❖ CSIR-UGC-NET/JRF- JUNE – 2018 PHYSICAL SCIENCES BOOKLET - [A]

➢ PART-B

1. Consider the three vectors $\vec{v}_1 = 2\hat{\imath} + 3\hat{k}, \vec{v}_2 = \hat{\imath} + 2\hat{\jmath} + 2\hat{k}$ and $\vec{v}_3 = 5\hat{\imath} + \hat{\jmath} + \alpha\hat{k}$, where $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$ are the standard unit vectors in a three-dimensional Euclidean space. These vectors will be linearly dependent if the value of α is

(a) 31/4 (b) 23/4
(c) 27/4 (d) 0

2. The fourier transform $\int_{-\infty}^{\infty} dx f(x) e^{ikx}$ of the function $f(x) = e^{-|x|}$ is

(a) $-\frac{2}{1+k^2}$ (b) $-\frac{1}{2(1+k^2)}$
(c) $\frac{2}{1+k^2}$ (d) $\frac{2}{(2+k^2)}$.

3. The value of the integral $\int_{-\pi/2}^{+\pi/2} dx \int_{-1}^{+1} dy\, \delta(\sin\, 2x)\delta(x-y)$ is

(a) 0 (b) 1/2
(c) $1/\sqrt{2}$ (d) 1

4. Consider the following ordinary differential equation : $\frac{d^2x}{dt^2} + \frac{1}{x}\left(\frac{dx}{dt}\right)^2 - \frac{dx}{dt} = 0$ with the boundary conditions $x(t=0) = 0$ and $x(t=1) = 1$. The value of $x(t)$ at t & is

(a) $\sqrt{e-1}$ (b) $\sqrt{e^2+1}$
(c) $\sqrt{e+1}$ (d) $\sqrt{e^2-1}$

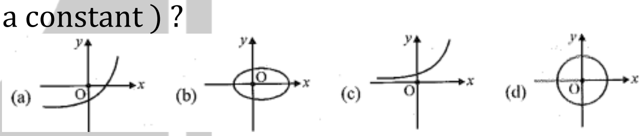
5. What is the value of α for which $f(x,y) = 2x + 3(x^2 - y^2) + 2i(3xy + \alpha y)$ is an analytic function of complex variable $z = x + iy$?

(a) 1 (b) 0

6. A particle moves in the one-dimensional potential $V(x) = \alpha x^6$, where $\alpha > 0$ is a constant. If the total energy of the particle is E, its time period in a periodic motion is proportional to

(a) $E^{-1/3}$ (b) $E^{-1/2}$
(c) $E^{1/3}$ (d) $E^{1/2}$

7. Which of the following figures best describes the trajectory of a particle moving in a repulsive central potential $V(r) = \frac{\alpha}{r}$ ($\alpha > 0$ is a constant) ?



8. Two particles A and B move with relativistic velocities of equal magnitude v, but in opposite directions, along the x-axis of an inertial frame of reference. The magnitude of the velocity of A, as seen from the rest frame of B, is

(a) $\frac{2v}{\left(1-\frac{v^2}{c^2}\right)}$ (b) $\frac{2v}{\left(1+\frac{v^2}{c^2}\right)}$
(c) $2v\sqrt{\frac{c-v}{c+v}}$ (d) $\frac{2v}{\sqrt{1-\frac{v^2}{c^2}}}$

9. A particle of mass m, kept in a potential $V(x) = -\frac{1}{2}kx^2 + \frac{1}{4}\lambda x^4$, [where k and λ are positive constants], undergoes small oscillations about an equilibrium point. The frequency of oscillations is

(a) $\frac{1}{2\pi}\sqrt{\frac{2\lambda}{m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

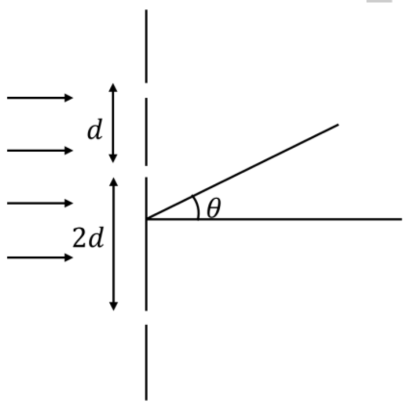
(c) $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{\lambda}{m}}$

10. Two points charges $+2Q$ and $-Q$ are kept at points with Cartesian coordinates (1,0,0) and (2,0, 0), respectively, in front of an infinite grounded conducting plate at $x = 0$. The potential at $(x, 0,0)$ for $x \geqslant 1$ depends on x as

(a) x^{-3} (b) x^{-5}

(c) x^{-2} (d) x^{-4}

11. The following configuration of three identical narrow slits are illuminated by monochromatic light of wavelength λ (as shown in the figure below). The intensity is measured at angle θ (where θ is the angle with the incident beam) at a large distance from the slits. If $\delta = \frac{2\pi d}{2}\sin\,\theta$, the intensity is proportional to



(a) $2\cos\,\delta + 2\cos\,2\delta$

(b) $3 + \frac{1}{8^2}\sin^2\,3\delta$

(c) $3 + 2\cos\,\delta + 2\cos\,2\delta + 2\cos\,3\delta$

(d) $2 + \frac{1}{\delta^2}\sin^2\,3\delta$

12. The electric field of a plane wave in a conducting medium is given by

$$\vec{E}(z,t) = \hat{\imath}E_0 e^{-s/3a}\cos\left(\frac{z}{\sqrt{3}a} - \omega t\right)$$

where ω is the angular frequency and $a > 0$ is a constant. The phase difference between the magnetic field $\vec{B}$ and the electric field $\vec{E}$ is

(a) 30° and $\vec{E}$ lags behind $\vec{B}$

(b) 30° and $\vec{B}$ lags behind $\vec{E}$

(c) 60° and $\vec{E}$ lags behind $\vec{B}$

(d) 60° and $\vec{B}$ lags behind $\vec{E}$

13. The electric field $\vec{E}$ and the magnetic field $\vec{B}$ corresponding to the scalar and vector potentials, $V(x,y,z,t) = 0$ and $\vec{A}(x,y,z,t) = \frac{1}{2}\hat{k}\mu_0 A_0(ct - x)$, where A_0 is a constant, are

(a) $\vec{E} = 0$ and $\vec{B} = \frac{1}{2}\hat{\jmath}\mu_0 A_0$

(b) $\vec{E} = -\frac{1}{2}\hat{k}\mu_0 A_0 c$ and $\vec{B} = \frac{1}{2}\hat{\jmath}\mu_0 A_0$

(c) $\vec{E} = 0$ and $\vec{B} = -\frac{1}{2}\hat{\imath}\cdot\mu_0 A_0$

(d) $\vec{E} = \frac{1}{2}\hat{k}\mu_0 A_0 c$ and $\vec{B} = -\frac{1}{2}\hat{\imath}\mu_0 A_0$

14. A particle of mass m is confined in a three-dimensional box by the potential

$$V(x,y,z) = \begin{cases} 0, & 0 \le x,y,z \le a \\ \infty, & \text{otherwise} \end{cases}$$

The number of eigenstates of Hamiltonian with energy $\frac{9\hbar^2\pi^2}{2ma^2}$ is

(a) 1 (b) 6

(c) 3 (d) 4

15. The Hamiltonian of a spin-$\frac{1}{2}$ particle in a magnetic field $\vec{B}$ is given by $H = -\mu\vec{B}\cdot\vec{\sigma}$, where μ is a real constant and $\bar{\sigma} = (\sigma_x, \sigma_y, \sigma_z)$ are the Pauli spin matrices. If $\bar{B} = (B_0, B_0, 0)$ and the spin state at time $t = 0$ is an eigenstate of σ_x, then of the expectation values $\langle\sigma_x\rangle, \langle\sigma_y\rangle$ and $\langle\sigma_z\rangle$

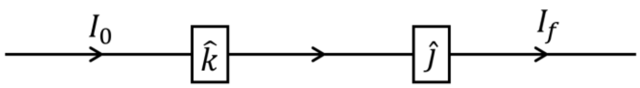
(a) Only $\langle\sigma_x\rangle$ changes with time

(b) Only $\langle\sigma_y\rangle$ changes with time

(c) Only $\langle\sigma_z\rangle$ changes with time

(d) All three change with time

16. Two Stern-Gerlach apparatus S_1 and S_2 are kept in a line (x-axis). The directions of their magnetic fields are along the positive z - and y-axes, respectively. Each apparatus only transmits particles with spins aligned in the direction of its magnetic field. If an initially unpolarized beam of spin-$\frac{1}{2}$ particles passes through this configuration, the ratio of intensities $I_0 : I_f$ of the initial and final beams, is



(a) 16: 1
(b) 2: 1
(c) 4: 1
(d) 1: 0

17. A particle of mass m is constrained to move in a circular ring to radius R. When a perturbation

$$V' = \frac{a}{R^2}\cos^2 \phi$$

(where a is a real constant) is added, the shift in energy of the ground state, to first ordor in a, is

(a) a/R^2 (b) $2a/R^2$
(c) $a/(2R^2)$ (d) $d/(\pi R^2)$

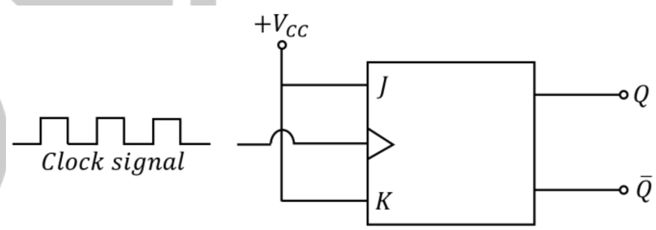
18. Which of the following statements concerning the coefficient of volume expansion α and the isothermal compressibility κ of a solid is true ?
(a) α and κ are both intensive variables.
(b) α is an intensive and k is an extensive variable.
(c) α is an extensive and κ is an intensive variable.
(d) α and k are both extensive variables.

19. The van der Waals equation for one mole of a gas is $\left(p + \frac{a}{V^2}\right)(V - b) = RT$. The corresponding equation of state for n moles of this gas at pressure p, volume V and temperature T, is
(a) $\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$
(b) $\left(p + \frac{a}{V^2}\right)(V - nb) = nRT$
(c) $\left(p + \frac{an^2}{V^2}\right)(V - nb) = RT$
(d) $\left(p + \frac{a}{V^2}\right)(V - nb) = RT$

20. The number of ways of distributing 11 indistinguishable bosons in 3 different energy levels is
(a) 3^{11} (b) 11^3
(c) $\frac{(13)!}{2!(11)!}$ (d) $\frac{(11)!}{3!8!}$

21. In a system of N distinguishable particles, each particle can be in one of two states with energies 0 and $-E$, respectively. The mean energy of the system at temperature T, is
(a) $-\frac{1}{2}N\left(1 + e^{E/k_gT}\right)$ (b) $-\frac{NE}{(1+e^{E/k_BT})}$
(c) $-\frac{1}{2}NE$ (d) $-\frac{NE}{(1+e^{-E/\kappa_BT})}$

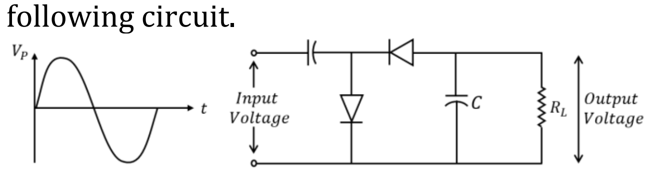
22. In the following JK flip-flop circuit, J and K inputs are tied together to $+V_{CC}$. If the input is a clock signal of frequency f, the frequency of the output Q is



(a) f (b) $2f$
(c) $4f$ (d) $f/2$

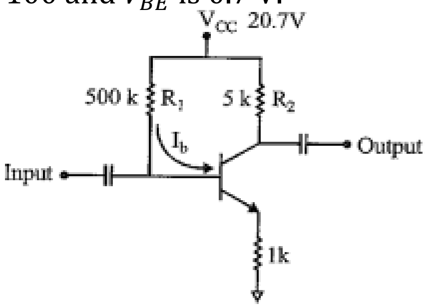
23. Which of the following gates can be used as a parity checker ?
(a) an OR gate
(b) a NOR gate
(c) an exclusive OR (XOR) gate
(d) an AND gate

24. A sinusoidal signal with a peak voltage V_p and average value zero, is an input to the following circuit.



Assuming ideal diodes, the peak value of the output voltage across the load resistor R_L, is
(a) V_P (b) $V_P/2$
(c) $2V_P$ (d) $\sqrt{2}V_P$

25. In the following circuit, the value of the common-emitter forward current amplification factor β for the transistor is 100 and V_{BE} is 0.7 V.



The base current I_B is

(a) $40\mu A$ (b) $30\mu A$

(c) $44\mu A$ (d) $33\mu A$

➢ PART - C

26. In the function $P_n(x)e^{-x^2}$ of a real variable $x, P_n(x)$ is a polynomial of degree n. The maximum number of extrema that this function can have is

(a) $n+2$ (b) $n-1$

(c) $n+1$ (d) n

27. The Green's function $G(x, x^2)$ for the equation $\frac{d^2y(x)}{dx^2}+y(x)=f(x)$, with the boundary values $y(0)=y\left(\frac{\pi}{2}\right)=0$, is

(a) $G(x,x')=\begin{cases} x\left(x'-\frac{\pi}{2}\right), & 0<x<x'<\frac{\pi}{2} \\ \left(x-\frac{\pi}{2}\right), & 0<x'<x<\frac{\pi}{2}\end{cases}$

(b) $G(x,x')=$
$\begin{cases} -\cos x'\sin x, & 0<x<x'<\frac{\pi}{2} \\ -\sin x'\cos x, & 0<x'<x<\frac{\pi}{2}\end{cases}$

(c) $G(x,x')=\begin{cases} \cos x'\sin x, & 0<x<x'<\frac{\pi}{2} \\ \sin x'\cos x, & 0<x'<x<\frac{\pi}{2}\end{cases}$

(d) $G(x,x')=\begin{cases} x\left(\frac{\pi}{2}-x'\right), & 0<x<x'<\frac{\pi}{2} \\ x'\left(\frac{\pi}{2}-x\right), & 0<x'<x<\frac{\pi}{2}\end{cases}$

28. The fractional error in estimating the integral $\int_0^1 x dx$ using Simpson's $\frac{1}{3}$-rule, using a step size 0.1 , is nearest to

(a) 10^{-4} (b) 0

(c) 10^{-2} (d) 3×10^{-4}

29. Which of the following statements is true for a 3×3 real orthogonal matrix with determinant $+1$?

(a) the modulus of each of its eigenvalues need not be 1 , but their product must be 1 .

(b) at least one of its eigenvalues is $+1$.

(c) all of its eigenvahues must be real.

(d) none of its eigenvalues need be real.

30. A particle of mass m moves in a central potential $V(r)=-\frac{k}{r}$ in an elliptic orbit $r(\theta)=\frac{a(1-e^2)}{1+e\cos\theta}$, where $0\leq\theta\leq2\pi$ and a and e denote the semi-major axis and eccentricity, respectively. If its total energy is $E=-\frac{k}{2a}$, the maximum kinetic energy is

(a) $E(1-e^2)$ (b) $E\frac{(e+1)}{(e-1)}$

(c) $\frac{E}{(1-e^2)}$ (d) $E\frac{(1-e)}{(1+e)}$

31. The Hamiltonian of a one-dimensional system is $H=\frac{xp^2}{2m}+\frac{1}{2}kx$, where m and k are positive constants. The corresponding Euler-Lagrange equation for the system is

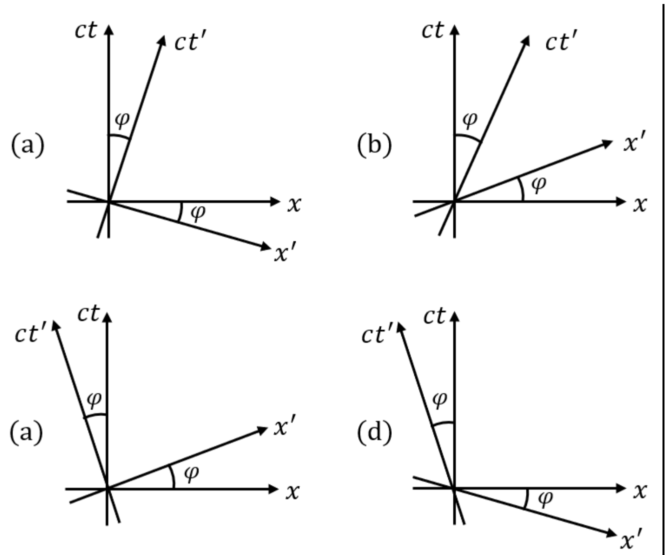
(a) $m\ddot{x}+k=0$

(b) $m\ddot{x}+2\dot{x}+kx^2=0$

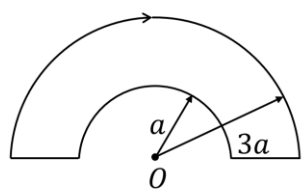
(c) $2mx\ddot{x}-m\dot{x}^2+kx^2=0$

(d) $mx\ddot{x}-2m\dot{x}^2+kx^2=0$

32. An inertial frame K' moves with a constant speed v with respect to another inertial frame K along their common x-axis in the positive x-direction. Let (x, ct) and (x', ct') denote the space-time coor dinates in the frame K and K', respectively. Which of the following space-time diagrams correctly describes the t'-axis ($x'=0$ line) and the x'-axis ($t'=0$ line) in the $x-ct$ plane ? (In the following figures $\tan\varphi=v/c$).



33. The loop shown in the figure below carries a steady current I.
The magnitude of the magnetic field at the point O is



(a) $\frac{\mu_0 I}{2a}$ (b) $\frac{\mu_0 I}{6a}$
(c) $\frac{\mu_0 I}{4a}$ (d) $\frac{\mu_0 I}{3a}$

34. In the region far from a source, the time dependent electric field at a point (r,θ,ϕ) is

$$\vec{E}(r,\theta,\phi) = \hat{\phi}E_0\omega^2\left(\frac{\sin\,\theta}{r}\right)\cos\,\left[\omega\left(t-\frac{r}{c}\right)\right]$$

where ω is angular frequency of the source. The total power radiated (average over a cycle) is

(a) $\frac{2\pi}{3}\frac{E_0^2\omega^4}{\mu_0 c}$ (b) $\frac{4\pi}{3}\frac{E_0^2\omega^4}{\mu_0 c}$
(c) $\frac{4}{3\pi}\frac{E_0^2\omega^4}{\mu_0 c}$ (d) $\frac{2}{3}\frac{E_0^2\omega^4}{\mu_0 c}$

35. A hollow waveguide supports transverse electric (TE) modes with the dispersion relation $k = \frac{1}{c}\sqrt{\omega^2 - \omega_{mn}^2}$, where ω_{mn} is the mode frequency. The speed of flow of electromagnetic energy at the mode frequency is

(a) c (b) ω_{mn}/k
(c) 0 (d) ∞

36. The energy of a free relativistic particle is $E = \sqrt{|\vec{p}|^2c^2 + m^2c^4}$, where m is its rest mass, $\vec{p}$ is its momentum and c is the speed of light in vacuum. The ratio v_g/v_p of the group velocity v_g of a quantum mechanical wave packet (describing this particle) to the phase velocity v_p is

(a) $|\vec{p}|c/E$ (b) $|\vec{p}|mc^3/E^2$
(c) $|\vec{p}|^2c^2/E^2$ (d) $|\vec{p}|c/2E$

37. The n-th energy eigenvalue E_n of a one-dimensional Hamiltonian $H = \frac{p^2}{2m} + \lambda x^4$, (where $\lambda > 0$ is a constant) in the WKB approximation, is proportional to

(a) $\left(n+\frac{1}{2}\right)^{4/3}\lambda^{1/3}$ (b) $\left(n+\frac{1}{2}\right)^{4/3}\lambda^{2/3}$
(c) $\left(n+\frac{1}{2}\right)^{5/3}\lambda^{1/3}$ (d) $\left(n+\frac{1}{2}\right)^{5/3}\lambda^{2/3}$

38. The differential scattering cross section $d\sigma/d\Omega$ for the central potential $V(r) = \frac{\beta}{r}e^{-\mu r}$, where β and μ are positive constants, is calculated in the first Born approximation. Its dependence on the scattering angle θ is proportional to (A is a constant below).

(a) $\left(A^2 + \sin^2\frac{\theta}{2}\right)$ (b) $\left(A^2 + \sin^2\frac{\theta}{2}\right)^{-1}$
(c) $\left(A^2 + \sin^2\frac{\theta}{2}\right)^{-2}$ (d) $\left(A^2 + \sin^2\frac{\theta}{2}\right)^{2}$

39. At $t = 0$, the wavefunction of an otherwise free particle confined between two infinite walls at $x = 0$ and $x = L$ is

$$\psi(x,t=0) = \sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} - \sin\frac{3\pi x}{L}\right).$$

Its wavefunction at a later time $t = \frac{mL^2}{4\pi\hbar}$ is

(a) $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} - \sin\frac{2\pi x}{L}\right)e^{-i\pi/6}$

(b) $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} + \sin\frac{3\pi x}{L}\right)e^{-i\pi/6}$

(c) $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L} - \sin\frac{3\pi x}{L}\right)e^{-i\pi/8}$

(d) $\sqrt{\frac{2}{L}}\left(\sin\frac{\pi x}{L}+\sin\frac{3\pi x}{L}\right)e^{ein/6}$

40. The pressure P of a system of N particles contained in a volume V at a temperature T is given by

$$P = nk_BT - \frac{1}{2}an^2 + \frac{1}{6}bn^3$$

where n is the number density and a and b are temperature independent constants. If the system exhibits a gas-liquid transition, the critical temperature is

(a) $\frac{a}{bk_B}$ (b) $\frac{a}{2b^2k_B}$

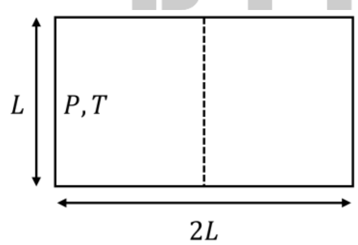
(c) $\frac{a^2}{2bk_B}$ (d) $\frac{a^2}{b^2k_B}$

41. Consider a particle diffusing in a liquid contained in a large box. The diffusion constant of the particle in the liquid is $1.0\times10^{-2}\ \mathrm{cm}^2/\mathrm{s}$. The minimum time after which the root-mean-squared displacement becomes more than 6 cm is

(a) 10 min (b) 6 min

(c) 30 min (d) $\sqrt{6}$ min

42. A thermally insulated chamber of dimensions $(L, L, 2L)$ is partitioned in the middle. One side of the chamber is filled with n moles of an ideal gas at a pressure P and temperature T, while the other side is empty. At $t = 0$, the partition is removed and the gas is allowed to expand freely. The time to reach equilibrium varies as



(a) $n^{1/3}L^{-1}T^{1/2}$ (b) $n^{2/3}LT^{-1/2}$

(c) $n^0LT^{-1/2}$ (d) $nL^{-1}T^{1/2}$

43. The maximum intensity of solar radiation is at the wavelength of $\lambda_{\text{sun}} \sim 5000$Å and corresponds to its surface temperature $T_{\text{sun}} \sim 10^4$ K. If the wavelength of the maximum intensity of an X-ray star is 5Å, its surface temperature is of the order of

(a) 10^{16} K (b) 10^{14} K

(c) 10^{10} K (d) 10^7 K

44. The full scale of a 3-bit digital-to-analog (DAC) converter is 7 V. Which of the following tables represents the output voltage of this 3-bit DAC for the given set of input bits?

(a)

Input bits	Output voltage
000	0
001	1
010	2
011	3

(c)

Input bits	Output voltage
000	1.25
001	2.5
010	3.75
011	5

(b)

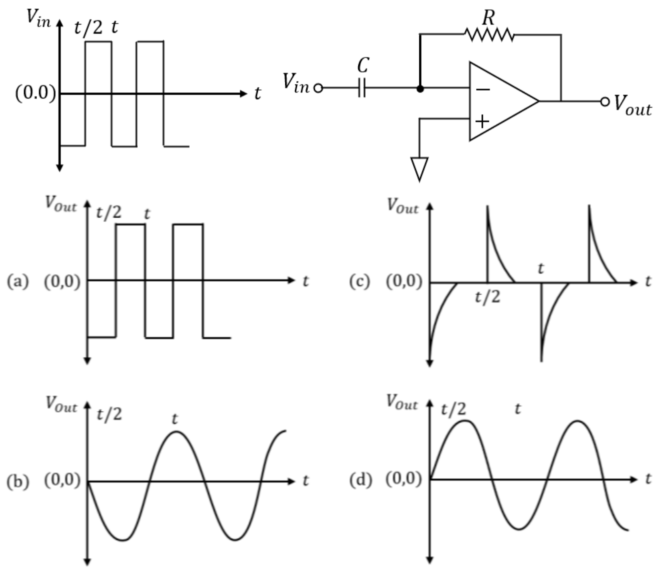
Input bits	Output voltage
000	0
001	1.25
010	2.5
011	3.75

(d)

Input bits	Output voltage
000	1
001	2
010	3

011	4

45. The input V_i to the following circuit is a square wave as shown in the following figure :
Which of the waveforms V_o best describes the output?



46. Two signals $A_1 \sin(\omega t)$ and $A_2 \cos(\omega t)$ are fed into the input and the reference channels, tespectively, of a lock-in amplifier. The amplitude of each signal is 1 V. The time constant of the lock-in amplifier is such that any signal of frequency larger than ω is filtered out. The output of the lock-in amplifier is

(a) 2 V (b) 1 V
(c) 0.5 V (d) 0 V

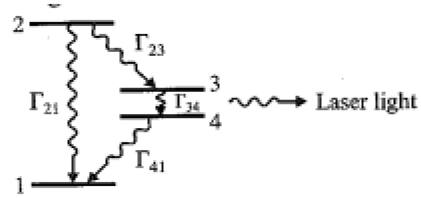
47. A photon energy 115.62keV ionizes a K-shell electron of a Be atom. One L-shell electron jumps to the K-shell to fill this vacancy and emits a photon of energy 109,2keV in the process. If the ionization potential for the L-shell is 6.4keV, the kinetic energy of the ionized efectron is

(a) 6.42keV (b) 12.82keV
(c) 20eV (d) 32oV

48. The value of the Lande g-factor for a fine structure level defined by the quantum numbers $L = 1$ and $J = 2$ and $S = 1$, is

(a) 11/6 (b) 4/3
(c) 8/3 (d) 3/2

49. The electronic energy level diagram of a molecule is shown in the following figure.



Let Γ_{ij} denote the decay rate for a transition from the level i and, . The molecules are optically pumped from level 1 to 2 . For the transition from level 3 to level 4 to be a lasing transition, the decay rates have to satisfy

(a) $\Gamma_{21} > \Gamma_{23} > \Gamma_{41} > \Gamma_{34}$
(b) $\Gamma_{21} > \Gamma_{41} > \Gamma_{23} > \Gamma_{34}$
(c) $\Gamma_{41} > \Gamma_{23} > \Gamma_{21} > \Gamma_{34}$
(d) $\Gamma_{41} > \Gamma_{21} > \Gamma_{34} > \Gamma_{23}$

50. Sodium Chloride (NaCl) crystal is a face centred cubic lattice, with a basis consisting of $Na^+$and Cl ions separated by half the body diagonal of a unit cube. Which of the planes corresponding to the Miller indices given below will not give rise to Bragg reflection of X-rays ?

(a) (2 2 0) (b) (2 4 2)
(c) (2 2 1) (d) (3 1 1)

51. The dispersion relation for the electrons in the conduction band of a semiconductor is given by $E = E_0 + \alpha k^2$, where α and E_0 are constants. If ω_c is the cyclotron resonance frequency of the conduction band electrons in a magnetic field B, the value of α is

(a) $\frac{\hbar^2 \omega_c}{4eB}$ (b) $\frac{2\hbar^2 \omega_c}{eB}$
(c) $\frac{\hbar^2 \omega_c}{eB}$ (d) $\frac{\hbar^2 \omega_c}{2eB}$

52. Hard discs of radius R are arranged in a two-dimensional triangular lattice. What is the fractional area occupied by the discs in the closests possible packing ?

(a) $\frac{\pi\sqrt{3}}{6}$ (b) $\frac{\pi}{3\sqrt{2}}$

(c) $\frac{\pi\sqrt{2}}{5}$ (d) $\frac{2\pi}{7}$

53. Which of the following elementary particle processes does not conserve strangeness ?

(a) $\pi^0 + p \rightarrow K^+ + \Lambda^0$

(b) $\pi^- + p \rightarrow K^0 + \Lambda^0$

(c) $\Delta^0 \rightarrow \pi^0 + n$

(d) $K^0 \rightarrow \pi^+ + \pi^-$

54. A deuteron d captures a charged pion π^-in the $l = 1$ state, and subsequently decays into a pair of neutrons (n) via strong interaction. Given that the intrinsic parities of π^-, d and n are $-1, +1$ and $+1$ respectively, the spin-wavefunction of the final state neutrons is a

(a) linear combination of a singlet and a triplet.

(b) singlet

(c) triplet

(d) doublet

55. The reaction $^{63}\mathrm{Cu}_{29} + p \rightarrow {}^{63}\mathrm{Zn}_{30} + n$ is followed by a prompt β-decay of zinc $^{63}\mathrm{Zn}_{30} \rightarrow {}^{63}\mathrm{Cu}_{29} + e^+ + v_e$. If the maximum energy of the position is 2.4MeV, the Q-value of the original reaction in MeV is nearest to [Take the masses of electrons, proton and neutron to be $0.5\mathrm{MeV/c^2}$, $938\mathrm{MeV/c^2}$ and $939.5\mathrm{MeV/c^2}$, respectively].

(a) -4.4 (b) -2.4

(c) -4.8 (d) -3.4

❖ ANSWER KEY

21. a	22. c	23. b	24. c	25. a
26. a	27. c	28. b	29. c	30. d
31. c	32. b	33. b	34. c	35. c
36. c	37. c	38. a	39. a	40. c
41. d	42. d	43. c	44. c	45. d
46. c	47. b	48. b	49. b	50. b
51. c	52. b	53. b	54. b	55. c
56. c	57. a	58. c	59. d	60. c
61. a	62. c	63. d	64. a	65. b
66. d	67. c	68. d	69. c	70. c
71. d	72. a	73. d	74. b	75. a