BITS PILANI DUBAI CAMPUS
FIRST SEMESTER 2012-13

COMPREHENSIV EXAMINATION (CLOSED BOOK)

Course No: EA C416 Duration: 3HRS Weightage: 40%

Course Name: Introduction to Nanoscience Max Marks:40 Date: 29.12.2012

Note: All the questions are compulsory.

Given: mass of electron= 9.1×10^{-31} Kg, Planck's constant h = 6.62×10^{-34} J.s, Boltzman constant k= 1.38×10^{-23} J/K

Q1. (A) Prove that the group velocity at the zone boundary of the optic branch as well as acoustic branch of lattice vibration of a diatomic linear chain is zero. (2)

(B) What is the Fermi energy for the free electron gas in silver, if the density of conduction electrons is 5.8×10^{28} m^{-3} . What is the Fermi Speed? (2)

Q2. Consider a particle of mass m and kinetic energy E incident on a potential step represented by

$V(x) = 0, \quad x < 0$

$= V_0, \quad x > 0$

Starting from Schrodinger equation, derive the expression for reflection and transmission coefficient for (i) $E < V_0$ (ii) $E > V_0$ (4+4=8)

Q3.(A)) In electron microscopy for characterization of nanomaterial , mention all the possible processes involved when an electron interacts with material. (2)

(B)Describe in detail the operation of molecular beam epitaxy method for fabrication of nanostructure. (2)

Q4 Describe in detail the operation of scanning tunneling microscope, used for the characterization of nanomaterial (4)

Q5. (A) Given chiral vector $\vec{C}= n\vec{a}_1 + m\vec{a}_2$, (where n and m are integers) and Θ is the chiral angle. What is the relationship between(n,m) and Θ. What are the values of Θ for zigzag and armchair carbon nanotubes? (2)

(B)For the following combination of (n,m), predict the type of CNT (e.g. chiral, zigzag or armchair): (A) (3,3) (B) (15,0) (C) (15,12) (D) (12,9) (2)

(C) For the following combination of (n,m), predict the nature of CNT (e.g. conducting or semiconducting) (A) (5,0) (B) (6,0) (C) (6,1) (D) (6,3) (2)

(D) Mention different methods for fabrication of carbon nano tubes and discuss one of the fabrication methods in detail. (4)

Q6. Describe in detail the principle of operation and typical applications of

(a) Piezoresistive pressure sensor (b) Conductometric gas sensor (2+2=4)

Q7.(a) Define quantum well, quantum wire and quantum dot(with diagrams)

(b) Mention the differences between Type-1 and Type-2 superconducting nanomaterial.

(c) Describe in detail any method of preparation of Quantum dot structure (2+2+2)

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FIRSTSEMESTER 2012-13

Test-1(Closed Book)

Course No: EA C416 **Duration: 50 Mints** **Weightage: 20%**

Course Name: Introduction to Nanoscience **Max Marks:20** **Date: 27.9.2012**

Note: All the questions are compulsory. Given, mass of the electron= 9.1×10^{-31} Kg,

Planck's constant $h=6.62 \times 10^{-34}$ J.s, Boltzmann constant $k=1.38 \times 10^{-23}$ J/K

Q 1. (A) Give the definition of primitive and non primitive lattices with examples. . (2)

(B) Find the Miller indices of a plane that makes intercepts in the ratio 2:3:4 on the coordinate axes of an orthorhombic crystal with a:b:c = 4:3:2. (2)

(C) A nanomaterial with f.c.c. lattice has density 6250 kg/ m^3 and molecular weight 60.2. Calculate the lattice constant . Given Avogadro Number 6.02×10^{26} kg/mole (2)

Q.2. Consider a set of crystal planes of a nanomaterial which are separated by $1.95 A^0$. If we use x-rays of wavelength $1.542 A^0$, find all possible Bragg angles for reflection from these planes. (2)

Q3. How to construct a reciprocal lattice. Calculate the reciprocal of a reciprocal vector for a cube of size a,b and c. (2)

Q 4.(A)Derive the dispersion relation for vibrations of one dimensional monoatomic chain in a nanocrystal. (4)

(B) Derive the expression for group velocity in the above . (2)

Q5(A) Give the definition of Brilluion Zone(B.Z.) . What are the ranges of this(1^{st} and 2^{nd} B.Z.) for monoatomic and diatomic nano crystal (2)

(B).In the case of vibrations of a monoatomic linear chain, for small ka, the phase velocity is 5000 m/s. Calculate the group velocity at $k=\pi / 2a$ where a is the lattice spacing. (2)

Good luck

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Quiz (Closed Book)

Course No: EA C416 **Duration: 30 Mints** **Weightage: 5%**

Course Name: Introduction to Nanoscience **Max Marks:5** **Date: 22.10.2012**

Note: All the questions are compulsory. Given, mass of the electron= 9.1×10^{-31} Kg,

Planck's constant $h=6.62 \times 10^{-34}$ J.s,

Q1. If the Fermi energy of the electron is 2.1 eV, find the

(a) Fermi velocity

(b) Fermi temperature in Kelvin (0.5+0.5=1)

Q2. What is the Fermi energy (in eV) of for the free electron gas in silver , if the density of conduction electron is 5.8×10^{28} m^{-3} . (1)

Q3.(a) Write time dependent and time independent Schrödinger equation for a quantum mechanical particle in one dimension.

(b) Write the expression for

(i) momentum and energy operator (ii) average value of position, momentum and energy

(c) What you mean by normalized wave function. Write the condition of normalization for a wavefunction. (1+1+1=3)

---- Good Luck------