Test Your fiziks concepts!

Topic: Quantum Mechanics

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

Q. A particle is in the ground state of an infinite square well potential is given by,

$$V(x)=\begin{cases}0 & \text{for } -a\le x\le a\\ \infty & \text{otherwise}\end{cases}$$

The probability to find the particle in the interval between $-\frac{a}{2}$ and $\frac{a}{2}$ is

(a) $\frac{1}{2}$ (b) $\frac{1}{2}+\frac{1}{\pi}$ (c) $\frac{1}{2}-\frac{1}{\pi}$ (d) $\frac{1}{\pi}$

Ans.: (b)

Solution.: The probability to find the particle in the interval between $-\frac{a}{2}$ and $\frac{a}{2}$ is

$$=\int_{-a/2}^{a/2}\sqrt{\frac{2}{2a}}\cdot\sqrt{\frac{2}{2a}}\cos\frac{\pi x}{2a}\cdot\cos\frac{\pi x}{2a}dx=\int_{-a/2}^{a/2}\frac{1}{a}\cos^2\frac{\pi x}{2a}dx=\frac{1}{a}\times\frac{1}{2}\left[\int_{-a/2}^{a/2}\left(1+\cos\frac{2\pi x}{2a}\right)dx\right]$$

$$=\frac{1}{2a}\left[x+\frac{a}{\pi}\sin\frac{\pi x}{a}\right]_{-a/2}^{a/2}=\frac{1}{2a}\left[\frac{a}{2}+\frac{a}{2}+\frac{a}{\pi}(1+1)\right]=\frac{1}{2a}\left[a+\frac{2a}{\pi}\right]=\left(\frac{1}{2}+\frac{1}{\pi}\right)$$

Note:

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Test Your fiziks concepts!

Topic: Electronics

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

Q. In an open circuited p-n junction diode, the barrier voltage at the junction is generated due to

(a) Minority carriers in the p and n sides

(b) Majority carriers in the p and n sides

(c) Immobile negative charge in the p-side and positive charge in the n-side

(d) Immobile positive charge in the p-side and negative charge in the n-side

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Ans.1: (c)

Solution.:

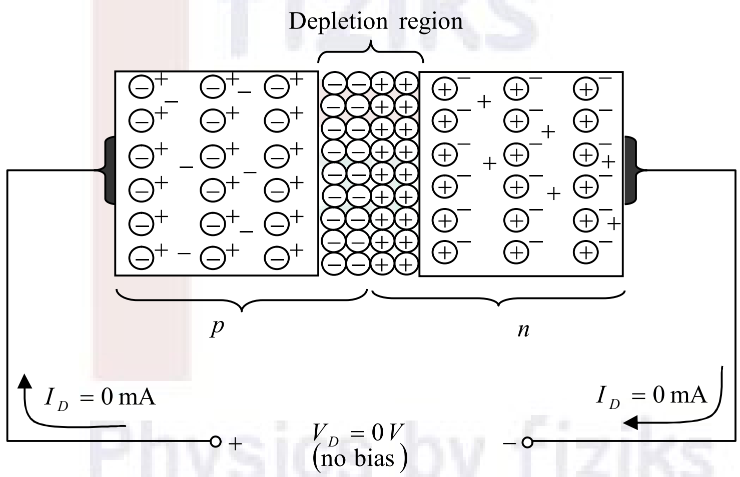

Figure: *p-n* junction with no applied bias.

Note:

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Test Your fiziks concepts!

Topic: Modern Physics

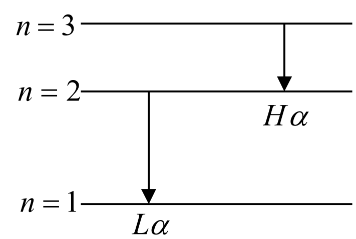
(For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

Q. In the hydrogen atom spectrum. the ratio of the longest wavelength in the Lyman series (final state $n=1$) to that in the Balmer series (final State $n=2$) is

(a) $\frac{36}{5}$ (b) $\frac{5}{27}$ (c) $\frac{27}{5}$ (d) $\frac{4}{3}$

Ans.: (b)

Solution.: According to Bohr Theory $\frac{1}{\lambda_L}=R\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)$



The longest wavelength in the Lyman series is

$$\Rightarrow \frac{1}{\lambda_L}=R\left(\frac{1}{1}-\frac{1}{2^2}\right)=R\left(\frac{3}{4}\right)\Rightarrow \lambda_L=\frac{4}{3R}$$

The longest wavelength in the Balmer series is

$$\Rightarrow \frac{1}{\lambda_B}=R\left(\frac{1}{2^2}-\frac{1}{3^2}\right)=R\left(\frac{1}{4}-\frac{1}{9}\right)=R\left(\frac{9-4}{36}\right)\Rightarrow \frac{1}{\lambda_B}=R\left(\frac{5}{36}\right)\Rightarrow \lambda_B=\frac{36}{5R}$$

$$\Rightarrow \frac{\lambda_L}{\lambda_B}=\frac{4}{3R}\times\frac{5R}{36}=\frac{5}{27}$$

Note:

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Test Your fiziks concepts!

Topic: Quantum Mechanics

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

Q. The wavefunction of a free particle of mass m, constrained to move in the interval $-L \le x \le L$, is $\psi(x) = A(L+x)(L-x)$, where A is the normalization constant. The probability that the particle will be found to have the energy $\frac{\pi^2\hbar^2}{2mL^2}$ is

(a) 0 (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{1}{2\sqrt{3}}$ (d) $\frac{1}{\pi}$

Ans.: (a)

Solution.: $E_n = \frac{n^2\pi^2\hbar^2}{8mL^2} \Rightarrow E_1 = \frac{\pi^2\hbar^2}{8mL^2}, \; E_2 = \frac{4\pi^2\hbar^2}{8mL^2} = \frac{\pi^2\hbar^2}{2mL^2}$

$$|\phi_1\rangle = \sqrt{\frac{2}{2L}}\cos\frac{\pi x}{2L}; \quad -L \le x \le L \quad \text{and} \quad |\phi_2\rangle = \sqrt{\frac{2}{2L}}\sin\frac{2\pi x}{2L}; \quad -L \le x \le L$$

$$P(E_2) = \frac{|\langle\varphi_2|\psi\rangle|^2}{\langle\psi|\psi\rangle} = \frac{\left|\int_{-L}^{L}\sqrt{\frac{2}{2L}}\sin\frac{2\pi x}{2L}A(L+x)(L-x)dx\right|^2}{\int_{-L}^{L}A^2(L+x)^2(L-x)^2dx} = 0$$

$$\int_{-L}^{L}\sin\frac{2\pi x}{2L}(L+x)(L-x)dx = 0 \text{ where, } \frac{2\pi x}{2L}(L+x)(L-x) \text{ is odd}$$

Note:

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Test Your fiziks concepts!

Topic: Electronics

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

Q. In a pn junction, dopant concentration on the p-side is higher than that on the n-side. Which of the following statements is not correct, when the junction is unbiased?

(a) The width of the depletion layer is larger on the n-side.

(b) At thermal equilibrium the Fermi energy is higher on the p-side.

(c) In the depletion region, number of negative charges per unit area on the p-side is equal to number of positive charges per unit area on the n-side

(d) The value of the built-in potential barrier depends on the dopant concentration.

Ans.: (b)

Solution.:

(a) Since p- region is heavily doped and n- region is lightly doped, on n- side width of depletion layer will be more and on p- side width of the depletion layer will be less.

(b) In an unbiased pn junction at thermal equilibrium the Fermi energy is at same level on both side.

(c) In the depletion region, number of negative charges per unit area on the p-side is equal to number of positive charges per unit area on the n-side

(d) The value of the built-in potential barrier depends on the dopant concentration since

$$V_0 = \frac{kT}{e}\ln\frac{N_A N_D}{n_i^2}$$

Note:

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Test Your fiziks concepts!

Topic: Modern Physics

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

Q. Let T_g and T_e be the kinetic energies of the electron in the ground and the third excited states of a hydrogen atom, respectively. According to the Bohr model, the ratio $\frac{T_g}{T_e}$ is

(a) 3 (b) 4 (c) 9 (d) 16

Ans.: (d)

Solution.: From Bohr model the kinetic energy and Total energy $\langle E \rangle$ and kinetic energy $\langle T \rangle$

$\langle T \rangle = -\frac{\langle E \rangle}{2}$ where $E_g = \frac{E_0}{1}$, $E_e = \frac{E_0}{16} \Rightarrow \frac{T_g}{T_e} = \frac{E_g}{F_e} = \frac{16}{1} = 16:1$

Note:

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