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

**2025**

( 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  
(any five) : 1×5=5

(a) Mechanical method for non-material  
synthesis is

- (i) ball milling method
- (ii) laser ablation
- (iii) spray pyrolysis
- (iv) sol-gel method

- (b) Quantum dot is
- (i) a material with one dimension in nano-range and other two large
  - (ii) a material with two dimensions in nano-range and other one large
  - (iii) a material with all dimensions in nano-range
  - (iv) None of the above
- (c) Back scattered electrons and secondary electrons from the samples are essential for imaging in
- (i) AFM
  - (ii) TEM
  - (iii) SEM
  - (iv) XRD
- (d) Coulomb interaction happens in
- (i) semiconductor
  - (ii) metals
  - (iii) insulators
  - (iv) None of the above
- (e) \_\_\_\_\_ is a powerful characterization tool to investigate electronic structure of solid-state nanostructure materials.
- (i) AFM
  - (ii) STM
  - (iii) FTIR
  - (iv) TEM



- (f) Excitations are
- (i) negatively charged
  - (ii) biosensors
  - (iii) MEMS
  - (iv) All of the above
2. (a) What is exciton? Which exciton is more commonly found in semiconductors and nanostructures? 1+1=2
- (b) How can the lowering of size affect band gap? 2
- (c) Mention any two size-dependent properties of nanomaterials. 2
3. (a) Why are the properties of nanomaterials different from bulk materials? 3
- (b) What are direct and indirect band gap semiconductors? Explain with  $E$  vs.  $k$  diagram. 3
- (c) Differentiate between shallow traps and deep traps. 2
4. (a) What is hopping conductivity? Mention different types of hopping conduction. 1+2=3

Or

- With lowering of the particle size of semiconductor why does nanoparticles band gap increase? 3
- (b) Show that for a three-dimensional bulk material, the density of states is inversely proportional to the square root of energy. 4

5. (a) Write briefly about the charging effect in quantum dot. 3  
(b) Describe briefly about various optical storage devices. 3  
(c) Explain the radiative and non-radiative electron-hole recombination processes in semiconductor nanoparticles. 3

6. What is vacuum deposition? Explain physical vapour deposition technique. 2+4=6

Or

What is top-down and bottom-up synthesis approach? Explain hydrothermal synthesis process. 2+4=6

7. Explain the working principle of TEM with schematic diagram. 6

Or

Discuss the working principle of scanning tunneling microscope (STM). How does an STM work in constant-height mode? 4+2=6

8. Write short notes on any *two* of the following : 3×2=6

- (a) Quantum dot heterostructure laser  
(b) Nanowires in light emitting diodes (LEDs)  
(c) Quantum dots in solar cells

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