## Module 4 ( Lecture 9 and 10) :Optical Properties

***Problem :***

1. Where were Au nanoparticles used in ancient times? (Rose window of Cathedral of Notre Dame and Lycurgus Cup)
2. What is the difference in the color of bulk and nanosized Au? (bulk Au: yellow and nanosized Au: Red)
3. How sunscreen based on "Traditional" ZnO different from nanoscale ZnO sunscreen? (Traditional ZnO based sunscreen is white in colour while nanoscale based sunscreen is transparent)
4. How will the interaction of light with the material affect its colour? (the colour will depend on the photon of which colour is absorbed and which is transmitted)
5. What is luminescence? (electrons are excited across the gap and they may generate new photons by re-emission)
6. How is fluorescence different from phosphorescence? (fluorescence lasts << 1s while phosphorescence lasts for > 1s or more)
7. Based on energy bands explain why Be is a metal? (presence of half-filled 2p band)
8. What is the energy range of visible spectrum? (1.7-3.1 eV)
9. What is the energy gap for which the material appears black or metallic? (< 1.7 eV)
10. What is the energy gap for which the material appears transparent? (> 3.1 eV)
11. What is the reason for generation of trap states? (defects such as vacancies, local lattice mismatches, dangling bonds or adsorbates at the surface)
12. What is the degree of confinement in quantum well, quantum wire and quantum box? ($1^o$, $2^o$ and $3^o$)
13. What is the effect of size on band gap? (band gap increases with decrease in size)
14. Interaction of conduction band electrons induced by interaction with electromagmetic radiation is called _____. (surface plasmon)
15. What is the condition of dielectric constant for surface plasmon resonance? ($\varepsilon' = -2\varepsilon_m$)

16. What is the relation of plasmon frequency according to Drude model? ($\omega_p^2 = Ne^2/(m \varepsilon_o)$)

17. Plasmon resonance shifts to _____ frequency for longitudinal coupling and shifts to _____ frequency for transverse coupling. (lower, higher)

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### *Solution :*

1. Rose window of Cathedral of Notre Dame and Lycurgus Cup
2. bulk Au: yellow and nanosized Au: Red
3. Traditional ZnO based sunscreen is white in colour while nanoscale based sunscreen is transparent
4. the colour will depend on the photon of which colour is absorbed and which is transmitted
5. electrons are excited across the gap and they may generate new photons by re-emission
6. fluorescence lasts << 1s while phosphorescence lasts for > 1s or more
7. presence of half-filled 2p band
8. 1.7-3.1 eV
9. < 1.7 eV
10. > 3.1 eV
11. defects such as vacancies, local lattice mismatches, dangling bonds or adsorbates at the surface
12. $1^o$, $2^o$ and $3^o$
13. band gap increases with decrease in size
14. surface plasmon
15. $\varepsilon' = -2\varepsilon_m$
16. $\omega_p^2 = Ne^2/(m\ \varepsilon_o)$
17. lower, higher