Test Your fiziks concepts!

Topic: Quantum Mechanics

(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

Q. The eigenstates corresponding to eigenvalues E_1 and E_2 of a time independent Hamiltonian are $|1\rangle$ and $|2\rangle$ respectively. If at $t=0$, the system is in a state $|\psi(t=0)\rangle = \sin\theta|1\rangle + \cos\theta|2\rangle$, then the value of $\langle\psi(t)|\psi(t)\rangle$ at time t will be

(a) 1

(b) $\dfrac{\left(E_1\sin^2\theta + E_2\cos^2\theta\right)}{\sqrt{E_1^2+E_2^2}}$

(c) $e^{iE_1t/\hbar}\sin\theta + e^{iE_2t/\hbar}\cos\theta$

(d) $e^{-iE_1t/\hbar}\sin^2\theta + e^{-iE_2t/\hbar}\cos^2\theta$

Ans.: (a)

Solution.: $|\psi(t=0)\rangle = \sin\theta|1\rangle + \cos\theta|2\rangle$

$$|\psi(t)\rangle = \sin\theta|1\rangle e^{\frac{-iE_1t}{\hbar}} + \cos\theta|2\rangle e^{\frac{-iE_2t}{\hbar}}$$

$$\langle\psi(t)|\psi(t)\rangle = \sin^2\theta\langle 1|1\rangle + \cos^2\theta\langle 2|2\rangle + 2\,\mathrm{Re}\,e^{\frac{-i(E_1-E_2)t}{\hbar}}\sin\theta\cdot\cos\theta\langle 1|2\rangle$$

$$= \sin^2\theta + \cos^2\theta + 0 = 1 \qquad \left(\because \langle 1|2\rangle = 0\right)$$

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Topic: Electronics

(For IIT-JAM, JEST, TIFR and CUET Aspirants)

Q. A phosphorous doped silicon semiconductor (doping density: $10^{17}/cm^3$) is heated from $100^0\,C$ to $200^0\,C$. Which one of the following statements is CORRECT?

(a) Position of Fermi level moves towards conduction band

(b) Position of dopant level moves towards conduction band

(c) Position of Fermi level moves towards middle of energy gap

(d) Position of dopant level moves towards middle of energy gap

Ans.: (c)

Test Your fiziks concepts!

Topic: Modern Physics

(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. Consider a free electron (e) and a photon (ph) both having $10\,eV$ of energy. If λ and P represents wavelength and momentum respectively, then

(mass of electron $=9.1\times10^{-31}\,kg$; speed of light $=3\times10^{8}\,m/s$)

(a) $\lambda_e=\lambda_{ph}$ and $P_e=P_{ph}$

(b) $\lambda_e<\lambda_{ph}$ and $P_e>P_{ph}$

(c) $\lambda_e>\lambda_{ph}$ and $P_e<P_{ph}$

(d) $\lambda_e>\lambda_{ph}$ and $P_e<P_{ph}$

Ans.: (c)

Solution.: For photon $p_{ph}=\dfrac{E}{c}$, $\lambda_{ph}=\dfrac{h}{p}=\dfrac{hc}{E}$

For electron $p_e=\dfrac{\sqrt{E^2-m^2c^4}}{c}$, $\lambda_e=\dfrac{h}{p}=\dfrac{hc}{\sqrt{E^2-m^2c^4}}$

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Topic: Quantum Mechanics

(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

Q. The wave function of a particle at time $t=0$ is given by $|\psi(0)\rangle=\frac{1}{\sqrt{2}}\left(|u_1\rangle+|u_2\rangle\right)$, where $|u_1\rangle$ and $|u_2\rangle$ are the normalized eigenstates with eigenvalues E_1 and E_2 respectively, $(E_2>E_1)$. The shortest time after which $|\psi(t)\rangle$ will become orthogonal to $|\psi(0)\rangle$ is

(a) $\frac{-\hbar\pi}{2(E_2-E_1)}$ (b) $\frac{\hbar\pi}{E_2-E_1}$ (c) $\frac{\sqrt{2}\hbar\pi}{E_2-E_1}$ (d) $\frac{2\hbar\pi}{E_2-E_1}$

Ans.: (b)

Solution.: $|\psi(0)\rangle=\frac{1}{\sqrt{2}}\left(|u_1\rangle+|u_2\rangle\right)\Rightarrow|\psi(t)\rangle=\frac{1}{\sqrt{2}}\left(|u_1\rangle e^{\frac{-iE_1t}{\hbar}}+|u_2\rangle e^{\frac{-iE_2t}{\hbar}}\right)$

$|\psi(t)\rangle$ is orthogonal to $|\psi(0)\rangle\Rightarrow\langle\psi(0)|\psi(t)\rangle=0\Rightarrow\frac{1}{2}e^{\frac{-iE_1t}{\hbar}}+\frac{1}{2}e^{\frac{-iE_2t}{\hbar}}=0$

$\Rightarrow e^{\frac{-iE_1t}{\hbar}}+e^{\frac{-iE_2t}{\hbar}}=0\Rightarrow e^{\frac{-iE_1t}{\hbar}}=-e^{\frac{-iE_2t}{\hbar}}\Rightarrow e^{i\frac{(E_2-E_1)}{\hbar}}=-1$

$\Rightarrow\cos\frac{(E_2-E_1)t}{\hbar}=\cos\pi\Rightarrow t=\frac{\pi\hbar}{E_2-E_1}$

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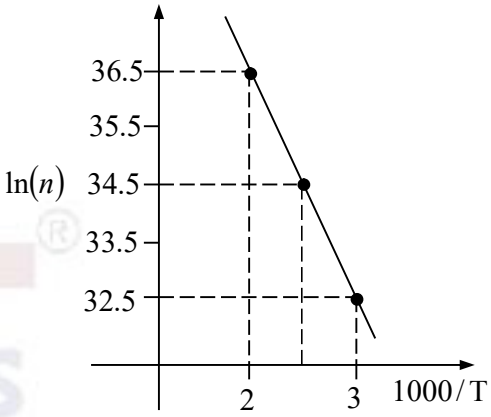
Topic: Electronics

(For IIT-JAM, JEST, TIFR and CUET Aspirants)

Q. In an intrinsic semiconductor, the free carrier concentration n (in cm^{-3}) varies with temperature T (in Kelvin) as shown in the figure below. The band gap of the semiconductor is (use Boltzmann constant $k_B = 8.625\times10^{-5} eVK^{-1}$)



(a) $1.44\,eV$

(b) $0.72\,eV$

(c) $1.38\,eV$

(d) $0.69\,eV$

Ans.: (d)

Solution: Since $n_i = n = \sqrt{N_c N_v}\exp\left(-\frac{E_g}{2kT}\right) \Rightarrow \frac{n_1}{n_2} = \exp\left[\frac{E_g}{2k}\left(\frac{1}{T_2}-\frac{1}{T_1}\right)\right]$

$$\Rightarrow E_g = 2k\ln\left(\frac{n_1}{n_2}\right)\Big/\left(\frac{1}{T_2}-\frac{1}{T_1}\right) = 2\times8.625\times10^{-5}\left(36.5-32.5\right)/\left(0.003-0.0002\right)$$

$$\Rightarrow E_g = 2\times8.625\times10^{-5}\times4/1\times10^{-3} = 0.69eV$$

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Topic: Modern Physics

(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. For a wave in a medium the angular frequency ω and the wave vector $\vec{k}$ are related by, $\omega^2 = \left(\omega_0^2 + c^2k^2\right)$, where ω_0 and c are constants. The product of group and phase velocities, i.e., $v_g.v_p$ is

(a) $0.25c^2$ (b) $0.4c^2$ (c) $0.5c^2$ (d) c^2

Ans.: (d)

Solution.: $\omega^2 = \left(\omega_0^2 + c^2k^2\right) \Rightarrow 2\omega\frac{d\omega}{dk} = 2c^2k \Rightarrow \frac{\omega}{k}\cdot\frac{d\omega}{dk} = c^2 \Rightarrow v_p.v_g = c^2$

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