

IIT-JAM 2022

Section A: Q.1-Q.10 Carry ONE mark each.

Q1. The equation $z^2 + \bar{z}^2 = 4$ in the complex plane (where \bar{z} is the complex conjugate of z) represents

- (a) Ellipse (b) Hyperbola (c) Circle of radius 2 (d) Circle of radius 4

Ans. 1: (b)

Q2. A rocket (S') moves at a speed $\frac{c}{2}$ m/s along the positive x -axis, where c is the speed of light. When it crosses the origin, the clocks attached to the rocket and the one with a stationary observer (S) located at $x=0$ are both set to zero. If S observes an event at (x, t) the same event occurs in the S' frame at

(a) $x' = \frac{2}{\sqrt{3}} \left(x - \frac{ct}{2} \right)$ and $t' = \frac{2}{\sqrt{3}} \left(t - \frac{x}{2c} \right)$

(b) $x' = \frac{2}{\sqrt{3}} \left(x + \frac{ct}{2} \right)$ and $t' = \frac{2}{\sqrt{3}} \left(t - \frac{x}{2c} \right)$

(c) $x' = \frac{2}{\sqrt{3}} \left(x - \frac{ct}{2} \right)$ and $t' = \frac{2}{\sqrt{3}} \left(t + \frac{x}{2c} \right)$

(d) $x' = \frac{2}{\sqrt{3}} \left(x + \frac{ct}{2} \right)$ and $t' = \frac{2}{\sqrt{3}} \left(t + \frac{x}{2c} \right)$

Ans. 2: (a)

Q3. Consider a classical ideal gas of N molecules equilibrium at temperature T . Each molecule has two energy levels, $-\epsilon$ and ϵ . The mean energy of the gas is

- (a) 0 (b) $N \epsilon \tanh \left(\frac{\epsilon}{k_B T} \right)$ (c) $-N \epsilon \tanh \left(\frac{\epsilon}{k_B T} \right)$ (d) $\frac{\epsilon}{2}$

Ans. 3: (c)

Q4. At a temperature T , let β and k denote the volume expansivity and isothermal compressibility of a gas, respectively. Then $\frac{\beta}{k}$ is equal to

- (a) $\left(\frac{\partial P}{\partial T}\right)_V$ (b) $\left(\frac{\partial P}{\partial V}\right)_T$ (c) $\left(\frac{\partial T}{\partial P}\right)_V$ (d) $\left(\frac{\partial T}{\partial V}\right)_P$

Ans. 4: (a)

Q5. The resultant of the binary subtraction $1110101 - 0011110$ is

- (a) 1001111 (b) 1010111 (c) 1010011 (d) 1010001

Ans. 5: (b)

Q6. Consider a particle trapped in a three-dimensional potential well such that

$U(x, y, z) = 0$ for $0 \leq x \leq a, 0 \leq y \leq a, 0 \leq z \leq a$ and $U(x, y, z) = \infty$ everywhere else. The degeneracy of the 5th excited state is

- (a) 1 (b) 3 (c) 6 (d) 9

Ans. 6: (c)

Q7. A particle of mass m and angular momentum L moves in space where its potential energy is

$U(r) = kr^2$ ($k > 0$) and r is the radial coordinate.

If the particle moves in a circular orbit, then the radius of the orbit is

- (a) $\left(\frac{L^2}{mk}\right)^{\frac{1}{4}}$ (b) $\left(\frac{L^2}{2mk}\right)^{\frac{1}{4}}$ (c) $\left(\frac{2L^2}{mk}\right)^{\frac{1}{4}}$ (d) $\left(\frac{4L^2}{mk}\right)^{\frac{1}{4}}$

Ans. 7: (b)

Q8. Consider a two-dimensional force field

$$\vec{F}(x, y) = (5x^2 + ay^2 + bxy)\hat{x} + (4x^2 + 4xy + y^2)\hat{y}$$

If the force field is conservative, then the values of a and b are

- (a) $a = 2$ and $b = 4$ (b) $a = 2$ and $b = 8$
(c) $a = 4$ and $b = 2$ (d) $a = 8$ and $b = 2$

Ans. 8: (b)

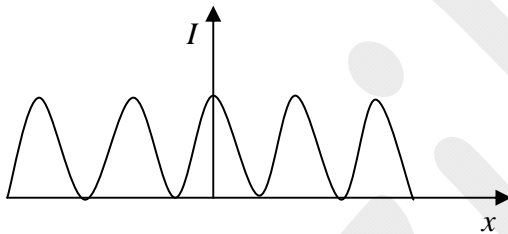
Q9. Consider an electrostatic field \vec{E} in a region of space. Identify the INCORRECT statement.

- (a) The work done in moving a charge in a closed path inside the region is zero
- (b) The curl of \vec{E} is zero
- (c) The field can be expressed as the gradient of a scalar potential
- (d) The potential difference between any two points in the region is always zero

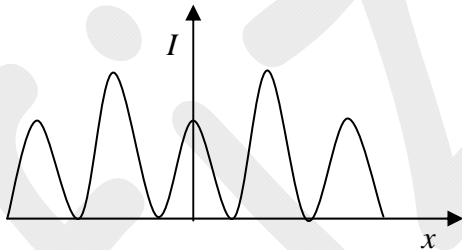
Ans. 9: (d)

Q10. Which one of the following figures correctly depicts the intensity distribution for Fraunhofer diffraction due to a single slit? Here, x denotes the distance from centre of the central fringe and I denotes the intensity.

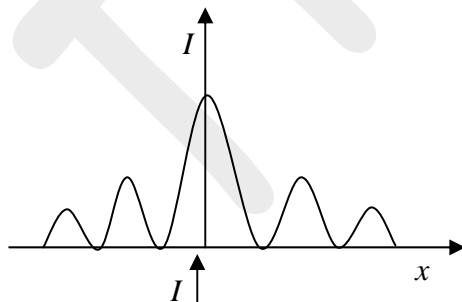
(a)



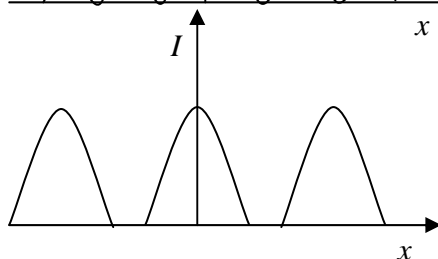
(b)



(c)



(d)



Ans. 10: (c)

Section A: Q.11-Q.30 Carry TWO marks each.

Q11. The function $f(x) = e^{\sin x}$ is expanded as a Taylor series in x , around $x = 0$, in the form $f(x) = \sum_{n=0}^{\infty} a_n x^n$. The value of $a_0 + a_1 + a_2$ is

- (a) 0 (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) 5

Ans. 11: (c)

Q12. Consider a unit circle C in the xy plane, centered at the origin. The value of the integral $\oint [(\sin x - y)dx - (\sin y - x)dy]$ over the circle C , traversed anticlockwise, is

- (a) 0 (b) 2π (c) 3π (d) 4π

Ans. 12: (b)

Q13. The current through a series RL circuit, subjected to a constant $emf \varepsilon$. Obeys $L \frac{di}{dt} + iR = \varepsilon$. Let $L = 1mH, R = 1k\Omega$ and $\varepsilon = 1V$. The initial condition is $i(0) = 0$ at $t = 1\mu s$, the current in mA is

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

Ans. 13: (c)

Q14. An ideal gas in equilibrium at temperature T expands isothermally to twice its initial volume. If $\Delta S, \Delta U$ and ΔF denote the changes in its entropy, internal energy and Helmholtz free energy respectively, then

- (a) $\Delta S < 0, \Delta U > 0, \Delta F < 0$ (b) $\Delta S > 0, \Delta U = 0, \Delta F < 0$
(c) $\Delta S < 0, \Delta U = 0, \Delta F > 0$ (d) $\Delta S > 0, \Delta U > 0, \Delta F = 0$

Ans. 14: (b)

Q15. In a dilute gas, the number of molecules with free path length $\geq x$ is given by $N(x) = N_0 e^{-x/\lambda}$, where N_0 is the total number of molecules and λ is the mean free path. The fraction of molecules with free path lengths between λ and 2λ is

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

Ans. 15: (d)

Q16. Consider a quantum particle trapped in a one-dimensional potential well in the region $[-L/2 < x < L/2]$, with infinitely high barriers at $x = -L/2$ and $x = L/2$. The stationary wave function for the ground state is $\psi(x) = \sqrt{\frac{2}{L}} \cos\left(\frac{\pi x}{L}\right)$. The uncertainties in momentum and position satisfy

(a) $\Delta p = \frac{\pi\hbar}{L}$ and $\Delta x = 0$

(b) $\Delta p = \frac{2\pi\hbar}{L}$ and $0 < \Delta x < \frac{L}{2\sqrt{3}}$

(c) $\Delta p = \frac{\pi\hbar}{L}$ and $\Delta x > \frac{L}{2\sqrt{3}}$

(d) $\Delta p = 0$ and $\Delta x = \frac{L}{2}$

Ans. 16: Marks to all

Q17. Consider a particle of mass m moving in a plane with a constant radial speed \dot{r} and a constant angular speed $\dot{\theta}$. The acceleration of the particle in (r, θ) coordinates is

(a) $2r\dot{\theta}^2\hat{r} - \dot{r}\dot{\theta}\hat{\theta}$

(b) $-r\dot{\theta}^2\hat{r} + 2\dot{r}\dot{\theta}\hat{\theta}$

(c) $\ddot{r}\hat{r} + r\ddot{\theta}\hat{\theta}$

(d) $\dot{r}\dot{\theta}\hat{r} + r\ddot{\theta}\hat{\theta}$

Ans. 17: (b)

Q18. A planet of mass m moves in an elliptical orbit. Its maximum and minimum distances from the Sun are R and r , respectively. Let G denote the universal gravitational constant, and M the mass of the Sun. Assuming $M \gg m$, the angular momentum of the planet with respect to the center of the Sun is

(a) $m \sqrt{\frac{2GMRr}{(R+r)}}$

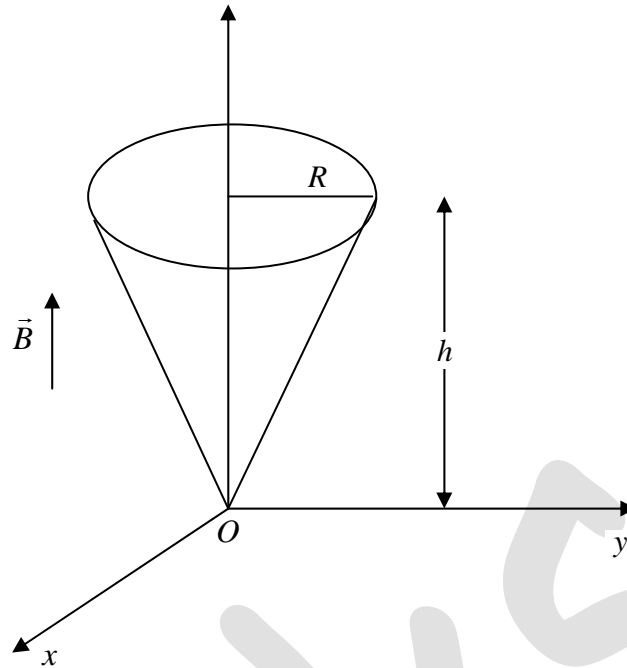
(b) $m \sqrt{\frac{GMRr}{2(R+r)}}$

(c) $m \sqrt{\frac{GMRr}{(R+r)}}$

(d) $2m \sqrt{\frac{2GMRr}{(R+r)}}$

Ans. 18: (a)

Q19. Consider a conical region of height h and base radius R with its vertex at the origin, Let the outward normal to its base be along the positive z -axis, as shown in the figure. A uniform magnetic field, $\vec{B} = B_0\hat{z}$ exists everywhere. Then the magnetic flux through the base (ϕ_b) and that through the curved surface of the cone (ϕ_c) are



(a) $\phi_b = B_0 \pi R^2; \phi_c = 0$

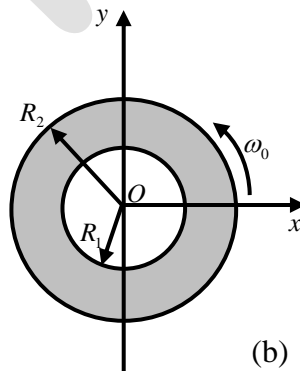
(b) $\phi_b = -\frac{1}{2} B_0 \pi R^2; \phi_c = \frac{1}{2} B_0 \pi R^2$

(c) $\phi_b = 0; \phi_c = -B_0 \pi R^2$

(d) $\phi_b = B_0 \pi R^2; \phi_c = -B_0 \pi R^2$

Ans. 19: (d)

Q20. Consider a thin annular sheet, lying on the xy -plane, with R_1 and R_2 as its inner and outer radii, respectively. If the sheet carries a uniform surface-charge density σ and spins about the origin O with a constant angular velocity $\vec{\omega} = \omega_0 \hat{z}$ then, the total current flow on the sheet is



(a) $\frac{2\pi\sigma\omega_0(R_2^3 - R_1^3)}{3}$

(b) $\sigma\omega_0(R_2^3 - R_1^3)$

(c) $\frac{\pi\sigma\omega_0(R_2^3 - R_1^3)}{3}$

(d) $\frac{2\pi\sigma\omega_0(R_2 - R_1)^3}{3}$

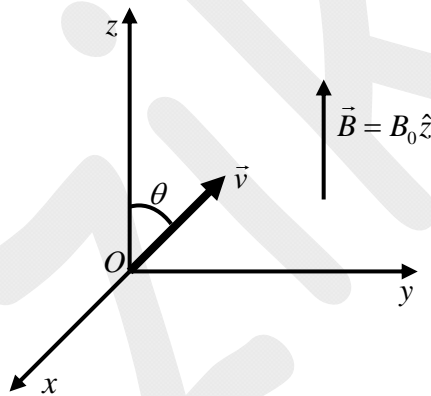
Ans. 20: (a)

Q21. A radioactive nucleus has a decay constant λ and its radioactive daughter nucleus has a decay constant 10λ . At time $t=0, N_0$ is the number of parent nuclei and there are no daughter nuclei present. $N_1(t)$ and $N_2(t)$ are the number of parent and daughter nuclei present at time t , respectively. The ratio $N_2(t)/N_1(t)$ is

- (a) $\frac{1}{9}[1-e^{-9\lambda t}]$ (b) $\frac{1}{10}[1-e^{-10\lambda t}]$ (c) $[1-e^{-10\lambda t}]$ (d) $[1-e^{-9\lambda t}]$

Ans. 21: (a)

Q22. A uniform magnetic field $\vec{B} = B_0\hat{z}$, where $B_0 > 0$ exists as shown in the figure. A charged particle of mass m and charge $q (q > 0)$ is released at the origin, in the yz -plane, with a velocity \vec{v} directed at an angle $\theta = 45^\circ$ with respect to the positive z -axis. Ignoring gravity, which one of the following is TRUE.



- (a) The initial acceleration $\vec{a} = \frac{qvB_0}{\sqrt{2}m}\hat{x}$
- (b) The initial acceleration $\vec{a} = \frac{qvB_0}{\sqrt{2}m}\hat{y}$
- (c) The particle moves in a circular path
- (d) The particle continues in a straight line with constant speed

Ans. 22: (a)

Q23. For an ideal intrinsic semiconductor, the Fermi energy at $0 K$

- (a) Lies at the top of the valence band
- (b) Lies at the bottom of the conduction band
- (c) Lies at the center of the band gap
- (d) Lies midway between center of the band gap and bottom the of conduction band

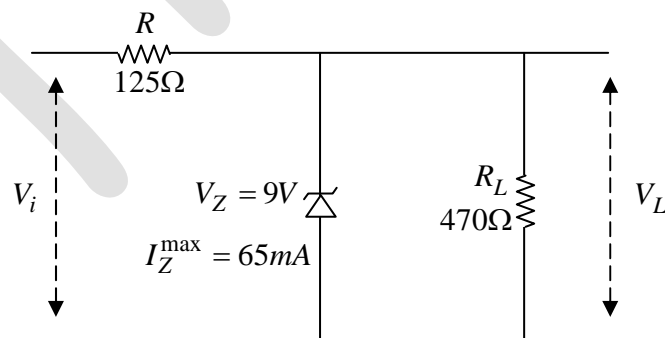
Ans. 23: (c)

Q24. A circular loop of wire with radius R is centered at the origin of the xy -plane. The magnetic field at a point within the loop is, $\vec{B}(\rho, \phi, z, t) = k\rho^3 t^3 \hat{z}$, where k is a positive constant of appropriate dimensions. Neglecting the effects of any current induced in the loop, the magnitude of the induced emf in the loop at t it is

- (a) $\frac{6\pi kt^2 R^5}{5}$
- (b) $\frac{5\pi kt^2 R^5}{6}$
- (c) $\frac{3\pi kt^2 R^5}{2}$
- (d) $\frac{\pi kt^2 R^5}{2}$

Ans. 24: (a)

Q25. For the given circuit, $R = 125\Omega$, $R_L = 470\Omega$, $V_Z = 9V$, and $I_Z^{\max} = 65mA$. The minimum and maximum value of the input voltage (V_i^{\min} and V_i^{\max}) for which the Zener diode will be in the 'ON' state are

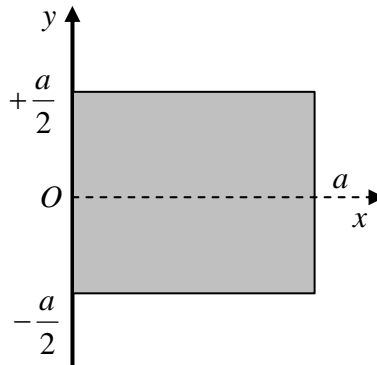


- (a) $V_i^{\min} = 9.0V$ and $V_i^{\max} = 11.4V$
- (b) $V_i^{\min} = 9.0V$ and $V_i^{\max} = 19.5V$
- (c) $V_i^{\min} = 11.4V$ and $V_i^{\max} = 15.5V$
- (d) $V_i^{\min} = 11.4V$ and $V_i^{\max} = 19.5V$

Ans. 25: (d)

Q26. A square laminar sheet with side a and mass M , has mass per unit area given by

$\sigma(x) = \sigma_0 \left[1 - \frac{x}{a} \right]$, (see figure). Moment of inertia of the sheet about y -axis is



- (a) $\frac{Ma^2}{2}$ (b) $\frac{Ma^2}{4}$ (c) $\frac{Ma^2}{6}$ (d) $\frac{Ma^2}{12}$

Ans. 26:(c)

Q27. A particle is subjected to two simple harmonic motions along the x and y axes, described by $x(t) = a \sin(2\omega t + \pi)$ and $y(t) = 2a \sin(\omega t)$. The resultant motion is given by

- (a) $\frac{x^2}{a^2} + \frac{y^2}{4a^2} = 1$ (b) $x^2 + y^2 = 1$
 (c) $y^2 = x^2 \left(1 - \frac{x^2}{4a^2} \right)$ (d) $x^2 = y^2 \left(1 - \frac{y^2}{4a^2} \right)$

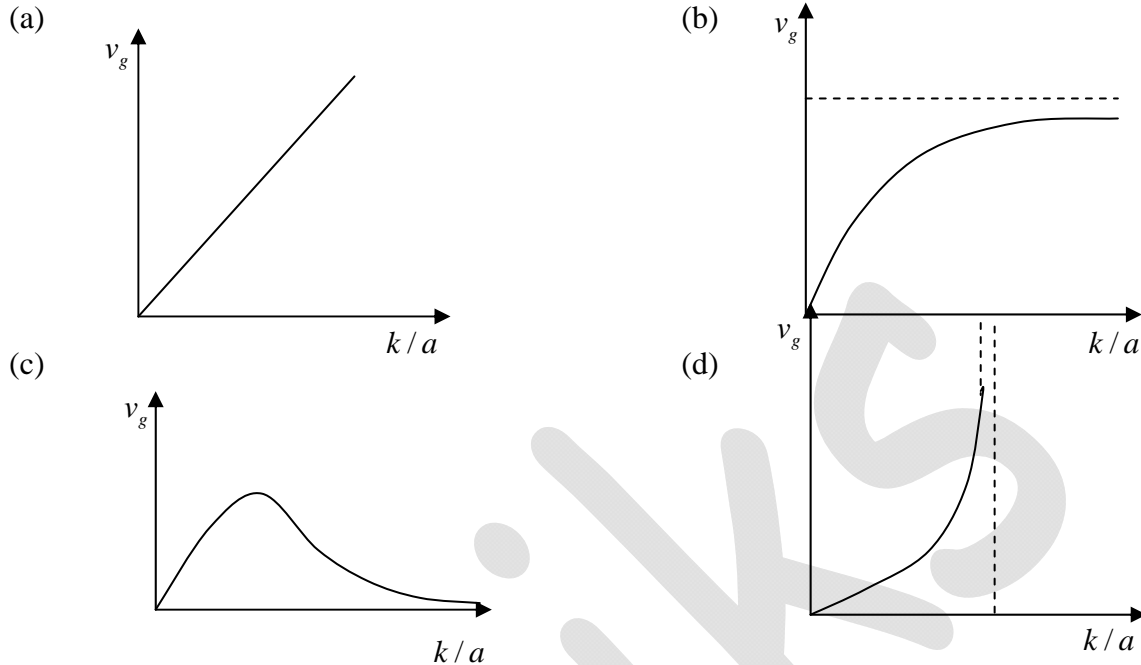
Ans. 27: (d)

Q28. For a certain thermodynamic system, the internal energy $U = PV$ and P is proportional to T^2 . The entropy of the system is proportional to

- (a) UV (b) $\sqrt{\frac{U}{V}}$ (c) $\sqrt{\frac{V}{U}}$ (d) \sqrt{UV}

Ans. 28: (d)

Q29. The dispersion relation for certain type of wave is given by $\omega = \sqrt{k^2 + a^2}$, where k is the wave vector and a is a constant. Which one of the following sketches represents v_g , the group velocity?



Ans. 29: (b)

Q30. Consider a binary number with m digits, where m is an even number. This binary number has alternating 1's and 0's, with digit 1 in the highest place value. The decimal equivalent of this binary number is

- (a) $2^m - 1$ (b) $\frac{(2^m - 1)}{3}$ (c) $\frac{(2^{m+1} - 1)}{3}$ (d) $\frac{2}{3}(2^m - 1)$

Ans. 30: (d)

Section B: Q.31 -0.4 Q.40 Carry TWO marks each.

Q31. Consider the 2×2 matrix $M = \begin{pmatrix} 0 & a \\ a & b \end{pmatrix}$, where $a, b > 0$. Then,

- (a) M is a real symmetric matrix
 (b) One of the eigenvalues of M is greater than b
 (c) One of the eigenvalues of M is negative
 (d) Product of eigenvalues M is b

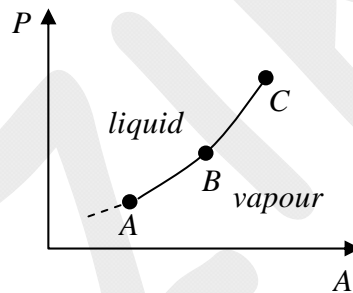
Ans. 31: (a), (b), (c)

Q32. In the Compton scattering of electrons, by photons incident with wave length λ ,

- (a) $\frac{\Delta\lambda}{\lambda}$ is independent of λ
- (b) $\frac{\Delta\lambda}{\lambda}$ increases with decreasing λ
- (c) there is no change in photon's wave length for all angle of deflection of the photon
- (d) $\frac{\Delta\lambda}{\lambda}$ increases with increasing angle of deflection of the photon

Ans. 32: (b), (d)

Q33. The figure shows a section of the phase boundary separating the vapour (1) and liquid (2) states of water in the $P-T$ plane. Here, C is the critical point. μ_1, v_1 and s_1 are the chemical potential, specific volume and specific entropy of the vapour phase respectively, while μ_2, v_2 and s_2 respectively denote the same for the liquid phase. Then



- (a) $\mu_1 = \mu_2$ along AB
- (b) $v_1 = v_2$ along AB
- (c) $s_1 = s_2$ along AB
- (d) $v_1 = v_2$ at the point C

Ans. 33: (a), (d)

Q34. A particle is executing simple harmonic motion with time period T . Let x, v and a denote the displacement, velocity and acceleration of the particle, respectively, at time t . Then,

- (a) $\frac{aT}{x}$ does not change with time
- (b) $(aT + 2\pi v)$ does not change with time
- (c) x and v are related by an equation of a straight line
- (d) v and a are related by an equation of an ellipse

Ans. 34: (a), (d)

Q35. A linearly polarized light beam travels from origin to point $A(1,0,0)$. At the point A , the light is reflected by a mirror towards point $B(1,-1,0)$. A second mirror located at point B then reflects the light towards point $C(1,-1,1)$. Let $\hat{n}(x, y, z)$ represent the direction of polarization of light at (x, y, z) .

(a) If $\hat{n}(0,0,0) = \hat{y}$, then $\hat{n}(1,-1,1) = \hat{x}$ (b) If $\hat{n}(0,0,0) = \hat{z}$, then $\hat{n}(1,-1,1) = \hat{y}$

(c) If $\hat{n}(0,0,0) = \hat{y}$, then $\hat{n}(1,-1,1) = \hat{y}$ (d) If $\hat{n}(0,0,0) = \hat{z}$, then $\hat{n}(1,-1,1) = \hat{x}$

Ans. 35: (a), (b)

Q36. Let (r, θ) denote the polar coordinates of a particle moving in a plane. If \hat{r} and $\hat{\theta}$ represent the corresponding unit vectors, then

(a) $\frac{d\hat{r}}{d\theta} = \hat{\theta}$ (b) $\frac{d\hat{r}}{dr} = -\hat{\theta}$ (c) $\frac{d\hat{\theta}}{d\theta} = -\hat{r}$ (d) $\frac{d\hat{\theta}}{dr} = \hat{r}$

Ans. 36: (a), (c)

Q37. The electric field associated with an electromagnetic radiation is given by $E = a(1 + \cos \omega_1 t) \cos \omega_2 t$. Which of the following frequencies are present in the field?

(a) ω_1 (b) $\omega_1 + \omega_2$ (c) $|\omega_1 - \omega_2|$ (d) ω_2

Ans. 37: (b), (c), (d)

Q38. A string of length L is stretched between two points $x=0$ and $x=L$. The endpoints are rigidly clamped. Which of the following can represent the displacement of the string from the equilibrium position?

(a) $x \cos\left(\frac{\pi x}{L}\right)$ (b) $x \sin\left(\frac{\pi x}{L}\right)$ (c) $x\left(\frac{x}{L} - 1\right)$ (d) $x\left(\frac{x}{L} - 1\right)^2$

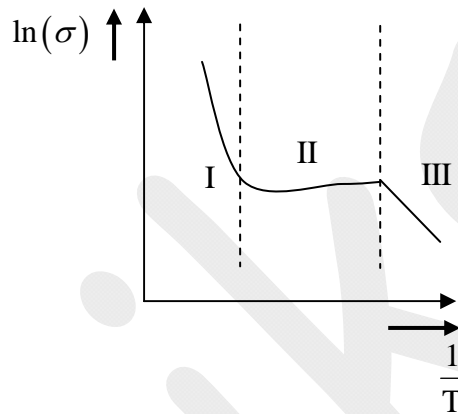
Ans. 38: (b), (c), (d)

Q39. The Boolean expression $Y = \overline{PQR} + Q\overline{R} + \overline{P}QR + PQR$ simplifies to

- (a) $\overline{P}R + Q$ (b) $PR + \overline{Q}$ (c) $P + R$ (d) $Q + R$

Ans. 39: (d)

Q40. For an n -type silicon, an extrinsic semiconductor, the natural logarithm of normalized conductivity (σ) is plotted as a function of inverse temperature. Temperature interval-I corresponds to the intrinsic regime, interval-II corresponds to saturation regime and interval-III corresponds to the freeze-out regime, respectively. Then



- (a) The magnitude of the slope of the curve in the temperature interval-I is proportional to the band gap, E_g
- (b) The magnitude of the slope of the curve in the temperature interval-III is proportional to the ionization energy of the donor, E_d
- (c) In the temperature interval-II, the carrier density in the conduction band is equal to the density of donors
- (d) In the temperature interval-III, all the donor levels are ionized

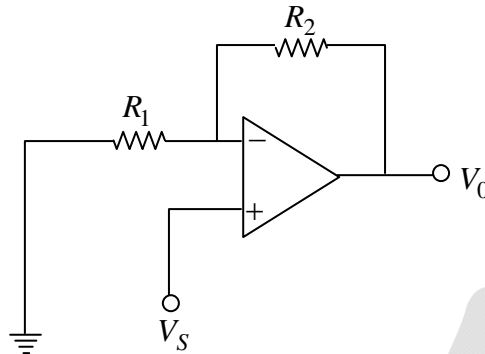
Ans. 40: (a), (b), (c)

Section C: Q.41 - Q.50 Carry ONE mark each.

Q41. The integral $\iint (x^2 + y^2) dx dy$ over the area of a disk of radius 2 in the xy plane is _____ π .

Ans. 41: 8 to 8

Q42. For the given operational amplifier circuit $R_1 = 120\Omega$, $R_2 = 1.5k\Omega$ and $V_s = 0.6V$, then the output current I_0 is _____ mA .

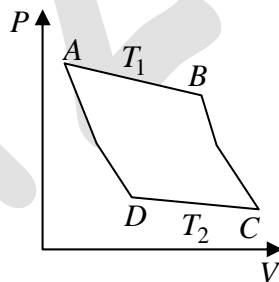


Ans. 42: 5 to 5

Q43. For an ideal gas, AB and CD are two isothermals at temperatures T_1 and T_2 ($T_1 > T_2$), respectively. AD and BC represent two adiabatic paths as shown in figure.

Let V_A, V_B, V_C and V_D be the volumes of the gas at A, B, C and D respectively. If $\frac{V_C}{V_B} = 2$, then

$$\frac{V_D}{V_A} = \underline{\hspace{2cm}}.$$



Ans. 43: 2 to 2

Q44. A satellite is revolving around the Earth in a closed orbit. The height of the satellite above Earth's surface at perigee and apogee are $2500km$ and $4500km$, respectively. Consider the radius of the Earth to be $6500km$. The eccentricity of the satellite's orbit is _____ (Round off to 1 decimal place).

Ans. 44: 0.1 to 0.1

Q45. Three masses $m_1 = 1, m_2 = 2$ and $m_3 = 3$ are located on the x -axis such that their center of mass is at $x = 1$. Another mass $m_4 = 4$ is placed at x_0 , and the new center of mass is at $x = 3$. The value of x_0 is _____.

Ans. 45: 6 to 6

Q46. A normal human eye can distinguish two objects separated by $0.35m$ when viewed from a distance of $1.0km$. The angular resolution of eye is _____ seconds (Round off to the nearest integer).

Ans. 46: 71 to 73

Q47. A rod with a proper length of $3m$ moves along x -axis, making an angle of 30° with respect to the x -axis. If its speed is $\frac{c}{2}m/s$, where c is the speed of light, the change in length due to Lorentz contraction is _____ m (Round off to 2 decimal places).

[Use $c = 3 \times 10^8 m/s$]

Ans. 47: 0.29 to 0.31

Q48. Consider the Bohr model of hydrogen atom. The speed of an electron in the second orbit ($n = 2$) is _____ $\times 10^6 m/s$ (Round off to 2 decimal places).

[Use $h = 6.63 \times 10^{-34} Js, e = 1.6 \times 10^{-19} C, \epsilon_0 = 8.85 \times 10^{-12} C^2 m^2 / N$]

Ans. 48: 1.08 to 1.12

Q49. Consider unit circle C in the xy plane with center at the origin. The line integral of the vector field, $\vec{F}(x, y, z) = -2y\hat{x} - 3z\hat{y} + x\hat{z}$, taken anticlockwise over C is _____ π .

Ans. 49: 2 to 2

Q50. Consider a $p-n$ junction at $T = 300K$. The saturation current density at reverse bias is $-20 \mu A/cm^2$. For this device, a current density of magnitude $10 \mu A/cm^2$ is realized with a forward bias voltage V_F . The same magnitude of current density can also be realized with a reverse bias voltage, V_R . The value of $|V_F/V_R|$ is _____ (Round off to 2 decimal places).

Ans. 50: 0.57 to 0.61

Section C: Q.51-Q60 Carry TWO marks each.

Q51. Consider the second order ordinary differential equation, $y'' + 4y' + 5y = 0$. If $y(0) = 0$ and $y'(0) = 1$, then the value of $y(\pi/2)$ is _____ (Round off to 3 decimal places).

Ans. 51: 0.041 to 0.045

Q52. A box contains a mixture of two different ideal monoatomic, 1 and 2, in equilibrium at temperature T . Both gases are present in equal proportions. The atomic mass for gas 1 is m , while the same for gas 2 is $2m$. If the *rms* speed of a gas molecule selected at random is $v_{rms} = x\sqrt{\frac{k_B T}{m}}$ then x is _____ (Round off to 2 decimal places).

Ans. 52: 1.49 to 1.51

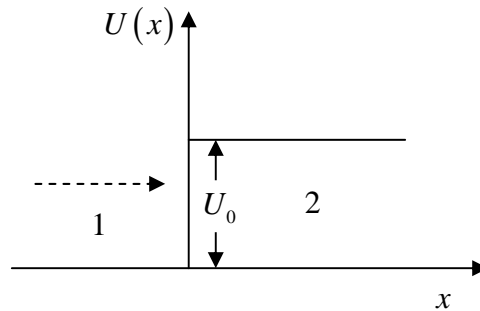
Q53. A hot body with constant heat capacity $800 J/K$ at temperature $925 K$ is dropped gently into a vessel containing $1 kg$ of water at temperature $300 K$ and the combined system is allowed to reach equilibrium. The change in the total entropy ΔS is J/K (Round off to 1 decimal place).

[Take the specific heat capacity of water to be $4200 J/kg K$. Neglect any loss of heat to the vessel and air and change in the volume of water.]

Ans. 53: 537.5 to 537.7

Q54. Consider an electron with mass m and energy E moving along the x -axis towards a finite step potential of height U_0 as shown in the figure. In region 1 ($x < 0$), the momentum of the electron is $p_1 = \sqrt{2mE}$. The reflection coefficient at the barrier is given by $R = \left(\frac{p_1 - p_2}{p_1 + p_2}\right)^2$,

where p_2 is the momentum in region 2. If, in the limit $E \gg U_0$, $R \approx \frac{U_0^2}{nE^2}$, then the integer n is _____.



Ans. 54: 16 to 16

Q55. A current density for a fluid flow is given by, $\vec{J}(x, y, z, t) = \frac{8e^t}{(1+x^2+y^2+z^2)} \hat{x}$.

At time $t = 0$, the mass density $\rho(x, y, z, 0) = 1$.

Using the equation of continuity, $\rho(1, 1, 1, 1)$ is found to be _____ (Round off to 2 decimal places).

Ans. 55: 2.70 to 2.74

Q56. The work done in moving a $-5 \mu C$ charge in an electric field

$\vec{E} = (8r \sin \theta \hat{r} + 4r \cos \theta \hat{\theta}) V/m$, from a point $A(r, \theta) = \left(10, \frac{\pi}{6}\right)$ to a point $B(r, \theta) = \left(10, \frac{\pi}{2}\right)$, is _____ mJ .

Ans. 56: 1 to 1

Q57. A pipe of $1m$ length is closed at one end. The air column in the pipe resonates at frequency of $400 Hz$. The number of nodes in the sound wave formed in the pipe is _____.

[Speed of sound = $320 m/s$]

Ans. 57: 5

Q58. The critical angle of a crystal is 30° . Its Brewster angle is _____ degree (Round off to the nearest integer).

Ans. 58: 63 to 63

Q59. In an LCR series circuit, a non-inductive resistor of 150Ω , a coil of $0.2H$ inductance and negligible resistance, and a $30\mu F$ capacitor are connected across an ac power source of $220V, 50Hz$. The power loss across the resistor is _____ W (Round off to 2 decimal places).

Ans. 59: 297 to 299

Q60. A charge q is uniformly distributed over the volume of a dielectric sphere of radius a . If the dielectric constant $\epsilon_r = 2$, then the ratio of the electrostatic energy stored inside the sphere to that stored outside is _____ (Round off to 1 decimal place).

Ans. 60: 0.1 to 0.1