PH:PHYSICS-2014

AI24BTECH11005 - Bhukya Prajwal Naik

1) The donor concentration in a sample of n-type silicon is increased by a factor of 100. The shift in the position of the Fermi level at 300 K , assuming the sample to be non degenerate is meV .

$$(k_BT = 25meV \text{ at } 300\ K)$$

2) A particle of mass m is subjected to a potential,

$$V(x,y) = \frac{1}{2}m\omega^2(x^2+y^2), -\infty \le x \le \infty, -\infty \le y \le \infty$$

The state with energy $4\hbar\omega$ is g-fold degenerate. The value of g is .

3) A hydrogen atom is in the state $\Psi = \sqrt{\frac{8}{21}}\psi_{200} - \sqrt{\frac{3}{7}}\psi_{310} + \sqrt{\frac{4}{21}}\psi_{321}$ where n, l, m in ψ_{nlm} denote the principal, orbital and magnetic quantum numbers, respectively. If $\mathbf{L}$ is the angular momentum operator, the average value of L^2 is ( ) $\hbar^2$

4) A planet of mass m moves in a circular orbit of radius r_0 in the gravitational potential $V(r) = -\frac{k}{r}$, where k is a positive constant. The orbital angular momentum of the planet is

a) $2r_0\ km$ b) $\sqrt{2r_0km}$ c) $r_0\ km$ d) $\sqrt{r_0km}$

5) The moment of inertia of a rigid diatomic molecule A is 6 times that of another rigid diatomic molecule B. If the rotational energies of the two molecules are equal, then the corresponding values of the rotational quantum numbers J_A and J_B are

a) $J_A = 2, J_B = 1$ b) $J_A = 3, J_B = 1$ c) $J_A = 5, J_B = 0$ d) $J_A = 6, J_B = 1$

6) The value of the integral

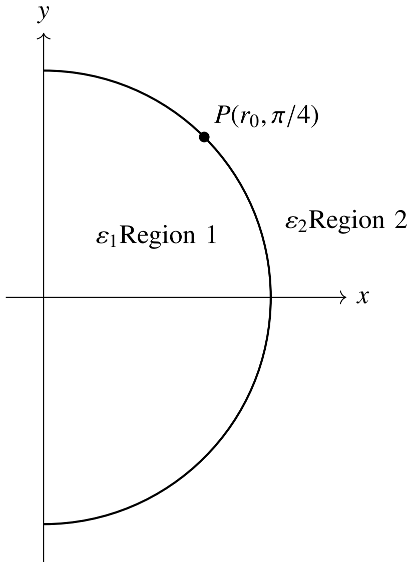
$$\oint_C \frac{z^2}{e^z+1}dz$$

where C is the circle $|z| = 4$, is

a) $2\pi i$
b) $2\pi^2 i$
c) $4\pi^2 i$
d) $4\pi^2 i$

7) A ray of light inside Region 1 in the xy-plane is incident at the semicircular boundary that carries no free charges. The electric field at the point $P(r_0, \pi/4)$ in plane polar coordinates is $\mathbf{E}_1 = 7\hat{e}_r - 3\hat{e}_\varphi$, where $\hat{e}_r$ and $\hat{e}_\varphi$ are the unit vectors. The

emerging ray in Region 2 has the electric field $\mathbf{E}_2$ parallel to x - axis. If ε_1 and ε_2 are the dielectric constants of Region 1 and Region 2 respectively, then $\frac{\varepsilon_2}{\varepsilon_1}$ is



8) The solution of the differential equation

$$\frac{d^2y}{dt^2} - y = 0$$

subject to the boundary conditions $y(0) = 1$ and $y(\infty) = 0$, is

a) $\cos t + \sin t$ b) $\cosh t + \sinh t$ c) $\cos t - \sin t$ d) $\cosh t - \sinh t$

9) Given that the linear transformation of a generalized coordinate q and the corresponding momentum p,

$$Q = q + 4ap$$
$$P = q + 2p$$

is canonical, the value of the constant a is .

10) The value of the magnetic field required to maintain non-relativistic protons of energy 1 MeV in a circular orbit of radius 100 mm is Tesla. (Given: $m_p = 1.67 \times 10^{-27}\ kg, e = 1.6 \times 10^{-19} C$) Q. 40 For a system of two bosons, each of which can occupy any of the two energy levels 0 and ε, the mean energy of the system at a temperature T with $\beta = \frac{1}{k_B T}$ is given by

a) $\frac{\varepsilon e^{-\beta\varepsilon}+2\varepsilon e^{-2\beta\varepsilon}}{1+2e^{-\beta\varepsilon}+e^{-2\beta\varepsilon}}$ b) $\frac{1+\varepsilon e^{-\beta\varepsilon}}{2e^{-\beta\varepsilon}+e^{-2\beta\varepsilon}}$ c) $\frac{2\varepsilon e^{-\beta\varepsilon}+\varepsilon e^{-2\beta\varepsilon}}{2+e^{-\beta\varepsilon}+e^{-2\beta\varepsilon}}$ d) $\frac{\varepsilon e^{-\beta\varepsilon}+2\varepsilon e^{-2\beta\varepsilon}}{2+e^{-\beta\varepsilon}+e^{-2\beta\varepsilon}}$

11) In an interference pattern formed by two coherent sources, the maximum and the minimum of the intensities are $9I_0$ and I_0, respectively. The intensities of the individual waves are

a) $3I_0$ and I_0 b) $4I_0$ and I_0 c) $5I_0$ and $4I_0$ d) $9I_0$ and I_0

12) ψ_1 and ψ_2 are two orthogonal states of a spin $\frac{1}{2}$ system. It is given that

$$\psi_1 = \frac{1}{\sqrt{3}}\begin{pmatrix}1\\0\end{pmatrix} + \sqrt{\frac{2}{3}}\begin{pmatrix}0\\1\end{pmatrix}$$

where $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ represent the spin-up and spin-down states, respectively. When the system is in the state ψ_2, its probability to be in the spin-up state is ________.