Engineering Physics

(PHY1701)

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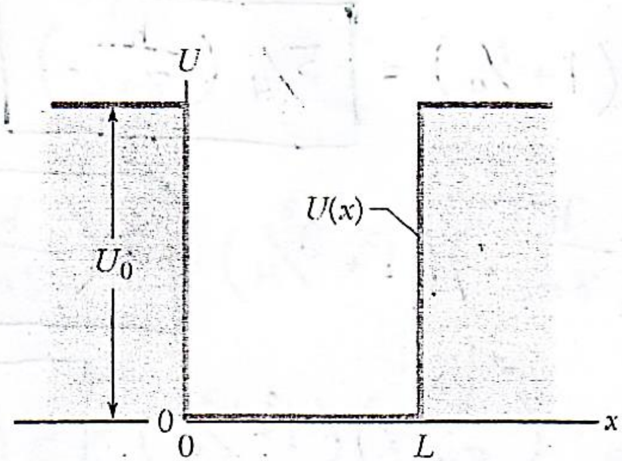
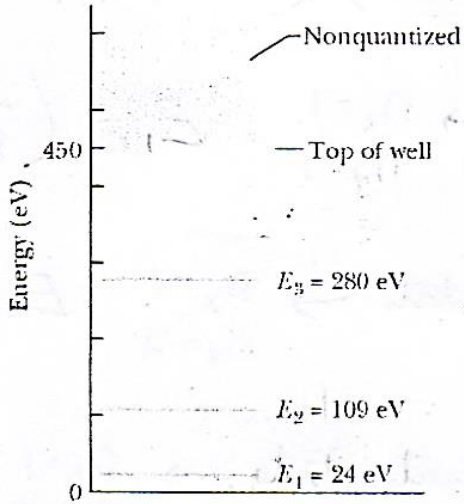
1D box:

(a) The figure below gives the energy levels for an electron trapped in a finite potential energy well 450 eV deep. If the electron is in the n = 3 state, what is its kinetic energy? (b) The electron then absorbs 500 eV of energy from an external source. What is its kinetic energy after this absorption, assuming that the electron moves to a position for which x > L.





(a) $E_3 = 280\,eV = K + U \quad U = 0 \longrightarrow \boxed{K = 280\,eV}$

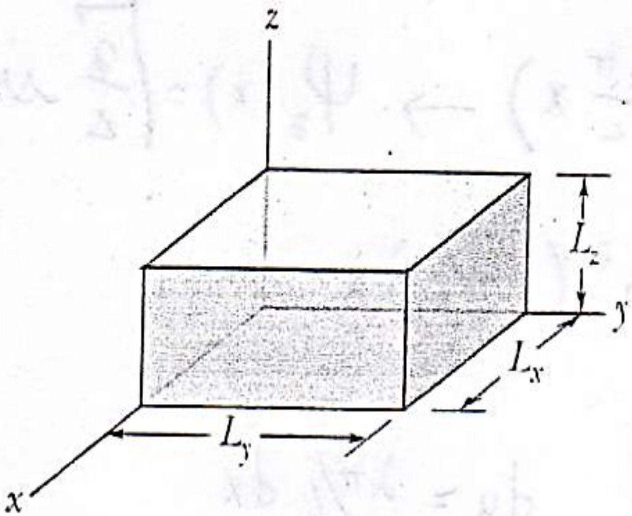
(b) $E_{total} = 280\,eV + 500\,eV = 780\,eV = K + U$

$U = 450\,eV$ for $x > L$

$K = 780\,eV - 450\,eV \longrightarrow \boxed{K = 230\,eV}$

3D Box:

An electron is contained in the rectangular box of the figure below, with widths L_x=800 pm, L_y=1600 pm and L_z=400 pm. What is the electron's ground-state energy in electron-volts?



$$E_{n_x, n_y, n_z} = \frac{h^2}{8m}\left(\frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2} + \frac{n_z^2}{L_z^2}\right)$$

ground state is given by $n_x = n_y = n_z = 1$

$$E_{1,1,1} = \frac{h^2}{8m}\left(\frac{1}{L_x^2} + \frac{1}{L_y^2} + \frac{1}{L_z^2}\right)$$

$$E_{1,1,1} = \frac{(6.63\times10^{-34}\ \text{J}\cdot\text{s})^2}{8(9.11\times10^{-31}\ \text{Kg})}\left[\frac{1}{(800\times10^{-12}\ \text{m})^2} + \frac{1}{(1600\times10^{-12}\ \text{m})^2} + \frac{1}{(400\times10^{-12}\ \text{m})^2}\right]$$

$$\boxed{E_{1,1,1} = 4.95\times10^{-19}\ \text{J} = 3.10\ \text{eV}}$$

Problem 7

Problem: Transmission Coefficient:

Electrons with energies of 3 eV is incident on a barrier of 30 eV high and 2 nm wide. (i) Find their respective transmission probability. (ii) How this is affected if the barrier is doubled in width?

$$T = e^{-2k_2 L}$$

$$k_2 = \frac{\sqrt{2m(U-E)}}{\hbar}$$

$$for\ E = 3\ eV; U = 30\ eV; L = 2nm$$

$$k_2 = \frac{\sqrt{2m(U-E)}}{\hbar} = \frac{\sqrt{2 \times 9.1 \times 10^{-31} \times (30-3) \times 1.6 \times 10^{-19}}}{1.054 \times 10^{-34}}$$

Transmission Coefficient:

$$= \frac{28.04 \times 10^{-25}}{1.054 \times 10^{-34}} = 2.6603 \times 10^{10}$$

$$T = e^{-2k_2L} = e^{-2\times2.6603\times10^{10}\times2\times10^{-9}} = (2.718)^{106.412} = 1.62 \times 10^{-46}$$

$$for\ E = 3\ eV; U = 30\ eV; L = 4\ nm$$

$$T = e^{-2k_2L} = e^{-2\times2.6603\times10^{10}\times4\times10^{-9}} = (2.718)^{212.824} = 2.62 \times 10^{-92}$$
