Lecture number: 1

CLASS: MSc/BS (Final year Physical)

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**NANO CHEMISTRY**

**1. INTRODUCTION**

The prefix (nano) in the word nano chemistry means a billionth (1 x 10-9 m). Atoms are very small and the diameter of a single atom can vary from 0.1 to 0.5 nm. It deals with various structures of matter having dimensions of the order of a billionth of meter.

**2. BASICS OF NANOCHEMISTRY**

**a. Nanoparticles**

Nanoparticles are the particles, the size of which ranges from 1-50 nm. Generally, they are obtained as colloids.

\*\*The colloidal particles have a tendency to remain single crystal and hence are called as **nanocrystals.**

\*\*A large percentage of atoms in nanocrystals are present on the surface Nanocrystals possess **electronic, magnetic** and **opticalproperties.**

\*\*Since the nanoparticles exhibit an electronic behavior, governed by the quantum physics, they are also called as **quantum dots**.

**b. Nanomaterials**

Nanomaterials are the materials having components with size less than 100 nm at least in one dimension.

\*\*Nanomaterials, **in one dimension**, are layers such as a thin films or surface coatings.

\*\*Nanomaterials, in **two dimensions,** are tubes such as nanotubes and nanowires.

\*\*Nanomaterials, **in three dimensions,** are particles like precipitates, colloids and quantum dots.

**c. Nano chemistry (or) Nanoscience**

Nano science is defined as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales.

**d. Nanotechnology**

Nanotechnology is defined as the design, characterization, production and applications of structures, systems and devices by controlling size and shape at 10-9 m scale or the single-atomic level.

**3.DISTINCTION BETWEEN NANO PARTICLES, MOLECULES AND BULCK MATERIALS**

**a.Nanoparticles**

\*\*The size of nano particles is less than 100 nm in diameter, molecules are in the range of picometers.

\*\* Molecule is a collection of atoms; nano particles are collection of few molecules that is less than 100 nm.

\*\*Surface area of nano particles is more than the bulk materials.

\*\* Nano particles possess size dependent properties.

\*\*Strength of nano materials is 3 - 10 times higher than bulk.

\*\*Corrosion resistance of nano material is more than bulk.

\*\* Nano particles, due to its size, possess unexpected optical (visible) properties.

\*\* Nano particles possess lower melting point than the bulk materials.

**b. Bulk material**

\*\*Bulk materials are larger in micron size.

\*\* Bulk materials contain thousands of molecules.

\*\*Surface area of bulk material is less than the nano particles.

\*\*Strength of nano materials is less than nanomaterial.

\*\* Bulk materials possess constant physical properties.

\*\*Corrosion resistance of bulk is less than the nano materials.

\*\* Bulk materials possess higher melting point than the nano materials.

**EXAMPLES**

1. Gold nano particles appear deep red to black colour in solution compared to yellow colour with Gold.

2. ZnO nano particles possesses superior UV blocking property compared to bulk material.

3. Gold nanoparticles melt at lower temperature ((3000C)) for2.5 nm, but gold slab melts at 1064OC.

4. **PROPERTIES OF NANO-MATERIALS**

**1. Melting Points**

Nano-materials have a significantly lower melting point and appreciable reduced lattice constants. This is due to huge fraction of surface atoms in the total amount of atoms.

**2. Optical Properties**

Reduction of material dimensions has pronounced effects on the optical properties. Optical properties of nano-materials are different from bulk forms.

The change in optical properties is caused by two factors

**(i) The quantum confinement of electrons within the nano-particles increases the energy level spacing.**  
\*\*The optical absorption peak of a semiconductor nano-particles shifts to a short wavelength, due to an increased band gap.

**(ii) Surface plasma resonance, which is due to smaller size of nano-particles than the wavelength of incident radiation.**

\*\*The colour of metallic nano-particles may change with their sizes due to surface plasma resonance.

**3. Magnetic Properties**

Magnetic properties of nano materials are different from that of bulk materials. Ferro-magnetic behaviour of bulk materials disappear, when the particle size is reduced and transfers to super-paramagnetic. This is due to the huge surface area.

**4. Mechanical Properties**  
The nano-materials have less defects compared to bulk materials, which increases the mechanical strength.

1. Mechanical properties of polymeric materials can be increased by the addition of nano-fillers.
2. (ii) As nano-materials are stronger, harder and more wear resistant and corrosion resistant, they are used in spark plugs.Nano-crystalline carbides are much stronger, harder and wear resistant and are used in micro drills.

**5. Electrical Properties**(i) Electrical conductivity decreases with a reduced dimension due to increased surface scattering. However, it can be increased, due to better ordering in micro-structure. Polymeric fibres

(ii) Nanocrystalline materials are used as very good separator plates in batteries, because they can hold more energy than the bulk materials. Nickel-metal hydride batteries made of nanocrystalline nickel and metal hydride, require far less frequent recharging and last much longer.

**6. Chemical Properties**

Any heat treatment increases the diffusion of impurities, structural defects and dislocations and can be easily push them to the nearby surface. Increased perfection will have increased chemical properties.