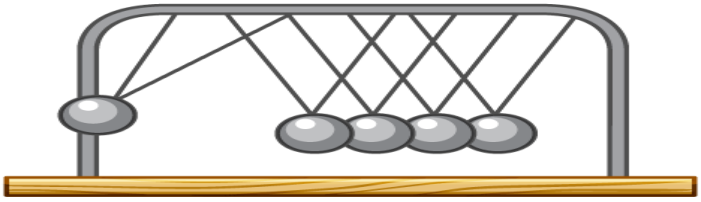
in the same material one can get arrange of properties . For example consider a semiconductor like CdS , which is normally reddish in color . If one brings down the particle size (i.e. diameter) of CdS to say(10 nm) , its But below about(6 nm (6nm)size a dramatic . powder still has red color change occurs in the optical properties of CdS . As illustrated in the photograph the color of (4 nm) size particles is orange , (3 nm) size particles is yellow and that of (2 nm)size particles is white .

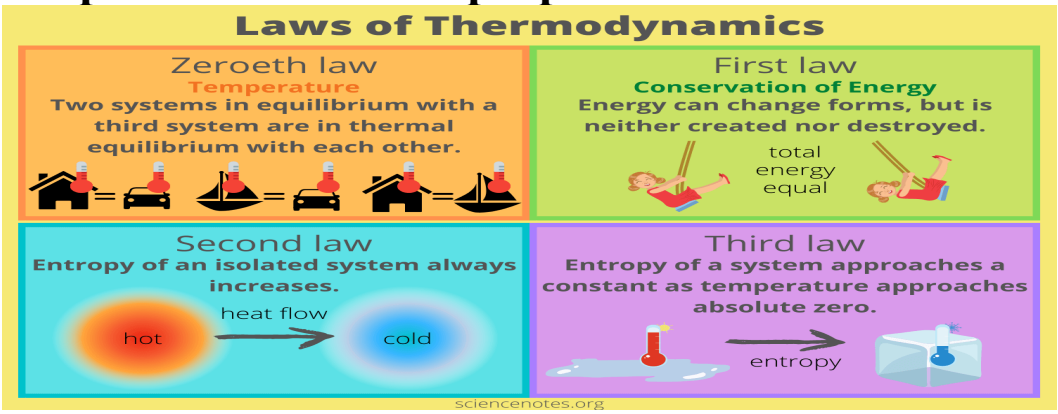
ox 4: CdS Nanoparticles (Colour Change with Particle Size)



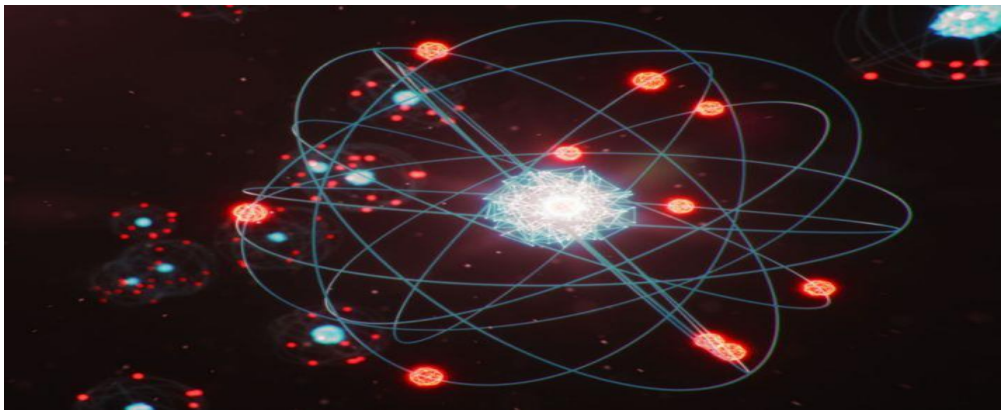
Not only the visual appearance but other properties also change dramatically .Therefore by changing the particle size of a material. one can achieve arrange of properties.
In Nanotechnology we are concerned with natural and synthetic materials in the size range of 1-100 nm .
At such a small size , very family are classical, Newtonian mechanics (Classical mechanics applies only to macroscopic objects. It is a physical theory that describes the motion of objects such as projectiles, machine parts, spacecraft, planets, stars, and galaxies. It also covers gravity, pressure, dynamic equilibrium, conservation of energy, and conservation of momentum.)



or thermodynamics (Thermodynamics explains the properties of materials by studying the relationship between heat, energy, and work. It helps us understand how the states of matter change as conditions change. Its fundamental principles, such as the conservation of energy and entropy, enable us to understand properties such as temperature, pressure, and density, and how they change within a system.) are not able to explain the observed properties of materials .



We have to use quantum mechanics sometimes (Quantum mechanics is a branch of physics that describes the behavior of matter and energy at the smallest scales, such as atoms and subatomic particles (electrons and photons). Quantum mechanics deals with non-trivial, probabilistic behavior based on "quantums," the specific units of energy or matter. Its fundamental principles include wave-particle duality, where particles sometimes behave as waves and sometimes as particles, as well as quantum phenomena such as quantum superposition and quantum tunneling.)directly and sometimes through subjects like solid state physics or chemistry which use it to explain the properties and phenomenon of different materials.



Box 1.1: Historical Milestones in the Development of Quantum Mechanics

Pre-quantum Era

- In 1669, Newton proposed that light had corpuscular or particle nature.
- Huygen claimed in 1690 that light had a wave nature.
- Kirchoff and others studied black body radiation around 1860.
- Maxwell proposed (1873) theory of electromagnetic waves.
- In 1803–04 Young performed double slit experiment, which showed that light had a wave nature.
- In 1887, Heinrich Hertz produced and detected electromagnetic radiation.

Old Quantum Theory Period

- In 1901, Max Planck showed that energy distribution in black body radiation could be explained properly only if one considered that the radiation was quantized or had a particle nature.
- In 1905, Einstein proposed a theory of photoelectric effect which decisively proved that quantum or particle nature was associated with electromagnetic waves.
- Compton effect (1920) could be explained only when particle nature of electromagnetic radiation was considered, supporting Max Planck's and Einstein's theories. Particles of electromagnetic waves were identified as 'photons'.
- De Broglie (1923) argued that if electromagnetic waves were particles (photons) then why not particles have waves associated with them?
- Bohr's atom model (1913) with stationary states (why electrons should have some fixed energies) could be explained with de Broglie hypothesis.

Box 1.1 (continued)

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Modern Quantum Theory Begins

- Heisenberg introduced (1925) Matrix Mechanics.
- Schrödinger equation (1926) gave the firm foundation for de Broglie hypothesis and later explained the electronic structure of atoms, molecules and solids.
- Davisson and Germer showed in 1927 that electrons can be diffracted. Regularly spaced atoms constitute multi-slit analogue of Young's double slit experiment.
- Heisenberg proposed uncertainty principle in 1928.

This marks the beginning of Quantum Mechanics as it is practiced now!