This question paper contains 3 printed pages.

6994 *Your Roll No*

M.Tech. / II Sem. **J**

NANOSCIENCE AND NANOTECHNOLOGY

Paper NSNT-204— Synthesis and Characterization of Nanomaterials

Time 3 hours *Maximum Marks* 38

(Write your Roll No on the top immediately on receipt of this question paper)

Question No 1 is compulsory

Answer any four from the remaining questions

1 Answer any five questions. Each question carries 2 marks

(a) How does the electron gun used in a Scanning electron microscope (SEM) and transmission electron microscope (TEM) produce a beam of monochromatic electrons? How is the filament current related to the beam current?

(b) How do you measure the barrier height using a scanning tunneling microscope?

(c) Draw an analogy between layered solids and graphite What is graphene?

(d) Preparation of cobalt aluminate from CoO and Al_2O_3 requires a reaction temperature of 1200°C. How could the reaction temperature be lowered?

(e) Diamond and indium antimonide (InSb) are both insulators, with band gaps (between the highest energy filled band and lowest energy empty band) of 5 5 eV and 0.15 eV respectively Are both materials transparent to visible light?

(f) Show that the spacing of (hkl) planes in real space is connected with the hkl reciprocal lattice vector length by $\mathbf{d}_{hkl} = 2\pi/|\mathbf{G}_{hkl}|$ $5\times2=10$

2 (a) The powder X-ray diffraction pattern of $LiSrH_3$ shows the following reflections 2θ = 23 25, 40.84, 47.53. 53 56, 69 49, 74 38 Index the data, determine the lattice type and lattice parameters

Turn over

(b) How are the bright field and the dark field images recorded using the transmitted and the diffracted electrons in a transmission electron microscope?

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3 (a) Explain in detail the methods of preparing porous solids citing suitable examples

(5 marks)

(b) What are the different manipulation modes of STM to manipulate adatoms for nanolithography

(2 marks)

4 (a) How are carbon nanotubes synthesized?

(b) What are the different imaging modes in an atomic force microscope (AFM)? Identify the region of operation for the different modes using a force – distance curve

7

5 (a) What are Phase transfer catalysts Discuss their role in nano particles synthesis

(3 marks)

(b) Metals damp intensity of light in a short distance Using the following electromagnetic wave equation, establish the relation between the damping (κ) constant and the dielectric constant ($\varepsilon(w)$)

$$C^2 \frac{\partial^2 E_x}{\partial z^2} = \varepsilon \frac{\partial^2 E_x}{\partial t^2} + \frac{\sigma}{\varepsilon_0} \frac{\partial E_x}{\partial t}$$

where E_x is the x component of electric field strength, ε is the dielectric constant, σ is the ac conductivity and ε_o is permittivity of empty space

7

6 (a) What are structure directing agents (SDA)?

(2 marks)

(b) Give examples of cationic and anionic surfactants

(2 marks)

(c) What are the effects (both elastic and inelastic) produced by electron bombardment on a thin specimen? Use a schematic diagram to show the interaction volume for various electron specimen interactions.

(3 marks)