علم النانو في الفيزياء الطبية

Nanoscience in Medical Physics

LECTURE ONE

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Metric System

The Metric System is an international decimal system of weights and measures, based on the metre for length and the kilogram for mass, that was adopted in France in 1795 and is now used in almost all countries. The historical development of these systems culminated in the definition of the International System of Units (SI), under the oversight of an international standards body.

The historical evolution of metric systems has resulted in the recognition of several principles. Each of the fundamental dimensions of nature is expressed by a single base unit of measure. The definition of base units has increasingly been realised from natural principles, rather than by copies of physical artefacts. For quantities derived from the fundamental base units of the system, units derived from the base units are used–e.g., the square metre is the derived unit for area, a quantity derived from length. These derived units are coherent, which means that they involve only products of powers of the base units, without empirical factors. For any given quantity whose unit has a special name and symbol, an extended set of smaller and larger units is defined that are related by factors of powers of ten. The unit of time should be the second; the unit of length should be either the metre or a decimal multiple of it; and the unit of mass should be the gram or a decimal multiple of it.

Metric systems have evolved since the 1790s, as science and technology have evolved, in providing a single universal measuring system. Before and in addition to the SI, some other examples of metric systems are the following: the MKS system of units and the MKSA systems, which are the direct forerunners of the SI;

the centimetre–gram–second (CGS) system and its subtypes, the CGS electrostatic (cgs-esu) system, the CGS electromagnetic (cgs-emu) system, and their still-popular blend, the Gaussian system; the metre–tonne–second (MTS) system; and the gravitational metric systems, which can be based on either the metre or the centimetre, and either the gram(-force) or the kilogram(-force).

Metric Measuring Devices

1	kilometer	(km)	$=10^{3}$m
1	decimeter	(dm)	$=10^{-1}$m
1	centimeter	(cm)	$=10^{-2}$m
1	millimeter	(mm)	$=10^{-3}$m
1	micrometer	(μm)	$=10^{-6}$m
1	nanometer	(nm)	$=10^{-9}$m
1	angstrom	(Å)	$=10^{-10}$m
1	picometer	(pm)	$=10^{-12}$m
1	femtometer	(fm)	$=10^{-15}$m

International Decimal System of Measures

Nano or Nano-Metre

Nano (symbol n) is a unit prefix meaning "one billionth". Used primarily with the metric system, this prefix denotes a factor of 10^{-9} or 0.000000001. It is frequently encountered in science and electronics for prefixing units of time and length. One nanometer is about the length that a fingernail grows in one second.

Nano-Material

Nanoscale materials are defined as a set of substances where at least one dimension is less than approximately 100 nanometers. A nanometer is one millionth of a millimeter – approximately 100,000 times smaller than the diameter of a human hair. Nanomaterials are of interest because at this scale unique optical, magnetic, electrical, and other properties emerge. These emergent properties have the potential for great impacts in electronics, medicine, and other fields.

The effect of reducing the size on the material properties

The material properties change as their size approaches the atomic scale. This is due to the surface area to volume ratio increasing, resulting in the material's surface atoms dominating the material performance. Owing to their very small size, nanoparticles have a very large surface area to volume ratio when compared to bulk material, such as powders, plate and sheet. This feature enables nanoparticles to possess unexpected optical, physical and chemical properties, as they are small enough to confine their electrons and produce quantum effects.

For example, copper is considered a soft material, with bulk copper bending when its atoms cluster at the 50nm scale. Consequently, copper nanoparticles smaller then 50nm are considered a very hard material, with drastically different malleability and ductility performance when compared to bulk copper. The change in size can also affect the melting characteristics; gold nanoparticles melt at much lower temperatures (300 °C for 2.5 nm size) than bulk gold (1064 °C). Moreover, absorption of solar radiation is much higher in materials composed of nanoparticles than in thin films of continuous sheets of material.

While bulk materials have constant physical properties regardless of size, the size of a nanoparticle dictates its physical and chemical properties. Thus, the properties of a material change as its size approaches nanoscale proportions and as the percentage of atoms at the surface of a material becomes significant.

Properties of materials are size-dependent in this scale range. Thus, when particle size is made to be nanoscale, properties such as melting point, fluorescence, electrical conductivity, magnetic permeability, and chemical reactivity change as a function of the size of the particle.

Nanoscience and Nanotechnology

Nanoscience is about the phenomena that occur in systems with nanometer dimensions. Some of the unique aspects of nanosystems arise solely from the tiny size of the systems. Nano is about as small as it gets in the world of regular chemistry, materials science, and biology. The diameter of a hydrogen atom is about one-tenth of a nanometer, so the nanometer scale is the very smallest scale on which we might consider building machines on the basis of the principles we learn from everyday mechanics, using the 1000 or so hydrogen atoms we could pack into a cube of size 1 nm×1 nm×1 nm. If this is all that there was to nanoscience, it would still be remarkable because of the incredible difference in scale between the nano world and the regular macroscopic world around us. In 1959, Richard Feynman gave a talk to the American Physical

Society in which he laid out some of the consequences of measuring and manipulating materials at the nanoscale. This talk, “There is plenty of room at the bottom,” is reproduced in its entirety in Appendix B. It does a far better job than ever I could of laying out the consequences of a technology that allows us to carry out routine manipulations of materials at the nanoscale and if you have not already read it, you should interrupt this introduction to read it now.

The remarkable technological implications laid out in Feynman’s talk form the basis of most people’s impression of Nanoscience. But there is more to Nanoscience than technology. Nanoscience is where atomic physics converges with the physics and chemistry of complex systems. Quantum mechanics dominates the world of the atom, but typical nanosystems may contain from hundreds to tens of thousands of atoms. In nanostructures, we have, layered on top of quantum mechanics, the statistical behavior of a large collection of interacting atoms. From this mixture of quantum behavior and statistical complexity, many phenomena emerge. They span the gamut from nanoscale physics to chemical reactions to biological processes. The value of this rich behavior is enhanced when one realizes that the total number of atoms in the systems is still small enough that many problems in Nanoscience are amenable to modern computational techniques. Thus studies at the nanometer scale have much in common, whether they are carried out in physics, materials science, chemistry, or biology. Just as important as the technological implications, in my view, is the unifying core of scientific ideas at the heart of Nanoscience. This book seeks to build this common core and to demonstrate its application in several disciplines.

The nanoworld is the intermediary between the atom and the solid, from the large molecule or the small solid object to the strong relationship between surface and volume. Strictly speaking, the nanoworld has existed for a long time and it is up to chemists to study the structures and properties of molecules. They have learnt (with the help of physicists) to manipulate them and build more and more complex structures. Progress in observation tools (electron microscopes, scanning-tunneling microscopes and atomic force microscopes) as well as in analysis tools (particularly X-ray, neutron and mass spectometry) has been a decisive factor. The production of nanoscopic material is constantly improving, as is the case for the process of catalysis and surfaces used in the nanoworld. A substantial number of new materials with nano elements such as ceramics, glass, polymers and fibers are making their way onto the market and are present in all shapes and forms in everyday life, from washing machines to architecture.

Nanotechnology and nanoscience have gained remarkable interest since the last decade and played an important role in improving modern applications due to its unique combination of properties. The materials on a nanoscale-size show a dimension of less than 100 nm according to the dimensions nanomaterials. The nanostructures could be classified into zero-dimensional (0D) (such as quantum dot, and nanopartical), one-dimensional (1D) (such as nanowires, nanoneedle, nanorod, and nanotube), two-dimensional (2D) (such as nanoflak, nanoleave, -and -nanosheet), -and -three-dimensional -(3D) (such -as -tetrapod, -and nanosphere)

Nanostructured materials have attracted much attention because of their unique mechanical, electrical and optical properties that differ from those of their bulk phases. The dimensions and sizes of materials play an important role to determine their properties, where the nanoscale-size of material allows to show greatly changed physical and chemical properties in comparison with same material in the micrometer scale. These variations are due to of effects that are related to the size of nanostructures and surface state. As the size of nanomaterial decreases, its surface area increases. Increment in the surface area will allow a greater population of its atoms/molecules to be displayed on the surface of nanomaterial rather than its interior. The large length-to-diameter ratio causes an increase in the surface-to-volume ratio. This condition in turn causes an increase in the number of surface atoms. Consequently, the surface atoms bond less with the partial surrounding interior atoms, which leads to change in the properties of the nanostructures. The surface area to volume ratio significantly increases to the level that the material properties are determined by the surface properties. This ratio offers unique characteristics that have extensive applications in various industrial sectors, including medical, electronics, and chemical sectors kinetic stability.

Nanoscience and Nanotechnology are becoming the most interesting subjects because they have many applications in various fields. Nanoparticle is defined as a microscopic particle of matter that is measured on the nanoscale usually in the range of 1–100 nanometers. The properties of nanoparticles may be tuned by controlling the size of the nanoparticles. The size and surface characteristics of nanoparticles can be easily manipulated. Nanoparticle is unique because it has large surface area and large surface energy. It is highly reactive and can be used as an excellent catalyst. Nanoparticles often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum size effects. We can reduce the dimension of nanoparticles to obtain thin films, quantum wires or quantum dots. These are the main reasons why we are using nanoparticles instead of bulk materials. Nanoparticles have extensive applications in biomedicine, optics and electronics. Nanoparticles are used in electrical batteries, filters, bio-labeling, optical receptors, sensors, drug delivery systems, detection of diseases, destruction of tumors, etc.