

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

TEST BOOKLET
LECT (ASH) T.E.-PHYSICS 2016

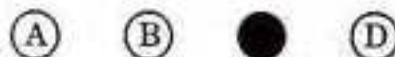
Time Allowed : 2 Hours]

[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 :



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 give 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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1. Which of the following forces is conservative ?

(A) $\vec{F} = (2xy + z^2)\hat{i} + x^2\hat{j} + 2xz\hat{k}$

(B) $\vec{F} = (2xy + z^2)\hat{i} + x^2\hat{j} + 4xz\hat{k}$

(C) $\vec{F} = (2xy + z^2)\hat{i} + 2x^2\hat{j} + 2xz\hat{k}$

(D) $\vec{F} = (4xy + z^2)\hat{i} + x^2\hat{j} + 2xz\hat{k}$

2. What must be the width of a rectangular guide so that the energy of electromagnetic radiation whose free space wavelength is 3.0 cm travels down the guide at 95% of the speed of light ?

(A) 1.3 cm

(B) 2.6 cm

(C) 4.8 cm

(D) 5.6 cm

3. Which of the following motions has non-holonomic constraint ?

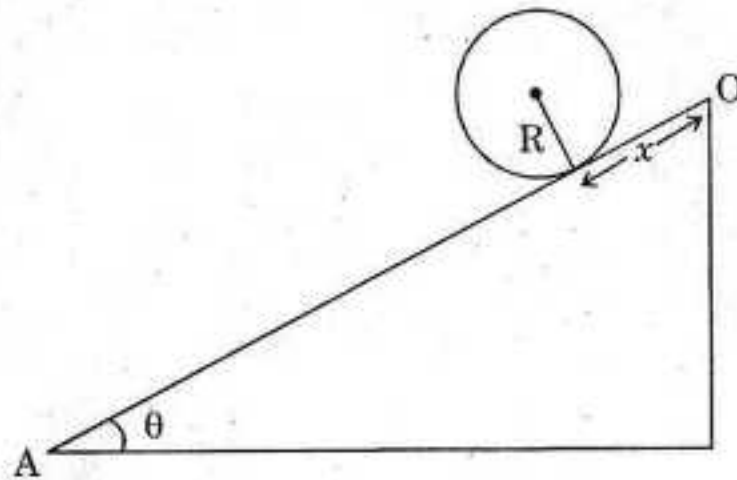
(A) Motion of a rigid body

(B) Simple pendulum with rigid support

(C) Rolling disc

(D) A bead on a circular wire

4. A cylinder of radius R and mass M rolls down an inclined plane making an angle θ with the horizontal (as shown). Find the equation of motion ($OA = S$).



- (A) $\frac{3}{2}M\ddot{x} - Mg \sin \theta = 0$ (B) $\frac{1}{2}M\ddot{x} + Mg \sin \theta = 0$
 (C) $\frac{3}{2}M\ddot{x} + Mg \cos \theta = 0$ (D) $\frac{1}{2}M\ddot{x} - Mg \cos \theta = 0$
5. A particle moves in a plane under the influence of a force whose magnitude is :

$$F = r^{-2} \left(1 - \frac{\dot{r}^2 - 2\ddot{r}r}{c^2} \right),$$

where r is the distance of the particle from the centre of force. Find the generalized potential that will result in such a force.

- (A) $U = \frac{2}{r} (1 + \dot{r}^2 c^{-2})$ (B) $U = \frac{1}{2r} (1 + \dot{r}^2 c^2)$
 (C) $U = \frac{1}{r} (1 + \dot{r}^2 c^{-2})$ (D) $U = \frac{3}{r} (1 + \dot{r}^2 c^2)$

6. Which of the following values of eccentricity (e) and total energy (E) correspond to elliptical orbits ?

(A) $e > 1 ; E > 0$

(B) $e = 1 ; E = 0$

(C) $e < 1 ; E < 0$

(D) $e = 0 ; E = -\frac{mk^2}{2J^2}$

7. Find the values of α and β , so that the equations :

$$Q = q^\alpha \cos(\beta p) \text{ and } P = q^\alpha \sin(\beta p)$$

is a canonical transformation.

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

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

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

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

8. Find the length of a rod of length 10.0 m in a frame of reference which is moving with $0.6c$ in a direction making angle of 30° with the rod.

(A) 8.5 m

(B) 9.3 m

(C) 6.9 m

(D) 10.2 m

9. Find the speed of an electron which has kinetic energy 2.0 MeV.
- (A) 0.3×10^8 m/s (B) 0.9×10^8 m/s
- (C) 1.3×10^8 m/s (D) 2.9×10^8 m/s
10. Which of the following atoms cannot exhibit Bose-Einstein condensation ?
- (A) ${}^1_1\text{H}$ (B) ${}^4_2\text{He}$
- (C) ${}^{23}_{11}\text{Na}$ (D) ${}^{39}_{19}\text{K}$
11. Find the skin depth for electromagnetic waves in sea water at 10^4 Hz.
- (Given, $\mu = 4\pi \times 10^{-7}$ H/m and $\sigma = 4.0$ mho/m)
- (A) 0.6 m (B) 0.9 m
- (C) 1.6 m (D) 2.5 m

12. If the average density of electrons in ionosphere is 6×10^{10} electrons/m³, find the phase velocity of plane electromagnetic wave of frequency 10^7 Hz.
- (A) 1.9×10^8 m/s (B) 2.6×10^8 m/s
(C) 3.1×10^8 m/s (D) 4.9×10^8 m/s
13. Assume that a particle can be confined to a spherical volume only if its circular orbit can be fitted with an integral multiple of de Broglie wavelength. Estimate the minimum kinetic energy of a proton confined to a nucleus of diameter 10^{-14} m.
- (A) 3.82 MeV (B) 1.96 MeV
(C) 0.82 MeV (D) 0.32 MeV
14. What is the shortest wavelength emitted by an X-ray tube if 5.0×10^4 kV is applied across it ?
- (A) 0.0848 nm (B) 0.0436 nm
(C) 0.0248 nm (D) 0.0156 nm

15. The mass absorption coefficient of aluminium for X-rays of a certain energy is $0.027 \text{ m}^2/\text{kg}$. What thickness of aluminium would attenuate the X-rays by 80% ? (Density of aluminium = 2700 kg/m^3)
- (A) 2.2 m (B) 0.2 m
(C) 0.02 m (D) 0.002 m
16. Electrons are accelerated by 340 volt and are reflected from a crystal. The first reflection maximum occurs when the glancing angle is 60° . Find the spacing of the crystal.
- (A) 0.018 nm (B) 0.028 nm
(C) 0.038 nm (D) 0.048 nm
17. In a diamond cube, the number of atoms per unit volume is :
- (A) $8/a^3$ (B) $6/a^3$
(C) $4/a^3$ (D) $2/a^3$

18. Find the maximum radius of a sphere that can just fit into the void at $\left(\frac{1}{2} \frac{1}{2} \frac{1}{2}\right)$ between the body centred atoms of bcc structure. Take r as the radius of the atom.
- (A) $0.055 r$ (B) $0.155 r$
- (C) $0.253 r$ (D) $0.312 r$
19. The lattice constant of the unit cell of α -iron, having bcc structure, is 0.29 nm. Find the number of atoms/mm² of the plane (1 0 0).
- (A) 1.2×10^{13} (B) 1.2×10^{11}
- (C) 1.2×10^{19} (D) 1.2×10^{17}
20. In a crystal whose primitives are 0.12 nm, 0.18 nm and 0.2 nm, a plane (2 3 1) cuts an intercept 0.12 nm along the X-axis. Find the length of the intercept along z-axis.
- (A) 0.12 nm (B) 0.20 nm
- (C) 0.31 nm (D) 0.40 nm

21. A particle is confined to move in a one-dimensional infinite square well of width 0.2 nm. It is found that when the energy of the particle is 230 eV, its eigen function has 5 antinodes. Find the nature of the particle.

- (A) proton (B) neutron
(C) electron (D) π^+ -meson

22. Calculations of Fermi energy (E_F) for some elements yield the following results :

Elements	E_F (eV)
Cu	7.04
Li	4.72
Rb	1.82
Cs	1.53
Ag	5.51
K	2.12

If the Fermi velocity of the electrons in one of the elements of the above series is 0.73×10^6 m/s, identify the element.

- (A) Cu (B) Rb
(C) Cs (D) Ag

23. Copper has a mass density of $8.9 \times 10^3 \text{ kg/m}^3$ and an electrical conductivity $6.4 \times 10^7 (\Omega\text{m})^{-1}$ at room temperature. Find the mean free time (Atomic weight of copper = 64) :

(A) $3.7 \times 10^{-16} \text{ s}$

(B) $2.7 \times 10^{-14} \text{ s}$

(C) $1.3 \times 10^{-12} \text{ s}$

(D) $3.2 \times 10^{-10} \text{ s}$

24. Calculate the frequency of radiation (in Hz) which must be incident on a substance placed in a magnetic field of strength $(5.0 \times 10^5/\pi) \text{ Amp/m}$, so that the electrons can absorb energy.

(Given, $\mu_0 = 4\pi \times 10^{-7} \text{ Henry/m}$; $\mu_B = 9.3 \times 10^{-24} \text{ Amp-m}^2$)

(A) 5.6×10^9

(B) 6.3×10^{10}

(C) 7.2×10^{11}

(D) 5.6×10^{12}

25. In an n-type semiconductor, the Fermi level lies 0.4 eV below the conduction band. If the concentration of donor atoms is doubled, find the new position of the Fermi level.

(Take, $K_B T = 0.03 \text{ eV}$)

(A) 0.38 eV below the conduction band

(B) 0.38 eV above the conduction band

(C) 0.80 eV below the conduction band

(D) 0.20 eV below the conduction band

26. If all the molecular dipoles in a 1.0 cm radius water drop are pointed in the same direction, calculate the intensity of polarization. Dipole moment of a water molecule is 6.0×10^{-30} C-m.

(A) 3.6×10^{-12} C/m²

(B) 8.4×10^{-10} C/m²

(C) 2.9×10^{-8} C/m²

(D) 1.6×10^{-6} C/m²

27. A water drop of radius 10^{-7} m is charged by an electron and is placed in an electric field. What should be the intensity of the electric field that can keep the drop stationary ?

(A) 400 V/m

(B) 326 V/m

(C) 256 V/m

(D) 181 V/m

28. The constant α of a transistor is 0.95. What would be the change in the collector current corresponding to a change of 0.4 mA in the base current in a common emitter arrangement ?

(A) 2.3 mA

(B) 3.6 mA

(C) 5.1 mA

(D) 7.6 mA

29. If P_{ab} is the probability of finding a particle in the range ($a < x < b$) at time t and $J(x, t)$ is the probability current, then :

(A) $\frac{dP_{ab}}{dt} = J(a, t) - J(b, t)$

(B) $\frac{dP_{ab}}{dt} = (J(a, b) - J(b, t))^2$

(C) $\frac{dP_{ab}}{dt} = J(a, b) + J(b, t)$

(D) $J_{ab} = J(a, b) - J(b, t)$

30. Which of the following relations corresponds to :

$$\Psi(x, t) = a\Psi_1(x) e^{-\frac{iE_1 t}{\hbar}} + b\Psi_2(x) e^{-\frac{iE_2 t}{\hbar}}$$

where a, b, Ψ_1 and Ψ_2 are real.

(A) $\Delta E \cdot \Delta t = \hbar / 2$

(B) $\Delta E \cdot \Delta t < \hbar / 2$

(C) $\Delta E \cdot \Delta t = 2\pi\hbar$

(D) $\Delta E \cdot \Delta t = 0$

31. Quantum mechanically, the allowed energies of rigid rotator are :

(A) $E_n = \frac{\hbar^2 n^2}{ma^2}; n = 0, 1, 2, \dots$

(B) $E_n = \frac{\hbar^2 (n+1)^2}{ma^2}; n = 0, 1, 2, \dots$

(C) $E_n = \frac{\hbar^2 n(n+1)}{ma^2}; n = 0, 1, 2, \dots$

(D) $E_n = \frac{\hbar^2 n^2 (n+1)^2}{ma^2}; n = 0, 1, 2, \dots$

32. Which of the following distributions applies to identical fermions ?

(A) $e^{-(\epsilon-\mu)/K_B T}$

(B) $1/[e^{(\epsilon-\mu)/K_B T} + 1]$

(C) $1/[e^{(\epsilon-\mu)/K_B T} - 1]$

(D) $\hbar\omega^3/[e^{(\epsilon-\mu)/K_B T} - 1]$

33. The de Broglie wavelength of the electron having energy 15 MeV would be :

(A) 5 nm

(B) 5 fm

(C) 13 nm

(D) 13 fm

34. Nuclear density (in the units of kg/m^3) is of the order of :

(A) 10^5

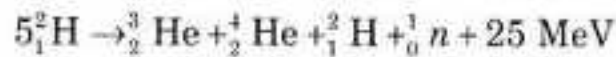
(B) 10^{10}

(C) 10^{17}

(D) 10^{19}

35. A singly charged positive ion is accelerated through a potential difference of 1000 V in a mass spectrograph. It then passes through a uniform magnetic field of 1500 Gauss, and then deflected into a circular path of radius 0.122 m. What is the mass number of the ion ?
- (A) 20 (B) 16
(C) 8 (D) 4
36. Which of the following sequences represents the *correct* magic numbers ?
- (A) 2, 8, 20, 38, 52, 80, 126
(B) 2, 8, 20, 28, 50, 82, 126
(C) 2, 8, 28, 36, 50, 82, 128
(D) 2, 8, 20, 32, 52, 80, 126
37. When a proton is bombarded on a hydrogen nucleus, the Coulomb barrier is about :
- (A) 1.2 MeV (B) 1.6 MeV
(C) 1.8 MeV (D) 2.2 MeV

38. Find the energy liberated if 10 kg of ^2H undergoes the following fusion reaction :



- (A) $4.2 \times 10^8\text{ J}$ (B) $2.3 \times 10^{10}\text{ J}$
(C) $1.69 \times 10^{13}\text{ J}$ (D) $2.42 \times 10^{15}\text{ J}$
39. ^{24}Na emits two γ -rays of energy 1378 keV and 2754 keV, respectively. Calculate the relative intensities of the two γ -rays after they have passed through 55.0 gm/cm^2 of Pb ($\rho = 11.0\text{ gm/cm}^3$). The linear absorption coefficients are 0.5 cm^{-1} for the 2754 keV and 0.6 cm^{-1} for the 1378 keV γ -rays.
- (A) 1.65 (B) 1.02
(C) 0.82 (D) 0.31
40. Deuterons are to be accelerated with a cyclotron. If its magnet produces a flux density of 2.5 T, what must be the frequency of the oscillating potential applied across the dees ?
- (A) 42.3 MHz (B) 33.6 MHz
(C) 28.3 MHz (D) 18.9 MHz

41. Which of the following detectors provides electrical signal ?

(A) Bubble chamber

(B) Cloud chamber

(C) Scintillation counter

(D) GM counter

42. Which of the following reactions is allowed ?

(A) $\Lambda \rightarrow \bar{p} + \pi^+$

(B) $\Lambda \rightarrow p + \pi^-$

(C) $\pi^+ + n \rightarrow K^0 + K^+$

(D) $n \rightarrow p + e^+ + \nu_e$

43. An antiproton comes to rest and annihilates with a proton. They produce π^+ , π^- and π^0 of equal energy. What is the average kinetic energy of each pion in MeV ?

(A) 487

(B) 317

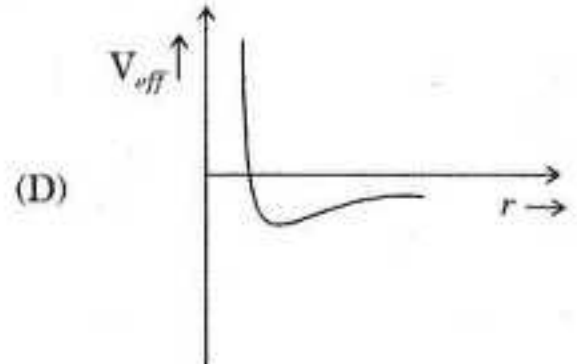
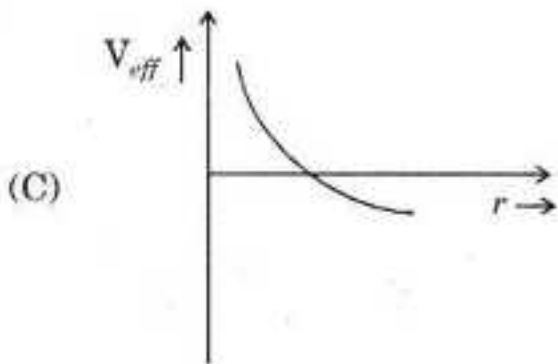
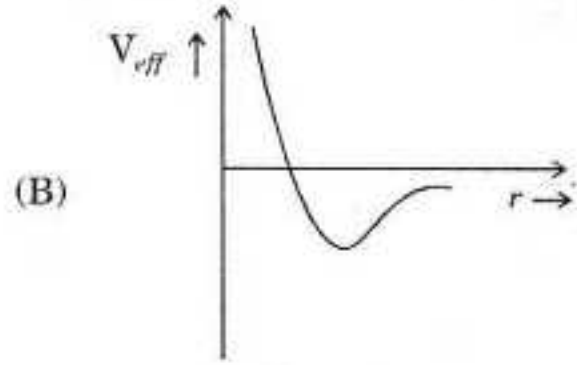
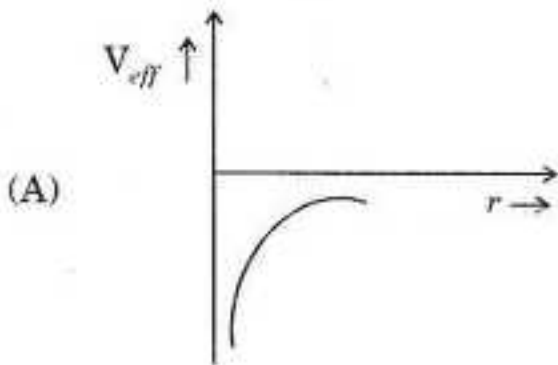
(C) 135

(D) 62

44. The probability current density of a spherical wave, $\Psi(r) = Ae^{ikr} / r$, travelling outward from a point is :

- (A) $|A|^2$ (B) $\frac{\hbar k}{mr^2} |A|^2$
 (C) $\frac{\hbar k}{r^2} |A|^2$ (D) $\frac{\hbar k}{m} |A|^2$

45. A particle of mass m is moving in the direction of r in a field of effective potential, $V_{eff} = -\frac{ZZ'e^2}{r} + \frac{l(l+1)\hbar^2}{2mr^2}$. Which of the following graphs best represents V_{eff} for $l = 1$?



46. The possible eigen vectors of

$$S_y = \frac{\hbar}{2} \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$$

are :

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

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

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

(D) $\frac{1}{\sqrt{2}} \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

47. An operator \hat{P} describing the interaction of two spin-1/2 particles is

$$\hat{P} = a + b\vec{\sigma}_1 \cdot \vec{\sigma}_2, \text{ where } a \text{ and } b \text{ are constants, and } \vec{\sigma}_1 \text{ and } \vec{\sigma}_2 \text{ are Pauli matrices.}$$

If \hat{S} is the total spin of the particles, then :

(A) $[\hat{S}^2, \hat{P}] = \hbar$

(B) $[\hat{S}^2, \hat{P}] = i\hbar S_z$

(C) $[\hat{S}^2, \hat{P}] = 0$

(D) $[\hat{S}^2, \hat{P}] = (a+b)$

48. A rigid rotator in a plane is acted by a perturbation represented by

$$H' = \frac{V_0}{2} (3\cos^2\phi - 1), \text{ where } V_0 \text{ is a constant. Calculate the first order correction}$$

to the ground state energy.

(A) $\frac{V_0}{2}$

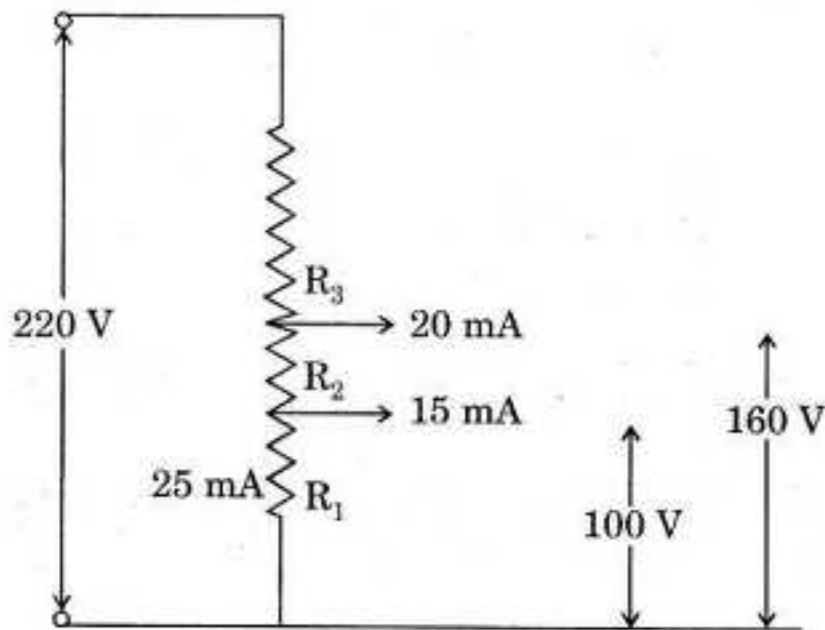
(B) V_0

(C) $\frac{V_0}{4}$

(D) $\frac{V_0^2}{4}$

49. In the context of partial wave analysis, the ratio of differential and total scattering cross-sections for s -wave scattering is :
- (A) $4\pi/k^2$
(B) $k^2/4\pi$
(C) $1/4\pi$
(D) $4\pi \sin^2 \theta$, where θ is the scattering angle
50. A distant galaxy is receding from the earth at 6.1×10^7 m/s. By how much is a green spectral line of wavelength 500 nm emitted by the galaxy shifted towards the red end of the spectrum ?
- (A) 115 nm
(B) 170 nm
(C) 185 nm
(D) 209 nm
51. Point out the *correct* order of electromagnetic spectrum in the increasing order of the wavelength.
- (A) Visible, X-rays, γ -rays, Radio waves, Microwaves
(B) Radio waves, Microwaves, Visible, X-rays, γ -rays
(C) γ -rays, Radio waves, X-rays, Visible, Microwaves
(D) γ -rays, X-rays, Visible, Microwaves, Radio waves

52. A tapped voltage divider is to be connected across a 220 V dc supply to provide outputs of 15 mA at 100 V and 20 mA at 160 V (as shown in figure). Find the total resistance of the divider.



- (A) 2500 Ω (B) 3500 Ω
(C) 4500 Ω (D) 6500 Ω
53. A multiplate capacitor is made up of 10 plates 4 cm \times 5 cm separated by mica sheets having thickness of 1.0 mm and a relative permittivity $\epsilon_r = 6$. Find its capacitance.

- (A) 956 pF (B) 733 pF
(C) 691 pF (D) 569 pF

54. The total power content of an AM wave is 1500 W. For a 100% modulation, find the power transmitted by carrier.

(A) 1500 W

(B) 1200 W

(C) 1000 W

(D) 900 W

55. Find the output voltage of an OP-AMP inverting adder for the following set of input voltages and resistors : (In all the cases, $R_f = 1.0 \text{ M}\Omega$)

$$V_1 = -3\text{V}, V_2 = 3\text{V}, V_3 = 2\text{V}; R_1 = 250 \text{ k}\Omega, R_2 = 500 \text{ k}\Omega, R_3 = 1 \text{ M}\Omega$$

(A) 0.04 V

(B) 1.3 V

(C) 3.0 V

(D) 4.0 V

56. Subtract 0111_2 from 1001_2 .

(A) 0111

(B) 0010

(C) 1000

(D) 0101

57. Which of the following Boolean identities is *correct* ?

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

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

(C) $(A + B)(A + \bar{B})(\bar{A} + C) = AC$

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

58. Find the density of impurity atoms (in m^{-3}) that must be added to an intrinsic silicon crystal to convert it to 10^{-2} ohm.m N-type silicon.

(Take, electron mobility for silicon = $0.13 \text{ m}^2/\text{volt.s}$)

(A) 4.6×10^{21}

(B) 3.2×10^{20}

(C) 1.7×10^{19}

(D) 0.9×10^{18}

59. In an N-P-N transistor, 10^{10} electrons enter the emitter in 10^{-6} s. 2% of the electrons are lost in the base. Calculate the current amplification factor.

(A) 29

(B) 32

(C) 49

(D) 57

60. The mid-frequency gain of an RC coupled amplifier is 200, and the lower and upper cut-off frequencies are 50 Hz and 100 kHz, respectively. Find the frequency in the low frequency range at which the gain is reduced to 150.
- (A) 21.9 Hz (B) 34.5 Hz
(C) 43.4 Hz (D) 56.8 Hz
61. A phase shift oscillator uses three identical RC sections in the feedback network. The values of components are $R = 100 \text{ k}\Omega$ and $C = 0.01 \mu\text{F}$. Find the frequency of oscillation.
- (A) 100.2 Hz (B) 50.4 Hz
(C) 16.8 Hz (D) 10.3 Hz
62. γ -rays (photons) are scattered from electrons initially at rest. If γ -rays are backscattered and their energy $E \gg m_e c^2$; the energy of the scattered photon is :
- (A) 0.5 MeV (B) 0.25 MeV
(C) 0.15 MeV (D) 0.09 MeV

63. For a one-dimensional harmonic oscillator, the value of $\oint p dx$ is :

(A) $\frac{\pi E}{\omega}$

(B) $\frac{2E}{\omega}$

(C) $\frac{2\pi E}{\omega}$

(D) $\frac{4\pi E}{\omega}$

64. The maximum kinetic energy transferred to a proton when hit by a photon of energy $h\nu$ is :

(A) $\frac{h\nu}{1 + \frac{m_p c^2}{2h\nu}}$

(B) $\frac{h\nu}{1 - \frac{m_p c^2}{2h\nu}}$

(C) $\frac{2h^2\nu^2}{m_p c^2}$

(D) $\frac{h\nu}{1 + \left(\frac{m_p c^2}{2h\nu}\right)^2}$

65. Consider a matrix \hat{A} , a ket $|\Psi\rangle$ and a ket $|\varphi\rangle$:

$$\hat{A} = \begin{pmatrix} 5 & 3+2i & 3i \\ -i & 3i & 8 \\ 1-i & 1 & 4 \end{pmatrix}; |\Psi\rangle = \begin{pmatrix} -1+i \\ 3 \\ 2+3i \end{pmatrix}; |\varphi\rangle = \begin{pmatrix} 6 \\ i \\ 5 \end{pmatrix}$$

Find $\langle \varphi | \hat{A} | \Psi \rangle$.

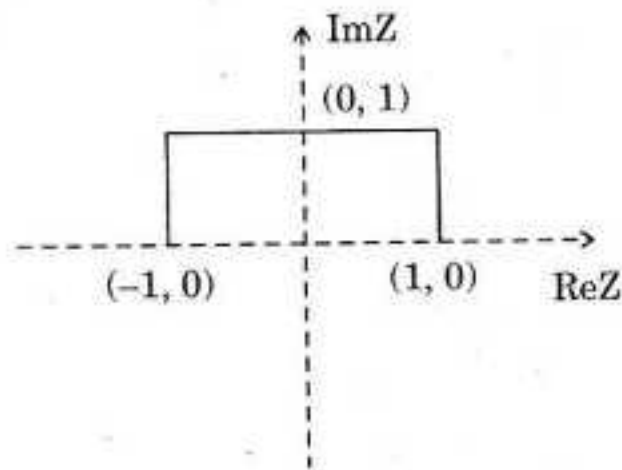
(A) $23 + 55i$

(B) $59 + 155i$

(C) $2 + 15i$

(D) $43 + 14i$

66. The value of the integral $\int_C dz z^2 e^z$, where C is an open contour in the complex z-plane (as shown) is :



- (A) $\frac{5}{e} + e$ (B) $e - \frac{5}{e}$
 (C) $\frac{5}{e} - e$ (D) $-\frac{5}{e} - e$
67. The generating function $F(x, t) = \sum_{n=0}^{\infty} P_n(x) t^n$ for the Legendre polynomials $P_n(x)$ is $F(x, t) = (1 - 2xt + t^2)^{-1/2}$. The value of $P_3(-1)$ is :
- (A) $5/2$ (B) $3/2$
 (C) $+1$ (D) -1
68. A 3×3 matrix M has $\text{Tr} [M] = 6$, $\text{Tr} [M^2] = 26$ and $\text{Tr} [M^3] = 90$. Which of the following can be the possible set of eigen values of M ?
- (A) $-1, 1, 4$ (B) $-1, 0, 7$
 (C) $-1, 3, 4$ (D) $-2, 2, 4$

69. Let $u(x, y) = x + \frac{1}{2}(x^2 - y^2)$ is the real part of analytic function $f(z)$ of the complex variable $z = x + iy$. The imaginary part of $f(z)$ is :
- (A) $y + xy$ (B) xy
(C) y (D) $y^2 - x^2$
70. To detect trace amounts of gaseous species in a mixture of gases, the preferred probing tool is :
- (A) Laser spectroscopy
(B) Ionization spectroscopy with X-rays
(C) NMR spectroscopy
(D) ESR spectroscopy
71. The far infrared rotational absorption spectrum of a diatomic molecule shows equilibrium lines with spacing 40 cm^{-1} . The position of the first Stokes line in the rotational Raman spectrum of this molecule is :
- (A) 20 cm^{-1} (B) 40 cm^{-1}
(C) 80 cm^{-1} (D) 120 cm^{-1}

72. Which of the following statements is *not* true as a consequence to predict the fact that the ground state of deuteron is a mixture of *s*- and *d*- states ?
- (A) It has a non-zero quadrupole moment
- (B) The n-p interaction is non-central
- (C) The orbital wave function is not spherically symmetric
- (D) The Hamiltonian does not conserve the total angular momentum
73. In LHC experiment, the Higgs boson (H) was found to decay into a photon and a Z-boson. If the rest masses of Higgs and Z bosons are $125 \text{ GeV}/c^2$ and $90 \text{ GeV}/c^2$, respectively, the energy of the photon will be (Take the decaying Higgs particle at rest).
- (A) 43 GeV
- (B) $35\sqrt{3}$ GeV
- (C) 30 GeV
- (D) $20\sqrt{3}$ GeV
74. Which of the following sets of Maxwell relations is *correct* ?
- (A) $T = \left(\frac{\partial U}{\partial V}\right)_S$ and $P = \left(\frac{\partial U}{\partial S}\right)_V$
- (B) $V = \left(\frac{\partial H}{\partial P}\right)_S$ and $T = \left(\frac{\partial H}{\partial S}\right)_P$
- (C) $P = -\left(\frac{\partial G}{\partial V}\right)_T$ and $V = \left(\frac{\partial G}{\partial P}\right)_S$
- (D) $P = -\left(\frac{\partial A}{\partial S}\right)_T$ and $S = \left(\frac{\partial A}{\partial P}\right)_V$

75. For an ideal Fermi gas, the electron velocity (V_F) at the Fermi surface is related to the electron concentration (n) as :
- (A) $V_F \propto n^{2/3}$ (B) $V_F \propto n$
(C) $V_F \propto n^{1/2}$ (D) $V_F \propto n^{1/3}$
76. A particle of unit mass moves along the X-axis under the influence of a potential, $V(x) = x(x-2)^2$. The particle is found to be in stable equilibrium at the point $x = 2$. The time period of oscillation of the particle is :
- (A) π (B) $\pi/2$
(C) $3\pi/2$ (D) 2π
77. The Hall coefficient of sodium depends on :
- (A) The effective charge carrier mass and carrier density
(B) The charge carrier density and relaxation time
(C) The charge carrier density only
(D) The effective charge carrier mass

78. Which of the following wave functions is quantum mechanically acceptable ?

(A) $\frac{e^{-i\alpha r}}{r^4}$

(B) $(1 - e^{-i\alpha r})$

(C) $e^{-i\alpha r} e^{-\beta(x^2+y^2+z^2)}$

(D) $\sin(\alpha r)$

79. The value of α for which $\Psi_1 = \phi_0 - 2\phi_1 + 3\phi_2$ is orthogonal to $\Psi_2 = \phi_0 - \phi_1 + \alpha\phi_2$ is :

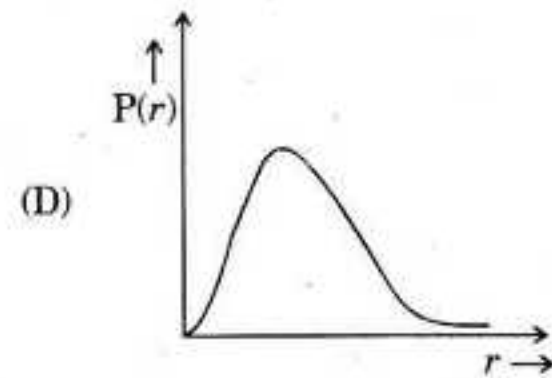
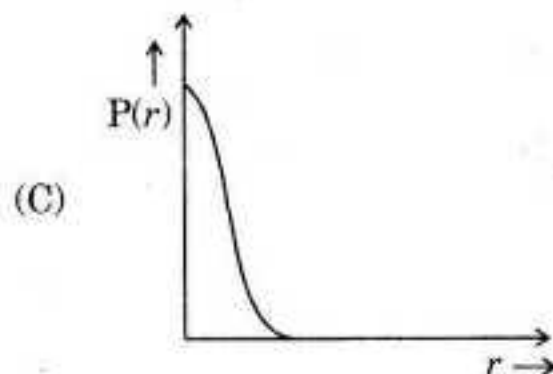
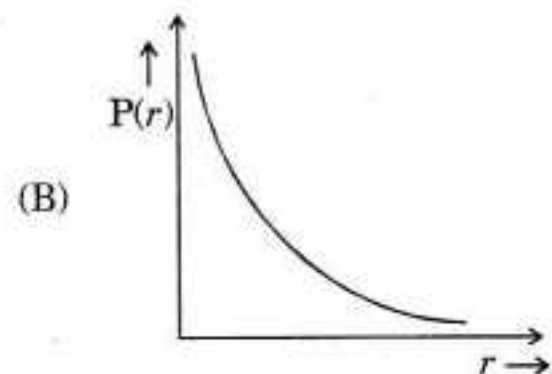
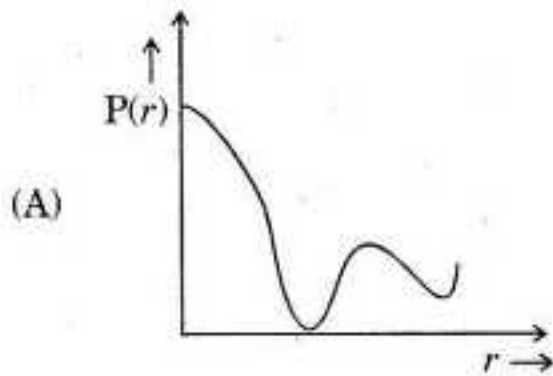
(A) 2

(B) 1

(C) -1

(D) -2

80. The radial probability density, $P(r)$, for the hydrogen atom in the ground state is best represented by :



81. What was the approximate increase in male literacy in HP between 2001 and 2011 (in percentage terms) ?
- (A) 5.48 (B) 6.35
(C) 7.88 (D) 9.15
82. In which district of H.P. is Madhav Rai Mandir ?
- (A) Kullu (B) Mandi
(C) Bilaspur (D) Solan
83. Identify the *correct* chronological order of the founding of following princely states ?
- (A) Mandi-Kullu-Suket (B) Suket-Mandi-Kullu
(C) Suket-Kullu-Mandi (D) Kullu-Suket-Mandi
84. When was the Jagirdar of Kutlchar conferred the title of Raja by the British ?
- (A) 1901 (B) 1909
(C) 1917 (D) 1929

85. In which District of H.P. is Chander Nahar lake ?
- (A) Shimla (B) Sirmaur
(C) Kullu (D) Solan
86. On the *Amavasya* (new moon) of which month is Diwali celebrated ?
- (A) Asauj (B) Kartik
(C) Magh (D) Paush
87. At which place in Hamirpur District of H.P. has the H.P.M.C. been sanctioned funds for setting up vegetable pack house ?
- (A) Rail (B) Sujanpur
(C) Nadaun (D) Bhotia
88. How many panchayats of H.P. are covered under the World Bank aided Mid Himalayan Watershed Development Project after additional financing ?
- (A) 710 (B) 830
(C) 880 (D) 920

89. In which river basin is Killar hydel project ?
- (A) Chenab (B) Ravi
(C) Satluj (D) Beas
90. Who was the Deputy Speaker of First H.P. Vidhan Sabha ?
- (A) Vidya Dhar (B) Tapinder Singh
(C) Krishan Chander (D) Lekh Ram Thakur
91. With which of the following is village Dhudike of Punjab associated ?
- (A) Shaheed Bhagat Singh (B) Lala Lajpat Rai
(C) Madan Lal Dhingra (D) Kartar Singh Saraba
92. Identify the Governor of Arunachal Pradesh who recommended President's rule in the state in January 2016 ?
- (A) Anil Goswami (B) Jyoti Prashad Rajkhowa
(C) Aziz Qureshi (D) Nabam Tuki

93. Where is Palais Royale which is said to be India's tallest skyscraper ?
- (A) New Delhi (B) Kolkata
(C) Bengaluru (D) Mumbai
94. According to Indian census, what is the minimum population for the classification of city ?
- (A) One Lakh (B) Five Lakhs
(C) Ten Lakhs (D) Fifty Lakhs
95. What is India's rank according to Transparency International's Corruption Perception Index, 2015 ?
- (A) 38 (B) 47
(C) 55 (D) 76
96. Who won the men singles title of the Australian Open 2016 ?
- (A) Andy Murray (B) Rafael Nadal
(C) Roger Federer (D) Novak Djokovic

97. Approximately what percentage seats did Aung San Suu Kyi's National League For Democracy win in November 2015 parliamentary elections in Myanmar ?
- (A) 55 percent (B) 65 percent
(C) 70 percent (D) 80 percent
98. Where is Triton island ?
- (A) in Arabian Sea (B) in Red Sea
(C) in South China Sea (D) in Mediterranean Sea
99. What is the capital of Syria ?
- (A) Damascus (B) Khartoun
(C) Juka (D) Sanaa
100. Which leader of the Republican Party of U.S.A. is advocating ban on the entry of Muslims to the United States ?
- (A) Jeb Bush (B) Chris Christie
(C) Donald Trump (D) Ted Cruz