

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

Q. The energy of the first excited quantum state of a particle in the two-dimensional potential

$$V(x, y) = \frac{1}{2} m \omega^2 (x^2 + 4y^2) \text{ is}$$

- (a) $2\hbar\omega$ (b) $3\hbar\omega$ (c) $\frac{3}{2}\hbar\omega$ (d) $\frac{5}{2}\hbar\omega$

Ans.: (d)

Solution.: $V(x, y) = \frac{1}{2} m \omega^2 (x^2 + 4y^2) = \frac{1}{2} m \omega^2 x^2 + \frac{1}{2} m 4\omega^2 y^2,$

$$E = \left(n_x + \frac{1}{2} \right) \hbar\omega + \left(n_y + \frac{1}{2} \right) 2\hbar\omega$$

For ground state energy $n_x = 0, n_y = 0 \Rightarrow E = \frac{\hbar\omega}{2} + \frac{1}{2} 2\hbar\omega = \frac{3\hbar\omega}{2}$

First excited state energy $n_x = 1, n_y = 0 \Rightarrow \frac{3\hbar\omega}{2} + \hbar\omega = \frac{5\hbar\omega}{2}$

Note:

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

Q. A transistor in common base configuration has ratio of collector current to emitter current β and ratio of collector to base current α . Which of the following is true?

(a) $\beta = \frac{\alpha}{(\alpha+1)}$

(b) $\beta = \frac{(\alpha+1)}{\alpha}$

(c) $\beta = \frac{\alpha}{(\alpha-1)}$

(d) $\beta = \frac{(\alpha-1)}{\alpha}$

Ans.: (a)

Solution.: $\because I_E = I_C + I_B \Rightarrow \frac{I_E}{I_C} = 1 + \frac{I_B}{I_C} \Rightarrow \frac{1}{\beta} = 1 + \frac{1}{\alpha} \Rightarrow \beta = \frac{\alpha}{1+\alpha}$

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

Q. Consider a one-dimensional harmonic oscillator of angular frequency ω . If 5 identical particles occupy the energy levels of this oscillator at zero temperature, which of the following statement about their ground state energy E_0 is not correct?

(a) If the particles are electrons, $E_0 = \frac{13}{2} \hbar \omega$

(b) If the particles are protons, $E_0 = \frac{25}{2} \hbar \omega$

(c) If the particles are spin-less fermions, $E_0 = \frac{25}{2} \hbar \omega$

(d) If the particles are bosons, $E_0 = \frac{5}{2} \hbar \omega$

Ans.: (b)

Solution.: If particles are electrons and protons then ground state energy

$$E_0 = 2 \times \frac{\hbar \omega}{2} + 2 \times \frac{3\hbar \omega}{2} + 1 \times \frac{5\hbar \omega}{2} = \frac{13\hbar \omega}{2}$$

If the particles are spin-less fermions, then energy is

$$E_0 = \frac{\hbar \omega}{2} + \frac{3\hbar \omega}{2} + \frac{5\hbar \omega}{2} + \frac{7\hbar \omega}{2} + \frac{9\hbar \omega}{2} = \frac{25\hbar \omega}{2}$$

If the particles are bosons $E_0 = 5 \times \frac{1}{2} \hbar \omega = \frac{5\hbar \omega}{2}$

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

Q. The ground state energy of an anisotropic harmonic oscillator described by the potential

$$V(x, y, z) = \frac{1}{2}m\omega^2 x^2 + 2m\omega^2 y^2 + 8m\omega^2 z^2 \text{ (in units of } \hbar\omega \text{)}$$

- (a) $\frac{5}{2}$ (b) $\frac{7}{2}$ (c) $\frac{3}{2}$ (d) $\frac{1}{2}$

Ans.: (b)

Solution.: $V(x, y, z) = \frac{1}{2}m\omega^2 x^2 + \frac{1}{2}m(2\omega)^2 y^2 + \frac{1}{2}m(4\omega)^2 z^2$

$$\omega_x = \omega, \omega_y = 2\omega, \omega_z = 4\omega$$

$$E_{n_x, n_y, n_z} = \left(n_x + \frac{1}{2}\right)\hbar\omega_x + \left(n_y + \frac{1}{2}\right)\hbar\omega_y + \left(n_z + \frac{1}{2}\right)\hbar\omega_z$$

For ground state: $n_x = 0, n_y = 0, n_z = 0$

$$E_{0,0,0} = \frac{1}{2}\hbar\omega + \frac{1}{2}\hbar 2\omega + \frac{1}{2}\hbar 4\omega = \frac{1}{2}\hbar\omega(1+2+4) = \frac{7}{2}\hbar\omega$$

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

Q. To operate a npn transistor in active region, its emitter-base and collector- base junction respectively, should be

- (a) forward biased and reversed biased (b) forward biased and forward biased
(c) reversed biased and forward biased (d) reversed biased and reversed biased

Ans.: (a)

Solution.: In active region: emitter-base junction is F.B.

: collector-base junction is R.B.

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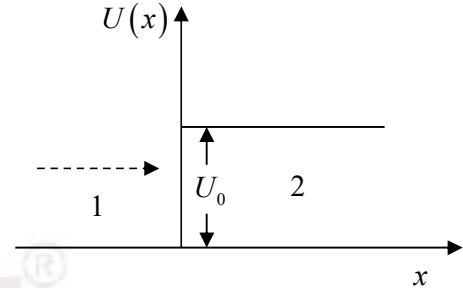
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Topic: Modern Physics

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

Q. Consider an electron with mass m and energy E moving along the x -axis towards a finite step potential of height U_0 as shown in the figure. In region 1 ($x < 0$), the momentum of the electron is $p_1 = \sqrt{2mE}$. The reflection coefficient at the barrier is given by $R = \left(\frac{p_1 - p_2}{p_1 + p_2} \right)^2$, where p_2 is the



momentum in region 2. If, in the limit $E \gg U_0$, $R \approx \frac{U_0^2}{nE^2}$, then the integer n is

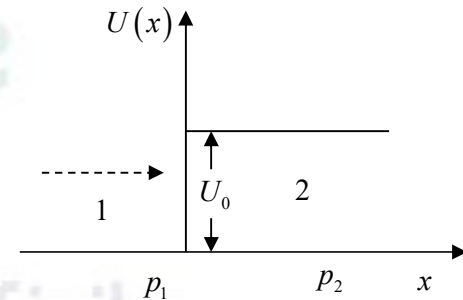
(a) 4 (b) 8 (c) 12 (d) 16

Ans.: (b)

Solution.:

In region -1, the momentum of electron is $p_1 = \sqrt{2mE}$

As, step potential in second region so the momentum of electron is $p_2 = \sqrt{2m(E - U_0)}$



The reflection coefficient at the barrier is $R = \left(\frac{p_1 - p_2}{p_1 + p_2} \right)^2$

$$R = \left(\frac{\sqrt{2mE} - \sqrt{2m(E - U_0)}}{\sqrt{2mE} + \sqrt{2m(E - U_0)}} \right)^2 = \sqrt{2mE} \left(\frac{1 - \sqrt{1 - \frac{U_0}{E}}}{1 + \sqrt{1 - \frac{U_0}{E}}} \right)^2$$

Form question $E \gg U_0$, $U_0 / E \ll 1$

$$R = \left(\frac{1 - \left(1 - \frac{U_0}{2E}\right)}{1 + \left(1 - \frac{U_0}{E}\right)} \right)^2 = \left(\frac{\frac{U_0}{2E}}{2 - \frac{U_0}{2E}} \right)^2 = \left(\frac{U_0}{4E} \right)^2 = \frac{U_0^2}{16E} \Rightarrow n = 16$$

Note:

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