TIME: 45 min

MAX. MARKS: 60

Roll No.: ....

....

Q1. State whether the following statements are true or false: [1×5]

a) The purple color of 20 nm in diameter gold particles dispersed in SiO_2 arises due to their localized surface plasmon resonance. ....

b) Plasmonic metal nanoparticles-enhanced fluorescence will be maximum when the fluorescent molecule is in contact with the particle surface. ....

c) Spherical plasmonic nanoparticles of size smaller than the incident wavelength absorbs no light if $\varepsilon''_{metal} = 0$. ....

d) In 3d transition elements, mainly the scattering of 4s electrons into the many 3d-states present at the Fermi level gives rise to considerable resistance. ....

e) Superparamagnetic particles will show zero coercivity under all conditions. ....

Q2. Choose appropriate word from the following word bank and fill in the blanks. [1×5]

Word Bank: (*enhanced, scattered, quenched, exterior, absorbed, interior, proximity*).

a) A homogeneous local field builds up in the .... of the nanoparticle, while a dipolar field is produced at the ...., resulting in the enhancement of the nearfield in the immediate vicinity of the nanoparticles.

b) In contact with plasmonic particles, fluorescence of a fluoroprobe gets ....

c) In plasmonic particles, the .... light is converted to heat and can be used for hyperthermia while the .... light can be used to detect the location of the particle.

Q3. Mention three important length scales for magnetic phenomena at nanoscale in ferromagnetic crystals. [3]

Q4. If you have both spherical and star-shaped gold nanoparticles, which one will you prefer as Raman substrate (under identical conditions) for a Raman scatterer? Why? [3]

Q5. What happens to the LSPR spectra (light absorption/scattering intensity, bandwidth, and wavelength of maximum absorption) when silver nanoparticles undergo aggregation? Explain with the help of a schematic diagram. [4]

Q6. Comment on the major causes of origins of colors in two classes of inorganic nanoparticles that have very large molar extinction coefficients compared to organic dyes. [3]

Q7. Define aspect ratio and state its effect on the longitudinal mode of LSPR. [1+1]

Q8. Draw a (schematic) plot of intensity of LSPR band of silica-silver core-shell particles as a function of amount of $HgCl_2$ added. Explain the behavior. [4]

Q9. Name four metals and one metal oxide that show ferromagnetic properties. [4]

Q10. Mention two applications of magnetic nanosystems. [2]

Q11. How are the calculations of magnetoresistance (MR) efficiency different from that of giant magnetoresistance (GMR)? [4]

Q12. The absorption coefficients of human (aorta) tissue and of water as a function of the excitation wavelength are shown. Based on it, predict at least two types of gold nanoparticle systems that will be better suited for the photoinduced hyperthermia studies of human tissue. Justify your answer. [2+2]
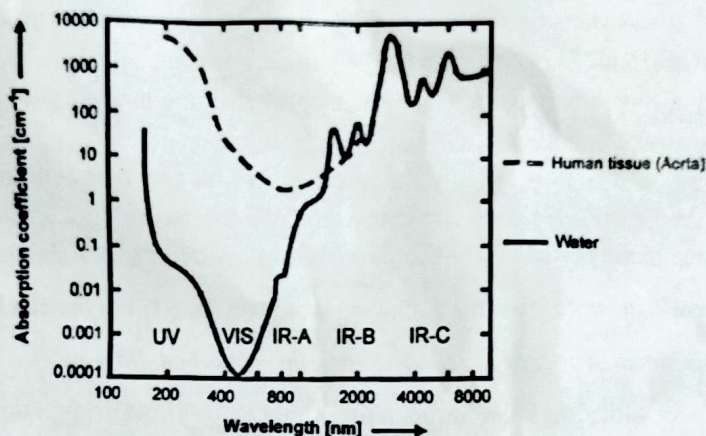
Figure. Absorption-coefficients of water and a typical human tissue (aorta) as a function of wavelength. The suitable region for optical excitation is between 650 and 1000 nm.

Q13. Mention different types of magnetoresistances observed. [5]

Q14. Compare spin-valve with pseudo-spin-valve GMRs. [4]

Q15. Calculate the value of the ε_1, real part of the dielectric constant, of the plasmonic metal when it shows localized surface plasmon resonance in water medium with refractive index, 1.33. [4]

Q16. Compare the absorbance values of gold nanoparticles in water and blood (with refractive index, 1.4). [4]

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$C_{ext} = 0.2303\varepsilon_{ext}/N_A$

$h = 6.63 \times 10^{-34}$ J s $= 4.14 \times 10^{-15}$ eV.s

$c = 2.99 \times 10^8$ m.s^{-1}

$$C_{ext(abs)} = \frac{24\pi^2 R^3 \varepsilon_m^{\frac{3}{2}}}{\lambda} \frac{\varepsilon_2}{(\varepsilon_1 + 2\varepsilon_m)^2 + \varepsilon_2^2}$$

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