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6 SEM TDC DSE PHY (CBCS) 2 (H)

2024

(May)

PHYSICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE-2

(Nanomaterials and Applications)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

1. Choose the correct option of the following :

1×5=5

(a) STM can only scan

(i) insulating surfaces

(ii) conducting surfaces

(iii) polymer materials

(iv) None of the above

(b) The resolving power of TEM is derived from

- (i) electrons
- (ii) specimens
- (iii) voltage applied
- (iv) pressure

(c) X-ray crystallography is a form of

- (i) Raman scattering
- (ii) Inelastic scattering
- (iii) Elastic scattering
- (iv) None of the above

(d) The main consequence of disorder in the electronic structures of the material is the appearance of

- (i) localized states
- (ii) valence band
- (iii) conduction band
- (iv) None of the above

(e) The phenomenon used by single-electron devices for their operations is

- (i) optical storage
- (ii) tunneling effect
- (iii) Coulomb blockage
- (iv) None of the above

2. (a) What is quantum confinement? 2

(b) Briefly explain top-down and bottom-up approaches with examples. 2+2=4

(c) What is excitonic Bohr radius? How is dielectric constant affect the excitonic Bohr radius of a semiconductor material? 1+1=2

(d) Calculate the ground state exciton binding energy for GaAs. Given, $m_e^* = 0.067 m_e$, $m_h^* = 0.5 m_e$. Where m_e is free electron mass and the dielectric constant of GaAs is 12.93. 3

3. (a) Define density of states. Derive an expression for density of states for two dimensional materials and plot it as a function of energy. 1+3+1=5

(b) Explain quantum wires and quantum dots on the basis of their dimensions. $1\frac{1}{2}+1\frac{1}{2}=3$

(c) Discuss the working of quantum dot heterostructures (QDHS) laser. 3

4. (a) What is a ball mill? Describe its working and state the various key factors responsible for selecting a grinding media in a ball mill. 1+4=5

- (b) Distinguish between Mott-Wannier and Frenkel excitons. 2
5. (a) What is Coulomb blockage effect? Why is Coulomb blockage observed usually at low temperature? 2+2=4
- (b) Explain the use of nanowires in making solar cells. 3
6. Discuss the working principle of an atomic force microscope (AFM). What are the different modes of operations of AFM? 4+2=6

Or

- Explain the construction and working principle of scanning electron microscopy (SEM). 6
7. Write short notes on any *two* of the following : 3×2=6
- (a) Carbon nanotubes based transistors
- (b) NEMS
- (c) Optical properties of nanostructures
