2.BASIC PRINCIPLES/PROPERTIES/FACTORS OF NANOMATERIALS

When the material size is reduced to nano scale then it exhibits different properties than the same material in bulk form.

- The factors that differentiate the nano materials from bulk materials are:
  (i) Quantum confinement
  (ii) Increase in surface area to volume ratio.

(i) QUANTUM CONFINEMENT

Quantum confinement is a quantum mechanical phenomenon that occurs when the motion of a particle is restricted to a small space, such as a nanoscale structure. This restriction causes the particle's energy levels to become discrete or quantized, instead of continuous.

- For example, when we apply the problem on particles in a potential well as well as in a potential box. The dimensions of such wells or boxes are of the order of de-Broglie wavelengths of electrons then their energy levels are changed. This effect is called Quantum Confinement.
- Quantum confinement significantly affects the optical, electrical & magnetic properties of nanomaterials.
- When electrons are confined, the particles will have more oscillations and this will result in the colour change of the materials.

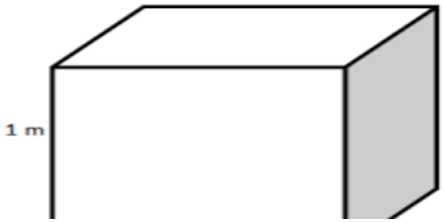
Example: Nano gold colloids are dispersed in ruby glass, the ruby glass exhibits red colour

- Quantum confinement comes when electrons and holes in a material are confined.
- to a potential well | Quantum well
- a) Quantum dot is a 0D confinement where particles are confined in all 3-dimensions.
- b) Quantum wire is a 1D confinement, where particles are confined in 2-dimensions and free to move along the third dimension.
- c) Quantum well is a 2D confinement where particles are confined in 1-dimension and free to move in other two dimensions.
- d) Bulk conductor is a 3D confinement, where particles are confined in 0-D.

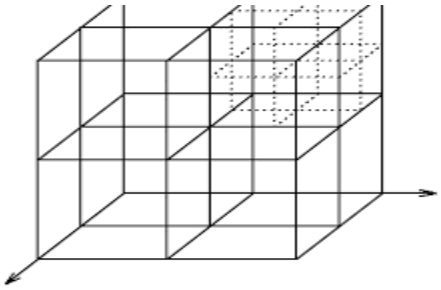
(ii) SURFACE AREA TO VOLUME RATIO

- The ratio of surface area of an object to its volume is known as surface to volume ratio.
- Nanomaterials have a large surface area to volume ratio when compared to bulk materials and it is a great measure for efficiency of nanotechnology.

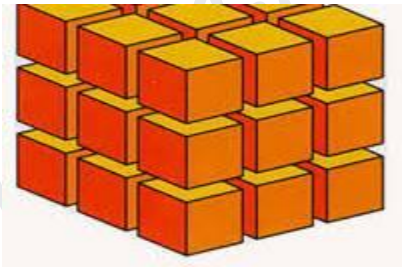
- Let us consider a sphere of radius 'r'. Then its
- Surface Area, SA = $4\pi r^2$
- Volume, V = $(4/3)\pi r^3$
- SA to V ratio = $(4\pi r^2) / (4/3)\pi r^3 = 3/r$
- Therefore, the SA to V ratio increases by decreasing the radius of the sphere.
- Examples: Let us consider a cube of surface area $6m^2$. When its V divided into 8 pieces its SA becomes $12m^2$. It means, when volume is divided into smaller pieces, the SA increases.



- cube with side 1m => SA= $6m^2$



- cube divided into 8 small cubes => SA= = $12m^2$



- cube divided into 27 small cubes => SA = $18m^2$
- By the above example ,we conclude that , due to increase in SA, more no. of atoms will appear at the surface, this makes nanomaterials more reactive.
- Thus reducing the dimensions of material affects the Reactivity, optical properties & magnetic properties.