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NPTEL

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Courses » Semiconductor Devices and Circuits

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Unit 2 - Week 1 : Excursion in Quantum Mechanics

Course outline

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Week 1 : Excursion in Quantum Mechanics

- Quantum Mechanics: Concept of Wave Particle, Schrodinger's Equation
- Quantum Mechanics: Particle in a Box
- Quantum Mechanics: Particle in a Box - Continued, Harmonic Oscillator
- Quiz : Assignment 1
- Assignment 1 solution

Week 2 : Excursion in Solid State Physics

Week 3 : Density

Assignment 1

The due date for submitting this assignment has passed.
As per our records you have not submitted this assignment.

Due on 2018-08-15, 23:59 IST.

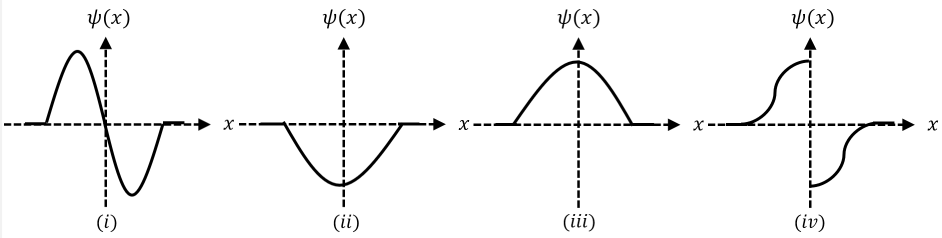
1) The wave-function of a particle must be "normalizable", because ***1 point***

- the particle's momentum must be conserved.
- the particle's charge must be conserved.
- the particle must exist somewhere in the space.
- the particle can not exist at two places at the same time.

No, the answer is incorrect.
Score: 0

Accepted Answers:
the particle must exist somewhere in the space.

2) Which of the following is **not** a valid quantum mechanical wave-function? ***1 point***



- (i)
- (ii)
- (iii)
- (iv)

No, the answer is incorrect.

The corresponding quantum mechanics operator in cartesian coordinate system is given by

- $-i\hbar\left(\vec{r}\times\vec{\nabla}\right)$
- $i\hbar\left(\vec{r}\times\vec{\nabla}\right)$
- $-i\hbar\left(\vec{\nabla}\times\vec{r}\right)$
- $-i\hbar\left(\vec{\nabla}.\vec{r}\right)$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$-i\hbar\left(\vec{r}\times\vec{\nabla}\right)$

4) In electron beam lithography patterns are exposed with electrons. The small wavelength of electrons helps to achieve small feature sizes (in order of nm). Assume an electron gun of energy $100\ \mathrm{keV}$. What is the wavelength of these electrons? Assume the mass of electron $= 9.109 \times 10^{-31}\ \mathrm{kg}$ and Planck's constant, $h = 6.626 \times 10^{-34}\ \mathrm{J.s}$. Neglect the relativistic effect. ***1 point***

- 1.5 nm
- 0.0039 nm
- 3.9 nm
- 0.015 nm

No, the answer is incorrect.
Score: 0

Accepted Answers:
0.0039 nm

5) An electron in an infinite one-dimensional potential well jumps from the $n = 3$ energy level to the ground state energy level and in doing so emits a photon of wavelength $20.9\ \mathrm{nm}$. What is the width of the well? Assume electron mass $= 9.11e-31\ \mathrm{kg}$, $h = 6.626e-34\ \mathrm{J.s}$ and $c = 3e8\ \mathrm{m/s}$. ***1 point***

- 0.225 nm
- 1.015 nm
- 22.5 nm
- 0.02 nm

No, the answer is incorrect.
Score: 0

Accepted Answers:
0.225 nm

6) A wave function is given by ***1 point***

$$\psi(x) = \begin{cases} 0, \text{ if } x < 0 \\ Ax(d-x), \text{ if } 0 \le x \le d \\ 0, \text{ if } x > d \end{cases}$$

What is the value of A?

- $\sqrt{2/L}$
- 1
- $\sqrt{30}L^{-5/2}$
- $\sqrt{15}L^{-3/5}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\sqrt{30}L^{-5/2}$

7) An electron is bound in an infinite one-dimensional potential well of width $7.3\ \mathrm{nm}$ along the x-axis. The system is at state $n = 2$. The probability of finding the electron per nm length at $x = 0.3\ \mathrm{nm}$ is closest to ***1 point***

- zero
- 0.018
- 0.024
- 0.0063

No, the answer is incorrect.
Score: 0

Accepted Answers:
0.018

8) Electrons are accelerated through an electric potential V and then fall on a pair of slits that have a separation of $100\ \mathrm{nm}$. The resultant interference pattern indicates that the electrons have a wavelength of $1\ \mathrm{nm}$. ***1 point***

i) What is the value of the accelerating electric potential V?
ii) After passing though the slits what is the minimum spread in the electron's momentum in the direction parallel to the plane of the slits and perpendicular to the average path of the electrons? Assume $h = 6.626 \times 10^{-34}\ \mathrm{J.s}$ and electron mass $m = 9.11 \times 10^{-31}\ \mathrm{kg}$. Ignore any relativistic effect.

- i) 1 V
  ii) infinity
- i) 1 V
  ii) zero
- i) 1.5 V
  ii) 3.87 e-25 kg.m/s
- i) 1.5 V
  ii) 5.27 e-28 kg.m/s

No, the answer is incorrect.
Score: 0

Accepted Answers:
i) 1.5 V
ii) 5.27 e-28 kg.m/s

9) The wave-function of a particle at a state 'n' is given by ***1 point***

$$\psi(x) = \begin{cases} (\sqrt{2/a})cos(3\pi x/a), \text{ for } |x| \leq a/2 \\ 0, \text{ for } |x| > a/2 \end{cases}.$$

What is the average momentum of the particle at the state 'n'.

- zero
- $\hbar\pi/a$
- $3\hbar\pi/a$
- None of the above.

No, the answer is incorrect.
Score: 0

Accepted Answers:
zero

10) Consider a particle of mass m moving in the one-dimensional potential $V(x) = A\delta(x)$ for $|x| < a$ and $V(x) = \infty$ elsewhere. The value of A for which the ground state energy of the system vanishes is **1 point**

- 0
- $\frac{\hbar^2}{ma}$
- $-\frac{\hbar^2}{ma}$
- $-\frac{2ma}{\hbar^2}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$-\frac{\hbar^2}{ma}$

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