# ENGINEERING CHEMISTRY

Department of Science and Humanities

# ENGINEERING CHEMISTRY

## Nanomaterials

***Class content:***

- ***Properties of Nanomaterials(contd.)***
  - ***Optical properties***
  - ***Electrical properties***
  - ***Mechanical properties***
  - ***Magnetic properties***
  - ***Applications***

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## Nanomaterials

### Optical Properties

- **Nanomaterials show unique optical properties**
- **Colour depends on the size of the particles**
  - Due to Surface Plasmon Resonance
  - Due to increase in band gap

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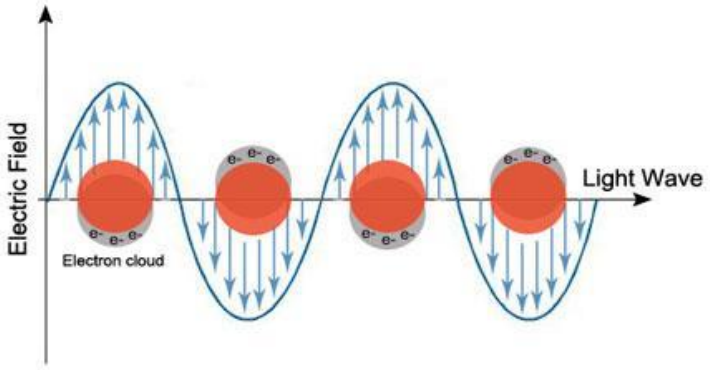
### Surface plasmon resonance (SPR)

- Metals have **positive lattice points** surrounded by a sea of electrons
- When radiation falls , the **surface electrons are polarised**
- These electrons oscillate with a frequency
- Collective oscillations of these electrons is called **Plasmons**
- When the plasmon frequency matches with the frequency of radiation falling, **resonance occurs** and radiation is absorbed and the material appears coloured
- **Plasmon frequency** depends on size, shape and nature of metal
- As size of nanoparticle changes, **colour changes**




Soiurce:https://www.cytodiagnostics.com/pages/gold-nanoparticle-properties

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### Increase in Energy gap

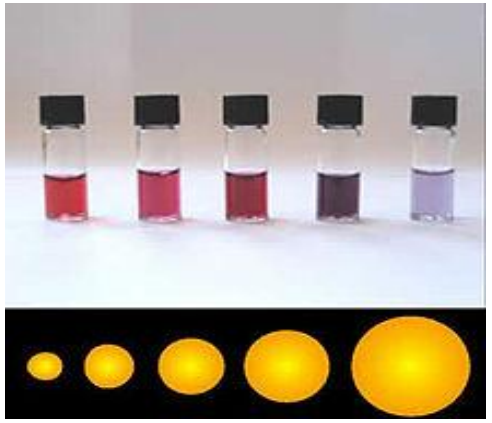
- Increases in energy gap between the **valence band and conduction band**
- As size of nanoparticles decreases the energy gap increases and the **wavelength of light absorbed** moves towards smaller values . This is referred to as **'blue shift'**

eg. colloidal suspensions of gold nanoparticles :

Gold spheres of > 50 nm absorb at λ = 575 nm

Gold spheres of 10- 20 nm absorb at λ = 524 nm

Gold spheres of 2-5 nm absorb at λ = 517 nm



Source::https://en.wikipedia.org/wiki/Colloidal_gold

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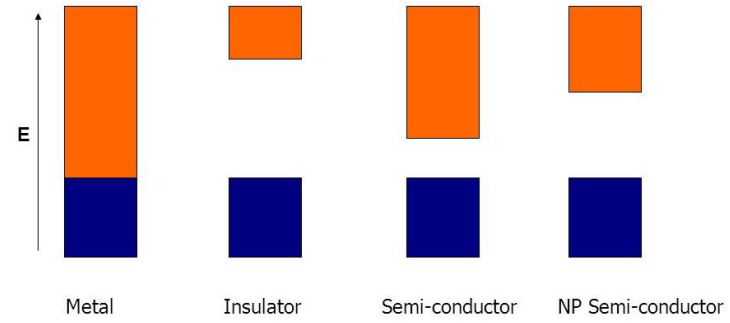
## Electrical Properties

**Electrical conductivity decreases for nanoparticles as compared to bulk material**

- **Due to spatial confinement**
  - The electronic bands in bulk material are continuous
  - In nano size materials the **electronic bands become discr**ete and the **band gap increases**
  - Some metals which are good conductors in bulk become semiconductors and insulators as their size is decreased to nano

Band gap increases as particle size decreases




Source:https://www.mknano.com/info-guide/what-are-nanoparticles.aspx

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- **Due to surface scattering**
  - Electrical conductivity decreases due to surface scattering
  - Electrons have a mean free path
  - If dimensions of the nanomaterial is smaller than the mean free path of the electron, **elastic or inelastic surface scattering** can happen
  - Elastic scattering will not affect conductivity but when inelastic scattering happens, the **scattered electron loses its velocity** and electrical conductivity decreases

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## Mechanical properties

### Strength of nanomaterials is greater than bulk material

- Mechanical properties may reach theoretical strength , which is **one or two orders of magnitude higher** than that of the bulk materials.

  e.g bending of bulk Cu happens readily but Cu particles < 50 nm are considered **super hard materials** that do not show same malleability and ductility as bulk Cu.

- The reason for this high strength is due to **reduced probability of defects** Large lattices in bulk materials have imperfections like **dislocations, kinks and vacancies** but for lattice with smaller cross-section, there is less probability of finding imperfections.

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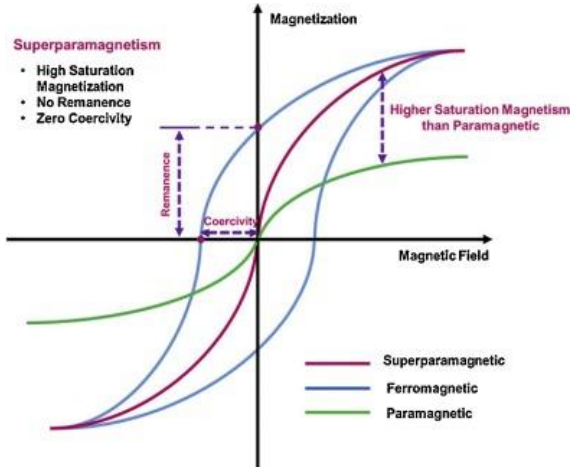
### Magnetic Properties

- **Magnetic properties of nanomaterials are distinctly different from that of the bulk materials**.
- In ferromagnetic materials like Fe,Co,Ni , **ferromagnetism changes to superparamagnetism** in the nanometer scale due to the high surface energy. The domains can flip directions . In the presence of magnetic field ,they get magnetised with high susceptibilities.




Source:https://www.sciencedirect.com/science/article/pii/S1674200116300852

- Bulk **gold and platinum** are non-magnetic but at the nanosize they act as magnetic particles

# THANK YOU

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