

Test Your fiziks concepts!**Topic: Quantum Mechanics****(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)**

Q. The two vectors $\begin{pmatrix} a \\ 0 \end{pmatrix}$ and $\begin{pmatrix} b \\ c \end{pmatrix}$ are orthonormal if

(a) $a = \pm 1, b = \pm 1/\sqrt{2}, c = \pm 1/\sqrt{2}$

(b) $a = \pm 1, b = \pm 1, c = 0$

(c) $a = \pm 1, b = 0, c = \pm 1$

(d) $a = \pm 1, b = \pm 1/2, c = 1/2$

Ans.: (c)

Solution: $|\phi_1\rangle = \begin{pmatrix} a \\ 0 \end{pmatrix}, |\phi_2\rangle = \begin{pmatrix} b \\ c \end{pmatrix}$

$$\langle \phi_1 | \phi_1 \rangle = 1 \Rightarrow a = \pm 1; \quad \langle \phi_2 | \phi_2 \rangle = 1 \Rightarrow |b|^2 + |c|^2 = 1$$

$$\langle \phi_1 | \phi_2 \rangle = 0 \Rightarrow (a \ 0) \begin{pmatrix} b \\ c \end{pmatrix} = 0 \Rightarrow a \cdot b + 0 \cdot c = 0 \Rightarrow a \cdot b = 0 \text{ so } b = 0$$

$$|c|^2 = 1 \Rightarrow c = \pm 1. \text{ Thus } a = \pm 1, b = 0, c = \pm 1$$

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Test Your fiziks concepts!**Topic: Electronics****(For IIT-JAM, JEST, TIFR and CUET Aspirants)**

Q. A battery with a constant *emf* ε and internal resistance r_i provides power to an external circuit with a load resistance made up by combining resistance R_L and $2R_L$ in parallel. For what value of R_L will the power delivered to the load be maximum?

(a) $R_L = \frac{r_i}{4}$

(b) $R_L = \frac{r_i}{2}$

(c) $R_L = \frac{2}{3}r_i$

(d) $R_L = \frac{3}{2}r_i$

Ans.: (d)**Solution.:**

Since R_L and $2R_L$ are in parallel so load $R = \frac{R_L \times 2R_L}{R_L + 2R_L} = \frac{2}{3}R_L$.

$$\text{Power through load } P = I^2 R = \left(\frac{\varepsilon}{r_i + R} \right)^2 R$$

For maximum power through load

$$\frac{dP}{dR} = 0 \Rightarrow \frac{(r_i + R)^2 \varepsilon^2 - \varepsilon^2 R \times 2(r_i + R)}{(r_i + R)^4} = 0 \Rightarrow (r_i + R) - 2R = 0 \Rightarrow R = r_i$$

$$\text{Thus, } R = r_i \Rightarrow \frac{2}{3}R_L = r_i \Rightarrow R_L = \frac{3}{2}r_i$$

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Test Your fiziks concepts!**Topic: Modern Physics****(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)**

Q. A γ -ray photon emitted from a ^{137}Cs source collides with an electron at rest. If the Compton shift of the photon is $3.25 \times 10^{-13} \text{ m}$, then the scattering angle is closets to (Planck's constant $h = 6.626 \times 10^{-34} \text{ Js}$, electron mass $m_e = 9.109 \times 10^{-31} \text{ kg}$ and velocity of light in free space $c = 3 \times 10^8 \text{ m/s}$)

- (a) 45° (b) 60° (c) 30° (d) 90°

Ans.: (c)

Solution.: $\therefore \Delta\lambda = \frac{h}{m_e c} (1 - \cos\theta)$

$$\Rightarrow \cos\theta = 1 - \frac{\Delta\lambda \cdot m_e c}{h} = 1 - \frac{3.25 \times 10^{-13} \times 9.109 \times 10^{-31} \times 3 \times 10^8}{6.6 \times 10^{-34}} = 0.866 = \frac{\sqrt{3}}{2}$$

$$\Rightarrow \theta = 30^\circ$$

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Test Your fiziks concepts!**Topic: Quantum Mechanics****(For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)**

Q. Consider a particle in a one-dimensional potential that satisfies $V(x) = V(-x)$. Let $|\psi_0\rangle$ and $|\psi_1\rangle$ denote the ground and the first excited states, respectively, and let $|\psi\rangle = \alpha_0|\psi_0\rangle + \alpha_1|\psi_1\rangle$ be a normalized state with α_0 and α_1 being real constants. The expectation value $\langle x \rangle$ of the position operator x in the state $|\psi\rangle$ is given by

- (a) $\alpha_0^2 \langle \psi_0 | x | \psi_0 \rangle + \alpha_1^2 \langle \psi_1 | x | \psi_1 \rangle$ (b) $\alpha_0 \alpha_1 [\langle \psi_0 | x | \psi_1 \rangle + \langle \psi_1 | x | \psi_0 \rangle]$
(c) $\alpha_0^2 + \alpha_1^2$ (d) $2\alpha_0 \alpha_1$

Ans.: (b)

Solution.: Since $V(x) = V(-x)$ so potential is symmetric.

$$\langle \psi_0 | x | \psi_0 \rangle = 0, \quad \langle \psi_1 | x | \psi_1 \rangle = 0$$

$$\langle \psi | x | \psi \rangle = (\alpha_0 \langle \psi_0 | + \alpha_1 \langle \psi_1 |) x (\alpha_0 | \psi_0 \rangle + \alpha_1 | \psi_1 \rangle) = \alpha_0 \alpha_1 [\langle \psi_0 | x | \psi_1 \rangle + \langle \psi_1 | x | \psi_0 \rangle]$$

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Test Your fiziks concepts!**Topic: Electronics****(For IIT-JAM, JEST, TIFR and CUET Aspirants)**

Q. Choose the correct statement from the following:

- (a) Silicon is a direct band gap semiconductor.
- (b) Conductivity of metals decreases with increase in temperature.
- (c) Conductivity of semiconductor decreases with increase in temperature.
- (d) Gallium Arsenide is an indirect band gap semiconductor. ®

Ans.: (b)

Solution.: Silicon is indirect and GaAs is a direct bandgap semiconductor. The conductivity of the semiconductor increases with temperature due to increase in carrier concentration. The conductivity of metals decreases with increase in temperature due to increase in number of phonons and hence electron-phonon scattering. Thus correct option is (b)

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Test Your fiziks concepts!**Topic: Modern Physics****(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)**

Q. A particle of rest mass m_0 is moving uniformly in a straight line with relativistic velocity βc , where c is the velocity of light in vacuum and $0 < \beta < 1$. The phase velocity of the de Broglie wave associated with the particle is,

- (a) βc (b) $\frac{c}{\beta}$ (c) c (d) $\frac{c}{\beta^2}$

Ans.: (b)

Solution: $E^2 = p^2 c^2 + m_0^2 c^4$

$$2E \frac{dE}{dp} = 2pc^2 \Rightarrow E \cdot v_g = pc^2 \Rightarrow \frac{E}{p} = \frac{c^2}{v_g} = v_p \Rightarrow v_p = \frac{c^2}{\beta c} = \frac{c}{\beta}$$

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