BASIC PHYSICS BEHIND THE SIZE DEPENDENT PROPERTIES OF NANOPARTICLES

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Introduction

- Physical and chemical properties of the substance are studied under normal conditions.
- From the knowledge of those properties, we can say about the substance whether it is a good material or not when good material or not when building a new material.
- When the properties of a substance are measured, they are actually collective properties and are not looking at the and are not looking at the behavior of the individual atoms or molecules.
- These properties are always assumed to be constant for a given substance. Further the properties for a large number of properties for a large number of particles are assumed to be true for any size group of particles.

- When we study chemistry we deal with atoms and molecules and the realm of matter of dimensions generally less than dimensions generally less than one nanometer (atomic scale).
- When we study condensed matter physics, we deal with solids of an infinite array of bound atoms or molecules of atoms or molecules of dimensions greater than 100nm (micro scale).

Nanoparticles : A small world

At the nanoscale, the microscopes we use to study the properties are

Scanning Tunneling Microscopes or Atomic Force Microscopes.

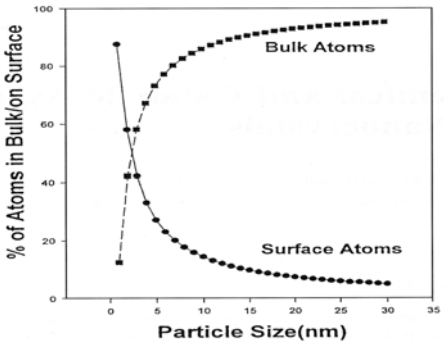
Surface Area :

- The nanostructures of a particular mass or particular volume have a much higher surface area when they are flat or elongated in shape.

Forces in nature : Gravitational Force
Electromagnetic Force
Weak Nuclear Force
Nuclear Force

Most important force at nanoscale level
Electromagnetic Force

Van der waal's force
weak force and becomes significant only at a very short distance



The increasing proportion of surface atoms with decreasing particle size compared with bulk metals makes small metal particles become highly reactive catalysts.

VERY IMPORTANT PROPERTY
Surface Area to Volume Ratio

Melting Point :

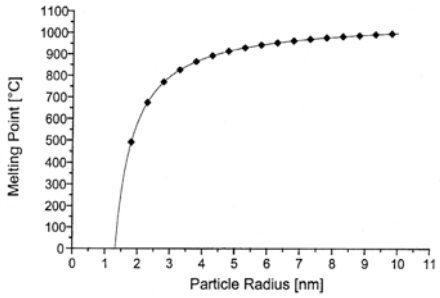
- **For free nanoparticles, the melting temperature is always lower than the bulk value.**

The melting point of nanosized solids should decrease because the binding energy decreases as material reaches nanometer dimensions.

Specific Heat :

- **The nanoparticles exhibit enhanced specific heat as compared to the bulk material except at low temperatures.**
- **Debye- Sommerfeld Model : $C_v = \gamma T + BT^3$**

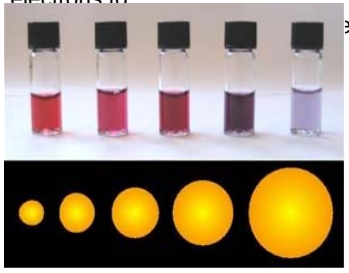
specific heat increases with decrease in the particle size



Color :

- **Clusters of nanoparticles of different sizes will have different colors.**

Collectively for a material, individual energy levels and energy level separations will be dependent on the size of the clusters, which therefore affect the energies needed for the transitions of electrons to



ent sizes will therefore have different absorption spectra

Conclusions:

- **Due to small mass of the nanoparticles, the gravitational force is neglected.**
- **Quantum mechanical descriptions may be required to understand selected characteristics and properties.**
- **Important property associated with nanoparticles is very large surface area to volume ratio.**

References :

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2.Introduction to Nanotechnology by Charles P.Poole Jr. and Frank J.Owens (Wiley Interscience (2003)).
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