Assignment 2_21 Topics in Nanosciences

Q.1. Describe the Turkevitch method of gold nanoparticles synthesis. Write down the chemical names of the precursors used in the gold nanoparticle synthesis reaction. [2,1,1]

Q.2. Describe a method to produce group 6 transition metal nanoparticles. Write down the chemical names of the precursors and the chemical equation for the typical reaction showing the metal nanoparticle formation. [3]

Q.3. (a) For a seed-mediated synthesis (growth) of gold nanoparticles, what kind of reducing agent – strong or weak – will one use and why?
(b) Give an example of such a reducing agent. [2+1]

Q.4. If you are given the precursor, $Fe(CO)_5$, what kind(s) of methods of synthesis will you adopt to prepare nanostructured Fe? Why? [1+1]

Q.5. What are SAMs? Discuss the principles of formation of SAMs. Mention two applications of SAMs. [1+1+1]

Q.6. Describe a method of synthesis of controlled sized CdS nanoparticles. [3]

Q.7. Suggest ways to prepare monomers in the following cases to form:
(a) Au nanoparticles from the precursor $HAuCl_4$.
(b) Fe_3O_4 nanoparticles from suitable Ferrous/Ferric salts precursors. [2+2]

Q.8. Why is the synthesis of uniformly sized and shaped nanocrystals being critical? [3]

Q.9 (a) Define monodisperse nanoparticles. [2]
(b) When the single nucleation event is almost impossible to achieve, mention (the steps) how one can control the particle size and prepare monodisperse (narrow size distribution) nanocrystals. [4]

Q.10. Discuss how one can prepare smaller nanoparticles out of a given quantity of (monomer) precursor. Use an appropriate equation to justify your answer. [2]

Q.11. Draw a schematic LaMer plot and discuss briefly what happens in each of the three stages along both the x- and y-axes. [3+3]

Q.12. Show that for spherical isotropic nanoparticles, the growth rate is independent of the actual particle size in the so-called reaction-controlled regime.

Q.13. The growth rate of spherical isotropic particles *under diffusion-controlled regime* is given by

$$\dot{r} = \frac{2\gamma_{NL} V_m^2 D C_0}{RT} \cdot \frac{1}{r}\left(\frac{1}{r^*} - \frac{1}{r}\right)$$

where the terms bear their usual significance.

(a) Draw a plot of the diffusion-controlled growth rate $\dot{r}$ as a function of the particle size *r (critical size r*).*

(b) Discuss the major features of the growth rate function for understanding the size distribution control mechanism. [2+2,2,2]

Q.14. The nanocrystal size evolution goes through the regimes of distribution focusing, then defocusing, and finally Oswald ripening. Under these circumstances, how is it possible to grow monodisperse colloidal nanocrystals? [10]

Q.15. Given that a hemispherical cap-shaped β phase nucleates from α phase on the planar surface of a foreign body δ. For this nucleation, determine the free energy barrier, $\Delta G(r)^*$, in the cases of: (i) complete affinity and (ii) complete non-affinity between the nucleating particle and the surface of the foreign body. Write down the physical significance of your mathematical derivations in each case. (3,3)

Q.16. (a) What are the roles of the capping agents in the colloid chemical synthesis of nanocrystals? [2]

(b) Discuss how one can obtain an octahedron-shaped nanoparticle by starting with a symmetrically truncated octahedron (fcc) seed crystal and a capping agent. [4]

Q.17. Mention the required criteria if one wishes to prepare an epitaxial (a) 2D layer-by-layer growth and (b) island growth of the deposit on substrates. [2+2]

Q.18. Discuss the influence of the diffusion on the growths of (a) spherical particles, (b) particles with corners present as the result of faceting, (c) and rod-shaped nanoparticles. [2+5+3]

Q.19. Describe the principles that one may apply for the formation of a pentapod nanoparticle. [4]