

2021

PHYSICS — HONOURS

Paper : DSE-A2(a)

(Nanomaterials)

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) What is the range of dimension of nanoparticles?
- (b) What are the major differences between the electrical conduction at the macroscale and nanoscale?
- (c) An x-ray beam of wavelength 0.71\AA is diffracted by a cubic KCl crystal. Calculate the glancing angle for the second-order reflection from (200) planes. (The interplanar spacing is 3.145\AA).
- (d) Show that quantum size effects become observable in the condition $\Delta x \leq \frac{\hbar}{\sqrt{mK_B T}}$ (symbols have their usual meaning).
- (e) What do you mean by quasi particles? Give examples.
- (f) The golden colour of gold particle is lost in nano dimension. — Explain.
- (g) What are the key points of operation of a single electron transistor (SET)?

Group - B

Answer **any three** questions.

2. How can XRD measurements be employed to evaluate the average crystal size of small grains? What factors contribute to the broadening of XRD peak? 3+2
3. Why are the direct bandgap materials preferred over indirect bandgap materials for optoelectronic device application? 5
4. What are the basic differences between NEMS and MEMS? Give some of their applications. 2+3
5. Compare the two approaches (top-down and bottom-up) for the synthesis of nanoparticles. 5
6. Write short note on the operation and application of Atomic Force Microscope (AFM). 5

Please Turn Over

Group - CAnswer *any four* questions.

7. (a) What is meant by coulomb blockade?
 (b) Show that potential e/c is required to transfer a single electron across a tunnel junction.
 (c) Determine the energy of the coulomb barrier for an island of 5 nm diameter. (Assuming the capacitance of the island contact junction as 1fF). 2+6+2
8. (a) Obtain the expressions of density of states for bulk and 2D systems.
 (b) Show these graphically as function of energy and explain the formation of subbands. 6+4
9. (a) For a rectangular potential barrier

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

$$= 0 \quad \text{otherwise.}$$

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 principle of Scanning Tunneling Microscopy (STM) on the basis of electron transmission. 6+4
10. (a) Draw the schematic diagram and explain the operation of Scanning Electron Microscope (SEM).
 (b) Discuss the limitations of SEM in surface characterization of nanofilm or nanosurface. 7+3
11. (a) What are the reasons of surface defects in nanofilms? Discuss its effect on electronic conduction.
 (b) What are the different informations of a nanocrystal we can extract from the study of its absorption spectra?
 (c) What do you understand by photo luminescence (PL)? State its use. 4+3+3
12. (a) What is exciton? Discuss its stability. Distinguish between Wannier–Mott and Frenkel exciton.
 (b) Discuss the use of ion-beam lithography in nano-fabrication. 6+4
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