant and the time of its flight, relative to the system, in which it is at rest, is 2×10^{-8} s.

(A) 40 m (B) 20 m

(C) 8 m (D) 4 m

21. An astronaut determines his velocity of approach as he nears the moon. He sends a radio signal of frequency 5×10^3 MHz and compares this frequency with its echo, observing a difference of 43 kHz. What is the velocity of the space vehicle relative to the moon ?

(A) 4.3×10^2 m/s (B) 1.3×10^3 m/s

(C) 0.9×10^4 m/s (D) 1.1×10^5 m/s

22. A π-meson of rest mass m_π decays into a μ-meson of rest mass m_μ and a neutrino of rest mass m_ν. Find the total energy of μ-meson.

(A) $\frac{1}{2m_\pi}\left(m_\pi^2 + m_\mu^2 - m_\nu^2\right)c^2$ (B) $\frac{1}{2}\left(m_\pi + m_\mu - m_\nu\right)c^2$

(C) $\frac{1}{m_\pi}\left(m_\pi^2 + m_\mu^2 + m_\nu^2\right)c^2$ (D) $\frac{1}{2m_\pi}\left(m_\pi^2 - m_\mu^2 + m_\nu^2\right)c^2$

23. One nucleon is present in *p*-state and another is in *d*-state. What are the possible values of orbital angular momentum, if both the nucleons coupled together ?

(A) 1, 2, 3 (B) 1, 2

(C) 1, 3 (D) 0, 1, 2, 3

24. Which of the following statements is *not* true for liquid drop model ?

(A) It fails to explain the measured magnetic moments of many nuclei

(B) It fails to explain the spins of nuclei

(C) It is not successful in explaining the excited states in most of the nuclei

(D) It fails to predict the emission of α- and β-particles

25. Using the shell model, predict the ground state spin and parity of $^{17}_{8}O$ nucleus.

(A) $\frac{5}{2}+$ (B) $\frac{5}{2}-$

(C) $\frac{3}{2}+$ (D) $\frac{3}{2}-$

26. The process of internal conversion is connected to :

(A) α-decay (B) β-decay

(C) γ-decay (D) None of these

27. Find the kinetic energy required to penetrate Coulomb barrier of a hydrogen nucleus.

(A) 20.3 MeV (B) 12.7 MeV

(C) 1.2 MeV (D) 0.2 MeV

28. A 0.01 mm thick $^{7}_{3}Li$ target is bombarded with a beam of flux of 10^{13} particles/cm^2-s. As a result 10^8 neutrons/s are produced. Find the cross-section for this reaction. (Given, density of lithium = 500 kg/m^3).

(A) 0.86 b (B) 0.53 b

(C) 0.23 b (D) 0.12 b

29. The Q-value of the $^{23}Na(n, \alpha)^{20}F$ reaction is –5.4 MeV. Find the threshold energy of the neutrons for this reaction. (Given, M_n = 1.00866 amu, M_{Na} = 22.99097 amu).

(A) 15.6 MeV (B) 10.3 MeV

(C) 5.6 MeV (D) 1.6 MeV

30. Deuterons are to be accelerated with a cyclotron. If its magnet produces a flux density of 2.47 T, what must be the frequency of the oscillating potential applied across the dees ?

(A) 8 MHz (B) 19 MHz

(C) 23 MHz (D) 42 MHz

31. A frequency modulated cyclotron is capable of accelerating protons to 500 MeV. Find the ratio of lowest and highest frequency needed in this case.

(A) 0.65 (B) 0.23

(C) 0.13 (D) 0.09

32. Which of the following characteristics is *true* in the case of proportional counter ?

(A) It generally operates at high voltage (~800 V to ~1000 V)

(B) Output pulse height does not depend upon the energy of incident particle

(C) The output pulse height is large, so no amplifier is needed

(D) Power supply used to feed voltage must be highly regulated

33. An α-article of energy 5.48 MeV is completely stopped in an ionization chamber. What is the pulse height in an external resistance of 1.0 MΩ ? Energy required to produce an ion pair is 35 eV and the capacitance of the chamber is 50 pF.

(A) 0.02 mV (B) 0.15 mV

(C) 0.5 mV (D) 1.62 mV

34. Which of the following reactions is *not* possible ?

(A) $\pi^+ + n \rightarrow \wedge^0 + K^+$

(B) $\bar{\nu}_e + p \rightarrow n + e^+$

(C) $p + \pi^- \rightarrow \Sigma^0 + \eta^0$

(D) $p + p \rightarrow p + p + p + \bar{p}$

35. Which of the following work functions can be useful in a photocell for detecting visible light ?

(A) 8.3 eV (B) 5.8 eV

(C) 4.2 eV (D) 2.5 eV

36. Find the de Broglie wavelength of an electron that has been accelerated through a potential difference of 100 V.

(A) 1.23 A^0 (B) 2.84 A^0

(C) 3.12 A^0 (D) 4.92 A^0

37. An electron has a speed of 500 m/s with an accuracy of 0.004%. Find the certainty with which we can locate the position of the electron.

(A) 0.093 m (B) 0.069 m

(C) 0.036 m (D) 0.008 m

38. A particle constrained to move along x-axis in the domain $0 \leq x \leq L$ has a wave function $\psi(x) = \sin(n\pi x/L)$, where n is an integer. Find the value of normalization constant of $\psi(x)$.

(A) $L^{-1/2}$ (B) $\sqrt{\frac{2}{L}}$

(C) $\frac{1}{L}$ (D) $\frac{2}{L}$

39. At time $t = 0$, the wave function for hydrogen atom is :

$$\psi(r,0) = \frac{1}{\sqrt{10}}\left(2\phi_{100} + \phi_{210} + \sqrt{2}\,\phi_{211} + \sqrt{3}\,\phi_{21,-1}\right)$$

Find the expectation value of the energy of the system.

(A) –13.8 eV (B) –7.48 eV

(C) –3.4 eV (D) –1.2 eV

40. The base vectors of a representation are $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$. Find a transformation matrix for transformation to another representation having base vectors.

$$\begin{pmatrix}\frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{2}}\end{pmatrix} \quad \text{and} \quad \begin{pmatrix}-\frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{2}}\end{pmatrix}$$

(A) $\begin{pmatrix}\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\end{pmatrix}$ (B) $\begin{pmatrix}-\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\end{pmatrix}$

(C) $\begin{pmatrix}\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}}\end{pmatrix}$ (D) $\begin{pmatrix}\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\\ -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}}\end{pmatrix}$

41. For Pauli's matrices (σ_x, σ_y, σ_z) :

(A) $\sigma_x\ \sigma_y\ \sigma_z = \frac{1}{\hbar}[x, p_x]$ (B) $\sigma_x\ \sigma_y\ \sigma_z = \frac{i}{\hbar}$

(C) $\sigma_x\ \sigma_y\ \sigma_z = i[x, p_x]$ (D) $\sigma_x\ \sigma_y\ \sigma_z = \hbar$

42. The first three energy levels of a nucleus are shown below :

4^+ ..... 187 keV

2^+ ..... 57.5 keV

0^+ ..... 0 keV

The expected spin-parity and energy of the next higher level is :

(A) (4^+; 300 keV) (B) (2^+; 400 keV)

(C) (6^+; 280 keV) (D) (6^+; 400 keV)

43. The ground state of $^{207}_{82}Pb$ nucleus has spin-parity $J^p = \frac{1^-}{2}$, while the first excited state has $J^p = \frac{5^-}{2}$. The electromagnetic radiation emitted when the nucleus makes a transition from the first excited state to the ground states is :

(A) E2 or E3 (B) M2 or E3

(C) E2 or M3 (D) M2 or M3

44. The lifetime of an atomic state is 1.0 ns. The natural line width of the spectral line in the emission spectrum of this state is of the order of :

(A) 10^{-10} eV (B) 10^{-9} eV

(C) 10^{-6} eV (D) 10^{-4} eV

45. The first Stokes line of a rotational Raman spectrum is observed at 13.0 cm^{-1}. Considering the rigid rotor approximation, the rotational constant is :

(A) 6.5 cm^{-1} (B) 3.2 cm^{-1}

(C) 2.1 cm^{-1} (D) 1.2 cm^{-1}

46. In a normal Zeeman effect experiment, spectral splitting of the line at wavelength 644.0 nm corresponding to the transition $5\ ^1D_2 \rightarrow 5\ ^1P_1$ of cadmium atoms is to be observed. If the spectrometer has a resolution of 0.01 nm, the minimum magnetic field needed to observe this is :

(A) 0.26 T (B) 0.51 T

(C) 2.6 T (D) 5.2 T

47. Neutrons moving with speed 10^3 m/s are used for the determination of crystal structure. If the Bragg angle for the first order diffraction is 30°, the interplanar spacing of the crystal is :

(A) 1.2 Å (B) 2.3 Å

(C) 4.1 Å (D) 5.4 Å

48. Which of the following transitions is *not* allowed in the case of an atom, according to the electric dipole radiation selection rule ?

(A) $2s \rightarrow 1s$ (B) $2p \rightarrow 1s$

(C) $2p \rightarrow 2s$ (D) $3d \rightarrow 1p$

49. The spacing between vibrational energy levels in CO molecule is found to be 8.44×10^{-2} eV. Find the force constant of the bond in CO molecule. (Given, reduced mass of CO = 1.14×10^{-26} kg).

(A) 1.87 N/m (B) 18.7 N/m

(C) 187 N/m (D) 1870 N/m

50. The degeneracy of the excited state of an atom having electronic configuration $1s^2 2s^2 2p^2 3d^1$ is :

(A) 6 (B) 10

(C) 15 (D) 20

51. The internal energy E of a system is given by $E = \frac{bS^3}{2VN}$, where b is a constant and other symbols have their usual meanings. The temperature of the system is given by :

(A) $\frac{bS^2}{2VN}$

(B) $\frac{3bS^2}{2VN}$

(C) $\frac{bS^3}{2V^2N}$

(D) $\frac{bS^2}{V^2N}$

52. Consider a Maxwellian distribution of the velocity of the molecules of an ideal gas. If V_{mp} and V_{rms} denote the most probable velocity and root mean square velocity, respectively, the magnitude of the ratio V_{mp}/V_{rms} is :

(A) 1

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

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

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

53. Consider a system of non-interacting particles in n-dimensional space obeying the dispersion relation $\varepsilon = BK^p$, where ε is the energy, K is the wave vector, p is an integer and B constant. The density of states, $N(\varepsilon)$, is proportional to :

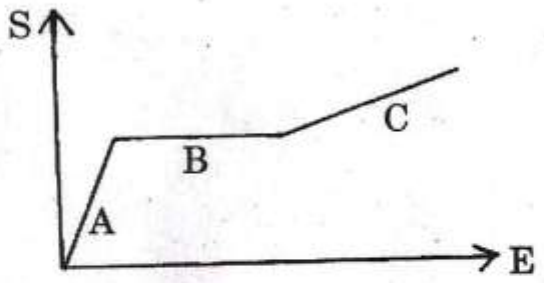
(A) $\varepsilon^{\frac{p}{n}-1}$

(B) $\varepsilon^{\frac{n}{p}-1}$

(C) $\varepsilon^{\frac{n}{p}+1}$

(D) $\varepsilon^{\frac{p}{n}+1}$

54. The entropy S of a thermodynamic system as a function of energy E is given by the following graph :



Which of the following inequalities is satisfied by the temperatures of the phases A, B, C denoted by T_A, T_B, T_C, respectively ?

(A) $T_C > T_B > T_A$ (B) $T_A > T_C > T_B$

(C) $T_B > T_C > T_A$ (D) $T_B > T_A > T_C$

55. The partition function of a system of N Ising spins is $Z = \lambda_1^N + \lambda_2^N$, where λ_1 and λ_2 are functions of temperature, but are independent of N. If $\lambda_1 >> \lambda_2$, the free energy per spin in the limit $N \to \infty$ is :

(A) $-K_B T \ln(\lambda_1/\lambda_2)$ (B) $-K_B T \ln(\lambda_2)$

(C) $-K_B T \ln(\lambda_1\lambda_2)$ (D) $-K_B T \ln(\lambda_1)$

56. If the number density of a free electron gas in three-dimensions is increased eight times, its Fermi energy will :

(A) increase by a factor of 4 (B) decrease by a factor of 4

(C) increase by a factor of 8 (D) decrease by a factor of 8

57. The dispersion relation of phonons in a solid is given by :

$$\omega^2(k) = \omega_0^2(3 - \cos k_x a - \cos k_y a - \cos k_z a)$$

The velocity of the phonons at large wavelength is :

(A) $\frac{\omega_0 a}{\sqrt{3}}$ (B) $\omega_0 a$

(C) $\sqrt{3}\omega_0 a$ (D) $\frac{\omega_0 a}{\sqrt{2}}$

58. The radius of the Fermi sphere of free electrons in a monovalent metal with an f_{cc} structure is (Take the volume of the unit cell as a^3)

(A) $\left(\frac{12\pi^2}{a^3}\right)^{\frac{1}{3}}$ (B) $\left(\frac{3\pi^2}{a^3}\right)^{\frac{1}{3}}$

(C) $\left(\frac{\pi^2}{a^3}\right)^{\frac{1}{3}}$ (D) $\frac{1}{a}$

59. The energy of an electron in a band as a function of its wave vector k is given by $E(k) = E_0 - C(\cos k_x a + \cos k_y a + \cos k_z a)$, where E_0, C and a are constants. The effective mass of the electron near the bottom of the band is :

(A) $\frac{2\hbar^2}{3Ca^2}$ (B) $\frac{\hbar^2}{3Ca^2}$

(C) $\frac{\hbar^2}{2Ca^2}$ (D) $\frac{\hbar^2}{Ca^2}$

60. A He-Ne laser operates by using two energy levels of Ne separated by 2.3 eV. Under steady conditions, the equivalent temperature of the system at which the ratio of the number of atoms in the lower state to that in the upper state will be 20, is approximately $\left(K_B = 8.6 \times 10^{-5} \frac{eV}{K}\right)$.

(A) 10^{15} K (B) 10^{10} K

(C) 10^{8} K (D) 10^{4} K

61. A thin metal film of 0.2 cm × 0.2 cm contains 4×10^{12} electrons. The magnitude of the Fermi wave vector of the system (in free electron approximation) is :

(A) $2\sqrt{\pi} \times 10^{7}$ cm^{-1} (B) $\sqrt{2\pi} \times 10^{7}$ cm^{-1}

(C) $\sqrt{\pi} \times 10^{7}$ cm^{-1} (D) $2\pi \times 10^{7}$ cm^{-1}

62. Which of the following matrices is an element of the group SU(2) ?

(A) $\begin{pmatrix} 2+i & \sqrt{2}i \\ 2 & +i \end{pmatrix}$ (B) $\begin{pmatrix} \frac{2+i}{\sqrt{3}} & -\frac{2}{\sqrt{3}} \\ \frac{2}{\sqrt{3}} & \frac{2-i}{\sqrt{3}} \end{pmatrix}$

(C) $\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$ (D) $\begin{pmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & \frac{1}{2} \end{pmatrix}$

63. The eigen values of the matrix $M = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$ are :

(A) 0, 1, 2 (B) 0, 0, 3

(C) 1, 1, 1 (D) 0, 0, 1

64. The value of the integral

$$\int_C \frac{z^3 dz}{z^2 - 5z + 6},$$

where C is a closed contour defined by the equation $2|z| - 5 = 0$, traversed in the anticlockwise direction, is :

(A) $-16\ \pi i$ (B) $16\ \pi i$

(C) $8\ \pi i$ (D) $2\ \pi i$

65. Given that :

$$\sum_{n=0}^{\infty} H_n(x) \frac{t^n}{n!} = e^{-t^2 + 2tx},$$

the value of $H_4(0)$ is :

(A) –6 (B) 24

(C) 6 (D) 12

66. A particle of mass m moves inside a bowl. If the surface of the bowl is given by

$$Z = \frac{1}{2}a\left(x^2 + y^2\right),$$

where a is constant, the Lagrangian of the particle is :

(A) $\frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\varphi}^2 - gar^2\right)$

(B) $\frac{1}{2}m\left[\left(1 + a^2r^2\right)\dot{r}^2 + r^2\dot{\varphi}^2\right]$

(C) $\frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\sin^2\theta\dot{\varphi}^2 - gar^2\right)$

(D) $\frac{1}{2}m\left[\left(1 + a^2r^2\right)\dot{r}^2 + r^2\dot{\varphi}^2 - gar^2\right]$

67. A particle is moving on an ellipse,

$$x^2 + 4y^2 = 8.$$

When the particle is at the point (2, 1), the x-component of its velocity is 6.0 m/s. What will be the y-component of its velocity at the same point (2, 1) ?

(A) –3.0 m/s (B) –2.0 m/s

(C) 1.0 m/s (D) 4.0 m/s

68. A particle of mass m moves in the one-dimensional potential,

$$V(x) = \frac{a}{3}x^3 + \frac{b}{4}x^4,$$

where $a, b > 0$. If one of the equilibrium points is $x = 0$, the angular frequency of small oscillations about the other equilibrium will be :

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

(C) $\frac{a}{\sqrt{12mb}}$ (D) $\frac{a}{\sqrt{24mb}}$

69. The electric field of a uniform plane wave propagating in dielectric non-conducting medium is given by :

$$\vec{E} = \hat{i}\,10\cos\left(6\pi \times 10^7 t - 0.4\pi z\right)\frac{V}{m}.$$

The phase velocity of the wave is :

(A) 1.5×10^8 m/s (B) 2.3×10^6 m/s

(C) 1.5×10^4 m/s (D) 2.3×10^2 m/s

70. If the vector potential

$$\vec{A} = \left(\alpha x\hat{x} + 2y\hat{y} - 3z\hat{z}\right)$$

satisfies the Coulomb gauge, the value of the constant α is :

(A) 3 (B) 2

(C) 1 (D) 0

71. The intensity of a laser in free space is 150 mW/m^2. The corresponding amplitude of the electric field (in V/m) of the laser is :

(Given, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N.m^2$).

(A) 10.6 (B) 8.4

(C) 6.9 (D) 3.5

72. Consider the wave function

$$\psi = \psi\left(\vec{r}_1, \vec{r}_2\right)\chi_s$$

for a system of two spin-half particles. If the spatial part of the wave function is given by :

$$\psi\left(\vec{r}_1, \vec{r}_2\right) = \frac{1}{\sqrt{2}}\left[\varphi_1\left(\vec{r}_1\right)\varphi_2\left(\vec{r}_2\right) + \varphi_2\left(\vec{r}_1\right)\varphi_1\left(\vec{r}_2\right)\right],$$

the spin part of the wave function would be :

(A) $\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)$ (B) $\frac{1}{\sqrt{2}}(\alpha\beta - \beta\alpha)$

(C) $\alpha\alpha$ (D) $\beta\beta$

73. Which of the following operators is Hermitian ?

(A) $\frac{d}{dx}$ (B) $\frac{d^2}{dx^2}$

(C) $i\frac{d^2}{dx^2}$ (D) $\frac{d^3}{dx^3}$

74. Consider the elastic scattering of a spinless particles in s-state. If the corresponding phase shift is 45° and the magnitude of incident wave vector is $\sqrt{3\pi}$ fm^{-1}, find the value of total scattering cross-section.

(A) $\frac{2\sqrt{2}}{3}$ fm^2 (B) 2 fm^2

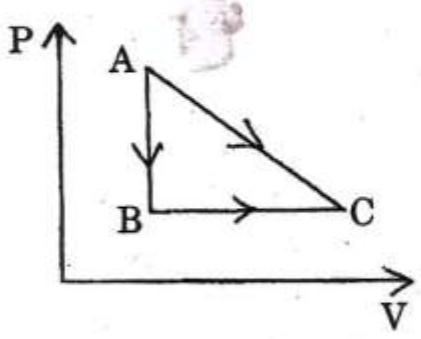
(C) $\frac{\sqrt{2}}{3}$ fm^2 (D) $\frac{1}{3}$ fm^2

75. If $\vec{S}_1$ and $\vec{S}_2$ are the spin operators of the two electrons in He-atom, the value of $< \vec{S}_1 . \vec{S}_2 >$ for the ground state is :

(A) $-\frac{1}{4}\hbar^2$ (B) $-\frac{3}{4}\hbar^2$

(C) 0 (D) $\frac{3}{2}\hbar^2$

76. A given quantity of gas is taken from the state A → C reversibly, by two paths, A → C directly and A → B → C as shown in the figure. During the process A → C, the work done by the gas is 100 J and the heat absorbed is 150 J. If during the process A → B → C, the work done by the gas is 30 J, the heat absorbed is :

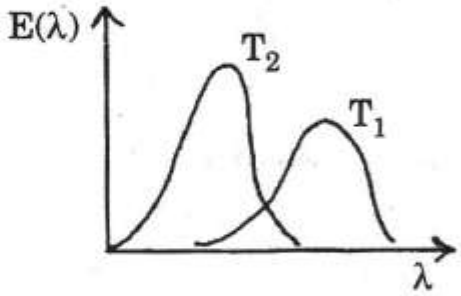


(A) 20 J (B) 80 J

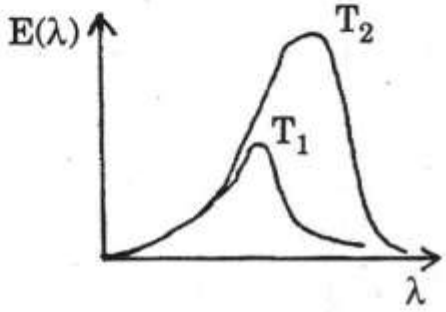
(C) 220 J (D) 280 J

77. Which of the following graphs represents the correct qualitative behavior of the energy density $E(\lambda)$ of blackbody radiation of wavelength λ at temperatures T_1 and T_2 ($T_1 < T_2$) ?

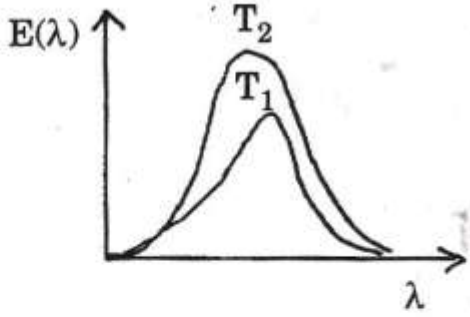
(A)



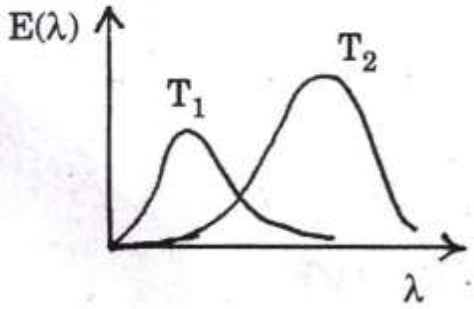
(B)



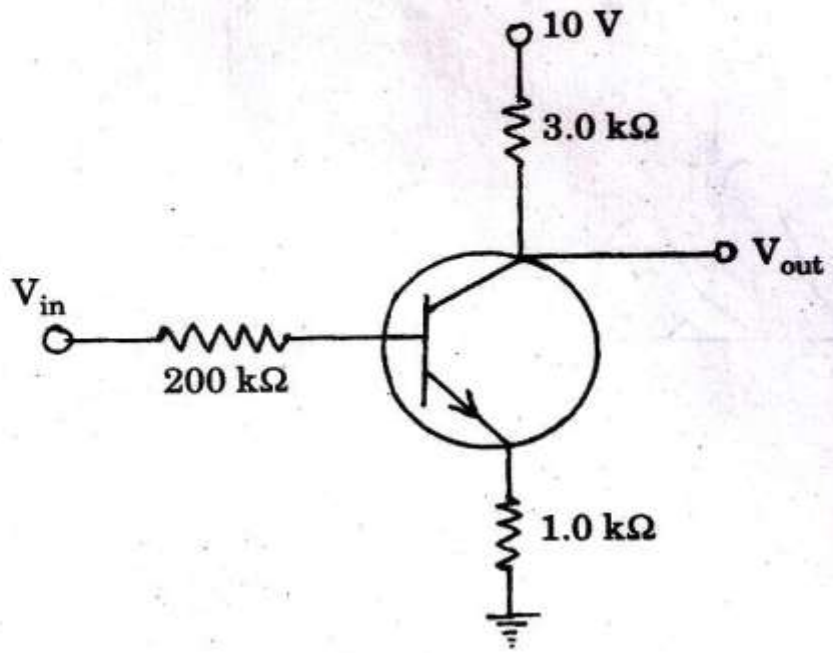
(C)



(D)



78. For the transistor, as shown, V_{BE} = 0.7 V and β_{dc} = 100. If V_{in} = 5.0 V, find V_{out}.



(A) 1.3 V (B) 3.2 V

(C) 5.7 V (D) 7.9 V

79. A plane electromagnetic wave travelling in free space is incident normally on a glass plate of refractive index 1.5. If there is no absorption, its reflectivity is :

(A) 2% (B) 4%

(C) 16% (D) 50%

80. The Hermite polynomial $H_n(x)$ satisfies the differential equation :

$$\frac{d^2H_n(x)}{dx^2} - 2x\frac{dH_n(x)}{dx} + 2nH_n(x) = 0.$$

The corresponding generating function

$$G(t, x) = \sum_{n=0}^{\infty} \frac{1}{n!} H_n(x)\, t^n$$

satisfies the equation :

(A) $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2t\frac{\partial G}{\partial t} = 0$

(B) $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2t^2\frac{\partial G}{\partial t} = 0$

(C) $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2\frac{\partial G}{\partial t} = 0$

(D) $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2\frac{\partial^2 G}{\partial x \partial t} = 0$

81. In which District of H.P. is Satdhara water spring ?

(A) Mandi (B) Chamba

(C) Bilaspur (D) Hamirpur

82. Which mountain range separates Kinnaur from Tibet ?

(A) Zaskar (B) Pir Panjal

(C) Dhauladhar (D) Shivalik

83. Which of the following stream is not a tributary of the Yamuna river ?

(A) Jalal (B) Asni

(C) Andhra (D) Baspa

84. Which of the following ancient writers has mentioned Kuluta (Kullu) in their works ?

(A) Panini (B) Vishakha Dutta

(C) Varahamihira (D) All of these

85. Who was the first English man to reach Rohtang pass ?

(A) J.G. Gerard (B) Lord Elgin

(C) William Moorcraft (D) E.J. Buck

86. Which agency executed the Toss Hydro Power Project in H.P. ?

(A) M/s Hydro Watt Ltd.

(B) M/s J.P. Industries Ltd.

(C) M/s Rangaraju Warehousing Pvt. Ltd.

(D) M/s Sai Engineering Foundation

87. On which day in 1954 was Bilaspur (Part C state) merged with Himachal Pradesh ?

(A) April 1 (B) July 1

(C) October 1 (D) None of these

88. As on 31-12-2015 approximately how many fair price shops were there in the rural areas of H.P. ?

(A) 3576 (B) 4537

(C) 5347 (D) 7354

89. Which District of H.P. received lowest number of foreign tourists during 2015 ?

(A) Una (B) Bilaspur

(C) Hamirpur (D) Chamba

90. How many Unani dispensaries were there in H.P. (upto December 2015) ?

(A) Zero (B) One

(C) Two (D) Three

91. With which game is P.R. Sreejesh associated ?

(A) Football (B) Tennis

(C) Cricket (D) Hockey

92. In which state of India is Bhitarkanika mangrove ?

(A) Tamil Nadu (B) Odisha

(C) Chhattisgarh (D) Goa

93. Which of the following is Mountain Railways of India ?

(A) Darjeeling (B) Kalka Shimla

(C) Nilgiri (D) All of these

94. In which state of India is Kaziranga National Park ?

(A) Sikkim (B) Asom

(C) Odisha (D) Rajasthan

95. Who is the youngest serving Chief Minister in India ?

(A) Arvind Kejriwal (B) Pema Khandu

(C) Akhilesh Yadav (D) Devendra Fadnavis

96. What is the proposed venue of 2018 Winter Olympics ?

(A) Konigsse (B) Luge

(C) Pycongchan (D) None of these

97. Who became the Prime Minister of Nepal after the resignation of K.P. Oli ?

(A) Pushpa Kamal Dahal Prachanda

(B) Sher Bahadur Deuba

(C) Onsari Gharti

(D) Krishna Bahadur Mahara

98. In Denmark Christmas is celebrated twice in a year ..... once in December and also in ..... .

(A) February (B) April

(C) July (D) October

99. Who is the Vice-Presidential candidate of Democratic Party of the United States in the election to be held in November, 2016 ?

(A) Mike Pence (B) Tim Kaine

(C) John McCaine (D) Mitt Romney

100. What is the capital of Saudi Arabia ?

(A) Abu Dhabi (B) Rabat

(C) Riyadh (D) Nairobi