No. of Printed Pages : 6

MPHE–027

M. SC. (PHYSICS)

(MSCPH)

Term-End Examination

December, 2025

MPHE–027 : NANOSCIENCE

Time : 2 Hours *Maximum Marks : 50*

***Note** : (i) Attempt any **five** questions.*

(ii) Use of calculator is allowed.

(iii) Symbols have their usual meanings.

(iv) Marks for each question are indicated against it.

(v) Physical constants are given at the end.

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1. (a) Draw and describe the Density of States (DoS) of 0-, 1-, 2- and 3-D materials. 5

   (b) Calculate the surface energy for a nickel crystal for (100) plane. Ni has FCC structure with atomic radius 1.25 Å. The heat of vaporization is 380.7 kJ mol^{-1}. 5

2. (a) Describe the phenomenon of Ostwald ripening based on the solute concentration given by Thompson-Freundlich relation. 5

   (b) Explain the working of DC sputter deposition system. What is the advantage of RF sputtering system over DC sputtering system ? 4+1

3. Describe the steps for pattern generation using photolithography. Which radiations/beams are preferred for fabricating nanostructures ? 8+2

4. (a) For a single wall carbon nanotube that rolls on the chiral vector is $\vec{r} = n\bar{a}_1 + m\bar{a}_2$. Find out the chiral angle and diameter of the CNT with : 5

$$(n, m) = (5, 5)$$

(b) What are aerogels ? Describe the steps involved in the silica aerogel synthesis. 2+3

5. (a) Describe the features of Type II semiconductor @ semiconductor core-shell particles with the help of a band

diagram. How can longer wavelength optical tuning be achieved in Type II particle ? 4+1

(b) Give a brief description of excitons. Differentiate between Frenkel exciton and Mott-Wannier exciton. 3+2

6. (a) Describe any *five* uses of nanomaterials in sensors. 5

(b) Discuss any *five* uses of nanotechnology in healthcare sector. 5

7. (a) For a classical wall measurement setup let the voltage be applied along the x-direction, and the magnetic field along the z-direction. Depict how the wall resistivity ρ_{xy} and the longitudinal resistivity ρ_{xx} varies with magnetic field. 2

(b) What are the experimental conditions and material characteristics required to observe quantum Hall effect ? 4

(c) Explain how the Hall resistivity and longitudinal resistivity vary with magnetic field in integer quantum Hall effect and in fractional quantum Hall effect. Can these phenomena be explained on the basis of free electron theory ? 4

8. (a) What is photonic band gap ? How is it different from an electronic band gap ? Explain *one* application of a photonic band gap material. 5

(b) What is the blocking temperature for a super paramagnetic particle ? Draw a typical hysteresis loop for a super paramagnetic material and state its characteristics. 5

Physical constants :

$h = 6.62 \times 10^{-34}$ J-s

$k_B = 1.38 \times 10^{-23} JK^{-1}$

$c = 3 \times 10^8 ms^{-1}$

$\epsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1}

$m_e = 9.1 \times 10^{-31}$ kg

$N_A = 6.022 \times 10^{26}$ $kmol^{-1}$

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