D PHYSICS

CSIR-NET, GATE, SET, JEST, IIT-JAM, BARC, TIFR

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Question Paper

GATE 2026

With Answer Key

PHYSICAL SCIENCE

1. An infinitely large non-conducting thin sheet in the xy plane ($z = 0$) carries a uniform surface charge density $\sigma = 17.70 \times 10^{-12} \mathrm{C.m^{-2}}$. The electric field in the region $z < 0$ is $\vec{E}_2 = \hat{x} + 2\hat{y} + 3\hat{z}$. Then, the electric field $\vec{E}_1$ in the region $z > 0$ will be

$$(\epsilon_0 = 8.85 \times 10^{-12} \mathrm{C^2 \cdot N^{-1} \cdot m^{-2}})$$

(a) $\vec{E}_1 = \hat{x} + 2\hat{y} + 5\hat{z}$ (b) $\vec{E}_1 = \hat{x} + 4\hat{y} + \hat{z}$

(c) $\vec{E}_1 = \hat{x} + 2\hat{y} + 3\hat{z}$ (d) $\vec{E}_1 = \hat{x} + 2\hat{y} + 4\hat{z}$

2. Which of the following options is correct for transformation of electric field $\vec{E}$ and magnetic field $\vec{B}$ under time reversal, i.e., $t \to -t$?

(a) $\vec{E} \to \vec{E}$ and $\vec{B} \to -\vec{B}$ (b) $\vec{E} \to -\vec{E}$ and $\vec{B} \to \vec{B}$

(c) $\vec{E} \to -\vec{E}$ and $\vec{B} \to -\vec{B}$ (d) $\vec{E} \to \vec{E}$ and $\vec{B} \to \vec{B}$

3. Given Q is the electromagnetic charge and S is the strangeness quantum number, identify the particle(s) for which $(Q - S) = 0$ is satisfied.

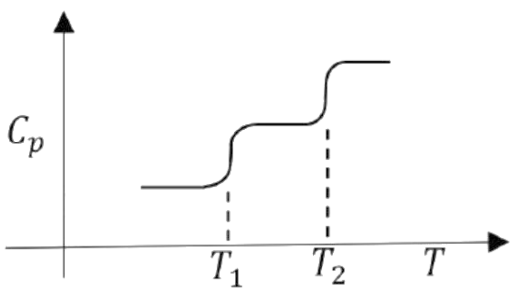
(a) K^+ (b) Ω^- (c) Σ^{*-} (d) Δ^{++}

4. Which one of the following is an allowed process?

(a) $p + \bar{p} \to \Lambda^0 + \Lambda^0$ (b) $p + \bar{p} \to \gamma$

(c) $\pi^- + p \to \pi^0 + n$ (d) $\pi^0 \to \gamma + \gamma + \gamma$

5. Schematic variation of the specific heat C_p of an ideal gas of diatomic molecules with temperature T is shown in the figure below. For rotational energy E_R and vibrational energy E_v of the molecule, which of the following options is/are correct? Here k_B is the Boltzmann constant.

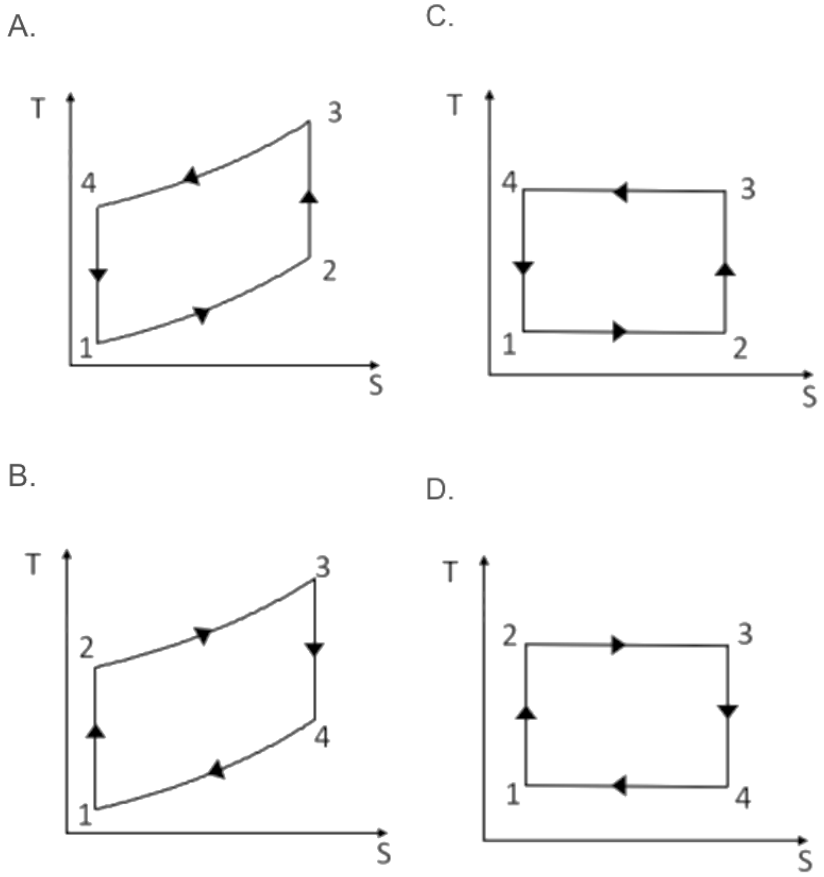


(a) $E_R \cong k_B T_1$ (b) $E_v \cong k_B T_2$ (c) $E_R \cong k_B T_2$ (d) $E_v \cong k_B T_1$

6. If the perturbation $V = \lambda x^3$ is added to the Hamiltonian of a one-dimensional harmonic oscillator, the matrix element $\langle m|V|0\rangle$ is/are non-zero for which of the following states? Here, the eigenstates of the harmonic oscillator are denoted by $|n\rangle$.

(a)$|m = 2\rangle$ (b)$|m = 3\rangle$ (c)$|m = 1\rangle$ (d)$|m = 5\rangle$

7. Consider the Otto cycle for an ideal gas engine consisting of two quasistatic adiabatic and two quasistatic isochoric processes. The correct temperature-entropy (T-S) phase diagram for the cycle is



8. Consider an electron in the energy eigenstate $\psi_{211}(\vec{r})$ of the hydrogen atom. Given that the radial probability distribution of the electron in such a state takes its maximum value at $r = n_0 a$, where a is the Bohr radius, and n_0 is an integer. The value of n_0 (in integer) is ____ The radial part of the wavefunction $\psi_{211}(\vec{r})$ is given by $R_{21}(r) = \frac{1}{\sqrt{24a^5}} r e^{-r/2a}$.

9. In free space, an electromagnetic wave is travelling whose wavevector is $\vec{k} = 10(\hat{x} + \sqrt{3}\hat{y})\mathrm{m}^{-1}$. The electric field component of this electromagnetic wave is given by $\vec{E}(\vec{r}, t) = \hat{z}600\cos(\vec{k}\cdot\vec{r} - \omega t)\mathrm{V}\cdot\mathrm{m}^{-1}$. The speed of light in free space is $c = 3.0 \times 10^8\ \mathrm{m.s^{-1}}$. The corresponding magnetic field $\vec{B}(\vec{r}, t)$ is

(a) $\vec{B}(\vec{r},t) = 10^{-5}(\sqrt{3}\hat{x} - \hat{y})\cos\,(\vec{k}\cdot\vec{r} - \omega t)\mathrm{V}\cdot\mathrm{m}^{-2}\cdot\ \mathrm{s}$

(b) $\vec{B}(\vec{r},t) = 2\times 10^{-6}(\sqrt{3}\hat{x} - \hat{y})\cos\,(\vec{k}\cdot\vec{r} - \omega t)\mathrm{V.m}^{-2}\cdot\ \mathrm{s}$

(c) $\vec{B}(\vec{r},t) = 10^{-6}(\sqrt{3}\hat{x} - \hat{y})\cos\,(\vec{k}\cdot\vec{r} - \omega t)\mathrm{V}\cdot\mathrm{m}^{-2}\cdot\ \mathrm{s}$

(d) $\vec{B}(\vec{r},t) = 2\times 10^{-5}(-\sqrt{3}\hat{x} + \hat{y})\cos\,(\vec{k}\cdot\vec{r} - \omega t)\mathrm{V}\cdot\mathrm{m}^{-2}\cdot\ \mathrm{s}$

10. Consider an operator $\hat{A}$ which is not Hermitian. Find the possible values of c and d such that the operator $\left(c\hat{A} - d\hat{A}^{\dagger}\right)$ is Hermitian.

(a)$c = 1$ and $d = 1$

(b)$c = i$ and $d = i$

(c)$c = i$ and $d = -i$

(d)$c = -1$ and $d = i$

11. For a scalar field $\psi(\vec{r})$ and a vector field $\vec{A}(\vec{r}), \vec{\nabla}\times(\vec{A}\psi)$ is equivalent to the expression

(a)$\vec{A}\times(\vec{\nabla}\psi) - \psi(\vec{\nabla}\times\vec{A})$

(b)$\psi(\vec{\nabla}\times\vec{A}) + \vec{A}\times(\vec{\nabla}\psi)$

(c)Null vector

(d)$\psi(\vec{\nabla}\times\vec{A}) - \vec{A}\times(\vec{\nabla}\psi)$

12. On a horizontal plane, a projectile of mass m is launched from the ground with speed v_0 at an angle θ_0 with the horizontal. In addition to the gravitational force (mg), it also experiences a drag force $\vec{F}_{drag} = -\gamma\vec{v}$, where $\vec{v}$ is its velocity and γ is a constant. It hits the ground at a distance R from the point of launch with its velocity making an angle θ with the horizontal, as shown schematically in the figure. Then which of the following options is correct?

(a)$R = \dfrac{v_0^2\sin\,2\theta}{g}\ \theta > \theta_0$

(b)$R = \dfrac{v_0^2\sin\,2\theta}{g}\ \theta < \theta_0$

(c)$R < \dfrac{v_0^2\sin\,2\theta_0}{g}\ \theta < \theta_0$

(d)$R < \dfrac{v_0^2\sin\,2\theta_0}{g}\ \theta > \theta_0$

13. The specific heat $C_p(T)$ of one mole of a material as a function of temperature T is given as $C_p(T) = AT + BT^3$, where $A = 0.695$ mJ. mol^{-1}. K^{-2} and $B = 0.045$ mJ. mol^{-1}. K^{-4}. When T is changed from 1 K to 10 K at constant pressure, then the change in entropy ΔS in mJ. mol^{-1}. K^{-1} (rounded off to one decimal place) is ___

14. Q. 14 For the energy dispersion of an electron in a one-dimensional solid $E(k) = E_0 - 2\gamma\cos(ka)$, the ratio of the effective mass of the electron in the solid to the free electron mass (m_e) at $k = 0$ is R_0. Taking $\gamma = 0.5\text{eV}$ and $a = 0.5$ nm, the value of R_0 (rounded off to two decimal place) is ___
($\hbar = 1.054 \times 10^{-34}$ J. s, $m_e = 9.1 \times 10^{-31}$ kg, electron charge $= 1.6 \times 10^{-19}$C)

15. For the electric field of an electromagnetic wave given below, which of the following statements is correct?

$$\vec{E} = \hat{x}E_0\cos(\omega t) + \hat{y}2E_0\cos\left(\omega t + \frac{\pi}{2}\right)$$

(a)The electric field is elliptically polarised with a ratio of major to minor axis being 2.

(b)The electric field is unpolarised with the two components being phase shifted by $\pi/2$.

(c)The electric field is circularly polarised with radius E_0.

(d)The electric field is linearly polarised with slope 2.

16. A rocket of length 18.0 m is moving at speed 0.9c (where c is the speed of light) parallel to its own length, relative to the earth. The length of the rocket measured in meters by an observer on earth (rounded off to two decimal places) is ___

17. A gas of non-interacting ^{4}He atoms (of mass m) is in a three-dimensional trap whose energy levels can be approximated by those of a harmonic oscillator potential $V(x, y, z) = \frac{1}{2}m\omega^2(x^2 + y^2 + z^2)$. The chemical potential of the gas at $T = 0$ K is

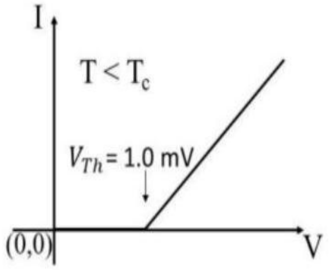
(a)0 $\quad$ (b) $\frac{3}{2}\hbar\omega$ $\quad$ (c) 3 $\hbar\omega$ $\quad$ (d) $\frac{1}{2}\hbar\omega$

18. Raman spectrum of a molecule was recorded using a source of wavelength 5000Å. The first Stokes line is observed at 5100Å. The first anti-Stokes line will appear at a wavelength L (in Å). The value of L (rounded off to nearest integer) is ___

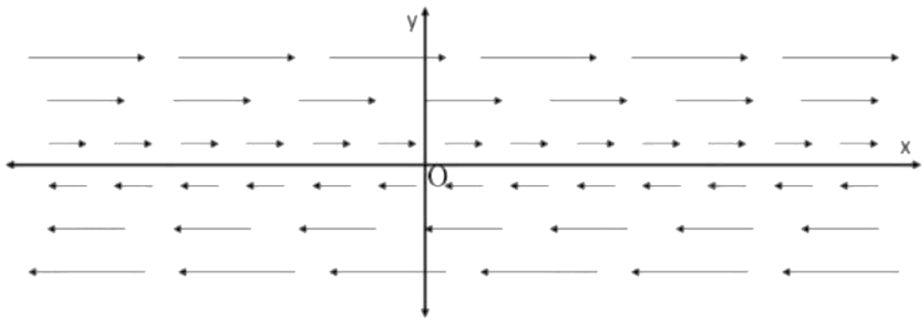
19. For which of the following functions does the Laplacian vanish?

(a) e^{x+iy} (b) $xe^{y} - ye^{x}$ (c) $yx^{2} - \frac{y^{3}}{3} - xy$ (d) $x\cos(y) - y\cos(x)$

20. Consider a metal-superconductor junction connected to a dc voltage V. At $T < T_c$, where T_c is the superconductor's transition temperature, the current I versus V behavior of this junction is shown schematically in the figure below. If the superconducting energy gap is DmeV. The value of D (rounded off to one decimal place) is ___



21. Sketch of a two-dimensional vector field $\vec{V}$ is shown below. Here, length and arrow head of the arrows denote magnitude and direction of the vector field, respectively. Which of the following statements is correct for $\vec{\nabla} \times \vec{V}$?



(a) It is zero everywhere in the two-dimensional space.

(b) Its magnitude is non-zero and its direction is into the two-dimensional plane.

(c) Its magnitude is non-zero and its direction is out of the two-dimensional plane.

(d) It points in opposite directions above and below the x-axis.

22. A projectile of mass m is launched from the ground with the initial speed v_0 at an angle 30° from the horizontal. Take the ground to be horizontal. Ignoring the drag, the magnitude of Hamilton's action $\int Ldt$ for the particle from the beginning till it hits the ground is $f \times \left(\frac{mv_0^3}{g}\right)$. The value of f (rounded off to two decimal places) is ___

23. A dielectric sphere carries a uniform polarization $P = 26\mu\text{C.cm}^{-2}$. The magnitude of the electric field at the center of the sphere is $E \times 10^{9}\ \text{N.C}^{-1}$. The value of E (rounded off to one decimal place) is ___

$$(\epsilon_0 = 8.85 \times 10^{-12}\text{C}^2 \cdot \text{N}^{-1} \cdot \text{m}^{-2})$$

24. The formula for energy E of a photon gas at temperature T in a two-dimensional box at equilibrium with $g_{2d}(v)$ denoting the density of states of photons is given below where symbols v, h and k_B have their standard meaning. The specific heat (C_V) of this photon gas obeys

$$E = \int_0^\infty dv g_{2d}(v) \frac{hv}{\exp\left(\frac{hv}{k_B T}\right) - 1}$$

(a) $C_V \propto T$ (b) $C_V \propto T^2$ (c) $C_V \propto T^4$ (d) $C_V \propto T^3$

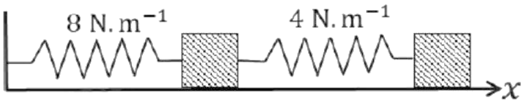
25. Given $|v_1\rangle = \frac{1}{\sqrt{2}}\binom{1}{i}$ and $|v_2\rangle = \frac{1}{\sqrt{2}}\binom{1}{-i}$, the tensor product $|v_1\rangle \otimes |v_2\rangle$ is

(a) $\frac{1}{2}\begin{pmatrix} 1 & i \\ i & -1 \end{pmatrix}$ (b) $\frac{1}{2}\begin{pmatrix} 1 & i \\ -i & 1 \end{pmatrix}$ (c) $\frac{1}{2}\begin{pmatrix} 1 \\ -i \\ i \\ 1 \end{pmatrix}$ (d) $\frac{1}{2}\begin{pmatrix} 1 \\ i \\ -i \\ 1 \end{pmatrix}$

26. A positive point charge is fixed at the origin. At some distance from it on the x axis, a point dipole is kept pointing in the $+y$ direction. The force on the dipole is

(a) 0 (b) in the $+x$ direction (c) in the $-y$ direction (d) in the $+y$ direction

27. Two 1 kg blocks are connected to two massless springs of spring constants $8\ \text{N.m}^{-1}$ and $4\ \text{N.m}^{-1}$. The system is kept on a frictionless horizontal floor with one end of a spring attached to a wall (see figure below). They are performing oscillatory motion along the x-axis with the normal mode frequencies ω_H and $\omega_L (\omega_H > \omega_L)$. The ratio $\frac{\omega_H}{\omega_L}$ (rounded off to two decimal places) is ___

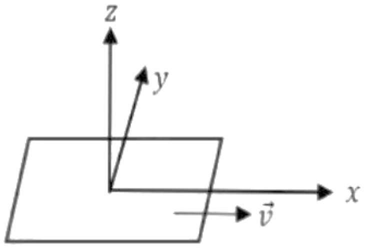


28. The energy E and degeneracy d of the second excited state of a three-dimensional, isotropic quantum harmonic oscillator with angular frequency ω are

(a) $E = \frac{7}{2}\hbar\omega, d = 6$ (b) $E = \frac{5}{2}\hbar\omega, d = 3$

(c) $E = \frac{7}{2}\hbar\omega, d = 3$ (d) $E = \frac{5}{2}\hbar\omega, d = 6$

29. An infinitely large thin sheet in the xy-plane carries uniform positive charge density and is moving with constant velocity $\vec{v}$ in the $+x$ direction (see figure below). The direction of the corresponding Poynting vector is



(a) $+x$ for $z < 0$ and $-x$ for $z > 0$ (b) $+x$ for both $z < 0$ and $z > 0$

(c) $-x$ for $z < 0$ and $+x$ for $z > 0$ (d) $-x$ for both $z < 0$ and $z > 0$

30. Consider the Pauli matrices $\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$, $\sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$, $\sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$.

The value of $\mathrm{Tr}(\sigma_z[\sigma_x, \sigma_y])$ is

(a) $2i$ (b) i (c) $\frac{i}{2}$ (d) $4i$

31. An atom has two energy levels with energy difference 2.2 eV between them. A gas of these atoms is with 8×10^{20} atoms in the upper state and 5×10^{20} atoms in the lower state. Ignoring spontaneous emission, the maximum possible energy released by this gas of atoms by stimulated emission is E Joules. The value of E (rounded off to one decimal place) is ___ ($e = 1.6 \times 10^{-19}$C)

32. Which one of the following statements is true?

(a) The decay $\Omega^- \to \Xi^0 + K^-$ is allowed.

(b) The decay $\Lambda \to p^+ + \pi^-$ is allowed and strangeness is violated.

(c) The decay $p^+ \to e^+ + \gamma$ is allowed.

(d) In the decay $\mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu$, CPT is violated.

33. Two identical particles with a fixed total energy $E = 2\hbar\omega$ are in thermal equilibrium in a one-dimensional harmonic oscillator potential $\frac{1}{2}m\omega^2x^2$. Let the entropy of the particles be

denoted by S_F if they are fermions with spin $\frac{1}{2}\left(S_Z = \pm\frac{\hbar}{2}\right)$ and S_B if they are bosons with spin 0 . Then, which of the following options is correct?
(k_B is the Boltzmann constant)

(a)$S_F = 4k_B \ln 2, S_B = 0$

(b)$S_F = 2k_B \ln 2, S_B = k_B \ln 2$

(c)$S_F = k_B \ln 2, S_B = k_B \ln 2$

(d)$S_F = 2k_B \ln 2, S_B = 0$

34. The Lagrangian

$$L_0 = \frac{1}{2}m\dot{q}^2 - \frac{1}{2}m\omega^2 q^2$$

with the generalized coordinate q is transformed to $L = L_0 + \alpha\frac{df(q)}{dt}$. Consider the following statements:
(i) Expression for the canonical momentum does not change.
(ii) The equation of the motion does not change.
Which of the following options is correct for the above statements?

(a)Both (i) and (ii) are not correct.

(b)(i) is correct and (ii) is not correct.

(c)(i) is not correct and (ii) is correct.

(d)Both (i) and (ii) are correct.

35. Consider operators $\hat{A}, \hat{B}$, and $\hat{C}$ for three observables of a quantum system satisfying $[\hat{A}, \hat{B}] = 0, [\hat{B}, \hat{C}] = 0$, and $[\hat{A}, \hat{C}] \neq 0$, with uncertainties $\Delta A, \Delta B, \Delta C$, respectively. From the options given below, which is/are implied by the commutation relations among $\hat{A}, \hat{B}$, and $\hat{C}$?

(a)$\Delta A \Delta C > 0$

(b)$\hat{A}, \hat{B}, \hat{C}$ can be simultaneously diagonalized.

(c)$\Delta A \Delta B > 0$

(d)$\hat{A}, \hat{B}$ can be simultaneously diagonalized.

36. The Hamiltonian for a quantum particle of mass m is given below, where $\omega < \Omega$. The Schrödinger equation for this system can be solved exactly using the orthogonal transformations: $x = \frac{x_1 - x_2}{\sqrt{2}}$ and $y = \frac{x_1 + x_2}{\sqrt{2}}$.

$$H = -\frac{\hbar^2}{2m}\left[\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right] + \frac{1}{2}m\Omega^2(x^2 + y^2) + m\omega^2 xy$$

The ground state energy of this system is

(a) $\frac{\hbar}{2}\left[\sqrt{\Omega^2+\Omega\omega}+\sqrt{\Omega^2-\Omega\omega}\right]$ (b) $\frac{\hbar}{2}\left[\sqrt{\Omega^2-\omega^2}+\sqrt{\Omega^2+\omega^2}\right]$

(c) $\hbar\left[\sqrt{\Omega^2-\omega^2}+\sqrt{\Omega^2+\omega^2}\right]$ (d) $\hbar\left[\sqrt{\Omega^2+\Omega\omega}-\sqrt{\Omega^2-\Omega\omega}\right]$

37. Rotational spectrum of a diatomic molecule consists of lines of equal spacing with an interval of 20.0 cm^{-1}. Its moment of inertia is found to be $I_0 \times 10^{-47}\ \mathrm{kg \cdot m^2}$, the value of I_0 (rounded off to one decimal place) is ___
($h = 6.6 \times 10^{-34}$ J. s, speed of light in vacuum $c = 3 \times 10^8\ \mathrm{m.s^{-1}}$)

38. Consider the distribution of outcomes generated by $N(N \gg 1)$ independent throws of (i) a coin or (ii) a six-sided dice. A coin (dice) is unbiased if both (all) its sides have equal probability to show up in a throw; it is biased otherwise. For the cases (i) and (ii) above, which of the following statements is/are true?

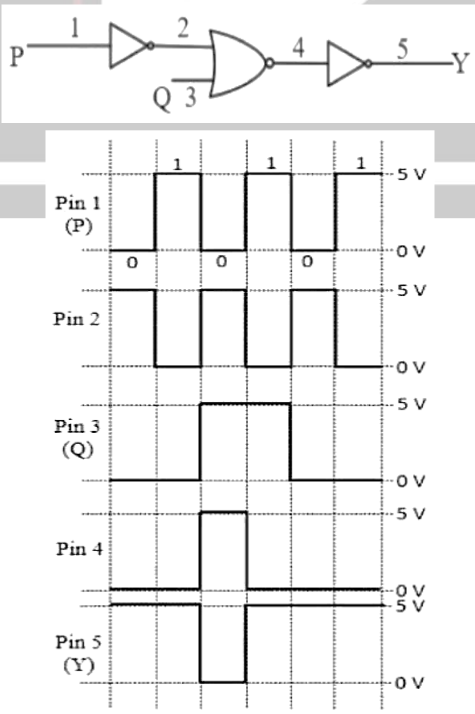
(a) The entropy of a biased dice is smaller than that of an unbiased dice.

(b) The entropy of an unbiased coin is greater than that of an unbiased dice.

(c) The entropy of a biased coin is greater than that of an unbiased coin.

(d) The entropy of an unbiased coin is smaller than that of an unbiased dice.

39. Considering the circuit and the associated signals measured at different pins (numbered as 1,2,3,4,5) shown in the figure, the correct option is



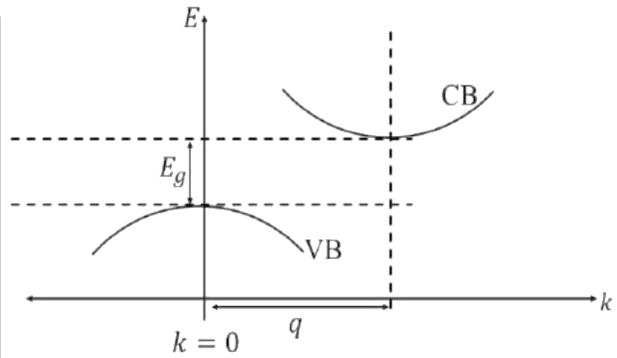
(a)The NOR and output NOT gates, are both faulty.

(b)NOR gate is faulty.

(c)NOT gate between pins 4 and 5 is faulty.

(d)NOT gate between pins 1 and 2 is faulty.

40. The dispersion $(E(k))$ of the conduction band (CB) and valence band (VB) for a semiconductor are shown schematically in the figure. Considering the possibility of an electron making a transition from the bottom of the CB to the top of the VB , which of the following options is/are correct?



(a)A photon can be emitted with an energy exactly equal to E_g.

(b)The transition is forbidden.

(c)A photon can be emitted with an energy less than E_g.

(d)A phonon can be created with a crystal momentum $\hbar q$.

41. Consider two particles with angular momenta $j_1 = 2\hbar$ and $j_2 = \hbar/2$. If the expression

$$|j = 5/2, m = 3/2\rangle = \begin{cases} c_1|j_1 = 2, m_1 = 1\rangle|j_2 = 1/2, m_2 = 1/2\rangle + \\ c_2|j_1 = 2, m_1 = 2\rangle|j_2 = 1/2, m_2 = -1/2\rangle \end{cases}$$

gives an eigenstate of the total angular momentum of the two particles, using standard notation. Which of the following is true?
(Hint: $\hat{J}_\pm|j, m\rangle = \sqrt{j(j+1) - m(m\pm 1)}|j, m \pm 1\rangle$)

(a)$c_1 = 0, c_2 = 1$

(b)$c_1 = \frac{2}{\sqrt{5}}, c_2 = \frac{1}{\sqrt{5}}$

$(c) c1=25, c_2 = \frac{1}{\sqrt{5}}$ (d) $c_1 = \frac{1}{\sqrt{2}}, c_2 = \frac{1}{\sqrt{2}}$

42. Consider two operators $\hat{A}$ and $\hat{B}$ which are related as $\hat{A} = \exp(i\theta\hat{B})$. If θ is a non-zero real number, which of the following statement(s) is(are) true?

(a) If $\hat{B}$ is Hermitian, then $\hat{A}$ is unitary.

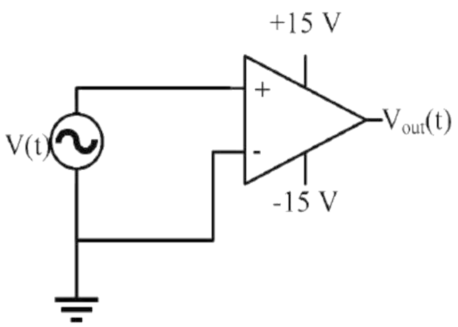
(b) If $\hat{B}$ is anti-Hermitian, then $\hat{A}$ is unitary.

(c) If $\hat{B}$ is Hermitian, then $|\mathrm{Det}(\hat{A})| = 1$.

(d) If $\hat{B}$ is anti-Hermitian, then $\hat{A}$ is Hermitian.

43. Consider a particle of mass $m = 9.0 \times 10^{-5}$ kg and charge $q = 3.0 \times 10^{-4}$C in a uniform electromagnetic field $\vec{E} = 2\hat{x}$ V. m^{-1}, $\vec{B} = 3\hat{z}$ V. m^{-2}. s. The particle is released from the coordinates $(0{,}5 \text{ m}, 0)$ at time $t = 0$. Starting from initial speed zero, it comes back to the y-axis for the first time at time t. The value of t in seconds (rounded off to two decimal places) is ____

44. In the circuit shown, $V(t) = 2\sin(2000\pi t)$ Volts, where t is in seconds, which of the following options is correct?
(take the opamp to be ideal)



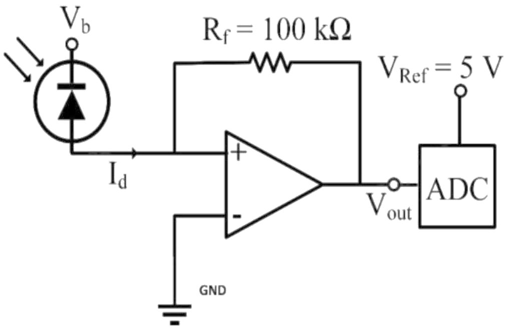
(a) V_{out} (t) is square wave with peak-to-peak voltage = 4 V and time period is 1 ms.

(b) V_{out} (t) is a sine wave with peak-to-peak voltage = 4 V and time period is 1 ms.

(c) V_{out} (t) is square wave with peak-to-peak voltage = 30 V and time period is 1 ms.

(d) V_{out} (t) is sine wave with peak-to-peak voltage = 30 V and time period of 1 ms.

45. The output signal (current I_d) of a reversed biased (with a voltage V_b) photodiode, on which light is incident, is fed to an amplifier (see figure). The output voltage is digitized by a 10 bit Analogue to Digital convertor (ADC) which has a reference voltage of 5 V . The smallest current I_d which can be measured by the circuit in nano-Amperes (rounded off to one decimal place) is ___



46. Copper has an electron number density of $8.3 \times 10^{28}\ \mathrm{m^{-3}}$. Its Fermi energy in eV (rounded off to one decimal place) is ___
($\hbar = 1.06 \times 10^{-34}$ J. s, mass of electron $\mathrm{m_e} = 9.10 \times 10^{-31}$ kg, charge of electron = 1.60×10^{-19}C)

47. A capacitor is made of two circular metal plates of radius 1 m separated by a distance of $d =$ 1 mm. The space between them is filled by a dielectric with permittivity $\epsilon_r = 5$. The capacitor is connected to a voltage $V = 10\sin\,(2\pi \times 10^6 \times t)$ volts, where t is in seconds. The maximum value of the magnetic field in between the plates at a radial distance $r =$ 0.5 m from the centre of the capacitor is $B \times 10^{-6}$ T. The value of B (rounded off to two decimal places) is ___
(Speed of light in vacuum $c = 3 \times 10^8$ m. s^{-1})

48. The function $f(z)$ of complex variable z given below,

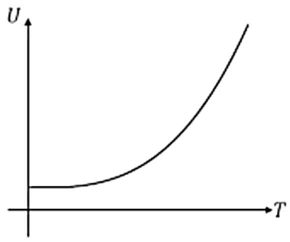
$$f(z) = \frac{z^2 - 5z + 4}{z^3 + 4z - z^2 - 4}$$

has singular points at $z =$

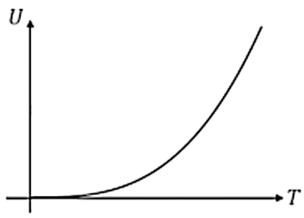
(a)$2i$ and $-2i$ (b)1 and $(2 + i)$ (c)($2 + i$) only (d)1 and $(2 - i)$

49. A gas of N classical particles that can occupy energy levels, ϵ_1 and $\epsilon_2 = \epsilon_1 + \Delta$ is in equilibrium with a reservoir at temperature T. From the schematics shown below, choose the correct dependence of the internal energy U on T.

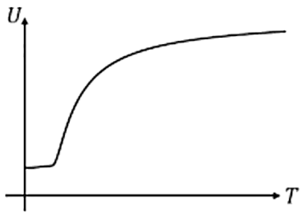
A.



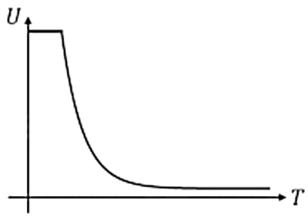
C.



B.



D.



50. The Hamiltonian of two interacting spin- $1/2$ particles is $H = \frac{A}{\hbar^2}\vec{S}_1 \cdot \vec{S}_2$, where $\vec{S}_1$ and $\vec{S}_2$ are the spin angular momenta of particles 1 and 2, respectively. Here, $A = 10.56\mathrm{eV}$. The energy in eV required to induce an excitation from the ground state to the excited state (rounded off to two decimal places) is ___

51. A symmetric rigid body has moment of inertia I_1, I_2, I_3 about its principal axes 1,2 , and 3 , respectively, with $I_1 = I_3 = I_\perp$ and $I_2 \neq I_\perp$. It is rotating in space with no torque on it so that its angular momentum $\vec{L}$ is constant. Let $\omega_1, \omega_2, \omega_3$ be the components of its angular velocity along the principal axes 1,2 , and 3 , respectively. Which of the following quantities is/are constant during the motion of this rigid body?

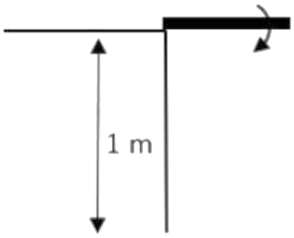
(a)Angle between axis 2 and $\vec{L}$

(b)$\omega_1^2 + \omega_3^2$

(c)$\omega_1 + \omega_3$

(d)ω_2

52. A 15 cm long scale is held horizontally with one of its ends on the edge of a 1 m high table and the other end resting on one's index finger. As the finger is removed (see figure below), the scale starts rotating about its end on the table. After 0.1 s , during which it has rotated by a negligibly small angle but has gained a rotational speed as it leaves the table and falls vertically towards the ground. When its centre of mass has fallen by 0.5 m , it has rotated by an angle θ. The value of θ in degrees (rounded off to one decimal place) is ___
$(\mathrm{g} = 9.8\ \mathrm{m.s^{-2}})$



53. An α particle moves towards a fixed nucleus carrying charge Ze, with initial speed v_0 and impact parameter b. Starting from a large distance from the nucleus, its distance of closest approach is r_m and its speed there is v_m. Then which of the following options is/are correct? $\left(k = \frac{1}{4\pi\epsilon_0} \text{ and } r_0 = k\frac{Ze^2}{mv_0^2}\right)$

(a)For $\frac{b}{r_0} \ll 1, r_m = 4r_0 + \frac{b^2}{2r_0}$ ignoring higher order corrections in $\frac{b}{r_0}$

(b)$v_0 b = 2v_m r_0$

(c)For $\frac{b}{r_0} \ll 1, r_m = 4r_0 + \frac{b^2}{8r_0}$ ignoring higher order corrections in $\frac{b}{r_0}$

(d)$v_0 b = v_m r_m$

54. Which of the following operators is/are self-adjoint?

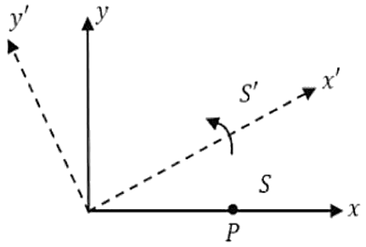
(a)$x^2\frac{d^2}{dx^2} + 3x\frac{d}{dx} + x^2$

(b)$(3x - 4x^3)\frac{d^2}{dx^2} + (3 - 12x^2)\frac{d}{dx} + 12$

(c)$(1 - x^2)\frac{d^2}{dx^2} - 2x\frac{d}{dx} + 3x$

(d)$x\frac{d^2}{dx^2} + x^2\frac{d}{dx} + \frac{5x}{3}$

55. Two frames S (solid lines) and S' (dashed lines) with common origin are shown in the figure below. Frame S is inertial while S' is rotating about the common z-axis. There is a point mass fixed at P on the x-axis of the S frame. The magnitude of the centrifugal force and the Coriolis force experienced by the mass in the S' frame is F_{cen} and F_{cor}, respectively. Which of the following options is correct for these forces?



(a)$F_{cen} \neq 0$ and $F_{cor} \neq 0$ and $F_{cen} = 2F_{cor}$

(b)$F_{cen} \neq 0$ and $F_{cor} \neq 0$ and $F_{cen} = \frac{F_{cor}}{2}$

(c)$F_{cen} \neq 0$ and $F_{cor} \neq 0$ and $F_{cen} = F_{cor}$

(d|)$F_{cen} = 0$ and $F_{cor} = 0$

❖ Answer Key

1. a	2. a	3. a	4.	5. a,b	6. b,c	7. b	8. 4 to 4	9. b	10. b
11. d	12. d	13. 21.1 to 21.3	14. 0.30 to 0.32	15. a	16. 7.60 to 8.00	17. b	18. 4901 to 4905	19. a,c	20. 2.0 to 2.0
21. b	22. 0.32 to 0.34	23. 9.0 to 10.0	24. b	25. c	26. d	27. 2.35 to 2.45	28. a	29. b	30. d
31. 52.0 to 53.0	32. b	33. d	34. c	35. a,d	36. b	37. 2.6 to 3.0	38. a,d	39. b	40. c,d
41. b	42. a,c,d	43. 0.60 to 0.70	44. c	45. 47.5 to 50.0	46. 6.0 to 7.5	47. 0.80 to 0.90	48. a	49. b	50. 0.56 to 10.56
51. a,b,d	52. 179.0 to 180.0	53. d	54. c	55. b					