

2025

PHYSICS — HONOURS

Paper : DSE-A-2.1

(Nanomaterials and Applications)

Full Marks : 65

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

Group - A

1. Answer *any five* questions : 2×5
- (a) “Bottom-up technique is more convenient for nano fabrication.” — Explain.
 - (b) Distinguish between the electrical band gap and the optical band gap.
 - (c) What condition determines whether a carbon nanotube (CNT) is metallic or semiconducting?
 - (d) What is meant by exciton Bohr radius?
 - (e) What are the major differences between electrical conduction at the nano scale and micro scale?
 - (f) State basic principles of MEMS (Micro electro mechanical systems).
 - (g) Why does CNT have high tensile strength?

Group - B

2. Answer *any three* questions :
- (a) (i) What do you mean by synthesis of nanomaterials? What is the basic principle of electron beam evaporation?
 - (ii) Write down some of the applications of electron beam evaporation. (1+2)+2
 - (b) (i) What are the different modes of operation of an atomic force microscope?
 - (ii) Write down some of the advantages of atomic force microscope. 2+3
 - (c) (i) What do you mean by quasi-particle?
 - (ii) What are the differences between real and quasi-particles? 2+3
 - (d) (i) Differentiate between direct and indirect band gap semiconductors.
 - (ii) Why are direct band gap materials preferred over indirect band gap materials for opto-electronic devices? 3+2
 - (e) (i) Determine the density of states for one dimensional nanomaterials.
 - (ii) Sketch the density of states as a function of energy for 1-D and 3-D systems. 3+2

Please Turn Over

(2420)

Group - C

Answer *any four* questions.

3. (a) For a rectangular potential barrier

$$V(x) = V_0 \text{ for } 0 \leq x \leq a \\ = 0 \text{ otherwise}$$

show that approximate expression of transmission coefficient is

$$T = \frac{16(V_0 - E)}{V_0^2} e^{-2ka}$$

where E is the energy of the particle and $E < V_0$ and $k^2 = \frac{2m(V_0 - E)}{\hbar^2}$.

- (b) Write down the working principle of Scanning Tunneling Microscope (STM).
- 6+4

4. (a) Explain how crystalline and amorphous materials can be distinguished using X-ray diffraction (XRD).

- (b) Discuss the change in the XRD profile of a nano-crystalline material from that of its bulk counterpart.

- (c) Calculate the de Broglie wavelength for a 1 KeV electron.

- (d) An electron of energy 608 eV is confined in an one dimensional box of length 1 Å. Calculate the quantum number
- n
- of the energy state of the electron.
- 2+2+3+3

5. (a) Briefly outline the sol-gel method for the synthesis of nanoparticles. Discuss its limitations.

- (b) Describe the basic working principle of molecular beam epitaxy (MBE).

- (c) What are the advantages and disadvantages of ball milling technique for synthesis of nanomaterials?
- (2+2)+3+3

6. (a) Define dielectric constant of a material.

- (b) What are the key features of dielectric constant of a quantum dot?

- (c) Compare the features of dielectric constant of a nanomaterial with its bulk counterpart.

- (d) Explain the role of size in changing the color of an object. What is the dimension of absorption coefficient?
- 2+2+3+(2+1)

7. (a) State the conditions to observe coulomb blockade effect in a nanoscale system.

- (b) What are deep level and shallow level defects?

- (c) An exciton does not directly contribute to the electrical conductivity. — Explain why?

- (d) What are plasmons?
- 3+3+2+2

(3)

D(6th Sm.)-Physics-H/DSE-A-2.1/CBCS

8. Write short notes on the following topics :

3+2+3+2

- (a) Applications of nanomaterials in medicines
 - (b) Applications of quantum dots in solar cells
 - (c) Basic structure of a single electron transistor
 - (d) Applications of carbon nanotubes.
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