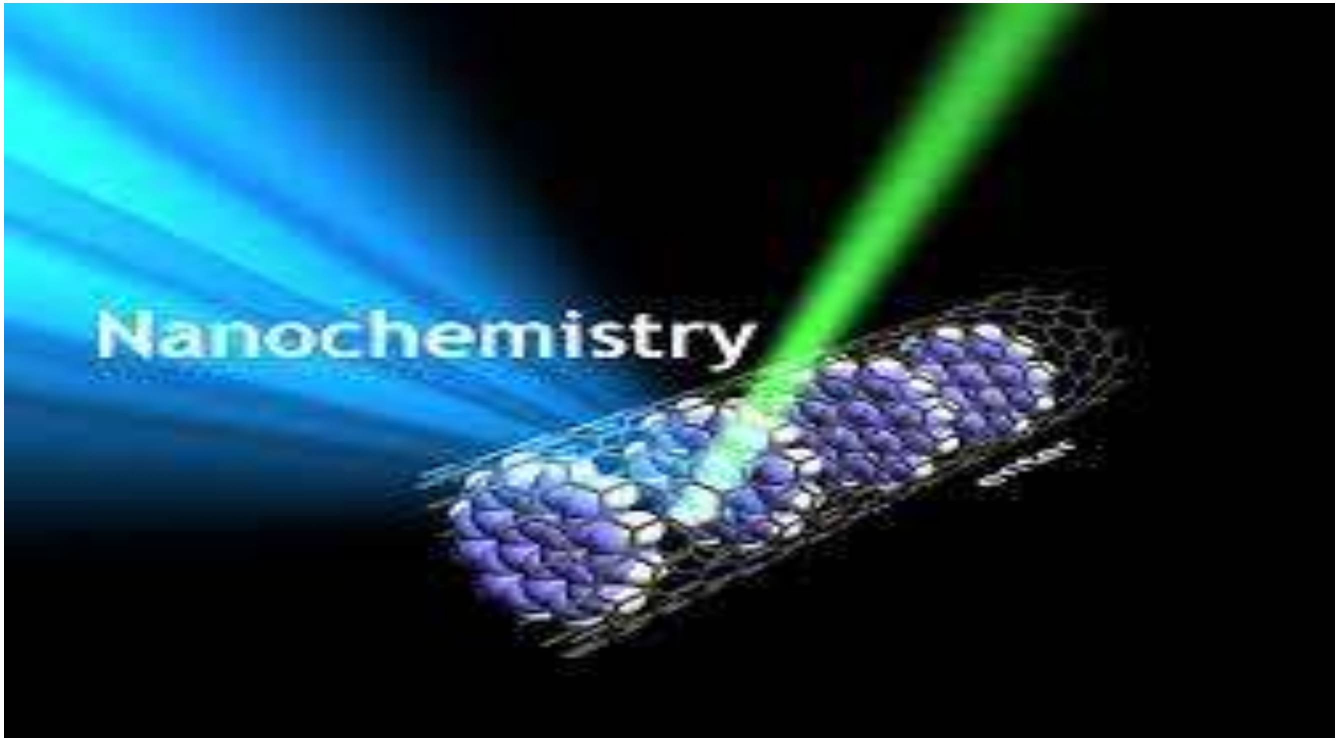
NANO CHEMISTRY



INTRODUCTION

The (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.

Definition: The manipulation of matter with at – least one dimension sized between **1 to 100 nanometers** (by National Nanotechnology Initiative)

A **Nanometre** is a unit of length in the metric system, equal to one billionth of a metre (10-9).

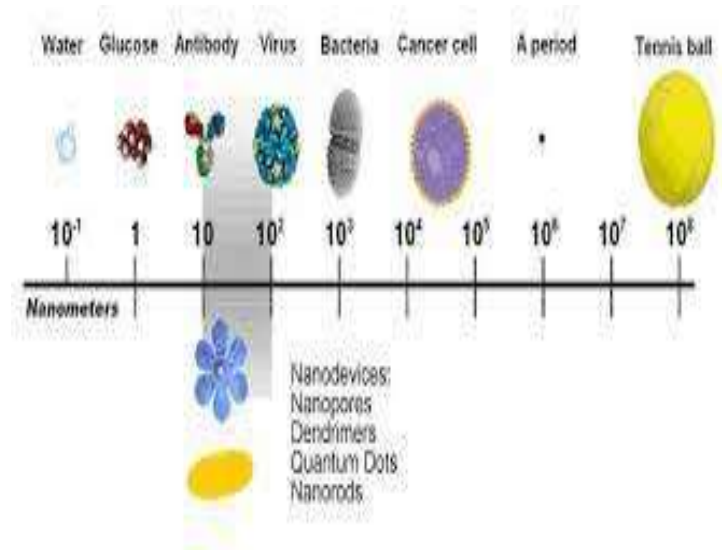
Defining Nanoscale

Cross section of human hair Nano - Dwarf

Nano size: 1 nm = 10-9Meter

Millimeter (mm) = 10-6 Meter

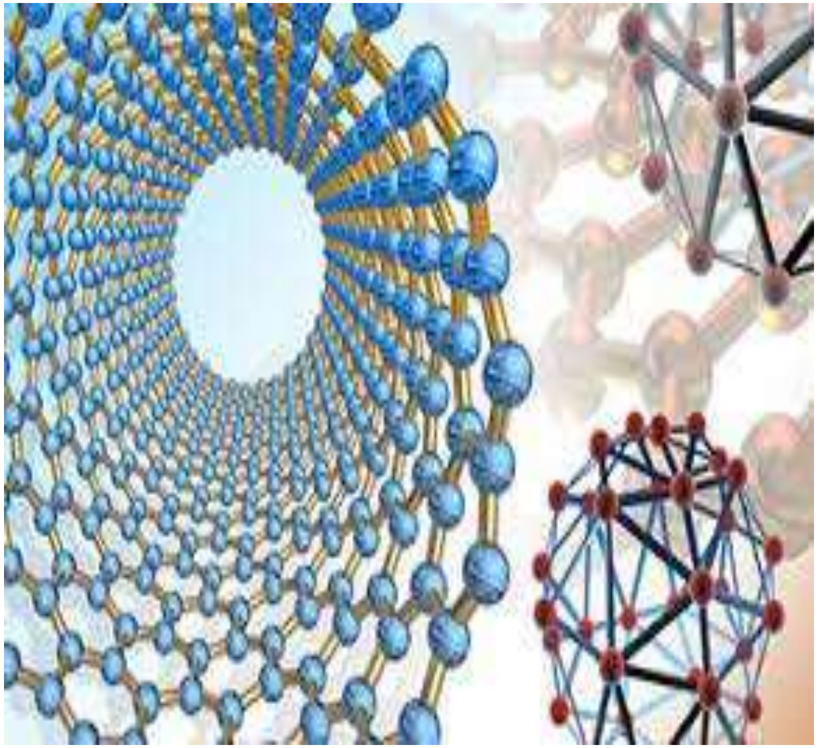
Combination of atoms or molecules to form objects of nanometer scale



BASICS OF NANOCHEMISTRY

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 nano crystals.
- A large percentage of atoms in nano crystals are present on the surface Nano crystals possess electronic, magnetic and optical properties. Since the nanoparticles exhibit an electronic behavior, governed by the quantum physics, they are also called as quantum dots.



Nanochemistry (or) Nanoscience

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

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.

DISTINCTION BETWEEN NANO PARTICLES, MOLECULES AND BULK MATERIALS

- The size of nano particles are less than 100 nm in diameter, molecules are in the range of picometers, but bulk materials are larger in micron size.
- Molecule is a collection of atoms, nano particles are collection of few molecules that is less than 100 nm but bulk materials contains thousands of molecules.
- Surface area of nano particles is more than the bulk materials.
- Strength of nano materials is 3 - 10 times higher than Nano particles possesses size dependent properties, but bulk materials possess constant physical properties.
- Corrosion resistance is more than the bulk materials, hence localised corrosion in nano materials is stopped.
- Behavior of bulk materials can be changed, but cannot enter inside the nano particles.
- Nano particles, due to its size, possess unexpected optical (visible) properties.

Examples

❖ Gold nano particles appear deep red to black colour in solution compared to yellow colour with Gold.
❖ ZnO nano particles possesses superior UV blocking property compared to bulk Material.

- Nano particles possesses lower melting point than the bulk materials. Gold nanoparticles melt at lower temperature (300 ^{0}C) for 2.5 nm, but Gold slab melts at 1064 ^{O}C.
- Sintering of nano particles takes place at lower temperature and in short time than the bulk materials.
- Electrical properties, resistivity of nano particles are increased by 3 times.
- Suspension of nano particles is possible, because nano particles possess high surface area, but bulk materials cannot.
- The wear resistance of nano particles are 170 times higher than the bulk materials.

Synthesis of Nanomaterials :

There are two general approaches for the synthesis of nanomaterials as

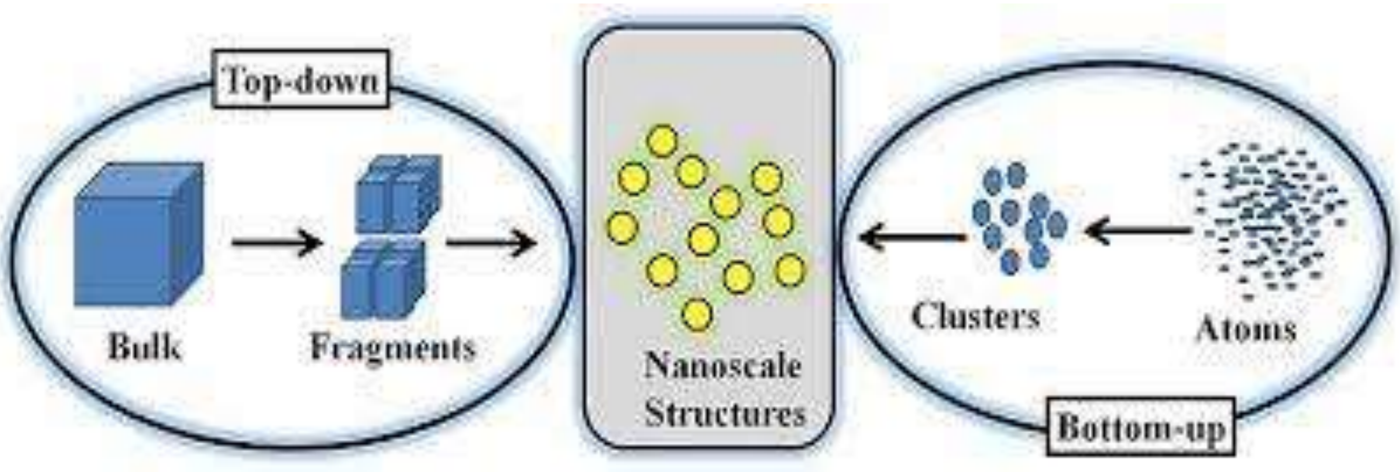
a) Top- down approach b) Bottom–up approach.

Top- down approach:

- In this approach, nanoscale devices are created by using larger, externally-controlled devices to direct their assembly.
- The top-down approach often uses the traditional workshop or micro- fabrication methods in which externally-controlled tools are used to cut, mill and shape materials into the desired shape and order.
- Attrition and milling for making nanoparticles are typical top-down processes.

Bottom-up Approach:

- In the bottom-up approach, molecular components arrange themselves into more complex assemblies atom-by-atom, molecule-by-molecule, cluster-by cluster from the bottom (e.g., growth of a crystal).
- Molecular components arrange themselves into some useful conformation using the concept of molecular self-assembly.
- For example, synthesis of nanoparticles by colloid dispersions.



Nanoparticle characterization is necessary to establish understanding and control of nanoparticle synthesis and applications.

Characterization is done by using a variety of different techniques like:

1. Scanning Tunneling microscope (STM)
2. Atomic force microscopy (AFM)
3. Electron microscopy (TEM, SEM)
4. Dynamic light scattering (DLS)
5. Fourier transform infrared spectroscopy (FTIR)
6. Ultraviolet-visible spectroscopy
7. Nuclear magnetic resonance (NMR)