1 The de Broglie wavelength of a helium atom at 300 K is 0.6Å. The de Broglie wavelength of neon atom (5 times heavier than helium) at 600 K will be :

(a) 6Å (b) 0.06Å

(c) $0.6 \times \sqrt{10}$Å (d) $\frac{0.6}{\sqrt{10}}$Å

2 In the Density matrix representation, the condition for a pure state is :

(a) $\hat{\rho}^2 = \hat{\rho}$ (b) $\hat{\rho}^2 = \hat{I}$

(c) $T_r\hat{\rho}^2 = T_r\hat{\rho}$ (d) $T_r\hat{\rho} = 1$

3 If the temperature of a black body enclosure is tripled, the number of photons will increase by a factor of :

(a) 2 (b) 9

(c) 8 (d) 27

4 The number of photon emitted per second from a 1 watt Ar-ion laser operating at 488 nm is approximately is :

(a) 10.23×10^{19} (b) 2.46×10^{18}

(c) 10.23×10^{18} (d) 2.46×10^{11}

5 It is required to operate a G.M. Counter with a maximum radial field 10^7 V/m. The applied voltage required if the radii of the wire and tube are 0.002 cm and 1 cm respectively.

(a) 10^7 Volts (b) 1242×10^7 Volts

(c) 1242 Volts (d) 12 Volts

6 KCl and KBr are alkali halides, both having the NaCl crystal structure. However, in the X-ray diffraction certain reflections are absent for KCl as compared to KBr, for example(1 11 1), (3 11 1), (3 33).
This difference in the two similar geometrical structures is because of the following :

(a) Atomic form factors of K and Cl are similar, but of K and Br are very different
(b) Atomic form factor of K and Cl are different but of K and Br are similar

(c) The structure factors of KCl and KBr are different

(d) Structure factors of KCl and KBr are different and the form factors of K and Br are also similar

7 Ripple factor is defined as the ratio between :

(a) $V_{ac} \cdot V_{dc}$ (b) V_{ac}/V_{dc}

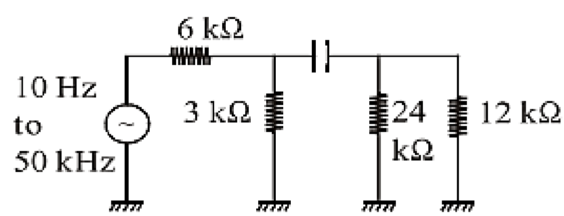
(c) V_{dc}/V_{ac} (d) V_{in}/V_{out}

8 Analysis of a X-ray diffraction pattern of a material crystallizing in a fcc-type structure gives a value of lattice constant as ' α ' Å. The nearest neighbor distance in the material is :

(a)a (b)$\sqrt{3}\frac{a}{2}$

(c) $\frac{a}{\sqrt{2}}$ (d) $\frac{a}{2}$

9 The input signal for the equivalent circuit shown below can have a frequency between 10 Hz and 50 kHz, then the value of the coupling capacitor is :



(a) 1μF (b) 10pF

(c) 1pF (d) 10μF

10. Solar cell is a type of :

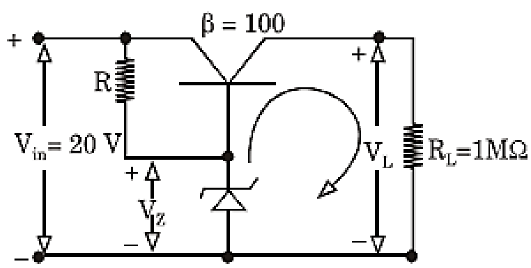
(a) Photo-conductive device

(b) Photo-emissive device

(c) Photo-voltaic device

(d) Electromagnetic device

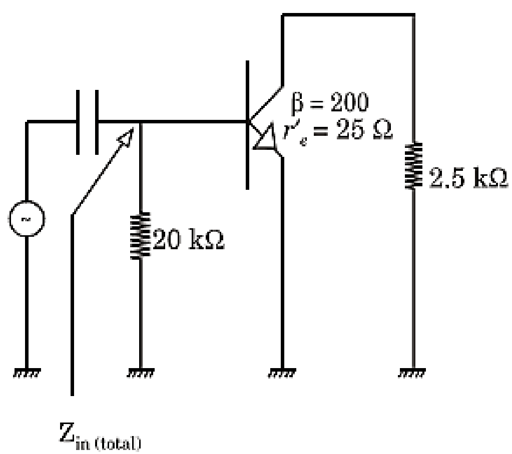
11 The load voltage in a Zener circuit shown below with a $V_Z = 15$ V is approximately.



(a) 15 V (b) 10 V

(c) 14.3 V (d) 15.7 V

12 The input impedance ($Z_{in\ t}$) of the Common-emitter amplifier given below is :



(a) 5kΩ (b) 4kΩ

(c) 2kΩ (d) 20kΩ

13 A positive clamping circuit is one that clamps :

(a) The positive extremity of the signal to the zero level

(b) The positive extremity of the signal to a positive dc voltage

(c) The negative extremity of the signal to the zero level

(d) The negative extremity of the signal to a positive dc voltage

14 A positive logic NAND gate performs same as the negative logic :

(a) XOR gate (b) OR gate

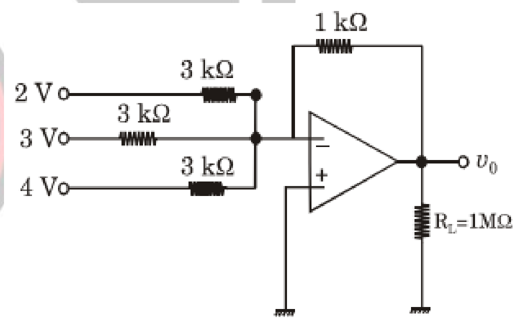
(c) AND gate (d) NOR gate

15 If $C = 0.1\mu F, R = 3.25k\Omega$ in a phase shift oscillator feedback circuit, then the frequency of oscillation is:

(a) 200kHz (b) 100 Hz

(c) 200 Hz (d) 100kHz

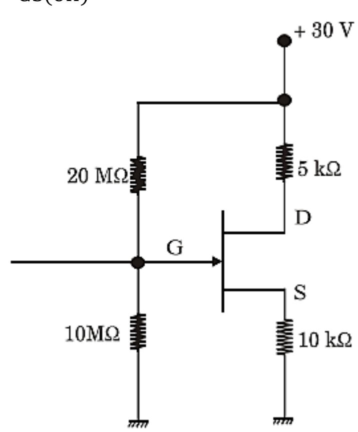
16 In a 3 -input OP-AMO summing amplifier shown below, the output voltage (v_0) is :



(a) −3 V (b) +3 V

(c) +6 V (d) −9 V

17 The drain current in the following circuit when $V_{GS(off)} = -4$ V is :



(a) 10 mA (b) 0.1 mA

(c) 100 mA (d) 5 mA

18 Which of the following molecules will not be sensitive to microwave spectroscopy?

(a) LiH (b) CO

(c) CH_4 (d) CCl_3

19 Light of wavelength 1.5μm incident on a material with a characteristic Raman frequency of 20×10^{12} Hz results in a Stokes shifted line of wavelength :

(a) 1.47μm (b) 1.57μm

(c) 1.67μm (d) 1.77μm

20 The short wavelength cut-off of the continuous X-ray spectrum from a nickel target is 0.0825 nm. The voltage requried to be applied to the X-ray tube must be :

(a) 0.15kV (b) 1.5kV

(c) 15kV (d) 150kV

21 The far infrared rotational absorption spectrum of a diatomic molecule shows equidistant lines with a spacing 20 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) 60 cm^{-1} (d) 120 cm^{-1}

22 If the Planck's constant were to be zero, then the total energy contained in a box filled with radiation of all frequencies at temperature T would be (where k is the Boltzmann constant and $T \neq 0$) :

(a) zero (b) infinite

(c) $\frac{3}{2} k$ T (d) k T

23 According to Hund's rule, the ground state of Si (Atomic No. 14) atom is :

(a) $^1P_1$ (b) $^3S_1$

(c) $^3D_3$ (d) $^3D_1$

24 In the first order Stark effect in hydrogen atom the ground state splits into :

(a) 2 levels (b) 3 levels

(c) 4 levels (d) does not split

25 There is no infrared absorption for nitrogen molecule because :

(a) its polarizability is zero

(b) it has no vibrational levels

(c) it has no rotational levels

(d) its dipole moment is zero

26 A source with a bandwidth of 10^{-3} nm centered about $\lambda = 500$ nm has a coherence length of :

(a) 0.25 m (b) 2.5μm

(c) 25 cm (d) 2.5 m

27 The second neighbour distance in a simple cubic system having lattice constant a is :

(a) $\sqrt{2}, a$ (b) a

(c) $\frac{\sqrt{3}}{2} \cdot a$ (d) $\sqrt{3} \cdot a$

28 Consider an infinite line of ions of alternating sign. If a distance between the adjacent ions is R, the Madelung constant for this chain of ions is :

(a) 4log 4 (b) 4log 2

(c) 2log 2 (d) 2log 4

29 The energy of formation of a vacancy in copper is 1eV. The number of vacancies per mole below its

melting point 1356°K is :

(a) 1.15×10^{20} (b) 4×10^{20}

(c) 2×10^{20} (d) 3.30×10^{20}

30 Consider the elastic vibrations of a crystal with one atom in the premitive cell. If m is mass of the atom, a is the nearest neighbour distance and c the force constant, the frequency of a lattice wave in terms of the wave vector k is :

(a)$\omega = \left(\frac{4c}{m}\right)^{\frac{1}{2}} \left|\sin \frac{ka}{2}\right|$ (b)$\omega = \left(\frac{4c}{m}\right)^{\frac{1}{2}} \sin^2 \frac{ka}{2}$

(c)$\omega = \left(\frac{4c}{m}\right)^{\frac{1}{2}} \cos \frac{ka}{2}$ (d) $\omega = \left(\frac{4c}{m}\right)^{\frac{1}{2}} \cos^2 \frac{ka}{2}$

31 The number of electrons per unit volume in metallic potassium is $1.33 \times 10^{2\varepsilon}$ atoms $/\mathrm{m}^3$ and if each potassium atom donates one electron to the electron gas, its Fermi energy in eV is :

(a) 4.72 (b) 3.23

(c) 2.05 (d) 1.85

32 An n-type semiconductor has an electron concentration of $3 \times 10^{20/\mathrm{m}^3}$. If the electron drift velocity is 100 m/s in an electric field of 200 V/m, the conductivity of this material (in units of $\Omega^{-1}\ \mathrm{m}^{-1}$) is :

(a) 24 (b) 36

(c) 48 (d) 96

33 The barium titanate has a cubic structure with lattice constant of 4Å. The experimentally observed saturation polarization in this crystal at room temperature is $3 \times 10^{-1}\ \mathrm{cm}^{-2}$. Its electric dipole moment in the unit of cm is :

(a) 0.5×10^{-29} (b) 1.0×10^{-29}

(c) 2×10^{-29} (d) 3×10^{-29}

34 The trivalent gadolinium ion has seven electrons in its outer orbital. The Landé g factor for this ion is :

(a) 1 (b) $\frac{3}{2}$

(c) 2 (d) $\frac{5}{2}$

35 If superconducting lead has a critical temperature of 7.26 K at zero magnetic field and a critical field of 8×10^5 A/m at 0 K, the critical field at 5 K is :

(a) 6.3×10^5 A/m (b) 2.5×10^5 A/m

(c) 4.2×10^5 A/m (d) 1.5×10^5 A/m

36 The ratio of the sizes (in terms of radii) of $^{208}_{82}$Pb and $^{26}_{12}$Mg nuclei is approximately :

(a) 2 (b) 4

(c) $2\sqrt{2}$ (d) 8

37 Magnetic moment of duteron $\mu_D \neq \mu_P + \mu_n$. This is due to :

(a) Spin dependence of nuclear force

(b) Tensor character of nuclear force

(c) Spin-orbit force part of nuclear force

(d) Hard core part of the nuclear force

38 What is the energy of a gamma radiation backscattered at an angle $\theta = 180°$, if the incident energy is 10MeV ?

(a) 10MeV (b) 5MeV

(c) 0.511MeV (d) 0.25MeV

39 Ionisation chamber is effectively used for the measurement of :

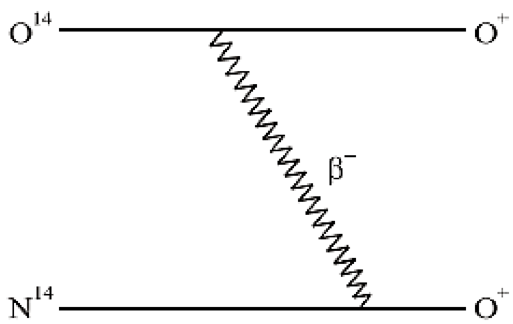
(a) Radiation

(b) Radiation Dose

(c) Strength of radiation

(d) Energy of radiation

40 Clarify the following decay mode in the category of allowed, forbidden and Fermi-Gamow-Teller transition :



(a) Fermi transition and allowed

(b) Fermi transition and second forbidden

(c) G-T transition and first forbidden

(d) G-T transition and allowed

41 What are the expected types of gamma ray transitions between the following states of odd 'A' nuclei :

$$f_{\frac{5}{2}} \longrightarrow \mathrm{P}_{\frac{3}{2}}.$$

(a) E3, M4, E5, M6 (b) M1, E2, M3, E4

(c) M4, E5, M6, E7 (d) M4, M1, E3, E4

42. In nuclear direct reactions, time of interaction is of the order of :

(a) 10^{-10}sec (b) 10^{-16}sec

(c) 10^{-22}sec (d) 10^{-30}sec

43. Based on the additive quantum numbers such as strangeness, Baryon number, charge of the particle and Isospin, indicate whether the following nuclear reaction cannot be induced with the following combination :

$$\pi^+ + n \rightarrow \pi^0 + k^+$$

(a) Q, B, S are conserved, but I_3 is not conserved

(b) Q, B are conserved, but S, I_3 are not conserved

(c) Q, I_3 are conserved, but B, S are not conserved

(d) B, S, I_3 are conserved, but Q is not conserved

44 The following decay states a conservation law that forbids it because :

$$n \rightarrow p + e^-$$

(a) conservation of angular momentum and conservation of Lepton numbers are both violated

(b) conservation of baryon number and conservation of Lepton number are both violated

(c) conservation of energy is violated

(d) conservation of electric charge is violated

45 The puzzle of magic numbers for nuclei was resolved by :

(a) introducing hard-core potential

(b) introducing Yukawa potential for shell model

(c) introducing tensor character to nuclear force

(d) introducing spin-orbit part in the nuclear potential

46 The position vector

$$\underset{\sim}{r} = x\hat{i} + y\hat{j} + z\hat{k}$$
$$\nabla \cdot (r^2 \quad r)$$

is given by :

(a) 0 (b) $5r^2$

(c) r^2 (d) $3r^2$

47. Fourier transform of $\frac{1}{r}$ is :

(a) $\frac{4\pi}{k^2}$ (b) $\left(\frac{4\pi}{k^2}\right)e^{-k}$

(c) $\frac{4\pi}{(k^2+1)}$ (d) $\frac{4\pi}{k^2}\cos\ k$

48. The probability that two friends have the same birth month is :

(a) $\frac{1}{6}$ (b) $\frac{1}{12}$

(c) $\frac{1}{36}$ (d) $\frac{1}{144}$

49. The solution of :

$$\frac{dy}{dx} - y = e^{\lambda x}$$

is :

(a) $e^{-\lambda x}$ (b) $\frac{1}{\lambda - 1}e^{\lambda x}$

(c) $e^{\lambda x}$ (d) $\frac{1}{\lambda}e^{-\lambda x}$

50 The matrix

$$\begin{bmatrix} 8 & x & 0 \\ 4 & 0 & 2 \\ 12 & 6 & 0 \end{bmatrix}$$

will become singular if the value of x is :

(a) 4 (b) 6

(c) 8 (d) 12

51. The function

$$f(z) = u(x,y) + iv(x,y)$$

is analytic at

$$z = x + iy.$$

The value of $\nabla^2 u$ at this point is :

(a) 0 (b) undefined

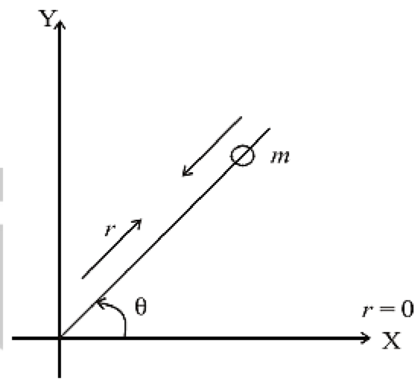
(c) π (d) $e^{-\pi^2}$

52 A particle of mass m is released from a large height. Resistive force is directly proportional to velocity $\bar{v}$ with k as a constant of proportionality. Asymptotic value of the velocity of particle is :

(a) $\frac{g}{k}$ (b) $\frac{k}{m}$

(c) $\frac{mg}{k}$ (d) $\frac{g}{\text{km}}$

53 A head of mass m slides on a smooth rod which is rotating about one end in a vertical plane with uniform angular velocity ω. The Lagrangian of the system is :



(a) $L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) - mgr\sin\ \theta$

(b) $L = \frac{1}{2}m(r^2\dot{\theta}^2) - mgr\sin\ \theta$

(c) $L = \frac{1}{2}m(\dot{r}^2 + \dot{\theta}^2) - mgr\sin\ \theta$

(d) $L = \frac{1}{2}m(r^2\dot{\theta}^2) + mgr\sin\ \theta$

54 A planet of mass m moves around the sun in an elliptic orbit. If L denotes the angular momentum of the planet, then the rate at which area is swept by the radial vector is

(a) $\frac{L}{2m}$ (b) $\frac{L}{m}$

(c) $\frac{2\,L}{m}$ (d) $\frac{\sqrt{2}\,L}{m}$

55 The momentum of an electron (rest mass m_0), which has the same kinetic energy as its rest mass energy, is

(a) $m_0 c$ (b) $\sqrt{2}m_0 c$

(c) $\sqrt{3}m_0c$ (d) $2m_0c$

56 A body of mass $\mathrm{M} = m_1 + m_2$ at rest splits into two parts of masses m_1 and m_2 by an internal explosion which generates a kinetic energy E. The speed of mass m_2 relative to mass m_1 is

(a) $\sqrt{\frac{\mathrm{E}}{m_1 m_2}}$ (b) $\sqrt{\frac{2\mathrm{E}}{m_1 m_2}}$

(c) $\sqrt{\frac{\mathrm{EM}}{m_1 m_2}}$ (d) $\sqrt{\frac{2\mathrm{EM}}{m_1 m_2}}$

57 For a system performing small oscilations, which of the following statements is correct?

(a) The number of normal modes and the number normal coordinates is equal

(b) The number of normal modes is twice the number of normal coordinates

(c) The number of normal modes is half of the number of normal coordinates

(d) There is no specific relationship between the number of normal modes and the number of normal coordinates

58 A plane polarized EM wave is incident normally on a metallic sheet of conductivity $\sigma = 6 \times 10^7$ $(\Omega \mathrm{m})^{-1}$ at optical frequency ($\omega = 4 \times 10^{15}$ s^{-1}). Upto what distance the ray can penetrate before its power gets attenuated by a factor $\frac{1}{e^2}$ inside the conductor? ($\mu = 1$)

(a) 28.9 nm (b) 2.89 nm

(c) 0.289 nm (d) 289 nm

59 A linear quadrupole is formed by joining two dipoles each of mmt $\vec{P}$ back-to-back. The electric potential and field at point P far away from the quadrupole is found to vary respectively with distance as :

(a) $\frac{1}{r^5}$ and $\frac{1}{r^4}$ (b) $\frac{1}{r^2}$ and $\frac{1}{r^3}$

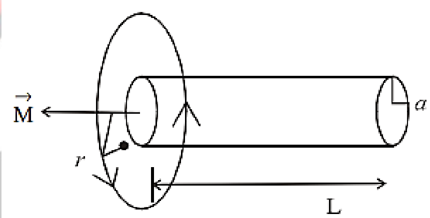
(c) $\frac{1}{r^4}$ and $\frac{1}{r^3}$ (d) $\frac{1}{r^3}$ and $\frac{1}{r^4}$

60 Two solid dielectric spheres each of radius ' a ' are separated by 'R' (R $\gg >$).
One of the spheres is given some charge Q while the other is neutral. Now, the separation between the two sphere is doubled. How much charge Q′ will be required on the first sphere so that the force remains the same?

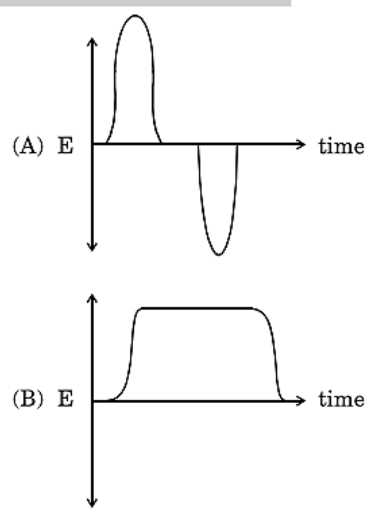
(a) $Q' = 4\sqrt{2}Q$ (b) $Q' = 2\mathrm{Q}$

(c) $Q' = \frac{Q}{2}$ (d) $Q' = \frac{Q}{4\sqrt{2}}$

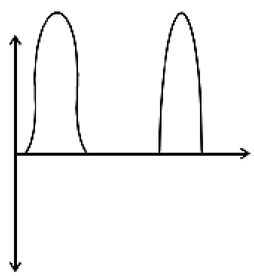
61 A cylindrical magnet of length ' L ' and radius ' a ' carries a uniform magnetization ' M ' along its axis. This magnet is allowed to pass through a circular metallic ring of radius $r (r > a)$ at a constant velocity $\vec{v}$.



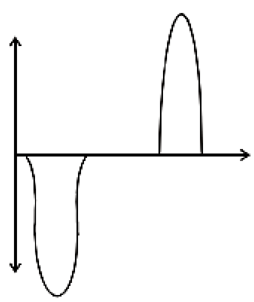
Which of the following figures best represent the emf induced in the metallic ring ?



(C)



(D)



62 A rectangular waveguide of sides 7.21 cm and 3.40 cm is used in the TM mode. Assuming that walls of the waveguide are perfect conductors, lowest cut-off frequency (ω_{mn}) is :

(a) $3.1 \times 10^{10}\ s^{-1}$ (b) $2 \times 10^{10}\ s^{-1}$

(c) $8 \times 10^{10}\ s^{-1}$ (d) $10 \times 10^{10}\ s^{-1}$

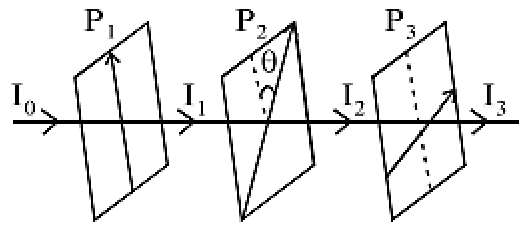
63 If a charged particle q moves along a circle of radius $r = 100$ mm in a uniform magnetic field $B = 10$mT, then the period of revolution of the particle

$$(m_p = 1.67 \times 10^{-27}\ \text{kg}, q = 1.6 \times 10^{-19}\text{C}).$$

(a) 6.55 ms (b) $6.55\mu s$

(c) 6.55 ns (d) $3\mu s$

64 Three polarizers P_1, P_2 and P_3 are arranged as shown in figure. Optical axis of P_1 and P_3 are prependicular to one another while the axis of P_2 makes an angle θ with that of P_1. If a beam of ordinary light of intensity I_0 is incident normally on P_1, then the intensity of light emerging from F_3 is :



(a) 0 (b) $\frac{I_0}{8}\sin^2 2\theta$

(c) $\frac{I_0}{2}$ (d) $\frac{I_0}{4}\sin^2 2\theta$

65 The variational method in perturbation theory, when applied to obtain the value of the ground state energy :

(a) always gives exact ground state energy

(b) give energy value lower than the exact ground state energy

(c) gives energy value which is sometimes higher than or sometimes lower than the exact ground state energy

(d) gives energy value higher than or equal to the exact ground state energy

66 The energy levels of one-dimensional harmonic oscillator with potential $v(x) = \frac{1}{2}kx^2$ are given by $hv\left(n+\frac{1}{2}\right)$ with $n = 0,1,2, \ldots \ldots$ If the potential is changed to $v(x) = \infty$ for $x < 0$ and

$$v(x) = \frac{1}{2}kx^2$$

for $x > 0$, the energy levels now, will be given by :

(a) $hv\left(n+\frac{3}{2}\right)$

(b) $2hv\left(n+\frac{1}{2}\right)$

(c) $hv\left(n+\frac{1}{2}\right)$, $n$odd only

(d) $hv\left(n+\frac{1}{2}\right)$, $n$even only

67 At $t = 0$ a one-dimensional harmonic oscillator is in a state given by :

$$\psi(x,0) = \frac{1}{2}u_0(x) + i\frac{\sqrt{3}}{2}u_1(x)$$

where u_0 and u_1 are first two normalized eigen states. (ω is natural angular frequency of the oscillator). Then :

(a) The expectation value of the energy is $\frac{5}{4}\hbar\omega$

(b) Energy measurement of this state will always give its value as $\frac{5}{4}\hbar\omega$

(c) The average value of energy is $\hbar\omega$

(d) The expectation value of energy is dependent on time

68 If the ϕ dependent part of the eigen function of an electron in a Hydrogen atom is $e^{2i\phi}$, then the minimum principal and minimum orbital angular momentum quantum numbers n and l respectively for this eigen function will be :

(a) $n = 3, l = 2$ (b) $n = 2, l = 1$

(c) $n = 1, l = 2$ (d) $n = 2, l = 2$

69 The ground state energy of a particle in an infinite square well is 1eV. If four particles obeying Bose Einstein statistics are kept in this well, then the ground state energy will be :

(a) 30eV (b) 10eV

(c) 4eV (d) $\frac{1}{4}$eV

70 A particle with spin $\frac{1}{2}$ is in state with eigenstate of S_z. Then the expectation values of S_x, S_x^2 in this state are given by :

(a) $-\frac{\hbar}{2}, \frac{1}{4}\hbar^2$ (b) $0, \frac{3}{4}\hbar^2$

(c) $\frac{\hbar}{2}, \frac{3}{4}\hbar^2$ (d) $0, \frac{1}{4}\hbar^2$

71 The differential cross-section for a central potential is equal to :

(a) $f(\theta,\phi)$ (b) $f^*(\theta,\phi)$

(c) $f^*(\theta,\phi)f(\theta,\phi)$ (d) $|f(\theta,\phi)|$

where asymptotic form of the wave function of the relative motion is given by :

$$A\left[e^{ikz} + \frac{f(\theta,\phi)}{r}e^{ikr}\right].$$

72 For a finite square well potential in one dimension :

(a) It is possible that no bound state exists

(b) There is always at least one bound state

(c) Bound states have degeneracy = 2

(d) Energy levels of bound states are equally spaced

73 The partition function of a two dimensional classical ideal gas of N particles, enclosed in area A and at the temperature T is given by :

(a) $Z = \frac{1}{N!}\left[\frac{A}{h^3}(2\pi mk\,T)^{\frac{3}{2}}\right]^N$

(b) $Z = \frac{1}{N!}\left[\frac{A}{h^2}(2\pi mk\,T)\right]^N$

(c) $Z = \frac{A}{h^2}(2\pi mk\,T)^N$

(d) $Z = \left[\frac{A}{h^3}(2\pi mk\,T)^{\frac{3}{2}}\right]^N$

74 Consider a system in contact with a heat and particle reservoir. It may be unoccupied or occupied by one particle with energy 0 and ∈. The

grand partition function will be $\left(\beta \equiv \frac{1}{k\,T}\right)$.

(a) $Z(\mu, T) = e^{-\epsilon\beta}$

(b) $Z(\mu, T) = \left(1 + e^{-\epsilon\beta}\right)^{-1}$

(c) $Z(\mu, T) = 1 + e^{-\epsilon\beta}$

(d) $Z(\mu, T) = 1 + e^{\mu\beta} + e^{(\mu-\epsilon)\beta}$

75 Consider a configuration of a system of 10 distinguishable particles in which there are 3 particles in state 1,3 particles in state 2 and 4 particles in state 3 . The total number of microstates is :

(a) 4200 (b) 864

(c) 102060 (d) 360

Answer Key				
1. d	2. d	3. d	4. b	5. c
6. a	7. b	8. c	9.	10. c
11. c	12. b	13. d	14. b	15. c
16. a	17.	18. c	19. c	20.
21.	22. b	23.	24. d	25. d
26. a	27. a	28. c	29.	30. a
31.	32. a	33.	34. b	35.
36. a	37. c	38.	39. b	40. a
41. b	42. c	43. c	44. a	45. d
46. b	47. a	48. b	49. b	50. a
51. a	52. c	53. a	54. a	55. c
56.	57. a	58. a	59. d	60. b
61. a	62.	63. b	64. b	65. d
66. c	67. a	68. a	69. c	70. d
71. c	72. b	73. b	74. d	75. a