CAREER SPECTRA DEHRADUN

PHYSICS ACADEMY

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MODEL PAPER -01

CSIR-NET

"CSIR-NET/JRF JUNE-2021"

For –

- **CSIR-NET/JRF**
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PART – A

1. A person finds a 2 rupee coin and decided to enter a game of gambling. The game has following rules.
(i) In each game only one rupee can won or loss
(ii) A person will be out of game if any time he has no many of he has 3rs or he lost 3 matches.
Find how many differential sequences of wins and losses are these so that a person may be out of game?
(a) 5 (b) 6 (c) 7 (d) 8

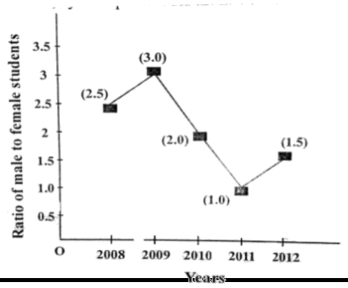
2. A transporter receives the same number of orders each day. Currently he has some pending orders (Backlog) to be shipped. If the uses 7 trucks then at the end of the 4^{th} day he can clear all the orders. Alternatively, if he use only 3 trucks, then all orders are cleared at the end of the 10^{th}day. what is the minimum number of trucks required so that there will be no pending order at the end of the 5^{th} day?
(a) 4 (b) 5 (c) 6 (d) 7

3. M and N are two positive real numbers such that $2M + N \leq 6$ and $M + 2N \leq 8$. For which of the following values of (M,N) the function f (M,N) = 3M + 6n will give max value?
(a) (4/3, 10/8) (b) (8/3,20/3) (b) (8/3,10/3) (d) (4/3, 20/3)

4. An electric train is going from north to south with speed of 100km/h. The wind is blowing from east to west with speed of 70km/h. The smoke will move in which direction
(a) North-east to south-west (b) SW to NE
(c) North (d) None of these

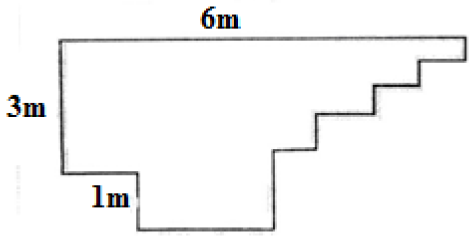
5. The roots of $ax^2 + bx + c = 0$ are real and positive. a,b and c are real. Then $ax^2 + b|x| + c = 0$ has.
(a) No roots (b) 2 real roots
(c) 3 real roots (d) 4 real roots

6. The ration of male to female students in a collage for 5 years is plotted in the following linr graph. If the number of female students doubled in 2009, by what percent did the number of male students increase in 2009.



(a) 40% (b) 80% (c) 140% (d) 120%

7. Find the perimeter of figure given below.

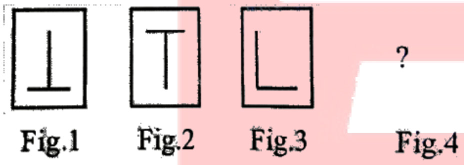


(a) 24m
(b) 20m
(c) 22m
(d) cannot determined

8. The ratio of cost price and marked price of an article is 2:3 and ratio of percentage profit and percentage discount is 3:2. What is the discount percentage?
(a)16.66% (b) 20% (c) 25% (d) 33.33%

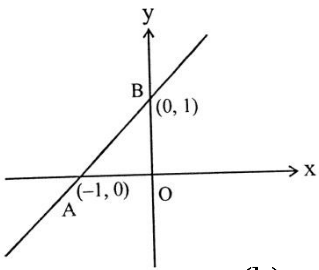
9. Identify the missing letter
ACD, DEI, KLW, FG?
(a) M (b) N (c) O (d) P

10. Identify the fourth figure:



11. What is the distance is cm between two parallel chords of lengths 32cm and 24cm in a circle of radius 20cm?
(a) 1 or 7cm (b) 2 or 14 cm (c) 3 or 21cm (d) 4 or 28cm

12. The line AB represent the equation



(a) x = y + 1 (b) y = x -1

(c) x = y – 1 (d) y = 1- x

13. There circles of equal radii touch each other is shown in figure. The radius of each circle is 1 cm. What is the area of region?

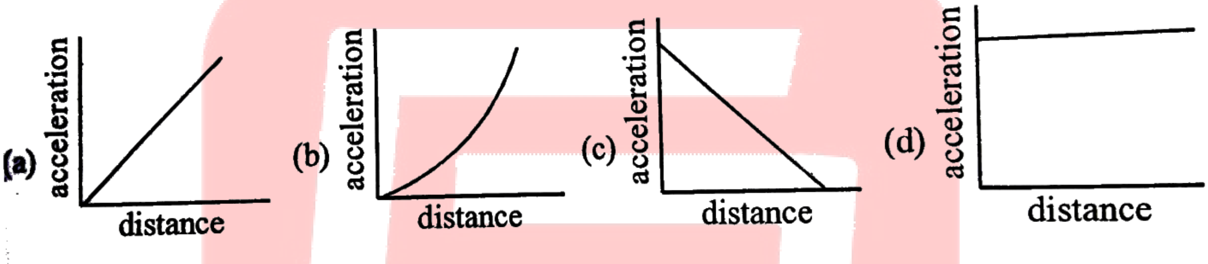
(a) $\left(\frac{2\sqrt{3}-\pi}{2}\right)cm^2$ (b) $\left(\frac{3\sqrt{3}-\pi}{3}\right)cm^2$

(c) $\frac{2\sqrt{3}}{\pi}$ cm^2 (d) None

14. How many area of 1 $unit^2$; square required to complete cover a square of area 1 $unit^2$?

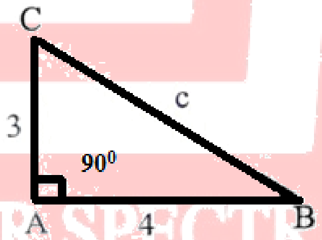
(a) 14 (b) 16 (c) 10 (d) 26

15. A ball is dropped from above the surface of the earth. Ignore air drug, the curve that best represents its variation of acceleration is:



16. In the following question compares the value of column A and column B.

Column A	c
Column B	5

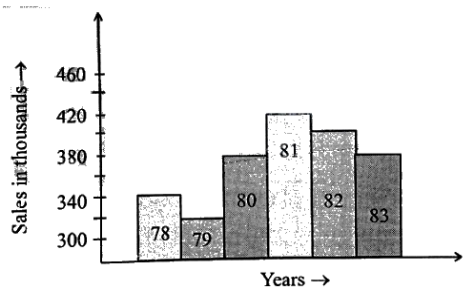


(a) Quantity of column A is greater. (b) Quantity of column b is greater

(c) Both are equal to each other

(d) It is impossible to draw the conclusion.

17. The following figure represents (in thousands), over the period 1978 to 1983. The sales in 1981 expected in 1979 by.



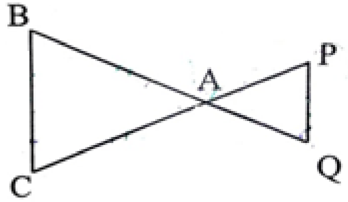
(a) One hundred (b) Ten hundred

(c) One lakh (d) Ten lakh

18. The next pair of letters in the series AZ, CX, FO ………….is.

(a) JQ (b) KP (c) IR (d) IV

19. In the figure, ΔACB ~ΔAPQ. If BC = 8, PQ = 4, AP = 2.8, find CA:



(a) 8 (b) 6.5 (c) 5.6 (d) None of these

20. The centre city little league is divided into ‘d’ divisor, each division has‘t’ teams and each team has ‘p’ players. How many players are there in the entire league?

(a) d + t + p (b) d t p (c) $\frac{pt}{d}$ (d) $\frac{d}{pt}$

PART – B

21. The Eigen values of the matrix P = $\begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$ are.

(a) $\frac{1}{2}(\sqrt{3} \pm i)$ When θ = 45^0 (b) $\frac{1}{2}(1 \pm \sqrt{3}i)$ When θ = 60^0

(c) $\frac{1}{2}(\sqrt{3} \pm i)$ When θ = 60^0 (d) $\frac{1}{2}(1 \pm \sqrt{3}i)$ When θ = 30^0

22. The value of $[\hat{x}^2, \sin \hat{p}_x]$, where $\hat{x}$ and $\hat{p}_x$ are x-component of the position and linear momentum operator respectively, is

(a) $2i\hbar\hat{x} \cos \hat{p}_x$ (b) $2i\hbar\hat{x} \cos \hat{p}_x + \hbar^2 \cos \hat{p}_x$

(c) $-2i\hbar\hat{x} \cos \hat{p}_x + \hbar^2 \cos \hat{p}_x$ (d) $2i\hbar\hat{x} \cos \hat{p}_x - \hbar^2 \cos \hat{p}_x$

23. Suppose ψ_{nlm} be the Eigen function of the Hamiltonian operator of the hydrogen atom where *n,l,m* are principal, orbital and magnetic quantum number respectively. Which of the following wave functions is an Eigen function of above mentioned Hamiltonian Operator?

(*a,b,c* are constants).

(a) $a\psi_{320} + b\psi_{420} + c\psi_{520}$ (b) $a\psi_{421} + b\psi_{420} + c\psi_{410}$

(b) $a\psi_{211} + b\psi_{311} + c\psi_{410}$ (d) $a\psi_{320} + b\psi_{422} + c\psi_{522}$

24. A particle moving one dimensionally is represented by the wave function.

$$\psi(x) = \left(\frac{\sqrt{2}}{\pi}\right)^{1/2} \frac{x + ix}{1 + ix^2}$$

The particle is most likely to find at.

(a) $x = \pm\frac{1}{2}$ (b) $x = 0$ (c) $x = \pm 1$ (d) $x = \pm\frac{3}{2}$

25. If a polynomial $f(x) = 4x^3 - 9x^2 + 11x + 2$ is written in terms of Legendre Polynomials $P_n(x)$ [n = 0, 1,2,……..] i.e. $f(x) = \sum_{n=0}^{\infty} k_n P_n(x)$, then k_3 will be equal to.

(a) 5/8 (b) 8/3 (c) 3/8 (d) 11/21

26. Lagrangian of a system is.

$$L = \frac{1}{2}m\left(\dot{s} - \frac{1}{2}\delta s\right)^2 - \frac{1}{2}ks^2$$

Which of the following is NOT correct?

(a) Equation of motion is $\ddot{s} + \left(\frac{k}{m} - \frac{\delta}{4}\right)s^2$ is constant.

(b) $\ddot{s} + \left(\frac{k}{m} - \frac{\delta}{4}\right)s^2$ is constant.

(c) For $\delta = 0$ dynamics is simple harmonic in nature.

(d) $\ddot{s} + \left(\frac{k}{m} - \frac{\delta}{4}\right)s^2$ is another constant of motion.

27. The value of the integral $\int_C \frac{zdz}{(9-z^2)(z+i)}$, where C is a circle $|z| = 2$ in the argand plane, described in the positive sense is equal to.

(a) π/2 (b) π/4 (c) π/3 (d) π/5

28. Consider $\frac{N}{2}$ photons in the state $\cos v|e_1\rangle + \sin v\, e^{i\phi}|e_2\rangle$ and $\frac{N}{2}$ photons in the state $-\sin v|e_1\rangle + \cos v\, e^{i\phi}|e_2\rangle$, where '$v$' is known and ϕ is unknown parameter and take any value between 0 to 2π. The probability of finding the photons in the state $\frac{1}{\sqrt{2}}(|e_1\rangle + i|e_2\rangle)$ is:

(a) $\frac{1}{2}$ (b) $\frac{1}{2}\cos^2 v$ (c) $\frac{1}{2}\sin^2 v$ (d) 0

29. According to shell model, the magnetic dipole moment for the nucleus $_{83}Bi^{209}$ in terms of nuclear Magneton μ_N is

(a) 3.8 μ_N (b) 1.2 μ_N (c) 2.62 μ_N (d) 0.76 μ_N

Ans:- *

30. A three variable truth table has high output for the following input conditions: 111, 010, 100 and 110. The corresponding Boolean expression will be.

(a) $Y = ABC + \bar{A}B\bar{C} + A\bar{B}\bar{C} + AB\bar{C}$ (b) $Y = \bar{A}BC + \bar{A}B\bar{C} + A\bar{B}\bar{C} + AB\bar{C}$

(c) $Y = \bar{A}BC + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$ (d) $Y = \bar{A}BC + \bar{A}B\bar{C} + \bar{A}\bar{B}\bar{C} + ABC$

31. The spin part of the wave function of a spin ½ particles is.

$|X_s\rangle = \cos\alpha|X_{1/2}\rangle + \sin\alpha\; e^{i\beta}|X_{-1/2}\rangle$

Suppose the x-component of spin is measured. The value α for which for probability of getting the result $\frac{\hbar}{2}$ will be maximum, (for a fixed value of β) will be.

(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{3}$ (d) None of these

32. Which of the following is NOT invariant under Lorentz transformation.

(a) $E^2 - p^2 c^2$ (b) $x^2 + y^2 + z^2 - c^2 t^2$

(c) $d^3 p$ (d) $\frac{d^3p}{E}$

33. Two particles A and B of mass *m* and one particle C of mass M are kept on the x axis in the order ABC. Particle A is given a velocity $v\hat{i}$. Consequently there are two collisions, both of which are completely inelastic. If the net energy loss because of these collisions is $\frac{7}{8}$ of the initial energy, the value of M is (Ignore frictional losses).

(a) c/4 (b) c/2 (c) 4m (d) 2m

34. For the Lagrangian L = $\frac{1}{2}q^2\dot{q}^2 - q^3$ with one degree of freedom, the Lagrange equation is obtained as.

$L + nq^3$ = constant

The value of the integer *n* is.

(a) 1 (b) 2 (c) -1 (d) -2

35. A carrier voltage of amplitude 100V and frequency 1000 kHz is amplitude modulate to a depth of 40%. When applied to a load of 50 Ω, then the power delivered by this AM wave will be.

(a) 72W (b) 96W (c) 108W (d) 132W

36. A system has energy level E_0 , $2E_0$, $3E_0$, ….., where the excited state are triply degenerate, Four non-interacting bosons are placed in this system. If the total energy of these bosons is $5E_0$, the number of microstates is:

(a) 2 (b) 3 (c) 4 (d) 5

37. In 1-dimesnion, an ensemble of *N* classical particles has energy of the form E = $\frac{p_x^2}{2m} + \frac{1}{2}kx^2$. The average internal energy of the system at temperature T is.

(a) $\frac{3}{2}Nk_BT$ (b) $\frac{1}{2}Nk_BT$ (c) $3\,Nk_BT$ (d) Nk_BT

38. The upper limit of the JFET current of a n-channel JFET is 12mA and the corresponding pinch off voltage is -4V. For a Gate voltage of -2V, drain current will be.

(a) 1mA (b) 1.5mA (c) 2mA (d) 3mA

39. A thin spherical shell of radius R ahs its surface maintained at potential $V_0 \cos\theta$. Electric field at the centre of the shell is.

(a) $\frac{V_0}{R}\ (\sin\theta\hat{\theta} - cos\theta\hat{r})$ (b) $\frac{V_0}{R}\ (\cos\theta\hat{\theta} - sin\theta\hat{r})$

(c) $\frac{V_0}{R}\hat{r}$ (d) $-\frac{V_0}{R}\hat{r}$

40. Consider an ideal gas whose entropy is given by.

$$S = \frac{n}{2}\left[\sigma + 5R\ ln\frac{U}{n} + 2R\ ln\frac{V}{n}\right]$$

Where, n = number of moles, R = universal gas constant, U = internal energy, V = volume, and σ = contant. The value of the specific heat at constant pressure will be.

(a) $\frac{3}{2}nR$ (b) $\frac{5}{2}nR$ (c) $\frac{7}{2}nR$ (d) $\frac{9}{2}nR$

41. Large heat reservoirs are available at 900K (H) and 300K (C). A reversible heat engine operates between H and C. For each 100cal of heat removed room H, the heat added to C will be.

(a) $\frac{100}{3}cal$ (b) $\frac{200}{3}cal$ (c) 100cal (c) 200cal

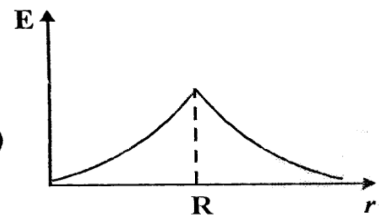
42. If H = $\frac{p^2}{2m} - max,$ value of poisson bracket [[x,H],H] is.

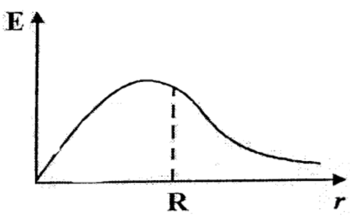
(a) a (b) ma (c) m (d) $-a$

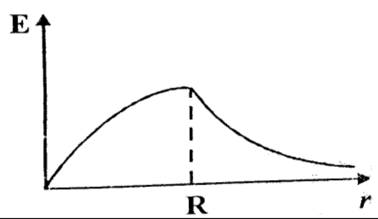
43. A sphere of radius R has surface charge density $\sigma = \sigma_0 \sin\theta \cos\phi$. Electric dipole moment of the sphere is.

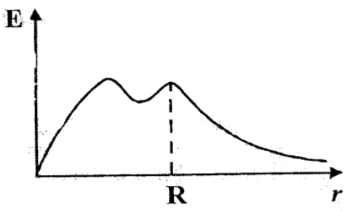
(a) $\frac{2}{3}\pi\sigma_0 R^3$ (b) $\pi\sigma_0 R^3$ (c) $\frac{4}{3}\pi\sigma_0 R^3$ (d) $\frac{\pi\sigma_0 R^3}{3}$

44. Charge density inside a sphere of radius R varies with radial distance a s$\rho = \rho_0 = \left(1 + \frac{r}{R}\right)$. The correct plot for radial variation of electric field is.

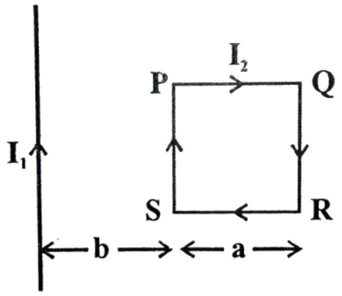
(a)


(b)


(c)


(d)


45. A long straight wire carrying a current I_1 and a square loop carrying a current I_2 lie in same plane as shown in the figure. Magnetic force on side PQ is.

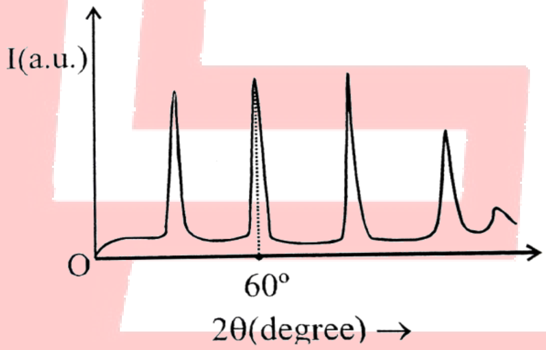


(a) $\frac{\mu_0 I_1 I_2 a}{2\pi b}$ (b) $\frac{\mu_0 I_1 I_2}{2\pi}\ln\left(1-\frac{r}{R}\right)$

(c) $\frac{\mu_0 I_1 I_2}{2\pi}\ln\left(1+\frac{b}{a}\right)$ (d) $\frac{\mu_0 I_1 I_2}{2\pi}\ln\left(1-\frac{a}{b}\right)$

PART – C

46. A beam of X-rays of wavelength 2.5Å us reflected from sodium (Na) metal having bcc structure. A graph between intensity (I) and diffraction angle (2θ) for this metal is shown in the figure below.



The volume of the primitive unit cell of this solid (in Å^3) is :

(a) 125 (b) 62.5 (c) 7.8 (d) 21.5

47. The tight binding energy dispersion (E-k) relation for electrons in a one-dimensional array of atoms having lattice constant a and total length L is:

$$E = 2E_0\left[sin^2\left(\frac{ka}{2}\right)-\frac{1}{6}sin^2(ka)\right]$$

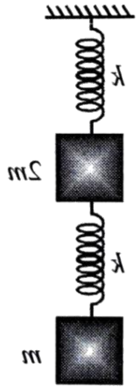
Where E_0 is constant and k is the wave-vector. The effective mass (m^*) at $k=\frac{\pi}{2a}$ is.

(a) $-\frac{\hbar^2}{E_0 a^2}$ (b) $\frac{\hbar^2}{E_0 a^2}$ (c) $\frac{3\hbar^2}{2E_0 a^2}$ (d) $-\frac{3\hbar^2}{2E_0 a^2}$

48. A solid sphere of mass *M*, radius R , rolls on a horizontal surface without sliding. If k and L be its total K.E. and angular momentum about point of contact with surface then value of $\frac{MkR^2}{L^2}$ is.

(a) $\frac{5}{14}$ (b) $\frac{5}{7}$ (c) $\frac{3}{5}$ (d) $\frac{3}{10}$

49. The masses are attached to springs as shown in the figure. Frequencies of normal nodes are .



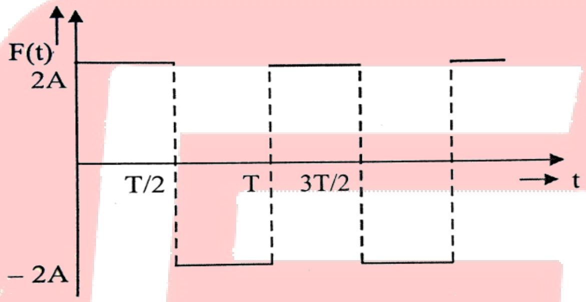
(a) $\sqrt{\frac{k}{m}}, \sqrt{\frac{2k}{m}},$

(b) $\sqrt{\frac{k}{m}}, \sqrt{\frac{k}{2m}},$

(c) $\sqrt{\frac{k}{m}\left(1+\frac{1}{\sqrt{2}}\right)}, \sqrt{\frac{k}{m}\left(1-\frac{1}{\sqrt{2}}\right)}$

(d) $\sqrt{\frac{k}{m}(\sqrt{2}-1)}, \sqrt{\frac{k}{2m}(\sqrt{2}+1)},$

50. The Laplace transform of the following square wave.



Is equal to.

(a) $\frac{A}{S}\ tanh\frac{ST}{4}$

(b) $\frac{A}{S}\ cosh\frac{ST}{4}$

(c) $\frac{2A}{S}\ tanh\frac{ST}{4}$

(d) $\frac{2A}{S}\ cosh\frac{ST}{4}$

51. Suppose the normalized wave function of the particle is given as.

$|\psi\rangle = e^{-|\lambda|^2/2} \sum_{n=0}^{\infty} \frac{\lambda^n}{\sqrt{n!}} |n\rangle$

Where λ is constant and $|n\rangle$ is an Eigen function of the Hamiltonian of a linear harmonic oscillator. Which of the following statement is TRUE?

(a) $|\psi\rangle$ is an Eigen function of the annihilation operator $\hat{a}$ corresponding to Eigen value λ^n.

(b) $|\psi\rangle$ is an Eigen function of the annihilation operator $\hat{a}$ corresponding to Eigen value λ^2.

(c) $|\psi\rangle$ is an Eigen function of the annihilation operator $\hat{a}$ corresponding to Eigen value λ.

(d) $|\psi\rangle$ is an Eigen function of the annihilation operator $\hat{a}$.

52. Consider the function: $f(x) = \int_0^x (t^2 - 3t + 2)dt$. The function $f(x)$ has.

(a) Maximum at x =1 and minimum at x = 2

(b) Minimum at x = 1, Maximum at x =2.

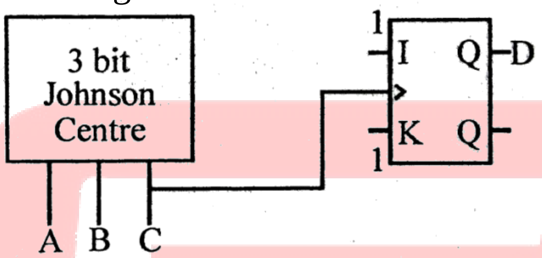
(c) Maximum at x =1 and x = 2.

(d) Minimum at x = 1 and x = 2.

53. Light of wave length 1.5μm. is incident on a material with a characteristic Raman frequency $20\times 10^{12} Hz$. This results in a stoke-shifted line of wave length.
(a) 1.47μm (b) 1.57μm (c) 1.67 μm (d) 1.77 μm

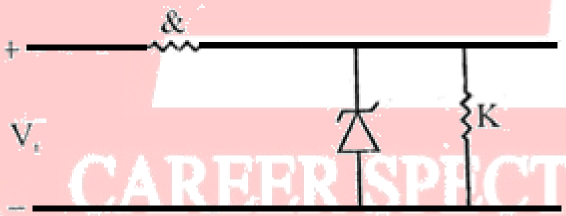
54. The work done by the force $\vec{F} = 4y\hat{\imath} - 3xy\hat{\jmath} + z^2\hat{k}$ in moving the particle over the circular path $x^2 + y^2 = 1$ form (1, 0,0) to (0,1,0) will be.
(a) $\pi + 1$ (b) $\pi - 1$ (c) $-\pi - 1$ (d) $-\pi + 1$

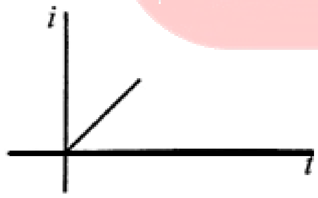
55. For the given circuit diagram shown determine the count sequence after 8

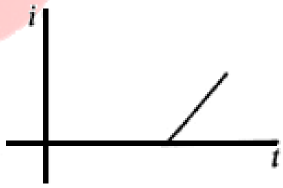


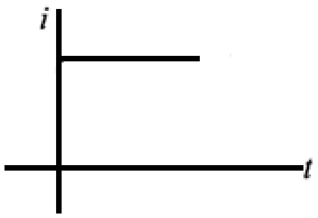
Assume initially ABCD is 1000.
(a) 9 (b) 10 (c) 11 (d) 12

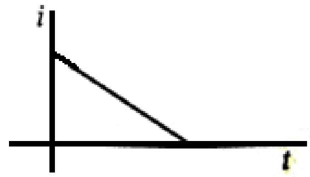
56. For the given Zener diode circuit which of the following represents the correct graph for 'i' across Zener diode.



(a)


(b)


(c)


(d)


57. A ring down from the top of a fixed sphere. If motion takes place without sliding, what is the angle at which the ring leaves contact with the sphere?

(a) $\cos^{-1}\frac{2}{3}$ (b) 30^0 (c) 45^0 (d) 60^0

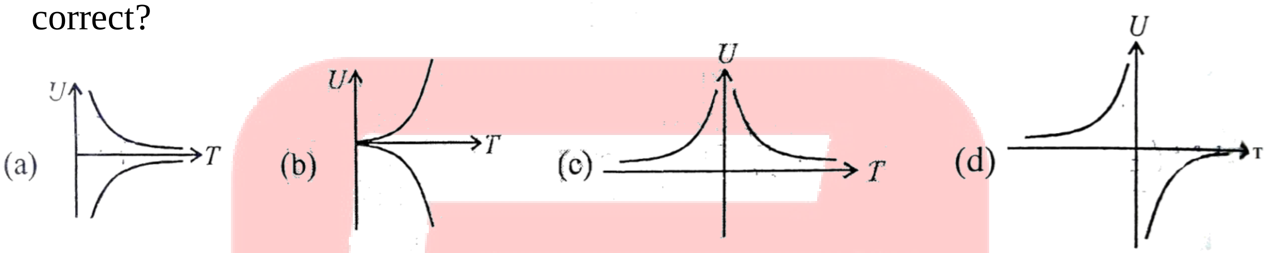
58. Consider the differential equation $\frac{dy}{dx} = ay - by^2$, where , $a ,b > 0$ and y (0) = y_0. As x → ∞, The solution y (x) will tend to.

(a) 0 (b) a/b (c) b/a (d) y_0

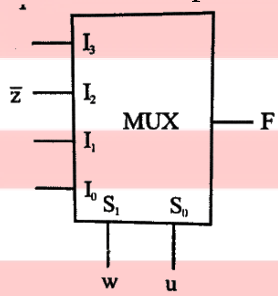
59. The entropy S of an ideal paramagnet in a magnetic field is given approximated by.

$$S = S_0 - CU^2$$

Where, U is the energy of the spin system and C is a constant. For the variation of internal energy with absolute temperature T, which of the following plots is correct?



60. The 4 to 1 multiplexer shown below implements the Boolean expression



$f(\omega, x, y, z) = \sum m\ (4, 5, 7, 8, 10, 12, 13)$

The input to I_1 and I_2 will be.

(a) $y\bar{z}, \bar{y} + \bar{z}$ (b) $\bar{y} + z, y \otimes z$

(b) $\bar{y} + z, y \oplus z$ (d) $x + \bar{y}, y \oplus z$

61. Consider two identical particles are moving independently under the following potentials respectively:

Particle 1: $V(x) = \begin{cases} 0 & for\ 0 < x < L \\ \infty & otherwise \end{cases}$

Particle 2: $V(x,y) = \begin{cases} 0 & for\ 0 < x < L, 0 < y < L \\ \infty & otherwise \end{cases}$

Which of the following statement of TRUE?

(a) Density of states of particle 1 is independent of energy whereas of particle 2 is Proportional to $E^{1/2}$

(b) Density of states of particle 1 is independent of energy whereas of particle 2 is Proportional to $E^{-1/2}$

(c) Density of states of particle 2 is independent of energy whereas of particle 1 is Proportional to $E^{1/2}$

(d) Density of states of particle 2 is independent of energy whereas of particle 1 is Proportional to $E^{-1/2}$.

62. Consider the one-dimensional harmonic oscillator whose unperturbed Hamiltonian is.

$$H_0 = \frac{p^2}{2m} + \frac{m\omega^2 q^2}{2}$$

The system is now subject to perturbation H' = gq^3, the second order correction to ground state energy is.

(a) 0

(b) $-\frac{11}{8}\frac{g^2}{\hbar\omega}\left(\frac{\hbar}{m\omega}\right)^3$

(c) $-\frac{9}{8}\frac{g^2}{\hbar\omega}\left(\frac{\hbar}{m\omega}\right)^3$

(d) $+\frac{9}{8}\frac{g^2}{\hbar\omega}\left(\frac{\hbar}{m\omega}\right)^3$

63. A particle of mass m in one-dimension is in the state.

$$\psi(x) = \begin{cases} \frac{1}{\sqrt{a^3}}(a-|x|), & |x| < a \\ 0 & |x| \geq a \end{cases}$$

What is the probability of finding the particle in the region $|x| < \frac{a}{2}$?

(a) $\frac{7}{24}$ (b) $\frac{7}{12}$ (c) $\frac{7}{16}$ (d) $\frac{7}{8}$

64. Consider the following complex integral:

$$\int_C (z - z^2)\, dz$$

Where z is denoted by a point (x,y) in argand plane and C is the upper half of the circle |z-2| = 3. The value of the integral along the lower half of the above given circle will be.

(a) 18 (b) -18 (c) 6 (d) -6

65. A three level system of atoms has N_1 atoms in level E_1 , N_2 atoms in level E_2 and N_3 atoms in level E_3 respectively ($N_2 > N_1 > N_3$ and $E_1 < E_2 < E_3$). Laser emission is possible between the levels.

(a) $E_2 \rightarrow E_1$

(b) $E_3 \rightarrow E_1$

(c) $E_3 \rightarrow E_2$

(d) $E_2 \rightarrow E_3$

66. If R_1 is the value of the rydberg constant assuming the mass of nucleus to be infinity large compared to that electron an if R_2 is the Ryderg constant taking nuclear mass to be 7500 times the mass of the electron, then the ratio ${R_1}/{R_2}$ is.

(a) A little less than unity
(b) A little more than unity
(c) Infinitely small
(d) infinitely large

67. A particle of mass m is moving under the following potential:

$$V(x) = \begin{cases} \infty & for\ x < 0 \\ 0 & for\ 0 < x < \frac{L}{2} \\ V_0 & for\ \frac{L}{2} < x < L \\ \infty & for\ x > L \end{cases}$$

The energy Eigen value E ($E > V_0$) of the particle will satisfy the following the equation:

(a) $\sqrt{E}\ tan\left(\sqrt{\frac{2m(E-V_0)}{\hbar^2}}\frac{L}{2}\right) + \sqrt{E-V_0}\tan\left(\sqrt{\frac{2mE}{\hbar^2}}\frac{L}{2}\right) = 0$

(b) $\sqrt{E}\ tan\left(\sqrt{\frac{2m(E-V_0)}{\hbar^2}}\frac{L}{2}\right) - \sqrt{E-V_0}\tan\left(\sqrt{\frac{2mE}{\hbar^2}}\frac{L}{2}\right) = 0$

(c) $\sqrt{E-V_0}\ tan\left(\sqrt{\frac{2m(E-V_0)}{\hbar^2}}\frac{L}{2}\right) - \sqrt{E}\ \tan\left(\sqrt{\frac{2mE}{\hbar^2}}\frac{L}{2}\right) = 0$

(d) $\sqrt{E-V_0}\ tan\left(\sqrt{\frac{2m(E-V_0)}{\hbar^2}}\frac{L}{2}\right) + \sqrt{E}\ \tan\left(\sqrt{\frac{2mE}{\hbar^2}}\frac{L}{2}\right) = 0$

68. Consider a system of N distinguishable and non interacting particle. The single particle energy spectrum is $\varepsilon_n = n\varepsilon$, with n = 0, 1, 2, …., +∞ and degeneracy g_n = n +1 ($\epsilon > 0$ *is a constant*). The system is in thermal equilibrium at temperature T, the partition function of the system is given by,

(a) $Q_N(V,T) = \left(\frac{n+1}{(1-e^{-\varepsilon/kT})}\right)^N$
(b) $Q_N(V,T) = \left(\frac{n+1}{(1-e^{-\varepsilon/kT})^2}\right)^N$
(c) $Q_N(V,T) = \left(\frac{1}{(1-e^{-\varepsilon/kT})^2}\right)^N$
(d) $Q_N(V,T) = \left(\frac{1}{(1-e^{-\varepsilon/kT})}\right)^N$

69. A particle of mass *m* moves in a 3-D potential V(r) = c $\left[\frac{r}{r_0} - \ell n\left(1+\frac{r}{r_0}\right)\right]$, where c and r_0 are positive constants of appropriate dimensions. The ground sate energy of the particle in $\frac{r}{r_0} \ll 1$ limit , is

(a) $\frac{1}{2}\sqrt{\frac{c\hbar^2}{mr_0^2}}$
(b) $\frac{3}{2}\sqrt{\frac{c\hbar^2}{mr_0^2}}$
(c) $\frac{1}{2}\sqrt{\frac{c\hbar^2}{2mr_0^2}}$
(d) $\frac{3}{2}\sqrt{\frac{c\hbar^2}{2mr_0^2}}$

70. The expectation value of the x-component of orbital angular momentum of a system in the state $\psi(\theta,\phi) = \sqrt{\frac{15}{8\pi}}\cos\theta \sin\theta \cos\phi$ is.

(a) $\sqrt{6}\hbar$ (b) $\sqrt{2}\,\hbar$ (c) $\sqrt{3}\,\hbar$ (d) 0

71. For the given nuclear reactions, choose the correct option

(I) $\Xi^- \to \Lambda^0 + \pi^-$ (II) $\mu^- \to e^- + \bar{\nu}_e + \nu_\mu$

(III) $\Lambda^0 \to n + \pi^0$ (IV) $P + P \to P + P + \pi^0$

(a) Reaction I, II and III are governed by weak interaction, reaction IV by strong interaction and V is forbidden reaction.

(b) Reaction IV and V are governed by strong interaction and reaction IV has $I_3 = 1$ and $I = 1$ and reaction V has $I_3 = \frac{1}{2}$ and $I = \frac{1}{2}$ and $\frac{3}{2}$ both

(c) Reaction I and III are governed by weak interaction, reaction IV by electromagnetic and reactions II and V are forbidden

(d) Reaction I, II and III are governed by weak interaction reaction IV by electromagenetic and V by strong interaction

Ans- *

72. A system consists of a distinguishable coin that can come up either heads or tails. All coins are tossed simultaneously. Then the maximum entropy corresponding to a macro state of the system is.

(a) k_B [ln2 + ln3] (b) $4k_B$ ln2

(c) k_B ln 3 (d) $2k_B$ ln2

73. For a thermodynamics system, the relation among the entropy S, volume V, internal energy U and number of particles N is given by.

$S = A\,(NVU)^{1/3}$, where A is constant.

The pressure (P) and specific heat (C_V) at constant volume respectively are.

(a) $\sqrt{\frac{A^3NT}{27V}}, \sqrt{\frac{A^3N}{12TV}},$ (b) $\sqrt{\frac{A^3NT^3}{27V}}, \sqrt{\frac{A^3NVT}{12}},$

(c) $\sqrt{\frac{NA^3T^3}{27V}}, \sqrt{\frac{NA^3VT}{27}},$ (d) $\sqrt{\frac{NA^3T^3}{12V}}, \sqrt{\frac{A^3NVT}{12}},$

74. For what value of a will transformation $q \to Q = q^\alpha \cos 2p$ and $p \to P = q^\alpha \sin 2p$ be canonical?

(a) $\alpha = 1$ (b) $\alpha = \frac{1}{2}$

(c) $\alpha = -1$ (d) $\alpha = 2$

75. In a nonmagnetic dielectric medium with dielectric constant $\epsilon_r = 4$, the electric field of a propagating plane wave with $\omega = 10^8$rad/s is given by $\vec{E} = (-\hat{\imath} + \sqrt{3}\hat{\jmath})\exp[j(\omega t - \vec{k}.\vec{r})]$

The propagation vector $\hat{k}$ (in unit of m^{-1}) is given by

(a) $\vec{k} = \frac{1}{\sqrt{3}}\hat{\imath} + \frac{1}{3}\hat{\jmath}$

(b) $\vec{k} = \frac{1}{3}\hat{z}$

(c) $\vec{k} = \frac{1}{2\sqrt{3}}\hat{\imath} + \frac{1}{6}\hat{\jmath}$

(d) $\vec{k} = -\frac{1}{\sqrt{3}}\hat{\imath} + \frac{1}{3}\hat{\jmath}$

Answer –Key

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