Selected Topics in Nanosciences

Assignment_3_21

Q.1. Define "intensive properties". Mention three intensive properties that do not obey the definition in nanomaterials. (1.5+15)

Q.2. Mention two broad features that arises from the small sizes of nanomaterials and mainly give rise to unique properties of nanomaterials. (2)

Q.3. When do the size effects begin to appear in materials? (3)

Q.4. Why do the surface-interface effects play a great role in determining the material properties in the nanomaterials unlike bulk materials? (2,2,2)

Q.5. Calculate the percentage of surface atoms in close-packed full-shell cluster having 4 shells. Show the steps of calculations. (3)

Q.6. (a) For a spherical particle of radius *R*, derive an expression for: (i) the surface area to volume ratio and (ii) the ratio of surface atoms (N_s) to total atoms (N_v). (Show the steps of calculations and assume the radius of an atom is *r*.)
(b) Show that for a gold nanoparticle (Au atomic radius = 0.179 nm), the ratio of surface atoms (N_s) to total atoms (N_v), i.e., $N_s/N_v \approx 1/R$ (when R, the particle radius, is given in nm unit).
(c) Based on this, calculate how many atoms will be at the surface of a spherical particle of radius, 5 nm, having around 8,000 total atoms. (1,3+2+1)

Q.7. Although frying pan made of aluminium metal are safely used for everyday cooking, fine powder of aluminum metal is used as fuel for rocket engines. How can you justify it? (3)

Q.8. What happen to the melting temperature and the solubility of the nanoparticles when their size decreases? Briefly justify your answers. (2,4)

Q.9. What is Sintering (Firing) and how is it related to nanoscience? (3)

Q.10. Define and explain the phenomenon, *Ostwald Ripening*. (3)

Q.11. What is meant by a "superhydrophobic self-cleaning surface"? Write down the conditions in terms of the dynamic contact angles and the roll-off angles. (4)

Q.12. How does the Cassie-Baxter model differ from the Wenzel model to explain the superhydrophobicity of a surface? (6)

Q.13. (a) A surface is patterned so as to have square pillars s μm on the side and h μm high placed d μm apart in a square array. Derive expressions for *r (roughness factor)*, f_1 and f_2 in terms of s, h and d.

(b) If the contact angle for the flat surface is measured to be 114°, find the apparent contact angle for the patterned surface according to the Wenzel and the Cassie-Baxter equations. For the Cassie-Baxter equation, assume that the liquid covers the top surfaces of the pillars completely. Comment on how the hydrophobicity changes with the same surface. Given: s = 50 μm, h = 10 μm and d = 150 μm. (3+3,2)

Hints: r = (surface area of the top of the pillars + surface area of the open sides of the pillars + surface area of the remaining substrate)/projected area

Wenzel theta = 116^o

Cassie-Baxter theta = 159.6^o