Arab Academy for Science & Technology & Maritime Transport

(AASTMT – Cairo Branch)

College of Engineering & technology

Electronics & Communication Engineering Department

Course : Solid State Electronics
Course Code : EC210
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Sheet # 5

Schrodinger Equation

Physical Constants:

Charge of electron (e) =1.6x10^{-19} C **Mass of electron (m_e) = 9.1x10^{-31} kg**
Mass of proton (m_p) = 1.672x10^{-27} kg **Plank's constant (h) = 6.63x10^{-34} J.s**
Speed of light (C) = 3x10^{8} m/s
1 eV = 1.6×10-19 J

Put (T) for the true statement or (F) for the false statement:

1. If an electron with energy 5 eV impinges a semi-infinite potential step of height 3 eV, the probability that the electron is reflected back is zero.
2. If an electron with energy 3 eV impinges a semi-infinite potential step of height 5 eV, the probability that the electron is transmitted through the step is zero.
3. The tunneling probability through a potential barrier of finite width increases with the width of the barrier.
4. The tunneling probability through a potential barrier of finite width increases with the height of the barrier.
5. The tunneling probability through a potential barrier of finite width increases with the energy of the particle.

Choose the correct answer justifying your choice:

1. If an electron has a wave function of the form $A\exp[ikx]$, the probability of finding the electron at $x = 5$ is
   (a) $A\exp[i5k]$ (b) $A\exp[i10k]$
   (c) $A^2\exp[i10k]$ (d) A^2
   e) $A^2\exp[i5k]$

2. If an electron with energy 5 eV impinges a semi-infinite potential step of height 3 eV, the energy of the electron in the higher potential region will
   (a) Decrease (b) increase
   (c) remain the same (d) be zero
   (e) Be negative

3. If an electron with energy 5 eV impinges a semi-infinite potential step of height 3 eV, the angular wave number of the electron in the higher potential region will
   (a) Decrease (b) increase
   (c) Remain the same (d) be zero
   (e) Be negative

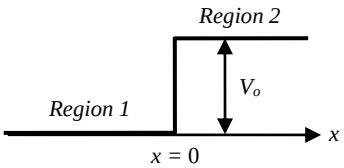
4. If an electron with energy 5 eV impinges a semi-infinite potential step of height 3 eV, the velocity of the electron in the higher potential region will
   (a) Decrease (b) increase
   (c) Remain the same (d) be zero
   (e) Be negative

5. If an electron with energy 2 eV impinges a semi-infinite potential step of height 6 eV, the ratio of the probability of finding the electron in the higher potential region at a distance 2.25 Å from the edge of the step to that at the edge of the step is approximately
   (a) 0.1 (b) 10
   (c) 10^{-3} (d) 0.01
   (e) Zero

Solve the following Problems:

1. An electron with energy E = 2 eV moves towards a potential step (shown in the figure) of height V_o = 6 eV. Given $\psi_1 = Ae^{ikx} + Be^{-ikx}$, and $\psi_2 = Ce^{-\alpha x}$

   (a) Calculate k and α.
   (b) What is the reflection coefficient R ?
   (c) What is the transmission coefficient T ?



2. An electron with a total energy E moves in a one dimensional region 1. At x = 0, there is a potential energy step of height V_o (as shown in the figure). Given $\psi_1 = Ae^{iax} + Be^{-iax}$, and $\psi_2 = Ce^{-x/b} + De^{x/b}$

   (a) Find the real numbers a and b (in terms of E and V_o).
   (b) Is the total energy of the electron less or greater than V_o? why?
   (c) Knowing that the wave function and its space derivative are single valued, continuous and finite find B, C, D in terms of A.