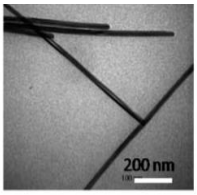
Topics in Nanoscience

Assignment-1-24

1. Define nanomaterials. (2)

2. Mention one application for each of the following cases. Also, name the nanomaterial's characteristics/properties that are utilized in the applications.
   (i) Metal-organic framework (FOM).
   (ii) An organic nanomaterial used in agriculture. (4+4)

3. Write the conventional names used to identify the following nanoparticles as shown in the TEM image. (2)



4. Differentiate Quantum Dots from Quantum Wells. (4)

5. "Organic pigment molecules used in dyeing textiles bleach when exposed to the sun while the glittering colors of peacock feathers do not." Explain. (3)

6. For a spherical particle of radius R (in nm), calculate (i) the surface area to volume ratio and (ii) the approx. ratio of surface atoms (N_s) to total atoms (N_v) is given by $\approx 1/R$. (2+3)

   Based on this, calculate approx. how many atoms will be at the surface of a spherical particle of radius, 5 nm, having a total of 8,000 atoms. At what size would one expect the proportion of surface atoms to be 100%? (2+2)

7. Surface is abundant, but why do the surface effects become dominant in determining the material properties in the nanomaterials? (4)

8. (a) How is hydrophobicity of a surface usually determined experimentally? (2)
   (b) Define "superhydrophobic" and "ultrahydrophobic" surfaces. (4)

9. "*CA hysteresis on hydrophobic surfaces increases with increasing surface roughness in the low-roughness region but drastically decreases when the roughness becomes large and the composite configuration, in which the liquid does not penetrate the asperities.*" Provide an

explanation for the above observations. (5)

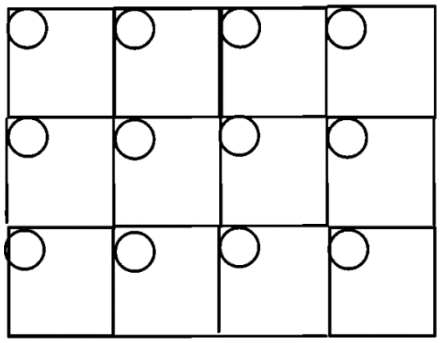
10. Compare the CA hysteresis and roll-off angle (α) values according to the Wenzel state and Cassie–Baxter state. Give justification. (4)

11. A silicon surface is patterned to have cylindrical pillars of diameter *d* and height *h* placed a distance *s* apart in a square array (see the Fig. below). The surface is slightly oxidized so as to have a contact angle of 50°.

(a) Find the roughness factor *r* and the fractions f_1 and f_2 of the Cassie-Baxter equation in terms of *d*, *h* and *s*.

(b) Find the apparent contact angle of the surface according to the Wenzel and Cassie-Baxter equation under the following conditions (i) as oxidized silicon (ii) surface coated with PTFE to give a contact angle of 114°.

(c) What is the critical contact angle to make the surface superhydrophilic if $d = 50\ \mu$m, $h = 10\ \mu$m and $s = 150\ \mu$m. (6+8+2)



12. Mention two unique properties of magnetic nanomaterials and mention one application for each. (4)

13. Compare SPR and LSPR? (4)