Major : Functional Nanomaterials EPL444

Name and Entry No. .....

Marks: 20 May 1, 2008
Time: 45 minutes

Q1. Find out the value of second energy level n =2 of exciton for Silicon (use permittivity = 12×10^{-10} F/m, effective mass of electron = 0.26 m_0 effective mass of hole = 0.36 m_o).

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Q2. Find out the allowed quantized energy levels for a single electron in a quantum well of width 0.2 nm. (Assume the potential barrier height as 150 eV).

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Q3. Find out the type and circumference (strictly in terms of lattice constant = 2.46 Å) of the following nanotubes (a) (3,2) (b) (2,0) (c) (3,3) (d) (5,0)

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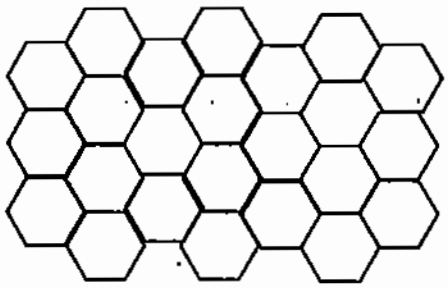
Q4. For a 2D graphene, what is the bravais lattice? Draw a primitive unit cell and a chiral vector C_h $5a_1 + 3a_2$ in the given graphene sheet.



Q5. You have a hollow Si sphere of radius 100 nm. If you add one electron to it how much its potential will change?

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Q6. Which statement(s) is (are) incorrect for a 2D graphene sheet.

a) Reciprocal lattice of graphene is rotated hexagon of real lattice
b) There are two basis atoms with spacing of a lattice constant
c) The separation between corners of the hexagon in reciprocal space if $\frac{2\pi}{a\sqrt{3}}$
d) Honeycomb hexagon is not a bravais lattice in graphene

Q7. In a 2D graphene, suppose a_1 and a_2 are the lattice vectors and b_1 and b_2 are the corresponding reciprocal lattice vectors. The angle between b_1 and b_2 will be

a) 30^0 b) 60^0
a) 90^0 d) 120^0

Q8. The magnetocrystalline anisotropy energy is proportional to (θ is the angle between easy axis and magnetization)

a. $\sin\theta$ b) $\sin^2\theta$
c) $\cos\theta$ d) $\cos^2\theta$

Q9. Bohr-exciton radius is considered as meter-stick in nanoscience. It is given by the formula

a) $a_B = \frac{m\hbar^2}{\varepsilon e^2}$ b) $a_B = \frac{\hbar^2}{me^2}$

c) $a_B = \frac{\varepsilon\hbar}{me^2}$ d) $a_B = \frac{\varepsilon\hbar^2}{me^2}$

Q10. How many degrees of freedom are in quantum well structures?

a. one c) two
b. three d) zero

Q11. An electron is accelerated to 2V voltage in vacuum, what is its corresponding wavelength?

a) 1.23 nm b) 2.19 nm
c) none of the above d) 0.87 nm

Q12. Bulk gold material is having melting temperature of about 1000°C but nano-size (~2 nm) gold particles are having melting temperature of about 500°C, because of

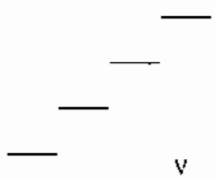
a) smaller number of atoms in nanoparticles
b) loose bonds between C atoms on the surface
c) smaller coordination number of atoms in nanoparticles
d) all of the above

Major Exam
Functional Nanomaterials EPL444 Part B

Marks: 25 May 01, 2008
Time: 75 minutes

Q1. What is an exciton? How does an exciton form? Write briefly what are two different types of excitons? Why does Bohr-exciton radius is defined as the meter stick to judge the quantum confinement in low dimensional systems? [4]

Q2. What is Coulomb blockade (CB)? Write conditions to observe the CB effect? What are the step height and step width (in terms of capacitance C) of the following I-V curve for a Quantum dot. [3]



Q3. Consider an e in two potential barriers (similar heights), one with spherical symmetry and other with cylindrical geometry. Qualitatively what will be the differences in their quantized energy levels and wavefunctions? [2]

Q4. What are the advantages of using Quantum well or dots as active layers in lasers? [2]

Q5. What is the idea behind quantum cellular automata (QCA)? What are the advantages of this approach? Make a XOR gate $Y = \overline{A}B + A\overline{B}$ using QCA, where A and B are input signals and Y is an output Signal. [3]

Q6. How do the properties of micromachines differ from macromachine? [1]

Q7. What is shape anisotropy in magnetism and what is its origin? Write a note on superparamagnetism. [3]

Q8. For 2D graphine show that reciprocal lattice veetors are given by: $\vec{b}_1 = \left(\frac{2\pi}{\sqrt{3}a}, \frac{2\pi}{a}\right), \vec{b}_2 = \left(\frac{2\pi}{\sqrt{3}a}, -\frac{2\pi}{a}\right)$ where **a** is the lattice constant. By using reciprocal space prove that nanotubes (5.0) and (3.0) is will be semiconductor and metallic , respectively. [6]

Q9. ATP is fuel of bio-motor. The conversion of ATP to ADP yields about 7 kcal/mole of energy. How? [1]