Semester -V

15CHU504 NANOCHEMISTRY 5H-5C

Instruction Hours/week:L: 5 T:0 P:0 Marks: Internal:40 External: 60 Total:100

Scope

The course allows one to get a fundamental idea about the Nano Chemistry. The course helps the students in improving their diverse skills in various areas such as laboratory skills, numerical and computing skills, ability to approach to the problems both analytically and logically, time management skills, etc. The principles in this course are used in almost every field such as medicines, food products, and electronics and even in construction industry.

Programme Outcome

1. To learn and understand the fundamentals of Nanochemistry.
2. To understand the use of nanoparticles in molecular electronics, super Conductors
3. To learn about the synthesis and stabilization of nanoparticles and to characterize them by experimental techniques.

Methodology:

Black board teaching, Discussion and Powerpoint Presentation.

UNIT-I

Basics of Nanochemistry: Introduction – definition – length scales – importance of nanoscale and its technology – self assembly of materials – self assembly of molecules – porous solids, nanowires, nanomachines and quantum dots.

UNIT-II

Nano Particles: Introduction – types of nanoparticles – preparation, properties and uses of gold, silicon, silver, zinc oxide, iron oxide, alumina and titania nanoparticles.

UNIT-III

Synthetic Techniques: Techniques to synthesize nanoparticles – top down and bottom up approaches – common growth methods – characterization of nanoparticles – applications and toxic effects of nanomaterials.

UNIT-IV

Nano Materials: Preparation, properties and applications of carbon nanotubes, nanorods, nano fibre and nanoclay.

UNIT-V

Instrumental Techniques: Electron microscopes – scanning electron microscopes (SEM) – transmission electron microscopes (TEM) – scanning probe microscopy – atomic force microscopy (AFM) – scanning tunneling electron microscope (STEM) – basic principles only.

TEXT BOOKS:

1. Shanmugam.S, 2010, Nanotechnology, MJP Publishers, Chennai.
2. Patrick Salomon, A Handbook on Nanochemistry, Dominant Publishers and Distributers, New Delhi.
3. S. Balaji, 2010, Nanobiotechnology, MJP Publishers, Chennai.

REFERENCES:

1. CNR Rao, 2006, The Chemistry of Nanomaterial: Synthesis, Properties and Applications, Vol. I and II, Springer.
2. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, 2005, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press.
3. Segreev, G. B., 2006, Nanochemistry, Elsevier, New York.
4. T.Pradeep, 2013, Nano- The Essentials, Mcraw Hill Edn, New York.

Programme Learning Outcome

- This program is also intended to train students in the multidisciplinary aspect of nanotechnology. Understand the term monomolecular films, how to perform measurements on these, and what role they play in emulsions, foams and in biological systems. Explain the unique properties of individual nanoparticles and carbon based nanomaterials. Understand the basic scientific principles related to the behavior of matter at the atomic level in chemical, biological, and mechanical systems. Understand how micro- and nano particles behave in liquids and gas regarding light scattering, sedimentation and diffusion, and be able to perform simple calculations of such properties.

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF CHEMISTRY

LECTURE PLAN

Name of the Staff : **R KUMAR**
Department : **CHEMISTRY**
Title of the Paper : **NANO CHEMISTRY**
Paper Code : **15CHU504**
Class & Section : **III - B. Sc – Chemistry**
Year and Semester : **2017–2018 and V-Semester**

Unit-I **Hours required – 13**

S. No.	Lecture Hour	Topics to be Covered	Support Materials
1.	1	Basics of Nanochemistry: Introduction	T1: 1-15
2.	1	Definition and length scales	T1: 1-17
3	1	length scales	T1: 1-17
4	1	Importance of nanoscale and its technology	R1: 78-86
5	1	Self assembly of materials	R1: 48-55
6	1	Self assembly of molecules	R1:145-148
7		Molecular Self-assembly of molecules	R1:145-148
8	1	Porous solids	R1:105-110 163-166
9	1	Nanowires	R1:105-110 163-166
10	1	Nanomachines	R1:7,107,235,236
11	1	quantum dots	R1: 192,208,243
12	1	Recapitulation and discussion of important questions	
13	1	Recapitulation and discussion of important questions	

Text Books:

T1: Er. Rakesh rathi, textbook of Nanotechnology chemistry (I Edition 2009), Sultan Chand & Sons, New Delhi – 2003.

Reference Book:

R1: Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, 2005, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press.

Unit-II **Hours required - 14**

S. No.	Lecture Hour	Topics to be Covered	Support Materials
1.	1	Nano Particles: Introduction	R1: 180-186
2.	1	Types of nanoparticles	R1: 76-86
3.	1	Types of nanoparticles	R1: 76-86
4.	1	Preparation of nano particles	R1: 58-74
5.	1	properties of nano particles	R1: 241
6	1	Uses of gold nano particles	R1: 75-78
7	1	Uses of silicon nano particles	R1: 75-78
8	1	Uses of silver nano particles	R1: 75-78
9	1	Uses of zinc oxide nano particles	R1: 75-78
10	1	Uses of iron oxide nanoparticles	R1: 75-78
11	1	Uses of alumina nanoparticles	R1: 75-78
12	1	Uses of titania nanoparticles	R1: 75-78
13	1	Recapitulation and discussion of important questions	
14	1	Recapitulation and discussion of important questions	

Text Books:

T1: Er. Rakesh rathi, textbook of Nanotechnology chemistry (I Edition 2009), Sultan Chand & Sons, New Delhi – 2003.

Reference Book:

R1: Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, 2005, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press.

Unit-III **Hours required -15**

S. No.	Lecture Hour	Topics to be Covered	Support Materials
1.	1	Introduction of Synthetic Techniques	R1: 121-124
2.	1	Techniques to synthesize nanoparticles	R1: 93-100
3.	1	Physical and chemical methods of synthesis	R1: 93-100
4	1	Biological methods	R1: 93-100
5.	1	Top down and bottom up approaches	R1: 26-27
6	1	Top down and bottom up approaches	R1: 26-27
7	1	Common growth methods	R1: 62-66
8	1	Common growth methods	R1: 62-66
9.	1	Characterization of nanoparticles	R1: 58-74
10	1	Characterization of nanoparticles	R1: 58-74
11	1	Applications of nanoparticles	T1: 112-138
12	1	Applications and toxic effects of nanomaterials.	T1: 112-138
13.	1	Toxic effects of nanomaterials.	T1: 112-138
14	1	Recapitulation and discussion of important questions	
15	1	Recapitulation and discussion of important questions	

Text Books:

T1: Er. Rakesh rathi, textbook of Nanotechnology chemistry (I Edition 2009), Sultan Chand & Sons, New Delhi – 2003.

Reference Book:

R1: Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, 2005, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press.

Unit – IV **Hours required -15**

S. No.	Lecture Hour	Topics to be Covered	Support Materials
1	1	Introduction of nano materials	T2: 114
2.	1	Carbon Based Nano materials	T2: 114-118
3	1	Metal Based nano materials	T2: 114-119
4	1	Introduction of carbon nanotubes	T2: 114
5	1	Preparation of carbon nanotubes	T2: 114-123
6	1	Preparation of carbon nanotubes	T2: 114-123
7	1	Properties of carbon nanotubes	T2: 114-123
8	1	Applications of carbon nanotubes	T2: 125-130
9	1	Nanorods	T1: 145-148
10	1	ZnO Nano rods	T1: 145-148
11	1	Gold oxide Nano roads	T1: 145-148
12	1	Nano fibre	
13	1	nanoclay	
14	1	Recapitulation and discussion of important questions	
15	1	Recapitulation and discussion of important questions	

Text Books:

T1: Er. Rakesh rathi, textbook of Nanotechnology chemistry (I Edition 2009), Sultan Chand & Sons, New Delhi – 2003.

T2: Charles. P. Poole, textbook of Introduction to Nanotechnology (Wiley student edition), Wiley india pvt Ltd, New Delhi – 2006.

Reference Book:

R1: Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, 2005, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press.

Unit - V **Hours required - 18**

S. No.	Lecture Hour	Topics to be Covered	Support Materials
1.	1	Instrumental Techniques	R1: 29
2.	1	Electron microscopes	R1: 30-31
3.	1	Scanning electron microscopes (SEM)	R1: 31-33
4	1	Instrumental Techniques: SEM	R1: 31-33
5.	1	Transmission electron microscopes (TEM)	R1: 34-36
6	1	Instrumental Techniques: TEM	R1: 34-36
7.	1	Scanning probe microscopy	R1: 36-38
8	1	Instrumental Techniques: Scanning probe microscopy	R1: 36-38
9.	1	Atomic force microscopy (AFM)	R1: 38-41
10	1	Instrumental Techniques: AFM	R1: 38-41
11.	1	Scanning tunneling electron microscope (STEM)	R1: 41-43
12	1	Instrumental Techniques: STEM	R1: 41-43
13	1	Difference between SEM and TEM	R1: 31-36
14.	1	Recapitulation and discussion of important questions	
15.	1	Recapitulation and discussion of important questions	
16.	1	Discussion of previous ESE question paper	

17	1	Discussion of previous ESE question paper	
18.	1	Discussion of previous ESE question paper	

SUPPORTING MATERIALS:

T1: V. Veeraiyan and A.N.S Vasudevan, textbook of allied chemistry (II Edition), Higmamount Publishing House, Chennai – 2005.

Reference Books:

R1: R. Gopalan & Sundaram, Allied chemistry (III Edition), Sultan Chand & Sons, New Delhi – 2003.

NANO CHEMISTRY

UNIT-I

Basics of Nano chemistry: Introduction – definition – length scales – importance of nano scale and its technology – self-assembly of materials – self-assembly of molecules – porous solids, nanowires, Nano machines and quantum dots.

Basics of Nano chemistry

An Introduction to Nano chemistry Concepts

Definition

Nano chemistry is concerned with generating and altering chemical systems, which develop special and often new effects as a result of the laws of the nano world. The bases for these are chemically active nonmetric units such as supramolecules or Nano crystals. Nano chemistry looks set to make a great deal of progress for a large number of industry sectors. Nanotechnology exists in the realm where many scientific disciplines meet.

Achievements in physics are getting progressively smaller – from valves to electronics, down to microelectronics and quantum computing. It mirrors the downsizing in focus in the biological sciences, from cells to genomics. Conversely, achievements in chemistry have been converging into the nanometer range from below – from atoms and molecules to supramolecular chemistry. Nano chemistry focuses on the unique properties of materials in the 1–100 nm scale. The physical, chemical, electrical, optical and magnetic properties of these materials are all significantly different from both the properties of the individual building blocks (individual atoms or molecules), and also from the bulk materials. Nano chemistry is a truly multidisciplinary field, forming a bridge between nanotechnology and biotechnology, spanning the physical and life sciences.

The Nano chemistry Research Institute (NRI) at Curtin carries out world-class research to provide innovative solutions to

- energy and resources
- materials and manufacturing
- electronics
- agricultural
- environmental management, and
- health and medical industries

Nano chemistry applications in the materials, resources and energy sectors range from the design of crystalline catalysts and the control of crystal size, morphology, phase and purity, to the design and use of additives to control crystallization and inhibit scale formation. In the biological field, control of chemistry at the supramolecular level can lead to the development of a wide variety of new and improved biomaterials, such as artificial bones and tissues, as well as new pharmaceuticals and improved methods of drug delivery.

ENGINEERING, SCIENCE

‘‘We are like dwarfs on the shoulders of giants, so that we can see more than they.’’ Bernard of Chartres, 12th century with Nano science being the discipline concerned with making, manipulating and imaging materials having at least one spatial dimension in the size range 1–1000 nm and nanotechnology being a device or machine, product or process, based upon individual or multiple integrated Nano scale components, then what is Nano chemistry? In its broadest terms, the denying feature of Nano chemistry is the utilization of synthetic chemistry to make Nano scale building blocks of different size and shape, composition and surface structure, charge and functionality. These building blocks may be useful in their own right. Or in a self-assembly construction process, spontaneous, directed by templates or guided by chemically or lithographically denied surface patterns, they may form architectures that perform an intelligent function and portend a particular use.

Objective of Nano chemistry

- Creating nanoparticles
- Allowing properties of Nano systems to evolve, manipulating and controlling them
- Encapsulating and transporting materials (e.g. deodorant with Nano droplets)

Nano chemistry used in:

- Cosmetics, e.g. sunscreen, toothpaste, skincare products
- Sanitary ware
- Built-in ovens and baking trays
- Gas-tight packaging
- Screens, photographic films
- Separating technology for waste water treatment and food production
- Catalyzers for chemical reactions
- Exhaust purification

It is also used in formation of: -

- Commercialization of Nano chemicals
- Nano oxides of precious, ferromagnetic, rare metals (Ti, Zr etc.)
- Nano polymers and membranes
- Nanomaterial’s (cement, fertilizers)
- Nano powders in chemical applications
- Nano green chemistry
- Nano energy applications
- Environmental applications of nanotechnology

When thinking about self-assembly of a targeted structure from the spontaneous organization of building blocks with dimensions that are beyond the sub-nanometer scale of most molecules or macromolecules, there are five prominent principles that need to be taken into consideration.

These are: (i) building blocks, scale, shape, surface structure, (ii) attractive and repulsive interactions between building blocks, equilibrium separation, (iii) reversible association–dissociation and/or adaptable motion of building blocks in assembly, lowest energy structure, (iv) building block interactions with solvents, interfaces, templates, (v) building-blocks dynamics, mass transport and agitation.

A challenge for perfecting structures made by this kind of self-assembly chemistry is to .nd ways of synthesizing (bottom-up) or fabricating (top-down) building blocks not only with the right composition but also having the same size and shape. No matter which way building blocks are made they are never truly monodispersing, less they happen to be single atoms or molecules. There always exists a degree of polydispersity in their size and shape, which is manifest in the achievable degree of structural perfection of the assembly and the nature and population of defects in the assembled system.

Equally demanding is to make building blocks with a particular surface structure, charge and functionality. Surface properties will control the interactions between building blocks as well as with their environment, which ultimately determines the geometry and distances at which building blocks come to equilibrium in a self-assembled system. Relative motion between building blocks facilitates collisions between them, whilst energetically allowed aggregation disaggregation processes and corrective movements of the self-assembled structure will allow it to attain the most stable form.

Providing the building blocks are not too strongly bound in the assembly it will be able to adjust to an orderly structure. If on the other hand the building blocks in the assembly are too strongly interacting, they will be unable to adjust their relative positions within the assembly and a less 1 ordered structure will result. Dynamic effects involving building blocks and assemblies can occur in the liquid phase, at an air/liquid or liquid/liquid interface, on the surface of a substrate or within a template co-assembly. As this text describes, building blocks can be made out of most known organic, inorganic, polymeric, and hybrid materials. Creative ways of making spheres and cubes, sheets and discs, wires and tubes, rings and spirals, with nm to cm dimensions, abound in the materials self-assembly literature.

They provide the basic construction modules for materials self-assembly over all scales, a new way of synthesizing electronic, optical, photonic, magnetic materials with hierarchical structures and complex form, which is the central theme running throughout this chapter. Nano-, a proxy denoting a factor, its origin in the Greek Nanos, meaning dwarf. The term is often associated with the time interval of a nanosecond, a billionth of a second, and the length scale of a nanometer, a billionth of a meter or 10 A°. In its broadest terms, Nano science and nanotechnology congers up visions of making, imaging, manipulating and utilizing things really small. Feynman's prescient Nano world ''on the head of a pin'' inspires scientists and technologists to venture into this uncharted Nano-terrain to do something big with something.

Large and Small Nanomaterial's

It was not so long ago in the world of molecules and materials that 1 nm (1 nm ¼ 10 A °) was considered large in chemistry while 1 mm (1 mm ¼ 1000 nm ¼ 10,000 A°) was considered small in engineering physics. Matter residing in the ''fuzzy interface'' between these large and small extremes of length scales emerged as the science of Nano scale materials and has grown into one of the most exciting and vibrant fields of endeavor, showing all the signs of having a revolutionary impact on materials as we know them today.

In our time, ‘‘Nano’’ has left the science reservation and entered the industrial technology consciousness and public and political perception. Indeed, bulk materials can be remodeled through bottom-up synthetic chemistry and top-down engineering physics strategies as nanomaterial’s in two main ways, the first by reducing one or more of their physical dimensions to the Nano scale and the second by providing them with Nano scale porosity. When talking about finely divided and porous forms of nanostructured matter, it is found that ‘nanomaterial’s characteristically exhibits physical and chemical properties different from the bulk as a consequence of having at least one spatial dimension in the size range of 1–1000 nm’’.

Length scales

Novel effects can occur in materials when structures are formed with sizes comparable to any one of many possible length scales, such as the de Broglie wavelength of electrons, or the optical wavelengths of high energy photons. In these cases quantum mechanical effects can dominate material properties. One example is quantum confinement where the electronic properties of solids are altered with great reductions in particle size. The optical properties of nanoparticles, e.g. fluorescence, also become a function of the particle diameter. This effect does not come into play by going from macroscopic to micrometer dimensions, but becomes pronounced when the nanometer scale is reached.

In addition to optical and electronic properties, the novel mechanical properties of many nanomaterials is the subject of Nano mechanics research. When added to a bulk material, nanoparticles can strongly influence the mechanical properties of the material, such as the stiffness or elasticity. For example, traditional polymers can be reinforced by nanoparticles (such as carbon nanotubes) resulting in novel materials which can be used as lightweight replacements for metals. Such composite materials may enable a weight reduction accompanied by an increase in stability and improved functionality.

Finally, nanostructured materials with small particle size such as zeolites, and asbestos, are used as catalysts in a wide range of critical industrial chemical reactions. The further development of such catalysts can form the basis of more efficient, environmentally friendly chemical processes.

The first observations and size measurements of Nano-particles were made during the first decade of the 20th century. Zsigmondy made detailed studies of gold sols and other nanomaterials with sizes down to 10 nm and less. He published a book in 1914. He used an ultra microscope that employs a *dark field* method for seeing particles with sizes much less than light wavelength.

There are traditional techniques developed during 20th century in Interface and Colloid Science for characterizing nanomaterial’s. These are widely used for *first generation* passive nanomaterial’s specified in the next section.

These methods include several different techniques for characterizing particle size distribution. This characterization is imperative because many materials that are expected to be Nano-sized are actually aggregated in solutions. Some of methods are based on light scattering.

Others apply ultrasound, such as ultrasound attenuation spectroscopy for testing concentrated Nano-dispersions and micro emulsions.

There is also a group of traditional techniques for characterizing surface charge or zeta potential of Nano-particles in solutions. This information is required for proper system stabilization, preventing its aggregation or flocculation. These methods include micro electrophoresis, electrophoretic light scattering and electroacoustic. The last one, for instance colloid vibration current method is suitable for characterizing concentrated systems.

Importance of Nano scale and its technology

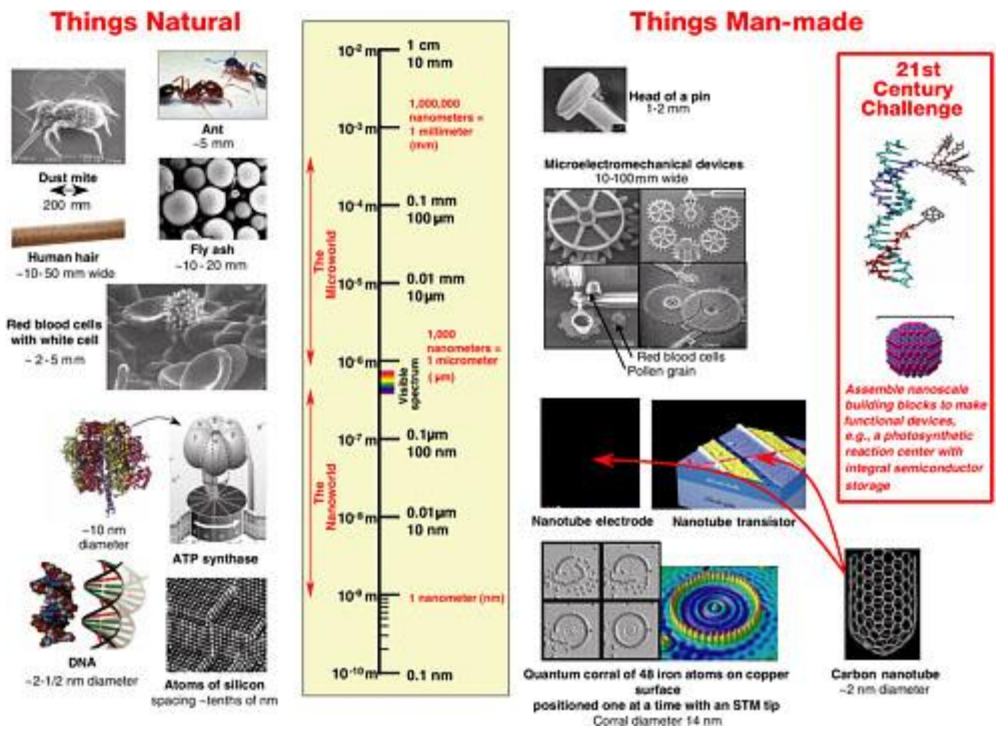
Nano scale science and technology, often spoken of as “Nano science” or “nanotechnology,” are simply science and engineering carried out on the nanometer scale, that is, 10^{-9} meters. In the last two decades, researchers began developing the ability to manipulate matter at the level of single atoms and small groups of atoms and to characterize the properties of materials and systems at that scale. This capability has led to the astonishing discovery that clusters of small numbers of atoms or molecules—Nano scale clusters—often have properties (such as strength, electrical resistivity and conductivity, and optical absorption) that are significantly different from the properties of the same matter at either the single-molecule scale or the bulk scale. For example, carbon nanotubes are much less chemically reactive than carbon atoms and combine the characteristics of the two naturally occurring bulk forms of carbon, strength (diamond) and electrical conductivity (graphite). Furthermore, carbon nanotubes conduct electricity in only one spatial dimension, that is, along one axis, rather than in three dimensions, as is the case for graphite. Nano scale science and engineering also seek to discover, describe, and manipulate those unique properties of matter at the Nano scale in order to develop new capabilities with potential applications across all fields of science, engineering, technology, and medicine.

The National Nanotechnology Initiative (NNI) was established primarily because Nano scale science and technology are predicted to have an enormous potential economic impact. Many potential applications of Nano scale science and technology have been touted in both the scientific and the popular press, and there has been no shortage of promises made for the ability of Nano scale technology to revolutionize life as we know it. Beyond any speculation or hype, the committee can point to current applications of nanoscale materials and to devices that are already impacting our nation’s commerce, as well as advances that are mature enough to promise impacts in the near future. Some of the current impacts, as well as anticipated longer-term impacts, of the technical revolution that will be ushered in by Nano scale science and technology are discussed in more detail below.

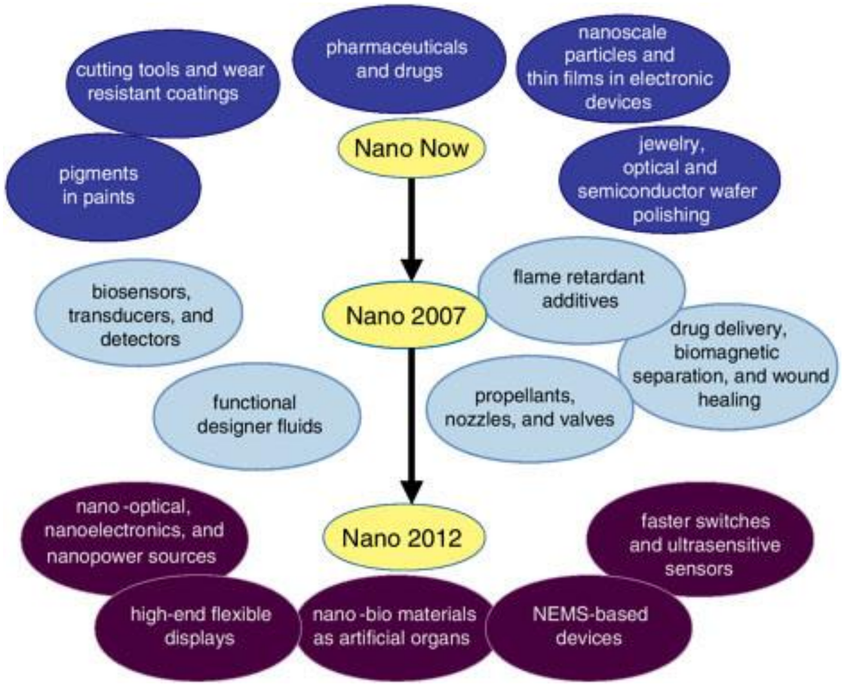
Present applications of Nano scale materials and phenomena

The earliest application of Nano scale materials occurred in systems where Nano scale powders could be used in their free form, without consolidation or blending. For example, Nano scale titanium dioxide and zinc oxide powders are now commonly used by cosmetics manufacturers for facial base creams and sunscreen lotions. Nano scale iron oxide powder is now being used as a base material for rouge and lipstick. Paints with reflective properties are also being manufactured using Nano scale titanium dioxide particles. Nanostructured wear-resistant coatings for cutting tools and wear-resistant components have been in use for several years. Nanostructured cemented carbide coatings are used on some Navy ships for their increased durability.

More recently, more sophisticated uses of Nano scale materials have been realized. Nanostructured materials are in wide use in information technology, integrated into complex products such as the hard disk drives the store information and the silicon integrated circuit chips that process information in every Internet server and personal computer. The manufacture of silicon transistors already requires the controlled deposition of layered structures just a few atoms thick (about 1 nanometer).



The size of Nano scale objects and phenomena compared with the size of small everyday objects.



Current applications of nanotechnology and time line for anticipated advances. Lateral dimensions are as small as 180 nanometers for the critical gate length, and semiconductor industry roadmaps call for them to get even smaller. With shorter gate lengths come smaller, faster, more power-efficient transistors and corresponding improvements in the cost and performance of every digital appliance. Similar processes are required for the manufacture of information storage devices. The giant magneto resistive (GMR) read heads in computer industry standard hard disk drives are composed of carefully designed layered structures, where each layer is just a few atoms thick.

The magnetic thin film on the spinning disk is also a nanostructured material. Last year IBM announced the introduction of an atomically thin layer of ruthenium (humorously referred to as “pixie dust”) to substantially increase the information storage density of its products. Greater storage density translates directly to the less expensive storage of information. Incorporating nanostructured materials and Nano scale components into complex systems, both magnetic data storage and silicon microelectronics provide a glimpse of the future of Nano scale science and technology.

In biomedical areas, structures called liposomes have been synthesized for improved delivery of therapeutic agents. Liposomes are lipid spheres about 100 nanometers in diameter. They have been used to encapsulate anticancer drugs for the treatment of AIDS-related Kaposi’s sarcoma. Several companies are using magnetic nanoparticles in the analyses of blood, urine, and other body fluids to speed up separation and improve selectivity. Other companies have developed derivative fluorescent Nano spheres and nanoparticles that form the basis for new detection technologies. These reagent nanoparticles are used in new devices and systems for infectious and genetic disease analysis and for drug discovery.

Many uses of Nano scale particles have appeared in specialty markets, such as defense applications, and in markets for scientific and technical equipment. Producers of optical materials and electronics substrates such as silicon and gallium arsenide have embraced the use of Nano size particles for chemo mechanical polishing of these substrates.

Nano size particles of silicon carbide, diamond, and boron carbide are used as lapping compounds to reduce the waviness of finished surfaces from corner to corner and produce surface finishes to 1-2 nm smoothness. The ability to produce such high-quality components is significant for scientific applications and could become even more important as electric devices shrink and optical communications systems become a larger part of the nation’s communications infrastructure.

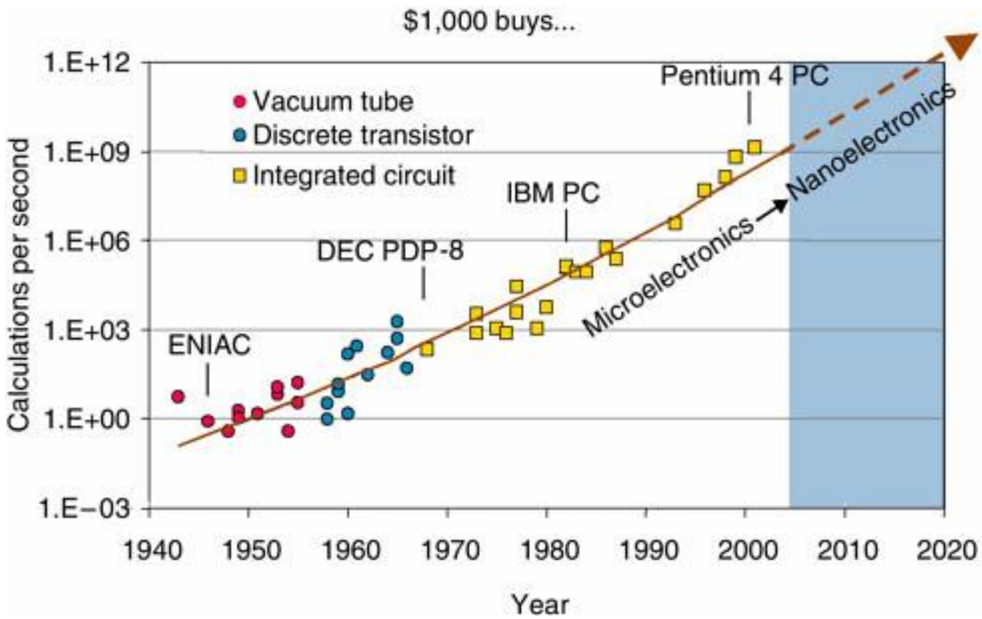
Nanotechnology and Computers

The history of information technology has been largely a history of miniaturization based on a succession of switching devices, each smaller, faster, and cheaper to manufacture than its predecessor. The first general-purpose computers used vacuum tubes, but the tubes were replaced by the newly invented transistor in the early 1950s, and the discrete transistor soon gave way to the integrated circuit approach.

Engineers and scientists believe that the silicon transistor will run up against fundamental physical limits to further miniaturization in perhaps as little as 10 to 15 years, when the channel length, a key transistor dimension, reaches something like 10 to 20 nm. Microelectronics will have become Nano electronics, and information systems will be far more capable, less expensive, and more pervasive than they are today. Nevertheless, it is disquieting to think that today’s rapid progress in information technology may soon come to an end. Fortunately, the fundamental physical limits of the silicon transistor are not the fundamental limits of information technology.

The smallest possible silicon transistor will probably still contain several million atoms, far more than the molecular-scale switches that are now being investigated in laboratories around the world.

But building one or a few molecular-scale devices in a laboratory does not constitute a revolution in information technology. To replace the silicon transistor, these new devices must be integrated into complex information processing systems with billions and eventually trillions of parts, all at low cost. Fortunately, molecular-scale components lend themselves to manufacturing processes based on chemical synthesis and self-assembly. By taking increasing advantage of these key tools of nanotechnology, it may be possible to put a cap on the amount of lithographic information required to specify a complex system, and thus a cap on the exponentially rising cost of semiconductor manufacturing tools.



The increasing miniaturization of components in computing and information technology

Thus, nanotechnology is probably the future of information processing, whether that processing is based on a Nano scale silicon transistor manufactured to tolerances partially determined by processes of chemical self-assembly or on one or more of the new molecular devices now emerging from the laboratory.

Developing applications of Nano scale technology

Several Nano scale technologies appear to be 3 to 5 years away from producing practical products. For example, specially prepared Nano sized semiconductor crystals (quantum dots) are being tested as a tool for the analysis of biological systems. Upon irradiation, these dots fluoresce specific colors of light based on their size. Quantum dots of different sizes can be attached to the different molecules in a biological reaction, allowing researchers to follow all the molecules simultaneously during biological processes with only one screening tool. These quantum dots can also be used as a screening tool for quicker, less laborious DNA and antibody screening than is possible with more traditional methods.[1]

Also promising are advances in feeding Nano powders into commercial sprayer systems, which should soon make it possible to coat plastics with Nano powders for improved wear and corrosion resistance. One can imagine scenarios in which plastic parts replace heavier ceramic or metal pieces in weight-sensitive applications. The automotive industry is researching the use of Nano sized powders in so-called Nano composite materials. Several companies have demonstrated injection-molded parts or composite parts with increased impact strength. Full-scale prototypes of such parts are now in field evaluation, and use in the vehicle fleet is possible within 3 to 5 years.

Several aerospace firms have programs under way for the use of Nano sized particles of aluminum or hafnium for rocket propulsion applications. The improved burn and the speed of ignition of such particles are significant factors for this market.

A number of other near-term potential applications are also emerging. The use of nanomaterials for coating surfaces to give improved corrosion and wear resistance is being examined on different substrates. Several manufacturers have plans to use nanomaterial in the surfaces of catalysts. The ability of nanomaterial's such as titania and zirconia to facilitate the trapping of heavy metals and their ability to attract biorganisms makes them excellent candidates for filters that can be used in liquid separations for industrial processes or waste stream purification. Similarly, new ceramic nanomaterial's can be used for water jet nozzles, injectors, armor tiles, lasers, lightweight mirrors for telescopes, and anodes and cathodes in energy-related equipment.

Advances in photonic crystals, which are photonic band gap devices based on Nano scale phenomena, lead us closer and closer to the use of such materials for multiplexing and all-optical switching in optical networks. Small, low-cost, all-optical switches are key to realizing the full potential for speed and bandwidth of optical communication networks. Use of Nano scale particles and coatings is also being pursued for drug delivery systems to achieve improved timed release of the active ingredients or delivery to specific organs or cell types.

As mentioned above, information technology has been, and will continue to be, one of the prime beneficiaries of advances in Nano scale science and technology. Many of these advances will improve the cost and performance of established products such as silicon microelectronic chips and hard disk drives. On a longer time, scale, exploratory Nano devices being studied in laboratories around the world may supplant these current technologies. Carbon nanotube transistors might eventually be built smaller and faster than any conceivable silicon transistor. Molecular switches hold the promise of very dense (and therefore cheap) memory, and according to some, may eventually be used for general-purpose computing. Single-electron transistors (SETs) have been demonstrated and are being explored as exquisitely sensitive sensors of electronic charge for a variety of applications, from detectors of biological molecules to components of quantum computers.

(Quantum computing is a recently proposed and potentially powerful approach to computation that seeks to harness the laws of quantum mechanics to solve some problems much more efficiently than conventional computers.) Quantum dots, discussed above as a marker for DNA diagnostics, are also of interest as a possible component of quantum computers. Meanwhile, new methods for the synthesis of semiconductor nanowires are being explored as an efficient way to fabricate Nano sensors for chemical detection.

Rather than quickly supplanting the highly developed and still rapidly advancing silicon technology, these exploratory devices are more likely to find initial success in new markets and product niches not already well-served by the current technology. Sensors for industrial process control, chemical and biological hazard detection, environmental monitoring, and a wide variety of scientific instruments may be the market niches in which Nano devices become established in the next few years.

The future of Nano scale science and technology

As efforts in the various areas of Nano scale science and technology continue to grow, it is certain that many new materials, properties, and applications will be discovered. Research in areas related to nanofabrication is needed to develop manufacturing techniques, in particular, a synergy of top-down with bottom-up processes. Such manufacturing techniques would combine the best aspects of top-down processes, such as microlithography, with those of bottom-up processes based on self-assembly and self-organization.

Additionally, such new processes would allow the fabrication of highly integrated two- and three-dimensional devices and structures to form diverse molecular and Nano scale components. They would allow many of the new and promising nanostructures, such as carbon nanotubes, organic molecular electronic components, and quantum dots, to be rapidly assembled into more complex circuitry to form useful logic and memory devices. Such new devices would have computational performance characteristics and data storage capacities many orders of magnitude higher than present devices and would come in even smaller packages.

Nano materials and their performance properties will also continue to improve. Thus, even better and cheaper Nano powders, nanoparticles, and Nano composites should be available for more widespread applications. Another important application for future nanomaterial will be as highly selective and efficient catalysts for chemical and energy conversion processes. This will be important economically not only for energy and chemical production but also for conservation and environmental applications. Thus, nanomaterial-based catalysis may play an important role in photo conversion devices, fuel cell devices, bioconversion (energy) and bioprocessing (food and agriculture) systems, and waste and pollution control systems.

Nano scale science and technology could have a continuing impact on biomedical areas such as therapeutics, diagnostic devices, and biocompatible materials for implants and prostheses. There will continue to be opportunities for the use of nanomaterial in drug delivery systems. Combining the new Nano sensors with Nano electronic components should lead to a further reduction in size and improved performance for many diagnostic devices and systems. Ultimately, it may be possible to make implantable, in vivo diagnostic and monitoring devices that approach the size of cells. New biocompatible nanomaterial and Nano mechanical components should lead to the creation of new materials and components for implants, artificial organs, and greatly improved mechanical, visual, auditory, and other prosthetic devices.

Exciting predictions aside, these advances will not be realized without considerable research and development. For example, the present state of Nano devices and nanotechnology resembles that of semiconductor and electronics technology in 1947, when the first point contact transistor was realized, ushering in the Information Age, which blossomed only in the 1990s. We can learn from the past of the semiconductor industry that the invention of individual manufactural and reliable devices does not immediately unleash the power of technology—that happens only when the individual devices have low fabrication costs, when they are connected together into an organized network, when the network can be connected to the outside world, and when it can be programmed and controlled to perform a certain function. The full power of the transistor was not really unleashed until the invention of the integrated circuit, with the reliable processing techniques that produce numerous uniform devices and connect them across a large wafer, and the computerized design, wafer-scale packaging, and interconnection

Self- assembly

Molecular synthesis is a technology that chemists use to make molecules by forming covalent bonds between atoms. Molecular self-assembly is a process in which molecules (or parts of molecules) spontaneously form ordered aggregates and involves no human intervention; the interactions involved usually are noncovalent. In molecular self-assembly, the molecular structure determines the structure of the assembly. Synthesis makes molecules; self-assembly makes ordered ensembles of molecules (or ordered forms of macromolecules). The structures generated in molecular self-assembly are usually in equilibrium states (or at least in metastable states).

Molecular self-assembly is ubiquitous in chemistry, materials science, and biology and has been so long before self-assembly emerged as a discrete field of study and as a synthetic strategy. The formation of molecular crystals, colloids, lipid bilayers, phase-separated polymers and self-assembled monolayers are all examples of molecular self-assembly, as are the folding of polypeptide chains into proteins and the folding of nucleic acids into their functional forms. Even the association of a ligand with a receptor is a form of self-assembly; the semantic boundaries between self-assembly, molecular recognition, complexion, and other processes that form more ordered from less ordered assemblies of molecules expand or contract at the whim of those using them.

Self-assembly is scientifically interesting and technologically important for at least four reasons. The first is that it is centrally important in life. The cell contains an astonishing range of complex structures such as lipid membranes, folded proteins, structured nucleic acids, protein aggregates, molecular machines, and many others that form by self-assembly. The second is that self-assembly provides routes to a range of materials with regular structures: molecular crystals, liquid crystals, and semi crystalline and phase-separated polymers are examples. Third, self-assembly also occurs widely in systems of components larger than molecules, and there is great potential for its use in materials and condensed matter science. Fourth, self-assembly seems to offer one of the most general strategies now available for generating nanostructures. Thus self-assembly is important in a range of fields: chemistry, physics, biology, materials science, Nano science, and manufacturing. There is an exciting opportunity for self-assembly to develop through the interchange of concepts and techniques among these fields.

Self-Assembly Is Not Limited to Molecules

Although the concepts of self-assembly were developed with molecules, and self-assembling processes currently are best understood and most highly developed for molecules, components of any size (from molecules to galaxies) can self-assemble in a permissive environment. The focus on self-assembly as a strategy for synthesis has been confined largely to molecules, because chemists are professionally concerned with manipulating the structure of matter at the molecular scale.

The expanding contact of chemistry with biology and materials science and the direction of technology toward nanometer- and micrometer-scale structures, however, has begun to broaden this focus to include matter at scales larger than the molecular. There are now three ranges of sizes of components for which self-assembly is important: molecular, Nano scale (colloids, nanowires and Nano spheres, and related structures), and meso- to macroscopic (objects with dimensions from microns to centimeters). The rules for self-assembly in each of these ranges are similar but not identical.

Because new types of aggregates, especially those with potential for application in microelectronics, photonics, near-field optics, and the emerging field of Nano science, have become increasingly important technologically, interest in self-assembly as a route to aggregates of components larger than molecules has grown. There are many opportunities for fabrication of useful structures of Nano and macro scale components using self-assembly; ultimately, self-assembly may prove to be more important in these areas than in molecular science!

Principles of Molecular Self-Assembly

The concepts of self-assembly historically have come from studying molecular processes. The success of self-assembly in a molecular system is determined by five characteristics of the systems.

Aggregation occurs when there is a net attraction and an equilibrium separation between the components. The equilibrium separation normally represents a balance between attraction and repulsion. These two interactions are fixed in molecular self-assembly.

Components:

A self-assembling system consists of a group of molecules or segments of a macromolecule that interact with one another. These molecules or molecular segments may be the same or different. Their interaction leads from some less ordered state (a solution, disordered aggregate, or random coil) to a final state (a crystal or folded macromolecule) that is more ordered.

Interactions:

Self-assembly occurs when molecules interact with one another through a balance of attractive and repulsive interactions. These interactions are generally weak (that is, comparable to thermal energies) and noncovalent (van der Waals and Coulomb interactions, hydrophobic interactions, and hydrogen bonds) but relatively weak covalent bonds (coordination bonds) are recognized increasingly as appropriate for self-assembly. Complementarity in shapes among the self-assembling components is also crucial.

Reversibility (or Adjustability):

For self-assembly to generate ordered structures, the association either must be reversible or must allow the components to adjust their positions within an aggregate once it has formed. The strength of the bonds between the components, therefore, must be comparable to the forces tending to disrupt them. For molecules, the forces are generated by thermal motion. Processes in which collision between molecules leads to irreversible sticking generate glasses, not crystals.

Environment:

The self-assembly of molecules normally is carried out in solution or at an interface to allow the required motion of the components. The interaction of the components with their environment can strongly influence the course of the process.

Mass Transport and Agitation:

For self-assembly to occur, the molecules must be mobile. In solution, thermal motion provides the major part of the motion required to bring the molecules into contact.

In Nano scale, mesoscopic, and macroscopic self-assembly systems, the components interact in ways that are analogous to those involving molecules. In designing such systems, the first challenge often is assuring the mobility of the components; as they become larger than molecules, Brownian motion rapidly becomes irrelevant, and gravity and friction become important. The choice of interactions between the components (that is, the choice of interactions allowing the system to approach equilibrium) is also important.

DESIGNING NEW, SELF-ASSEMBLING SYSTEMS

We believe that the design of systems of components with Nano- to macro scale dimensions for self-assembly can be aided enormously by considering analogies with molecular systems. To test this belief, we have explored one of many imaginable systems of self-assembling macroscopic components: systems based on capillary interactions.

These studies have demonstrated that it is practical to design new systems of self-assembling components essentially *de novo* and suggest that such systems can find rapid application. The objective of this program has been more to demonstrate the usefulness of transferring concepts from molecular systems to these larger systems than to solve practical problems, but the progression from fundamental studies to applications has been astonishingly rapid.

Nanowires Applications in Energy

Researchers at MIT have developed a solar cell using graphene coated with zinc oxide nanowires. The researchers believe that this method will allow the production of low cost flexible solar cells at high enough efficiency to be completive.

Sensors powered by electricity generated by piezoelectric zinc oxide nanowires. This could allow small, self-contained, sensors powered by mechanical energy such as tides or wind

Researchers are using a method called Aerotaxy to grow semiconducting nanowires on gold nanoparticles. They plan to use self-assembly techniques to align the nanowires on a substrate; forming a solar cell or other electrical devices. The gold nanoparticles replace the silicon substrate on which conventional semiconductor based solar cells are built.

Researchers at the Nies Bohr Institute have determined that sunlight can be concentrated in nanowires due to a resonance effect. This effect can result in more efficient solar cells, allowing more of the energy from the sun to be converted to electricity.

Using light absorbing nanowires embedded in a flexible polymer film is another method being developed to produce low cost flexible solar panels.

Researchers at Lawrence Berkeley have demonstrated an inexpensive process for making solar cells. These solar cells are composed of cadmium sulfide nanowires coated with copper sulfide.

Researchers at Stanford University have grown silicon nanowires on a stainless steel substrate and demonstrated that batteries using these anodes could have up to 10 times the power density of conventional lithium ion batteries. Using silicon nanowires, instead of bulk silicon fixes a problem of the silicon cracking that has been seen on electrodes using bulk silicon. The cracking is caused because the silicon swells it absorbs lithium ions while being recharged, and contracts as the battery is discharged and the lithium ions leave the silicon. However, the researchers found that while the silicon nanowires swell as lithium ions are absorbed during discharge of the battery and contract as the lithium ions leave during recharge of the battery the nanowires do not crack, unlike anodes that used bulk silicon.

Nanowire Applications in the Environment

- Using silver chloride nanowires as a photo catalysis to decompose organic molecules in polluted water.
- Using an electrified filter composed of silver nanowires, carbon nanotubes and cotton to kill bacteria in water.
- Using nanowire mats to absorb oil spill
- Nanowire Applications in Electronics
- Using electrodes made from nanowires that would enable flat panel displays to be flexible as well as thinner than current flat panel displays.
- Using nanowires to build transistors without p-n junctions.
- Using nanowires made of an alloy of iron and nickel to create dense memory devices. By applying a current magnetized sections along the length of the wire. As the magnetized sections move along the wire, the data is read by a stationary sensor. This method is called race track memory.
- Using silver nanowires embedded in a polymer to make conductive layers that can flex, without damaging the conductor.
- Sensors using zinc oxide Nano-wire detection elements capable of detecting a range of chemical vapors.

Nano machine

- A Nano machine, also called a nanites, is a mechanical or electromechanical device whose dimensions are measured in nanometers (millionths of a millimeter, or units of 10^{-9} meter).
- Nano machines are largely in the research-and-development phase, but some primitive devices have been tested. An example is a sensor having a switch approximately 1.5

nanometers across, capable of counting specific molecules in a chemical sample. The first useful applications of Nano machines will likely be in medical technology, where they could be used to identify pathogens and toxins from samples of body fluid. Another potential application is the detection of toxic chemicals, and the measurement of their concentrations, in the environment.

- The microscopic size of Nano machines translates into high operational speed. This is a result of the natural tendency of all machines and systems to work faster as their size decreases. Nano machines could be programmed to replicate themselves, or to work synergistically to build larger machines or to construct Nano chips. Specialized Nano machines called Nano robots might be designed not only to diagnose, but to treat, disease conditions, perhaps by seeking out invading bacteria and viruses and destroying them.
- Another advantage of Nano machines is that the individual units require only a tiny amount of energy to operate. Durability is another potential asset; nanites might last for centuries before breaking down. The main challenge lies in the methods of manufacture. It has been suggested that some Nano machines might be grown in a manner similar to the way plants evolve from seeds.

Quantum Dots & Nanoparticles

Quantum dots are very, very tiny particles on the order of a nanometer in size. They are composed of a hundred to a thousand atoms.

These semiconductor materials can be made from an element, such as silicon or germanium, or a compound, such as CdS or CdSe. These tiny particles can differ in color depending on their size. Below is a collection of CdSe quantum dot nanoparticles that different in size as a result of how long they were allowed to form in the synthesis reaction that is described in the "Lab Manual for Nano scale Science and Technology", Preparation of CdSe Quantum Dot Nanoparticles.

Color is well known to be influenced by particle size in both quantum dots and nanoparticles. The synthesis of gold Nano particles is also described in the Video Lab Manual as Synthesis of Colloidal Gold. Below are some images of gold as nanoparticles and in bulk.

The left test tube contains gold nanoparticles in a citrate solution. The right test tube is the result of adding a NaCl solution to the citrate solution. The smaller chloride ion causes the color of the solution to change from red to blue.

Applications

Quantum dots are of much interest for the other other unusual properties that they possess. These other properties include electrical and nonlinear optical properties. These unique properties of nano sized particles are partly the result of the unusually high surface to volume ratios for their particles, as many as one-third of the atoms are on the surface of the particle. As a result, electrons and "holes" (holes result when an electron moves away from a bond, leaving a positively charged particle) are confined in a limited space inside the cluster.

These quantum electrical properties make these quantum dots of particular interest in the electronics industry. There small size means that electrons do not have to travel as far as with larger particles, thus electronic devices can operate faster.

Quantum dots can emit light if excited, the smaller the dot, the higher the energy of the emitted light. This ability to create dots that emit a rainbow of colors suggest that they could be used as biosensors. Unlike the dyes currently being used as biosensors, quantum dots do not degrade as rapidly. It is possible to make light-emitting diodes (LEDs) from quantum dots. They may also be used to emit white light for backlighting laptop computer screens. There is also great promise for using quantum dots in other solid state electronic devices. Quantum dots may someday be used as lasers.

Smart Medicine

Cancer develops when abnormal cells in the body begin to grow and spread very fast. These bad cancer cells are often not that different from healthy cells, which makes cancer treatment difficult. Most cancer treatments kill some of the healthy cells along with the bad cells, making patients sick. What if you could design a treatment that would only target the cancer cells and leave the healthy cells untouched? Nanotechnology may one day make this possible.

While nanotechnology is not yet used to treat diseases, many new technologies are being tested. Scientists have many ideas about how nanoparticles might be used to combat diseases. One promising idea for cancer treatment is using magnetic nanoparticles to carry the drug to the tumor area. When cancer drugs enter the blood stream, they get pumped through the body's system of arteries and veins.

The drugs reach the tumor but also every other part of the body. Cancer drugs are designed to kill cancer cells but since they can go anywhere in the bloodstream, they may also kill healthy cells. Attaching drugs to magnetic particles would allow doctors to keep the medicine in a specific place by using magnets to hold them there. Using Nano-sized particles is key because they are small enough to go through the blood stream.

Possible Questions

Unit 1

1. nanometre is equal to how many centimeters

   a) 10^{-7} b) 10^{-3} c) 10^{-8} **d) 10^{-9}**

2. The most important property of nanomaterials is

   a) Temperature b) pressure **c) friction** d) force

3. ______ are the extentions of bucky balls.

   a) Geodesic domes b) Hexagons **c) Carbon nanotubes** d) AFM and STM

4. Nanocoatings and nanocomposites are finding uses in?

   a) bicycles **b) bicycles and automobiles** c) tooth d) brushes

5. The prefix "nano" comes from a...

   a) French word meaning billion **b) Greek word meaning dwarf**

   c) Spanish word meaning particle d) Latin word meaning invisible

6. Who first used the term nanotechnology and when?

   a) Richard Feynman, 1959 b) Norio Taniguchi, 1974

   c) Eric Drexler, 1986 d) Sumio Iijima, 1991

7. "Cold welding properties combined with the ductility make them suitable for metal-metal bonding especially in the?"

   a) automobile industry **b) electronic industry**

   c) spinning industry d) cosmetic industry

8."Very small particles have special atomic structures with discrete electronic states, which give rise to special properties in addition to which behavior?"

a) super-paramagnetism b) super-magnetism

c) super-speciality d) electrical behaviour

9."Nanostructured metal clusters and colloids of mono- or plurimetallic composition have a special impact in which applications?"

a) industrial b) electrical **c) catalytic** d) mechanical

10.Which finds application for rechargeable batteries for cars or consumer goods?

a) CO_2 **b) MnO_2** c) SO_2 d) C

11. Optical tweezers...

a) Are used to remove facial hair with miniaturized laser beams

b) Use light to manipulate particles as small as a single atom

c) Are a nanotechnology-based tool for stamp collectors

d) Don't exist

12. And what exactly is a quantum dot?

a) A semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons in all three spatial directions.

b) The sharpest possible tip of an Atomic Force Microscope

c) A fictional term used in science fiction for the endpoints of wormholes

d) Unexplained spots that appear in electron microscopy images of nanostructures smaller than 1 nanometer

13. Colloidal suspension is known as?

a) gel b) gel **c) sol** d) electrical

14. “In sol-gel process the starting material is processed to form a dispersible oxide and forms a sol in contact with?”

a) water b) water **c) water or dilute acid** d) acid or alkali

15. Calcination of the gel produces?

a) calcium b) Phosphorus c) sulphur **d) oxide**

16. Who coined the word 'nanotechnology'?

a) Eric Drexler b) Richard Feynmann c) Sumio Tijima d) Richard Smalley

17. Nanoscience can be studied with the help of...

a) quantum mechanics b) Newtonian mechanics c) macro-dynamics d) geophysics

PART-B

1. What is self-assembly? Write a brief note on self-assembly of materials and molecules.
2. What is meant by nano machine and quantum dots? How it's classified?
3. Give a brief explanation with neat diagram for nano machines and quantum dots.
4. What is nanoscale? Give a brief explanation about nanoscale and its technology.
5. Define nanochemistry. Discuss about the porous solids and nanowires
6. Give a brief explanation with neat diagram for nano machines and quantum dots.

15CHU504
Karpagam Academy of Higher Education
Coimbatore-21
(For the candidate admitted on 2015 onwards)
Department of Chemistry
V- semester
Nano Chemistry

UNIT I- Objective Questions for online examination (Each carry 1 Marks)

Question	Option A	Option B	Option C	Option D	Answer
1 nanometre is equal to how many centimeters	10-7	10-3	10-8	10-9	10-9
The most important property of nanomaterials is	Temperature	pressure	friction	force	friction
______ are the extentions of bucky balls.	Geodesic domes	Hexagons	Carbon nanotubes	AFM and STM	Carbon nanotubes
Nanocoatings and nanocomposites are finding uses in?	bicycles	automobiles	bicycles and automobiles	tooth brushes	bicycles and automobiles
which One of the following is first scientific report of synthesized colloidal gold particles.	Granqvist	Buhrman	Michael Faraday	flemming	Michael Faraday
Popular inert- gas evaporation technique was published by ?	Granqvis	Buhrman	Granqvist and Buhrman	Michael Faraday	Granqvist and Buhrman
Nanophase silicon, which differs from normal silicon with respect to property	electronic	physical	mechanical	physical and electronic	physical and electronic
Nanostructured semiconductors are known to show various?	non-linear optical properties	optical properties	chemical properties	linear properties	non-linear optical properties
The beautiful tone of the which colour is obtained only when both these nanoparticles and the superlattice are present	red	blue	yellow	orange	blue
Nanostructured semiconductors are used as window layers in ?	cells	walls	solar cells	thermal	solar cells
Cold welding properties combined with the ductility make them suitable for metal-metal bonding especially in the ?	automobile industry	electronic industry	spinning industry	cosmetic industry	electronic industry
Very small particles have special atomic structures with discrete electronic states, which give rise to special properties in addition to which behavior?	super-paramagnetism	super-magnetism	super-speciality	electrical behaviour	super-paramagnetism
Nanostructured metal clusters and colloids of mono- or plurimetallic composition have a special impact in which applications?	industrial	electrical	catalytic	mechanical	catalytic
Which finds application for rechargeable batteries for cars or consumer goods?	CO_2	MnO_2	SO_2	C	MnO_2
Among the following which one is a gas sensors?	CO_2	MnO_2	SO_2	C	CO_2
Polymer based composites with a high content of inorganic particles leading to a high dielectric constant are interesting materials for which structure?	aromatic	platy	linear	photonic band gap	photonic band gap
A nanometer is a?	millionth of a meter	trillionth of a meter	billionth of a meter	millimeter	billionth of a meter
Which one of the following is a typical example of ‘top down’ method of synthesis of nanomaterials?	Mechanical attrition	physical attrition	nano attrition	chemical attrition	Mechanical attrition
Which milling is typically achieved using high energy shaker, planetary ball and tumbler mills?	physica	Mechanical	electrical	thermal	Mechanical
Nanoparticles are produced by the shear action during ?	powdering	shaking	grinding	mixing	grinding
Nanotechnology, in other words, is	Carbon engineering	Atomic engineering	Small technology	Microphysics	Small technology
If the mechanical milling imparts sufficient energy to the constituent powders which is formed?	heterogeneous alloy	homogeneous alloy	low density alloy	high density alloy	homogeneous alloy
Based on the energy of the milling process and which properties of the constituents the alloy can be rendered amorphous by this processing?	electrical	chemical	thermodynamic	mechanical	thermodynamic

where single crystals are etched in an aqueous solution for producing nanomaterials it is?	bottom up method	up down method	down method	top down method	top down method
which one of the following is consisting of sol-gel method, precipitation.	bottom up method	up down method	down method	top down method	bottom up method
where materials containing the desired precursors are mixed in a controlled fashion to form which solution?	acid	acid	colloidal	water	colloidal
The width of carbon nanotube is	1 nm	1.3nm	1.55nm	10 nm	1.3nm
colloidal suspension is known as?	gel	gel	sol	electrical	sol
In sol-gel process the starting material is processed to form a dispersible oxide and forms a sol in contact with ?	water	water	water or dilute acid	acid or alkali	water or dilute acid
Calcination of the gel produces?	calcium	calcium	sulphur	oxide	oxide
In sol-gel process removal of the liquid from the sol yields the gel, and the sol/gel transition controls the ?	process	particle size and shape	partical size	partical shape	particle size and shape
Sol-gel processing refers to the hydrolysis and condensation of alkoxide-based precursors such as ?	M(OR)z	M(OR)z	SiO_2	$Si(OEt)_4$	$Si(OEt)_4$
$MOR + H_2O \rightarrow MOH + ROH$ it is?	hydrolysis	condensation	addition	Decomposition	hydrolysis
Gelation resulting from the formation of an oxide- or alcohol- bridged network by which reaction?	polycondensation	substitution	addition	Decomposition	polycondensation
The aging process of gels can exceed about?	6 days	6 days	7 days	8 days	7 days
Ostwald ripening is also referred to as ?	polycondensation	coarsening	sol-gel	Decomposition	coarsening
Drying of gel is a complicated process due to fundamental changes in the structure of ?	sol	sol	gel	product shape	gel
Monolith is termed as?	xerogel	gel	sol	syneresis	xerogel
If the solvent (such as water) is extracted under supercritical or near super critical conditions, the product is an ?	xeroge	gel	aerogel	sol	aerogel
Dehydration, during which surface- bound M-OH groups are removed, there by stabilizing the gel against ?	decomposition	Rehydration	dehydration	condensation	Rehydration
Who coined the word Nanotechnology?	Eric Drexler	Buhrman	Granqvist and Buhrman	Michael Faraday	Eric Drexler
Densification and decomposition of the gels at high temperatures about?	$<800^0C$	$>700^0C$	$>800^0C$	$>900^0C$	$>800^0C$
The ratio of thermal conductivity of silver to that of a carbon nanotube is	0.11	0.42	4.17	0.05	0.05
In homogeneous CVD, particles form in the gas phase and diffuse towards a cold surface due to thermophoretic forces, and can either be scrapped of from the cold surface to give nano-powders, or deposited onto a substrate is called?	dense films	thin films	particulate films	thin and particulate films	particulate films
In heterogeneous CVD, the solid is formed on the substrate surface, which catalyses the reaction and a dense film is formed?	dense film	light films	particulate films	thin films	dense film
which one is occurs only when the vapour is supersaturated and in these processes homogeneous nucleation in the gas phase is utilised to form particles?	evaporation	vapourisation	dense film	Condensation	evaporation
which one of the following is vaporised using thermal evaporation sources such as crucibles, electron beam evaporation devices?	zinc oxide	metal oxide	suboxide	hydroxide	suboxide
which one of the method is specifically suitable for the preparation of ultrapure and non-agglomerated nanoparticles of metal?	Microwave Plasma Processing	Sputtered Plasma Processing	CVD processing	CVC Processing	Sputtered Plasma Processing

This technique is similar to the previously discussed CVC method but employs plasma instead of high temperature for decomposition of the metal organic precursors?	Microwave Plasma Processing	Sputtered Plasma Processing	CVD processing	CVC processing	Microwave Plasma Processing
In this process a laser beam is used as the primary excitation source of ablation for generating clusters directly from a solid sample in a wide variety of applications?	Microwave Plasma Processing	Sputtered Plasma Processing	CVD processing	Laser ablation	Laser ablation
How much is 1 micron in meter ?	10-5meter	10-4 meter	10-6 meter	10-8 meter	10-6 meter
What is the diameter of the hydrogen atom?	1 nm	0.001 nm	0.1 nm	0.01 nm	0.1 nm
What is the diameter of human hair?	75000 nm	65000 nm	85000 nm	5000 nm	75000 nm
What is the size of a nanoshell?	100 nm	1 nm	10 nm	1000 nm	100 nm
Nano particles of which atom are used to control collateral damage due to explosion?	Copper	Aluminium	Carbon	Lead	Aluminium
Which ratio decides the efficiency of nanosubstances?	Weight/volume	Surface area/volume	Volume/weight	Pressure/volume	Surface area/volume
Nanoscience can be studied with the help of	quantum mechanics	Newtonian mechanics	macro-dynamics	geophysics	quantum mechanics
The size of nanoparticles is between	100 to 1000 nm	0.1 to 10 nm	1 to 100 nm	0.01 to 1 nm	1 to 100 nm
The two important properties of nanosubstances are	pressure and friction	sticking and friction	sticking and temperature	temperature and friction	sticking and friction
What is the general name for the class of structures made of rolled up carbon lattices?	nanotubes	nonosheets	nanorods	nano particals	nanotubes

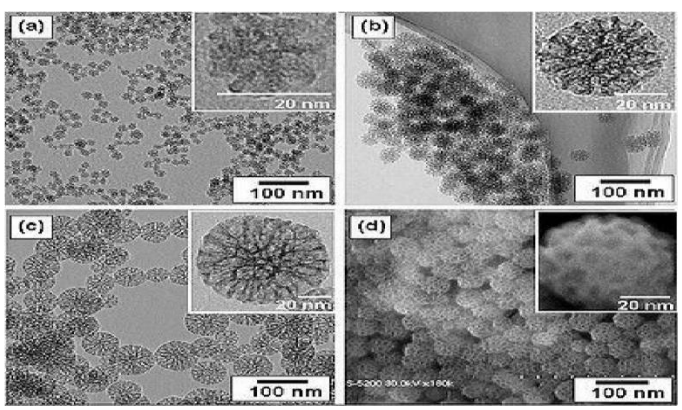
UNIT-II

Nano Particles: Introduction – types of nanoparticles – preparation, properties and uses of gold, silicon, silver, zinc oxide, iron oxide, alumina and titania nanoparticles.

Nano particles

Introduction

In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter. Coarse particles cover a range between 2,500 and 10,000 nanometers. Fine particles are sized between 100 and 2,500 nanometers. Ultrafine particles, or **nanoparticles**, are between 1 and 100 nanometers in size.



The reason for this double name of the same object is that, during the 1970 and 80s, when the first thorough fundamental studies with "nanoparticles" were underway in the USA (by Granqvist and Buhrman) and Japan, (within an ERATO Project) they were called "ultrafine particles" (UFP). However, during the 1990s before the National Nanotechnology Initiative was launched in the USA, the new name, "nanoparticle," had become fashionable (see, for example the same senior author's paper 20 years later addressing the same issue, lognormal distribution of sizes). Nanoparticles may or may not exhibit size-related properties that differ significantly from those observed in fine particles or bulk materials. Although the size of most molecules would fit into the above outline, individual molecules are usually not referred to as nanoparticles.

Nano and bulk materials

A goal of QM2 is to develop a wide range of materials with extraordinary surface-, interface-, Nano-, and bulk properties. Energy-transfer techniques such as microwave and plasmas can be applied to transform simple chemicals into solid-state Nano- and hetero structures (e.g., p-n junctions) and to obtain material systems with enhanced functionalities. Combining functional polymers with dipolar and anisotropic particles allows to create organic-inorganic composites with interesting (e.g., magnetic) properties.

Targeted production of new surfaces, for instance on nanoparticles, produce hybrid core-shell or Janus-like structures with a wide application potential. Vapor phase methods such as chemical vapor deposition (CVD) and atomic layer deposition (ALD) are employed to selectively synthesize and modify various nanostructures with atomically precise composition and structural features. Similarly, charge-transfer processes across molecular – semiconductor interfaces and hetero-junctions are driven by the electronic coupling and charge transfer between the adsorbate and substrate are key steps in the development of photovoltaic and organic electronics.

Graphene-hybrids are an example for interface-materials with new properties. They combine the pure surface material graphene with other phases in a layered structure under very controlled conditions in order to functionalize graphene and to bestow it with new properties.

Electronic correlations and magnetism has proven to be a good playground in search for new materials with interesting physical properties and functions. In particular in the fields of multiferroics and frustrated magnetism new materials or classes of materials have been discovered. One local focus is on the growth of large single crystals of transition-metal oxides. The demand for sources of coherent light, which cannot be realized by the direct lasing process, drives the development of new crystalline materials of nonlinear optics.

Importance of Nano researchers

Nano scale science and technology, often spoken of Nano science or nanotechnology are simply science and engineering carried out on the nanometer scale, that is, 10^{-9} meters. Following figure provides some sense of how this scale relates to familiar, everyday scales. In the last two decades, researchers began developing the ability to manipulate matter at the level of single atoms and small groups of atoms and to characterize the properties of materials and systems at that scale.

This capability has led to the astonishing discovery that clusters of small numbers of atoms or molecules Nano scale clusters often have properties (such as strength, electrical resistivity and conductivity, and optical absorption) that are significantly different from the properties of the same matter at either the single-molecule scale or the bulk scale. For example, carbon nanotubes are much less chemically reactive than carbon atoms and combine the characteristics of the two naturally occurring bulk forms of carbon, strength (diamond) and electrical conductivity (graphite). Furthermore, carbon nanotubes conduct electricity in only one spatial dimension, that is, along one axis, rather than in three dimensions, as is the case for graphite. Nano scale science and engineering also seek to discover, describe, and manipulate those unique properties of matter at the Nano scale in order to develop new capabilities with potential applications across all fields of science, engineering, technology, and medicine.

The National Nanotechnology Initiative (NNI) was established primarily because Nano scale science and technology are predicted to have an enormous potential economic impact. Many potential applications of Nano scale science and technology have been touted in both the scientific and the popular press, and there has been no shortage of promises made for the ability of Nano scale technology to revolutionize life as we know it. Beyond any speculation or hype, the committee can point to current applications of Nano scale materials and to devices that are already impacting our nation‘s commerce, as well as advances that are mature enough to promise impacts in the near future is a time line for anticipated impacts.

Nanoparticle Applications and Uses

- Nanoparticles have one dimension that measures 100 nanometers or less. The properties of many conventional materials change when formed from nanoparticles. This is typically because nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive to some other molecules.
- Nanoparticles are used, or being evaluated for use, in many fields. The list below introduces several of the uses under development.

Nanoparticle Applications in Medicine

- The use of polymeric micelle nanoparticles to deliver drugs to tumors.
- The use of polymer coated iron oxide nanoparticles to break up clusters of bacteria, possibly allowing more effective treatment of chronic bacterial infections.

- The surface change of protein filled nanoparticles has been shown to affect the ability of the nanoparticle to stimulate immune responses. Researchers are thinking that these nanoparticles may be used in inhalable vaccines.
- Researchers at Rice University have demonstrated that cerium oxide nanoparticles act as an antioxidant to remove oxygen free radicals that are present in a patient's bloodstream following a traumatic injury. The nanoparticles absorb the oxygen free radicals and then release the oxygen in a less dangerous state, freeing up the nanoparticle to absorb more free radicals.
- Researchers are developing ways to use carbon nanoparticles called Nano diamonds in medical applications. For example Nano diamonds with protein molecules attached can be used to increase bone growth around dental or joint implants.
- Researchers are testing the use of chemotherapy drugs attached to Nano diamonds to treat brain tumors. Other researchers are testing the use of chemotherapy drugs attached to Nano diamonds to treat leukemia.

Nanoparticle Applications in Manufacturing and Materials

Ceramic silicon carbide nanoparticles dispersed in magnesium produce a strong, lightweight material.

A synthetic skin that may be used in prosthetics has been demonstrated with both self-healing capability and the ability to sense pressure. The material is a composite of nickel nanoparticles and a polymer. If the material is held together after a cut it seals together in about 30 minutes giving it a self-healing ability. Also the electrical resistance of the material changes with pressure, giving it a sense ability like touch.

Silicate nanoparticles can be used to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could slow down the process of spoiling or drying out in food.

Zinc oxide nanoparticles can be dispersed in industrial coatings to protect wood, plastic, and textiles from exposure to UV rays.

Silicon dioxide crystalline nanoparticles can be used to fill gaps between carbon fibers, thereby strengthening tennis racquets.

Silver nanoparticles in fabric are used to kill bacteria, making clothing odor-resistant.

Nanoparticle Applications and the Environment

- Researchers are using photo catalytic copper tungsten oxide nanoparticles to break down oil into biodegradable compounds. The nanoparticles are in a grid that provides high surface area for the reaction, is activated by sunlight and can work in water, making them useful for cleaning up oil spills.
- Researchers are using gold nanoparticles embedded in a porous manganese oxide as a room temperature catalyst to breakdown volatile organic pollutants in air.
- Iron nanoparticles are being used to clean up carbon tetrachloride pollution in ground water.
- Iron oxide nanoparticles are being used to clean arsenic from water wells.

Nanoparticle Applications in Energy and Electronics

- Researchers have used nanoparticles called nano tetrapod's studded with nanoparticles of carbon to develop low cost electrodes for fuel cells. This electrode may be able to replace the expensive platinum needed for fuel cell catalysts.

- Researchers at Georgia Tech, the University of Tokyo and Microsoft Research have developed a method to print prototype circuit boards using standard inkjet printers. Silver nanoparticle ink was used to form the conductive lines needed in circuit boards.
- Combining gold nanoparticles with organic molecules creates a transistor known as a NOMFET (Nanoparticle Organic Memory Field-Effect Transistor). This transistor is unusual in that it can function in a way similar to synapses in the nervous system.
- A catalyst using **platinum-cobalt nanoparticles** is being developed for fuel cells that produces twelve times more catalytic activity than pure platinum. In order to achieve this performance, researchers anneal nanoparticles to form them into a crystalline lattice, reducing the spacing between platinum atoms on the surface and increasing their reactivity.
- Researchers have demonstrated that sunlight, concentrated on nanoparticles, can produce steam with high energy efficiency. The "solar steam device" is intended to be used in areas of developing countries without electricity for applications such as purifying water or disinfecting dental instruments.
- A lead free solder reliable enough for space missions and other high stress environments using **copper nanoparticles**.
- **Silicon nanoparticles** coating anodes of lithium-ion batteries can increase battery power and reduce recharge time.
- Semiconductor nanoparticles are being applied in a low temperature printing process that enables the manufacture of low cost solar cells.
- A layer of closely spaced **palladium nanoparticles** is being used in a hydrogen sensor. When hydrogen is absorbed, the palladium nanoparticles swell, causing shorts between nanoparticles. These shorts lower the resistance of the palladium layer.

Company	Products
CytImmune	Gold nanoparticles for targeted delivery of drugs to tumors
Invitrogen	Q-dots for medical imaging
Antaria	Zinc oxide nanoparticles used in coatings to reduce UV exposure
Nanoledge	Epoxy resins strengthened with nanoparticles

Titanium dioxide

Titanium dioxide ($TiO2$) is the most widely used white pigment, for example in paints. It has high brightness and a very high refractive index. The light passes through the crystal slowly and its path is substantially altered compared to air. If you have many small particles orientated in different directions, a high refractive index will lead to the scattering of light as not much light passes through. In lenses, high refractive index means high clarity and high polarising power. Titanium dioxide has a higher refractive index than diamond and there are only a few other substances that have a higher refractive index. Cinnabar (mercury sulphide) is an example. Historically, cinnabar was used as a red pigment.

Uses for white pigment

Four million tons of pigmentary $TiO2$ are consumed annually. Apart from producing a white colour in liquids, paste or as coating on solids, $TiO2$ is also an effective pacifier, making substances more opaque. Here are some examples of the extensive range of applications:

- Paints
- Plastics
- Papers
- Inks

- Medicines
- Most toothpastes
- Skimmed milk; adding TiO_2 to skimmed milk makes it appear brighter, more opaque and more palatable.

TiO_2 in sunscreens

Almost every sunscreen contains titanium dioxide. It is a physical blocker for UVA (ultraviolet light with wavelength of 315–400 nm) and UVB (ultraviolet light with wavelength of 280–315 nm) radiation. It is chemically stable and will not become decolourised under UV light. TiO_2 particles have to be coated with silica or alumina. This is because TiO_2 particles that come into contact with water produce hydroxyl radicals which are potentially carcinogenic. The silica or alumina coating prevents the titanium dioxide particles from coming into contact with the skin and with water making titanium dioxide very safe to use.

Alumina Nano particle uses

Drug and gene delivery

Bio detection of pathogens

Detection of proteins

Probing of DNA structure

Tissue engineering

Tumour destruction via heating (hyperthermia)

Separation and purification of biological molecules and cells

MRI contrast enhancement

Phagokinetic studies

Possible Questions

Unit-II

1. Nanoscience can be studied with the help of

   a) quantum mechanics b) Newtonian mechanics c) macro-dynamics d) geophysics

2. The size of nanoparticles is between

   a) 100 to 1000 nm b) 0.1 to 10 nm **c) 1 to 100 nm** d) 0.01 to 1 nm

3. The two important properties of nano substances are

   a) pressure and friction **b) sticking and friction**

   c) sticking and temperature d) temperature and friction

4. What is the general name for the class of structures made of rolled up carbon lattices?

   a) nanotubes b) nonosheets c) nanorods d) nano particals

5. Atomic number of zinc

   a) 30 b) 47 c) 79 d) 12

6. Atomic number of iron

   a) 24 b) 22 **c) 26** d) 30

7. Atomic number of aluminium

   a) 13 b) 18 c) 20 d) 35

8. Atomic number of Titanium

   a) 20 b) 28 **c) 22** d) 24

9. Which of the following is used to make both nano-particles and nano-powders?Chemical

   a) vapour deposition **b) Sol-gel technique** c) Plasma arching d) Electro deposition

10. Which method can be used to prepare iron nitriles nano-crystals using ammonia gas? Pulsed

    a) laser deposition b) Sol-gel technique

    c) Electro-deposition **d) Mechanical crushing**

11. Nano-particles exhibit super plastic behaviour is

    a) No behaviour b) semi behaviour **c) Good behaviour** d) Bad behaviour

12. Which of the following is used to modify the optical properties of a material system?

    a) Electricity b) Magnetic field c) Pressure **d) Light**

PART-B

1. Discuss about the preparation, properties and uses of alumina and titania nanoparticles.
2. Write a preparation, properties and uses of Au and Ag nanoparticles.
3. what are the systems used and how nanoparticles are useful in the field of nanotechnology?
4. Write a preparation, properties and uses of Si and Ag nanoparticles.
5. Discuss about the preparation, properties and uses of zinc oxide and iron oxide nanoparticles
6. Discuss about the preparation, properties and uses of Au and FeO nanoparticles
7. write the uses of gold, silver, silicon and zinc oxide nano particles?

15CHU504
Karpagam Academy of Higher Education
Coimbatore-21
(For the candidate admitted on 2015 onwards)
Department of Chemistry
V- semester
Nano Chemistry

UNIT III- Objective Questions for online examination (Each carry 1 Marks)

Question	Option A	Option B	Option C	Option D	Answer
The hardness of a standard SWNT is ____ Pa.	63×10^{6}	25×10^{6}	25×10^{9}	25×10^{-9}	25×10^{9}
The bulk modulus of a standard SWNT is ____ that of diamond.	less than	greater than	equal to	less than or equal to	greater than
How much current can be passed through 1 cm^2 cross-section of a metal nanotube?	10-9	10 9	1000	0.001	10 9
The electrical conductivity of a nanotube is ____ times that of copper.	10	100	1000	1/100	1000
An MWNT possesses electrical superconductivity up to temperature of...	12 K	12°C	100	100°	12 K
At room temperature, the thermal conductivity of a copper wire is ____ watt/(m.K).	3500	350	385	38.5	385
In radial direction, the thermal conductivity of a nanotube is ____ watt/(m.K).	3500	385	350	0	0
The thermal stability of a nanotube is seen up to ____ K in vacuum.	100	1000	2200	3100	3100
The thermal conductivity of an SWNT along length is ____ watt/(m.K).	35	350	385	3500	3500
The size of a quantum dot is ____ nm	5	10	50	100	5
The wavelength of visible light is ____ nm.	40-70	400-700	4000-7000	40000-70000	4000-7000
The capacity of a normal human eye to see the smallest object is ____ µm.	10000	1000	100	10	10
The width of a carbon nanotube is ____ nm.	1	1.3	2.5	10	2.5
The thermal stability of a nanotube is seen up to ____ K in air.	100	1000	2000	3100	2000
Nanoparticles of which substance were found on the surface of the sword of Tipu Sultan?	Gold	Lead	Carbon	Silicon	Silicon
Nano particles of which atom are used to control collateral damage due to explosion?	Copper	Aluminium	Carbon	Lead	Carbon
Who prepared and explained nanotubes for the first time?	Sumio Tijima	Richard Smalley	Eric Drexler	Richard Feynmann	Sumio Tijima
The suffix '-ene' in the name of fullerene shows the presence of _____ in the molecule.	one triple bond	one double bond	two single bonds	two triple bonds	one double bond
With the help of _____, Robert F. Curl and others discovered fullerene.	electron microscope	magnetic resonance	condensation technique	mass spectrograph	mass spectrograph
In the structure of fullerene each carbon atom forms covalent bonds with ____ other carbon atoms.	one	two	three	four	three
Who had invented the famous 'Geodesic' dome structure?	Eric Drexler	Buckminster Fuller	Richard Smalley	Faraday	Buckminster Fuller
The largest cluster of carbon atoms in Bucky balls known till today consists of ____ carbon atoms.	60	75	180	540	540
The smallest cluster of carbon atoms in Bucky balls known till today consists of ____ carbon atoms.	75	60	20	15	20
The tensile strength of an MWNT is ____ Pa.	63×10^{6} [B	63	63×10^{8}	63×10^{9}	63×10^{9}
The compressive strength of a nanotube _____ its tensile strength.	is less than	is greater than	is equal to	may be greater	is less than
A TCO is a semiconductor which has:	high electrical resistivity and high optical transparency	high electrical conductivity and high optical transparency	high electrical conductivity and low optical transparency	low electrical resistivity and low optical transparency	high electrical conductivity and high optical transparency

Graphene is a:	wide band-gap semiconductor	gapless-band semiconductor	not a semiconductor but behaves like graphite	a narrow bandgap semiconductor	gapless-band semiconductor
Which is the best electrical conductor at 298 K?	TiO	MnO	CoO	NiO	TiO
Which superconductor has the highest value of T_c (critical temperature)?	NbTi	Nb_3Sn	K_3C_{60}	$YBa_2Cu_3O_7$	$YBa_2Cu_3O_7$
Band gaps affect semiconducting properties. Which is the *correct* ordering of band gaps in these III-V semiconductors?	GaSb < InSb	GaP > GaAs	InAs > InP	GaP < Si	GaP > GaAs
Thin films of GaAs deposited by CVD are best made by which of the following reactions at appropriate temperatures	Ga + As	$GaH_3 + AsH_3$	$GaMe_3 + AsH_3$	$GaPh_3 + AsH_3$	$GaMe_3 + AsH_3$
Which statement is *incorrect* about semiconductors?	A charge carrier may be either a positive hole or an electron	Ga-doped Si is a p-type semiconductor	n- and p-type semiconductors are intrinsic semiconductors	Doping Si with As introduces a donor level below the conduction band	n- and p-type semiconductors are intrinsic semiconductors
$GaAs_x P_{1-x}$ is used in light emitting diodes (LEDs). When $x = 0.10$ and $x = 0.65$, the wavelengths of the emitted light are 780 and 630 nm respectively. These correspond to emissions which are:	$x = 0.10$, red; $x = 0.65$, green	$x = 0.10$, red; $x = 0.65$, orange	$x = 0.10$, infrared; $x = 0.65$, green	$x = 0.10$, infrared; $x = 0.65$, orange	$x = 0.10$, infrared; $x = 0.65$, orange
Metal films deposited from organometallic precursors by CVD are often contaminated with carbon. Why are ethyl derivatives less likely than methyl derivatives to give significant carbon content in a thin film?	C_2H_6 is more volatile than CH_4	A C_2H_5 group contains a β-H atom	C_2H_5 groups readily combine to give C_4H_{10}	α-H abstraction from the C_2H_5 group occurs	A C_2H_5 group contains a β-H atom
Many ceramic materials consist of metal oxides or silicates with additives that give white or coloured pigments. Which combination of pigment and colour is *incorrect* ?	TiO_2; white	Cr_2O_3; green	cobalt oxides-based pigments; blue	SnO_2; yellow	SnO_2; yellow
Examples of superconducting materials with $T_c > 35$ K include all but one of the following. Which is the odd one out?	NbTi	MgB_2	Cs_3C_{60}	$YBa_2Cu_3O_7$	NbTi
Thin films of TiC are:	used for wear-resistant coatings	semiconducting	used in solar cells	phosphorescent	used for wear-resistant coatings
Which of the following pairings is *incorrect* ?	UO_2; anion-deficient structure	AgBr; Frenkel defect	TiO; non-stoichiometric solid	$CaTiO_3$; perovskite	UO_2; anion-deficient structure
The best general description of a Chevrel phase is that it comprises a:	a ternary molybdenum chalcogenide	a binary molybdenum chalcogenide	a molybdenum sulfide	a ternary or binary tungsten chalcogenide	a ternary molybdenum chalcogenide
To be classed as ''nanoscale'', an object must have one dimension that is of the order of:	10^{-10} m	10^{-12} m	10^{-9} m	10^{-15} m	10^{-9} m
A graphene sheet differs from the framework of a fullerene because:	the graphene sheet consists of C_n rings in which $n = 5$ and 6, but in a fullerene $n = 5$	the graphene sheet consists of C_n rings in which $n = 6$, but in some fullerenes $n = 5$	the graphene sheet consists of C_n rings in which $n = 6$, but in fullerenes $n = 5$ and 6	the graphene sheet consists of C_n rings in which $n = 5$ or 6, but in most fullerenes $n = 6$	the graphene sheet consists of C_n rings in which $n = 6$, but in fullerenes $n = 5$ and 6
Nanotubes usually form in bundles. Which is the best description of such a bundle?	The tubes are connected together by covalent C-C bonds	The tubes are randomly organized, with the axes of the tubes lying in random directions	The tubes are aligned, axes parallel, with van der Waals forces operating between adjacent tubes	The bundles are of discrete sizes, and dipole-dipole forces hold the tubes together	The tubes are aligned, axes parallel, with van der Waals forces operating between adjacent tubes
α-AgI is an ion conductor. Which statement is *correct* ?	The Ag^+ ions form a rigid lattice through which I^- ions can migrate	The Ag^+ ions randomly occupy tetrahedral holes in a bcc arrangement of I^- ions	Ag^+ ions move between octahedral holes in an fcc lattice of I^- ions	I^- ions randomly occupy octahedral holes in a ccp lattice of Ag^+ ions	The Ag^+ ions randomly occupy tetrahedral holes in a bcc arrangement of I^- ions
Which of the following is an example of top-down approach for the preparation of nanomaterials?	Gas phase agglomeration	Molecular self-assembly	Mechanical grinding	Molecular beam epitaxy	Mechanical grinding

Which of the following is an example of bottom-up approach for the preparation of nanomaterials?	Etching	Dip pen nano-lithography	Lithography	Erosion	Dip pen nano-lithography
The properties like melting point, solubility, color, etc changes on varying the	Size	Composition	Surface properties	None of the mentioned	Size
The properties like dispersibility, conductivity, etc changes on varying the	Size	Composition	Surface properties	None of the mentioned	Surface properties
Quantum confinement results in	Energy gap in semiconductor is proportional to the inverse of the square root of size	Energy gap in semiconductor is proportional to the inverse of the size	Energy gap in semiconductor is proportional to the square of size	Energy gap in semiconductor is proportional to the inverse of the square of size	Energy gap in semiconductor is proportional to the inverse of the square of size
Which of the following is the principal factor which causes the properties of nanomaterials to differ significantly from other materials?	Size distribution	Specific surface feature	Quantum size effects	All the mentioned	All the mentioned
Select the incorrect statement from the following options.	Self-assembly is a top-down manufacturing technique	In self-assembly, weak interactions play very important role	Self-assembling molecules adopt a organised structure which is thermodynamically more	Compared to the isolated components, the self-assembled structure has a higher	Self-assembly is a top-down manufacturing technique
Which of the following is the application of nanotechnology to food science and technology?	Agriculture	Food safety and biosecurity	Product development	All of the mentioned	All of the mentioned
What are the advantages of nano-composite packages?	Lighter and biodegradable	Enhanced thermal stability, conductivity and mechanical strength	Gas barrier properties	All of the mentioned	All of the mentioned
The efficiency of today's best solar cell is about	15-20%	40%	50%	75%	40%
In which of the following the atoms do not move from each other?	Shape memory alloys	Nano materials	Dielectrics	Static materials	Nano materials
Which of the following uses radio frequency to produce nano-particles?	Plasma arching	Chemical vapour deposition	Sol-gel technique	Electro deposition	Plasma arching
Which of the following methods can be used to produce nano-powders of oxides?	Plasma arching	Sol-gel technique	Chemical vapour deposition	Mechanical crushing	Chemical vapour deposition
Which of the following is used to make both nano-particles and nano-powders?	Chemical vapour deposition	Sol-gel technique	Plasma arching	Electro deposition	Sol-gel technique
Which method can be used to prepare iron nitriles nano-crystals using ammonia gas?	Pulsed laser deposition	Sol-gel technique	Electro-deposition	Mechanical crushing	Mechanical crushing
Nano-particles exhibit super plastic behaviour is	No behaviour	semi behaviour	Good behaviour	Bad behaviour	Good behaviour
Which of the following is used to modify the optical properties of a material system?	Electricity	Magnetic field	Pressure	Light	Light

UNIT-III

Synthetic Techniques: Techniques to synthesize nanoparticles – top down and bottom up approaches – common growth methods – characterization of nanoparticles – applications and toxic effects of nanomaterials.

SYNTHESIS OF NANOPARTICLES

Materials having unique properties arising from their Nano scale dimensions Nanomaterial with fast ion transport are related also to nanoionics and Nano electronics Nano scale materials can also be used for bulk applications Nano materials are sometimes used in solar cells which combats the cost of traditional solar silicon cells Nano materials.

Approaches - bottom up approach - top down approach

SYNTHESIS OF NANOMATERIALS

These seek to arrange smaller components into more complex assemblies Use chemical or physical forces operating at the Nano scale to assemble basic units into larger structures examples:

1. Indiun gallium arsenide (InGaAs) quantum dots can be formed by growing thin layers of InGaAs on GaAs
2. Formation of carbon nanotubes BOTTOM UP APPROACH

These seek to create smaller devices by using larger ones to direct their assembly. The most common top-down approach to fabrication involves lithographic patterning techniques using short wavelength optical sources TOP DOWN APPROACH

Three methods of synthesis	: 1.	Physical 2. Chemical 3. Biological METHODS
Two methods of Mechanical	: 1.	High energy ball milling 2. Melt mixing
Vapour	: 1.	Physical vapour deposition

2. Laser ablation 3. Sputter deposition 4. Electric arc deposition 5. Ion implantation

PHYSICAL METHODS OF SYNTHESIS

Simplest method of making nanoparticle in the form of powder various types of mills • Planetary • Vibratory • Rod • Tumbler

HIGH ENERGY BALL MILLING

Consists of a container filled with hardened steel or tungsten carbide balls Material of interest is fed as flakes 2:1 mass ratio of balls to materials Container may be filled with air or inert gas Containers are rotated at high speed around a central axis Material is forced to the walls and pressed against the walls

Control the speed of rotation and duration of milling- grind material to fine powder (few nm too few tens of nm) Some materials like Co, Cr, W, Al-Fe, Ag-Fe etc. are made Nano crystalline using ball mill.

To form or arrest nanoparticles in glass – amorphous solid, lacking symmetric arrangement of atoms/molecules Metals, when cooled at very high cooling rates (10^5- 10^6 K/s) can form amorphous solids- metallic glasses Mixing molten streams of metals at high velocity with turbulence- form nanoparticles Ex: a molten stream of Cu-B and molten stream of Ti form nanoparticles of TiB_2

MELT MIXING EVAPORATION BASED METHOD PHYSICAL VAPOUR DEPOSITION

Material of interest as source of evaporation an inert or reactive gas A cold finger (water or liquid N_2 cooled) Scraper All processes are carried out in a vacuum chamber so that the desired purity of end product can be obtained

Materials to be evaporated are held in filaments or boats of refractory metals like W, Mo etc. Density of the evaporated material is quite high and particle size is small (< 5 nm) Acquire a stable low surface energy state Cluster-cluster interaction- big particles are formed Removed by forcing an inert gas near the source (cold finger)

If reactive gases such as O_2, N_2, H_2, and NH_3 are used, evaporated material will react with these gases forming oxide, nitride or hydride particles. Nanoparticles formed on the cold finger are scraped off Process can be repeated several times

Vaporization of the material is effected by using pulses of laser beam of high power the set-up is an Ultra High Vacuum (UHV) or high vacuum system Inert or reactive gas introduction facility, laser beam, target and cooled substrate Laser giving UV wavelength such as Excimer laser is necessary laser vaporization (ablation)

Powerful laser beam evaporates atoms from a solid source Atoms collide with inert or reactive gases Condense on cooled substrate Gas pressure- particle size and distribution Single Wall Carbon Nanotubes (SWNT) are mostly synthesized by this method

Thin film synthesis using lasers Mixture of reactant gases is deposited on a powerful laser beam in the presence of some inert gas like helium or argon Atoms or molecules of decomposed reactant gases collide with inert gas atoms and interact with each other, grow and are then deposited on cooled substrate laser pyrolysis.

Many nanoparticles of materials like Al_2O_3, WC, and SiN_4 are synthesized by this method Gas pressure- particle sizes and their distribution

Widely used thin film technique, specially to obtain stoichiometric thin films from target material (alloy, ceramic or compound) Non porous compact films Very good technique to deposit multi-layer films 1. DC sputtering 2. RF sputtering 3. Magnetron sputtering SPUTTER DEPOSITION

Target is held at high negative voltage Substrate may be at positive, ground or floating potential Argon gas is introduced at a pressure <10 Pa High voltage (100 to 3000 V) is applied between anode and cathode Visible glow is observed when current flows between anode and cathode DC SPUTTERING

Glow discharge is set up with different regions such as - cathode glow - Crooke's dark space -negative glow -Faraday dark space -positive column - anode dark space - anode glow

These regions are a result of plasma- a mixture of electrons, ions, neutrals and photos Density of particles depends on gas pressure

If the target to be spluttered is insulating High frequency voltage is applied between the anode and cathode alternatively keep on changing the polarity Oscillating electrons cause ionization 5 to 30 MHz frequency can be used 13.56 MHz frequency is commonly used RF SPUTTERING

RF/DC sputtering rates can be increased by using magnetic field Magnetron sputtering use powerful magnets to confine the plasma to the region closest to the 'target'. This condenses the ion-space ratio, increases the collision rate, and thus improves deposition rate MAGNETRON SPUTTERING

When both electric and magnetic field act simultaneously on a charged particle, the force on it is given by Lorentz force. $F = q (E+ v \times B)$ By introducing gases like O_2, N_2,H_2, NH_3 , CH_4 while metal targets are sputtered, one can obtain metal oxides like Al_2O_3, nitrides like TiN, carbides like WC etc.- "Reactive sputtering"

Simplest and most useful methods Mass scale production of Fullerenes, carbon nanotubes etc. Consists of a water cooled vacuum chamber and electrodes to strike an arc in between them Gap between the electrodes is 1mm High current- 50 to 100 amperes Low voltage power supply- 12 to 15 volts ELECTRIC ARC DEPOSITION

Inert or reactive gas introduction is necessary- gas pressure is maintained in the vacuum system when an arc is set up, anode material evaporates. This is possible as long as the discharge can be maintained

CHEMICAL METHODS OF SYNTHESIS

Simple techniques Inexpensive Instrumentation Low temperature (<350ºC) synthesis Doping of foreign atoms (ions) is possible during synthesis Large quantities of material can be obtained Variety of sizes and shapes are possible Self-assembly or patterning is possible ADVANTAGES

Nanoparticles synthesized by chemical methods form “colloids” Two or more phases (solid, liquid or gas) of same or different materials co-exist with the dimensions of at least one of the phases less than a micrometer May be particles, plates or fibers Nano materials are a subclass of colloids, in which the dimensions of colloids are in the nanometer range colloids and colloids in solution.

Reduction of some metal salt or acid Highly stable gold particles can be obtained by reducing chloroauric acid ($HAuCl_4$) with tri sodium citrate ($Na_3C_6H_5O_7$) $HAuCl_4 + Na_3C_6H_5O_7$ $Au^+ + C_6H_5O_7^- + HCl + 3\ NaCl$ Metal gold nanoparticles exhibit intense red, magenta etc., colours depending upon the particle size.

SYNTHESIS OF METAL NANOPARTICLES BY COLLOIDAL ROUTE

Gold nanoparticles can be stabilized by repulsive Columbic interactions also stabilized by thiol or some other capping molecules in a similar manner, silver, palladium, copper and few other metal nanoparticles can be synthesized.

Wet chemical route using appropriate salts Sulphide semiconductors like CdS and ZnS can be synthesized by precipitation to obtain Zns nanoparticles, any Zn salt is dissolved in aqueous (or non-aqueous) medium and H_2S is added $ZnCl_2$+ H_2S ZnS + 2 HCl SYNTHESIS OF SEMU-CONDUCTOR NANOPARTICLES BY COLLOIDAL ROUTE

Steric hindrance created by "chemical capping" Chemical capping- high or low temperature depending on the reactants High temp reactions- cold organometallic reactants are injected in solvent like trioctylphosphineoxide(TOPO) held at > 300ºC Although It Is a very good method of synthesis, most organometallic compounds are expensive.

2 types of materials or components- "sol" and "gel" M. Edelman synthesized them in 1845 Low temperature process- less energy consumption and less pollution Generates highly pure, well controlled ceramics Economical route, provided precursors are not expensive Possible to synthesize nanoparticles, Nano rods, nanotubes etc., SOL GEL METHOD

Sols are solid particles in a liquid- subclass of colloids Gels – polymers containing liquid The process involves formation of 'sols' in a liquid and then connecting the sol particles to form a network Liquid is dried- powders, thin films or even monolithic solid Particularly useful to synthesize ceramics or metal oxides

BIOLOGICAL METHODS

Green synthesis 3 types: 1. Use of microorganisms like fungi, yeast (eukaryotes) or bacteria, actinomycetes (prokaryotes) 2. Use of plant extracts or enzymes 3. Use of templates like DNA, membranes, viruses and diatoms

Microorganisms are capable of interacting with metals coming in contact with hem through their cells and form nanoparticles. The cell- metal interactions are quite complex certain microorganisms are capable of separating metal ions. SYNTHESIS USING MICROORGANISMS.

Pseudomonas stuzeri Ag259 bacteria are commonly found in silver mines. Capable of accumulating silver inside or outside their cell walls Numerous types of silver nanoparticles of different shapes can be produced having size <200nm intracellular Low concentrations of metal ions (Au, Ag^+ etc.) can be converted to metal nanoparticles by Lactobacillus strain present in butter milk.

Fungi – Fusarium oxysporum challenged with gold or silver salt for app. 3 days' produces gold or silver nanoparticles extracellular. Extremophilic actinomycete Thermomonospora sp. produces gold nanoparticles extracellular. Semiconductor nanoparticles like CdS, ZnS, PbS etc., can be produced using different microbial routes.

Sulphate reducing bateria of the family Desulfobacteriaceae can form 2-5nm ZnS nanoparticle. Klebsiella pneumoniae can be used to synthesize CdS nanoparticles. when $[Cd(NO_3)_2]$ salt is mixed in a solution containing bacteria and solution is shaken for about1 day at ~38ºC ,CdS nanoparticle in the size range ~5 to 200 nm can be formed.

Leaves of geranium plant (Pelargonium graveolens) have been used to synthesize gold nanoparticles Plant associated fungus- produce compounds such as taxol and gibberellins

Exchange of intergenic genetics between fungus and plant. Nanoparticles produced by fungus and leave have different shapes and sizes. SYNTHESIS USING PLANT EXTRACTS

Nanoparticles obtained using Colletotrichum sp., fungus is mostly spherical while thoe obtained from geranium leaves are rod and disk shaped.

Finely crushed leaves (Erlenmeyer flask) boiled in water (1 min) cooled and decanted added to $HAuCl_4$ aq. Solution gold nanoparticles within a minute.

CdS or other sulfide nanoparticles can be synthesized using DNA. DNA can bind to the surface of growing nanoparticles. ds Salmon sperm DNA can be sheared to an average size of 500bp. Cadmium acetate is added to a desired medium like water, ethanol, propanol etc.

SYNTHESIS USING DNA

Reaction is carried out in a glass flask- facility to purge the solution and flow with an inert gas like N_2. Addition of DNA should be made and then Na_2S can be added drop wise. Depending on the concentrations of cadmium acetate, sodium chloride and DNA, nanoparticles of CdS with sizes less than ~10 nm can be obtained. DNA bonds through its negatively charged PO_4 group to positively charged (Cd^+) nanoparticle surface.

Various inorganic materials such as carbonates, phosphates, silicates etc are found in parts of bones, teeth, shells etc. Biological systems are capable of integrating with inorganic materials widely used to synthesize nanoparticles

USE OF PROTEINS, TEMPLATES LIKE DNA, S- LAYERS ETC

Ferritin is a colloidal protein of Nano size. Stored iron in metabolic process and is abundant in animals. Capable of forming 3 dimensional hierarchical structure. 24 peptide subunits – arranged in such a way that they create a central cavity of ~6 nm. Diameter of polypeptide shell is 12 nm. Ferritin can accommodate 4500 Fe atoms.

FERRITIN

Ferritin without inorganic matter in its cavity is called Apo ferritin and can be used to entrap desired nanomaterial inside the protein cage. Remove iron from ferritin to form Apo ferritin Introduce metal ions to form metal nanoparticles inside the cavity

Horse spleen ferritin diluted with sodium acetate buffer (placed in dialysis bag) sodium+ thioglycolic acetate acid dialysis bag kept under N_2 gas flow for 2-3 hrs.

PROCEDURE TO CONVERT FERRITIN TO APOFERRITIN

Solution needs to be replaced from time to time for 4-5 hrs. Saline for 1 hr refreshed saline for 15-20 hrs.

APOFERRITIN

Apo ferritin mixed with NaCl and N-tris methyl-2-aminoethanosulphonic acid (TES) aq. Cadmium acetate added and stirred with constant N_2 spurging aq. Solution of Na_2S is added twice with 1 hr. interval.

Toxicity of Nano particles

The toxicity of carbon nanotubes has been an important question in nanotechnology. As of 2007, such research had just begun. The data is still fragmentary and subject to criticism. Preliminary results highlight the difficulties in evaluating the toxicity of this heterogeneous material. Parameters such as structure, size distribution, surface area, surface chemistry, surface charge, and agglomeration state as well as purity of the samples, have considerable impact on the reactivity of carbon nanotubes. However, available data clearly show that, under some conditions, nanotubes can cross membrane barriers, which suggests that, if raw materials reach the organs, they can induce harmful effects such as inflammatory and fibrotic reactions. Under certain conditions CNTs can enter human cells and accumulate in the cytoplasm, causing cell death.

Results of rodent studies collectively show that regardless of the process by which CNTs were synthesized and the types and amounts of metals they contained, CNTs were capable of producing inflammation, epithelioid granulomas(microscopic nodules), fibrosis, and biochemical/toxicological changes in the lungs. Comparative toxicity studies in which mice were given equal weights of test materials showed that SWCNTs were more toxic than quartz, which is considered a serious occupational health hazard when chronically inhaled. As a control, ultrafine carbon black was shown to produce minimal lung responses.

Carbon nanotubes deposit in the alveolar ducts by aligning lengthwise with the airways; the nanotubes will often combine with metals. The needle-like fiber shape of CNTs is similar to asbestos fibers. This raises the idea that widespread use of carbon nanotubes may lead topleuralmesothelioma, a cancer of the lining of the lungs, or peritoneal, a cancer of the lining of the abdomen (both caused by exposure to asbestos). A recently published pilot study supports this prediction. This is of considerable importance, because research and business communities continue to invest heavily in carbon nanotubes for a wide range of products under the assumption that they are no more hazardous than graphite. Our results suggest the need for further research and great caution before introducing such products into the market if long-term harm is to be avoided.

Possible Questions

Unit-III

1. How much is 1 micron in meter?

   a) 10-5meter   b) 10^{-4} meter   **c) 10-6 meter**   d) 10-8 meter

2. What is the diameter of the hydrogen atom?

   a) 1 nm   b) 0.001 nm   **c) 0.1 nm**   d) 0.01 nm

3. What is the diameter of human hair?

   a) 75000 nm   b) 65000 nm   c) 85000 nm   d) 5000 nm

5. The thickness of a transistor is ____ nm.

   a) 50   **b) 90**   c) 2,000   d) 5,000

6. The size of a virus is ____ nm.

   a) 2   b) 20   **c) 50**   d) 2000

7. The diameter of a bucky ball is ____ nm.

   a) 1,000   b) 100   c) 10   **d) 1**

8. The width of a typical DNA molecule is ____ nm.

   a) 1   **b) 2**   c) 5   d) 10

9. Which is the best electrical conductor at 298 K?

   a) TiO   b) MnO   c) CoO   d) NiO

10. Which superconductor has the highest value of Tc (critical temperature)?

    a) NbTi   b) Nb_3Sn c) K_3C_{60} **d) $YBa_2Cu_3O_7$**

11. Band gaps affect semiconducting properties. Which is the correct ordering of band gaps in these III-V semiconductors?"

    a) GaSb < InSb   **b) GaP > GaAs**   c) InAs > InP   d) GaP < Si

12. Thin films of GaAs deposited by CVD are best made by which of the following reactions at appropriate temperatures

    a) Ga + As   b) $GaH_3 + AsH_3$ **c) $GaMe_3 + AsH_3$**   d) $GaPh_3 + AsH_3$

PART-B

1. Write briefly on various approaches in nanoparticle synthesis.
2. What are all the characterization made in nanoparticles and explain about the toxic effects of nanomaterials.
3. How to synthesize nanoparticles? Explain brief note on common growth methods.
4. Explain the role of top down and bottom approaches in nanotechnology.
5. What is the difference between top down and bottom up approaches?

15CHU504
Karpagam Academy of Higher Education
Coimbatore-21
(For the candidate admitted on 2015 onwards)
Department of Chemistry
V- semester
Nano Chemistry

UNIT II- Objective Questions for online examination (Each carry 1 Marks)

Question	Option A	Option B	Option C	Option D	Answer
The prefix "nano" comes from a ...	French word meaning billion	Greek word meaning dwarf	Spanish word meaning particle	Latin word meaning invisible	Greek word meaning dwarf
Who first used the term nanotechnology and when?	Richard Feynman, 1959	Norio Taniguchi, 1974	Eric Drexler, 1986	Sumio Iijima, 1991	Eric Drexler, 1986
What is a buckyball?	A carbon molecule (C60)	Nickname for Mercedes-Benz's futuristic concept car (C111)	Plastic explosives nanoparticle (C4)	Concrete nanoparticle with a compressive strength of 20 nanonewtons (C20)	A carbon molecule (C60)
Which of these historical works of art contain nanotechnology?	Lycurgus cup	Medieval stained glass windows in churches	Damascus steel swords	smallest cup	Lycurgus cup
What is depicted in this famous image?	Artist's nanoscale illustration of the Circus Maximus in Rome	Scanning Tunneling Microscope image of electrons surrounded by iron atoms	Simulation of underwater volcanoes near the Hawaiian Islands	Nanoscale version of a bear trap to capture nanoparticles	Artist's nanoscale illustration of the Circus Maximus in Rome
Richard Feynman is often credited with predicting the potential of nanotechnology. What was the title of his famous speech given on December 29, 1959?	There is a tiny room at the bottom	Things get nanoscopic at the bottom	Bottom? What bottom?	There is plenty of room at the bottom	There is a tiny room at the bottom
How many oxygen atoms lined up in a row would fit in a one nanometer space?	None; an oxygen atom is bigger than 1 nm	One	Seven	Seventy	None; an oxygen atom is bigger than 1 nm
Which one of these statements is NOT true?	Gold at the nanoscale is red	Copper at the nanoscale is transparent	Silicon at the nanoscale is an insulator	Aluminum at the nanoscale is highly combustible	Copper at the nanoscale is transparent
Which of these consumer products is already being made using nanotechnology methods?	Fishing lure	Golf ball	Sunscreen lotion	lipstick	Fishing lure
If you were to shrink yourself down until you were only a nanometer tall, how thick would a sheet of paper appear to you?	170 meters	1.7 kilometers (a bit more than a mile)	17 kilometers	170 kilometers	1.7 kilometers (a bit more than a mile)
What is graphene?	A new material made from carbon nanotubes	A one-atom thick sheet of carbon	Thin film made from fullerenes	A software tool to measure and graphically represent nanoparticles	A new material made from carbon nanotubes
Which of these well-known phrases from Star Trek depends on the (fictional) use of nanotechnology?	Beam me up, Scotty!	Tea. Earl Grey. Hot.	You will be assimilated. Resistance is futile.	All of the above	Tea. Earl Grey. Hot.
What is grey goo?	A hypothetical substance composed of out-of-control self-replicating nanobots that consumes all living matter on Earth	The feeder material used to grow grey nanoparticles in the laboratory	Toxic byproduct resulting from the synthesis of carbon nanotubes	Waste product from the production of nanoglue made from the membranes on the feet of the Madagascan Grey Gecko	The feeder material used to grow grey nanoparticles in the laboratory

Which one of these condiments is unique due to the nanoscale interactions between its ingredients?	Ketchup	Mustard	Mayonnaise	All of the above	Mustard
Nanorobots (nanobots)...	Do not exist yet	Exist in experimental form in laboratories	Are already used in nanomedicine to remove plaque from the walls of arteries	Will be used by NASA in the next unmanned mission to Mars	Do not exist yet
What is the 2017 budget for the U.S. National Nanotechnology Initiative?	$587 million	$917 million	$1.4 billion	$2.1 billion	$587 million
Plasmonics is...	A field of nanophotonics that holds the promise of molecular-size optical device technology	The science of fluorescent nanoparticles used in modern fireworks	A hypothetical science used in science fiction weaponry (plasma cannons)	The technology used to design and build the laser-guided photonic gyroscopes used in aviation.	The science of fluorescent nanoparticles used in modern fireworks
Optical tweezers...	Are used to remove facial hair with miniaturized laser beams	Use light to manipulate particles as small as a single atom	Are a nanotechnology-based tool for stamp collectors	Don't exist	Are a nanotechnology-based tool for stamp collectors
And what exactly is a quantum dot?	A semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons in all three spatial directions.	The sharpest possible tip of an Atomic Force Microscope	A fictional term used in science fiction for the endpoints of wormholes	Unexplained spots that appear in electron microscopy images of nanostructures smaller than 1 nanometer	A semiconductor nanostructure that confines the motion of conduction band electrons, valence band holes, or excitons in all three spatial directions.
10 nm = _____ m	10-7	10-3	10-8	10-9	10-7
The size of nanoparticles is between _____ nm.	100 to 1000	0.1 to 10	1 to 100	0.01 to 1	1 to 100
The diameter of hydrogen atom is...	1	10	0.1	0.01	0.1
Carbon atoms make ____ type of bond with other carbon atoms.	covalent	ionic [	metallic	hydrogen	covalent
Fullerene or bucky ball is made up of ____ carbon atoms.	100	20	75 [	60	60
The thermal conductivity of a standard SWNT along its length is ____ watt/(m.K)	3500	385	35000	35	3500
1 m = _____ nm.	10-9	10-8	10 9	10 8	10 9
"There is plenty of room at the bottom." This was stated by _____.	Eric Drexler	Richard Feynmann	Harold Croto	Richard Smalley	Richard Feynmann
Who coined the word 'nanotechnology'?	Eric Drexler	Richard Feynmann	Sumio Tijima	Richard Smalley	Eric Drexler
According to the definition by CRN, nanotechnology is...	mechanical engineering	atomic engineering	Newtonian mechanics	micro-electronics	atomic engineering
Nanoscience can be studied with the help of...	quantum mechanics	Newtonian mechanics	macro-dynamics	geophysics	quantum mechanics
Greeks and Romans had used nanoparticles in the manufacture of...	cosmetics for eyes	medicines	metal articles	hair-dye	hair-dye
Egyptians were using ____ to prepare make-up for eyes.	nanoaluminium	nanocopper	nanosteel	nanolead	nanolead
The sword of Tipu Sultan was made of...	nanolead	nanoaluminium	Damascus steel	Pure iron	Damascus steel
_____ contains nanoparticles prepared by using biologically processed metal ores.	Homeopathic medicines	Modern antibiotics	Ayurvedic 'Bhasmas'	Modern cosmetics	Ayurvedic 'Bhasmas'
Who was the first scientist to describe that substances having nanodimensions possess altogether different and unique properties?	Richard Feynmann	Eric Drexler	Archimedes	Michael Faraday	Michael Faraday
Which of the following does not apply to nanotechnology?	It is a general-purpose technology	It can be called Green	Newtonian mechanics can describe	It involves rearrangement	It involves rearrangement
The diameter of human hair is ____ nm.	50,000	75,000	90,000	100,000	50,000
The diameter of human hair is ____ m.	5×10^{-8}	5×10^{-7}	5×10^{-6}	5×10^{-5}	5×10^{-5}

The cut-off limit of human eye is ____ nm.	2,000	5,000	10,000	50,000	10,000
The size of E.Coli bacteria is ____ nm.	2,000	5,000	50	90	2,000
The size of RBC is ____ nm.	50	90	2,000	5,000	5,000
The thickness of a transistor is ____ nm.	50	90	2,000	5,000	90
The size of a virus is ____ nm.	2	20	50	2000	50
The diameter of a bucky ball is ____ nm.	1,000	100	10	1	1
The width of a typical DNA molecule is ____ nm.	1	2	5	10	2
1 micrometer (micron) = ______ m.	10-9	10-8	10-7	10-6	10-6
1 micrometer (micron) = ______ nm.	1,000	100	10	0.01	1,000
The full form of STM is...	Scanning Tunneling Microscope	Scientific Technical Microscope	Systematic Technical Microscope	Super Tensile Microscope	Scanning Tunneling Microscope
What does 'F' stand for in AFM?	Fine	Fornt	Force	Flux	Force
Which ratio decides the efficiency of nanosubstances?	Weight/volume	Surface area/volume	Volume/weight	Pressure/volume	Surface area/volume
The surface area to volume ratio of a sphere with radius 1 cm is R_1 and that of a sphere with radius 5 cm is R_2. Then R_1 = ____ R_2.	3	1/3	5	1/5	5
The surface area to volume ratio of a cube with side 1 unit is R_1 and that of a cube with side 10 units is R_2. Then R_2 = ____ R_1.	1/10	10	1/100	100	1/10
The two important properties of nanosubstances are...	pressure and friction	sticking and friction	sticking and temperature	temperature and friction	sticking and friction
Atomic number of gold	79	89	64	42	79
Atomic number of silicon	12	15	14	18	12
Atomic number of silver	43	45	47	49	47
Atomic number of zinc	30	47	79	12	30
Atomic number of iron	24	22	26	30	26
Atomic number of aluminium	13	18	20	35	13
Atomic number of Titanium	20	28	22	24	22

UNIT-IV

Nano Materials: Preparation, properties and applications of carbon nanotubes, nano rods**,** nano fibre and nano clay.

Nano materials

For the purpose of this article, most current Nano materials could be organized into four types:

- Carbon Based Materials
- Metal Based Materials
- Dendrimers
- Composites

Carbon Based Materials

These Nano materials are composed mostly of carbon, most commonly taking the form of a hollow spheres, ellipsoids, or tubes. Spherical and ellipsoidal carbon nano materials are referred to as fullerenes, while cylindrical ones are called nanotubes. These particles have many potential applications, including improved films and coatings, stronger and lighter materials, and applications in electronics.

Metal Based Materials

These Nano materials include quantum dots, Nano gold, Nano silver and metal oxides, such as titanium dioxide. A quantum dot is a closely packed semiconductor crystal comprised of hundreds or thousands of atoms, and whose size is on the order of a few nanometers to a few hundred nanometers. Changing the size of quantum dots changes their optical properties.

Dendrimers

These Nano materials are Nano sized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis. Also, because three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery.

Composites

Composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials. Nanoparticles, such as Nano sized clays, are already being added to products ranging from auto parts to packaging materials, to enhance mechanical, thermal, barrier, and flame-retardant properties.

Unique Properties

The unique properties of these various types of intentionally produced Nano materials give them novel electrical, catalytic, magnetic, mechanical, thermal, or imaging features that are highly desirable for applications in commercial, medical, military, and environmental sectors. These materials may also find their way into more complex nanostructures and systems. As new uses for materials with these special properties are identified, the number of products containing such nano materials and their possible applications continues to grow.

Nano rods

In nanotechnology, Nano rods are one morphology of Nano scale objects. Each of their dimensions range from 1–100 nm. They may be synthesized from metals or semiconducting materials. Standard aspect ratios (length divided by width) are 3-5. Nano rods are produced by direct chemical synthesis. A combination of ligands act as shape control agents and bond to different facets of the Nano rod with different strengths. This allows different faces of the Nano rod to grow at different rates, producing an elongated object.

One potential application of Nano rods is in display technologies, because the reflectivity of the rods can be changed by changing their orientation with an applied electric field. Another application is for micro electro mechanical systems (MEMS). Nano rods, along with other noble metal nanoparticles, also function as the agnostic agents. Nano rods absorb in the near IR, and generate heat when excited with IR light. This property has led to the use of nano rods as cancer therapeutics. Nano rods can be conjugated with tumor targeting motifs and ingested. When a patient is exposed to IR light (which passes through body tissue), nano rods selectively taken-up by tumor cells are locally heated, destroying only the cancerous tissue while leaving healthy cells intact.

Nano rods based on semiconducting materials have also been investigated for application as energy harvesting and light emitting devices.

Synthesis

ZnO Nano rods

Zinc oxide (ZnO) Nano rod, also known as nanowire, has a direct band gap energy of 3.37 eV, which is similar to that of GaN, and it has an excitation binding energy of 60 meV. More interestingly, the optical band gap of ZnO Nano rod can be tuned by changing the morphology, composition, size etc. Recent years, ZnO Nano rods have been intensely used to fabricate Nano-scale electronic devices, including field effect transistor, ultraviolet photo detector, Schottky diode, and ultra-bright light emitting diode (LED). Various methods have been developed to fabricate the single crystalline, wurtzite ZnO Nano rods. Among those methods, growing from vapor phase is the most developed approach. In a typical growth process, ZnO vapor is condensed onto a solid substrate. ZnO vapor can be generated by three methods: thermal evaporation, chemical reduction, and Vapor Liquid-Solid (VLS) method. In the thermal evaporation method, commercial ZnO powder is mixed with SnO_2 and evaporated by heating the mixture at elevated temperature. In the chemical reduction method, zinc vapor, generated by the reduction of ZnO, is transferred to the growth zone, followed by reoxidation to ZnO. The VLS process, originally proposed in 1964, is the most commonly used process to synthesize single crystalline ZnO Nano rods. In a typical process, catalytic droplets are deposited on the substrate and the gas mixtures, including Zn vapor and a mixture of CO/CO_2, react at the catalyst-substrate interface, followed by nucleation and growth. Typical metal catalysts involve gold, copper, nickel, and tin. ZnO nanowires are grown epitaxial on the substrate and assemble into monolayer arrays. Metal-organic chemical vapor deposition (MOCVD) has also been recently developed. No catalyst is involved in this process and the growth temperature is at 400 ~500 °C, i.e. considerably milder conditions compared to the traditional vapor growth method.

Gold nano rods

The seed-mediated growth method is the most common and achieved method for synthesizing high quality gold Nano rods. A typical growth protocol involves the addition of citrate-capped gold Nano spheres, served as seeds, to the bulk $HAuCl_4$ growth solution. The growth solution is obtained by the reduction of HAuCl4 with ascorbic acid in the presence of cetyltrimethyl ammonium bromide (CTAB) surfactant and silver ions. Longer Nano rods (up to an aspect ratio of 25) can be obtained in the absence of silver nitrate by use of a three-step addition procedure. In this protocol, seeds are sequentially added to growth solution in order to control the rate of heterogeneous deposition and thereby the rate of crystal growth.

The shortcoming of this method is the formation of gold nano spheres, which requires non-trivial separations and cleanings. In one modifications of this method sodium citrate is replaced with a stronger CTAB stabilizer in the nucleation and growth procedures. Another improvement is to introduce silver ions to the growth solution, which results in the nano rods of aspect ratios less than five in greater than 90% yield. Silver, of a lower reduction potential than gold, can be reduced on the surface of the rods to form a monolayer by under potential deposition. Here, silver deposition competes with that of gold, thereby retarding the growth rate of specific crystal facets, allowing for one-directional growth and rod formation.

Nano Materials

Classification:

1. Three dimensional
2. Two dimensional
    a. Nano rod
    b. Nano tubes
    c. Nano wires
3. One dimensional

One dimensional nanomaterials

One dimensional nanomaterial's such as then films and engineered developed and used in the electronic field. In silicon integrated-circuit industry mono layers (layer that are one atom or molecule) are commonly made and used in chemistry. The formation & properties of these layers are reasonably understood from its complex formation. The control of this composition and smoothness of surface to made advanced level of Nano materials. Engineered surface with tailored properties such as large surface area (or) specific reactivity are used routinely in the large of applications such as in the fuel cell and catalysts.

Two dimensional nanomaterials

Two dimensional nanomaterials such as tubes and wires are considerable interest among the scientific community. This novel electrical and mechanical properties are the subject of intense research,

a) Carbon nanotubes

b) Inorganic nanotubes

c) Nano wires

d) Biopolymers

e) Nano ribbons

a) Carbon nanotubes,

Carbon nanotubes were first absorbed by sumio Lijima in 1991.

CNT are extended tubes and rolled grapheme sheets they are two types,

1) Single walled (one tubes)

2) Multi walled (several concentric tubes)

these differ in few nm in diameters to cm long.
They are mechanically very strong.

Example,

Young ‘s modulus is over terapascel making CNTs as stiff as diamond.

They are flexible (about their axis) and can also conduct electricity.

Ex, sensors, electronic devise.

Nano horns:

It is also a types with an irregular horn-like shape. Copare to another nanotube the synthesis of mono horns is very easy and low cost, and it also to gas and liquid permeate to inside easily.

b) Inorganic nanotubes:

Inorganic nanotubes (or) fuller like materials based on layered compounds such as molybdenum disulphate.

They have excellent tribiological properties like catalytic reactivity, high capacity for HLi storage in H-Li batteries.

c) Nano wires:

Nanowires are ultrafine wire (or) linear assay of dots formed by self-assembly. It has potential application in high density data storage in electronic nana devise.

d) Bio-Polymers:

Such as DNA molecules after a range of opportunities.

The combination of one-dimensional nana structure consisting of biopolymers and inorganic compounds opens up a numbers of scientific and technological opportunities.

e) Nano ribbons:

These are solid objects (unlike nanotubes which are hallow) with a near uniform rectangular cross-section.

It is used in opto-electronics and chemical sensor.

Three dimensional nanomaterials:

Fullerenes (Carbon 60)

1980 now class of carbon materials was discovered called carbon (C60) Harry Kroto & Richard smally. The experimental chemists who discovered C60 named 'buck miniter fullerene 'after the names of architect Buck miniter fulles, who was well known about carbon cage.

Buck minister fullerene:

In 1990, buck minister fuller develops the configuration of a football like carbon sheets. That is called buck minister fullerene. C60 are spherical molecules about 1nm in diameter comprising 60 carbon atoms arranged as 20 hexagons and pentagons. The larger quantities of C60 was developed by resistively heating graphite rods in a Helium atmosphere.

Several applications for fullerenes such as miniature ‘ball bearings ‘‘to lubricant surface drug delivery.

PROPERTIES

Property of Strength

Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus respectively. This strength results from the covalent sp^2 bonds formed between the individual carbon atoms. In 2000, a multi-walled carbon nanotube was tested to have a tensile strength of 63 gigapascals (9,100,000 psi). (For illustration, this translates into the ability to endure tension of a weight equivalent to 6,422 kilograms-force (62,980 N; 14,160 lbf) on a cable with cross-section of 1 square millimeter (0.0016 sq in).) Further studies, such as one conducted in 2008, revealed that individual CNT shells have strengths of up to ~100 gigapascals (15,000,000 psi), which is in agreement with quantum/atomistic models. Since carbon nanotubes have a low density for a solid of 1.3 to 1.4 g/cm^3, its specific strength of up to 48,000 kN·m·kg^{-1} is the best of known materials, compared to high-carbon steel's 154 kN·m·kg^{-1}.

Under excessive tensile strain, the tubes will undergo plastic deformation, which means the deformation is permanent. This deformation begins at strains of approximately 5% and can increase the maximum strain the tubes undergo before fracture by releasing strain energy. Although the strength of individual CNT shells is extremely high, weak shear interactions between adjacent shells and tubes lead to significant reduction in the effective strength of multi-walled carbon nanotubes and carbon nanotube bundles down to only a few GPa. This limitation has been recently addressed by applying high-energy electron irradiation, which crosslinks inner shells and tubes, and effectively increases the strength of these materials to ~60 GPa for multi-walled carbon nanotube sand ~17 GPa for double-walled carbon nanotube bundles. CNTs are not nearly as strong under compression. Because of their hollow structure and high aspect ratio, they tend to undergo buckling when placed under compressive, torsional, or bending stress.

Property of Hardness

Standard single-walled carbon nanotubes can withstand a pressure up to 25 GPa without [plastic/permanent] deformation. They then undergo a transformation to super hard phase nanotubes. Maximum pressures measured using current experimental techniques are around 55 GPa. However, these new super hard phase nanotubes collapse at an even higher, albeit unknown, pressure. The bulk modulus of super hard phase nanotubes is 462 to 546 GPa, even higher than that of diamond (420 GPa for single diamond crystal).

Property of Wettability

The surface wettability of CNT is of importance for its applications in various settings. Although the intrinsic contact angle of graphite is around 90°, the contact angles of most as-synthesized CNT arrays are over 160°, exhibiting a super hydrophobic property. By applying a low voltage as low as 1.3V, the extreme water repellant surface can be switched into super hydrophilic.

Kinetic properties

Multi-walled nanotubes are multiple concentric nanotubes precisely nested within one another. These exhibit a striking telescoping property whereby an inner nanotube core may slide, almost without friction, within its outer nanotube shell, thus creating an atomically perfect linear or rotational bearing. This is one of the first true examples of molecular nanotechnology, the precise positioning of atoms to create useful machines. Already, this property has been utilized to create the world's smallest rotational motor. Future applications such as a gigahertz mechanical oscillator are also envisioned.

Thermal properties

All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction", but good insulators laterally to the tube axis. Measurements show that a SWNT has a room-temperature thermal conductivity along its axis of about 3500 $W \cdot m^{-1} \cdot K^{-1}$; compare this to copper, a metal well known for its good thermal conductivity, which transmits 385 $W \cdot m^{-1} \cdot K^{-1}$. A SWNT has a room-temperature thermal conductivity across its axis (in the radial direction) of about 1.52 $W \cdot m^{-1} \cdot K^{-1}$, which is about as thermally conductive as soil. The temperature stability of carbon nanotubes is estimated to be up to 2800 °C in vacuum and about 750 °C in air.

Applications of Carbon Nanotubes, Nano rods, Nano Fiber and Nano clay:

Nano materials used in

- Nano materials in medicine
- In energy sector
- In computer technology
- In catalysis
- In water purification
- In communication sector
- In food
- Fabric industry
- For environment
- Auto miles
- In ceramic industry
- Veterinary

NANO MATERIALS IN MEDICINE

The nanomaterials are known as Nano bots are used in the medicinal technology. These nanotubes have the potential to repair of metabolic (or) genetic defects.

IN ENERGY SECTOR:

- In fuel cell manufacture if we are using Nano materials, we can improve the efficiency of the process with low cast materials.
- Nickel-methyl hydride (Ni-MH) batteries made up of nanomaterials, it has less frequent for recharging because of its larger boundary area.

IN COMPUTER TECHNOLOGY:

- The computer parts which are made up of Nano crystalline materials have a better thermal conductivity and longer-lasting durable life time.
- The use of Nano phosphors reduce the cast of the displays in high-definition televisions (HDTV)

IN CATALYSIS:

Platinum nanoparticles are automotive catalysis because of its very high surface area. Nanoparticle could reduce the amount of platinum.

IN WATER PURIFICATION:

The iron nanoparticles are used for ground water purification to remove the water pollutants such as industrial and plasticize wastes.

IN COMMUNICATION SECTOR:

Nano materials are incorporated into wireless LAN system to attain a magnetic resonance of suitable frequency.

IN FOOD:

- Nano materials are used not only in the taste of food but also in food safety.

- Nano capsules are used as flavor enhancers and Nano particles have the ability to remove the chemicals which bind in the food materials.

IN FABRIC INDUSTRY:

Silver Nano particles that combat odour through killing bacteria and this capacity has been extended to successfully to would the dressing.

IN ENVIRONMENT:

Nanomaterial used in storable solar energy cells will reduce the ash, soot, hydrocarbon, NO_2, and CO_2, emissions.

IN AUTOMOBILES:

Using nanomaterial in automobiles to increase the engine efficiency to make storage with light weight and reduce the toxic emission.

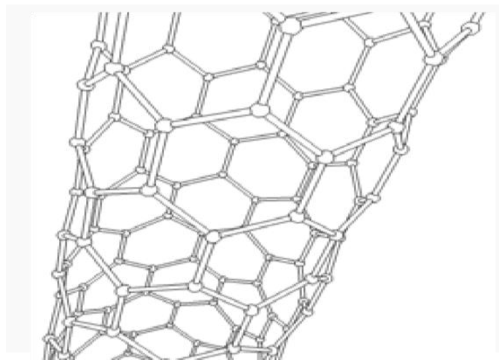
IN CERAMIC INDUSTRY:

Ceramics are very hard brittle and hard to machine. Nano crystalline ceramics are produced into varies shapes in lower temperature and as well as in high temperature.

VETERINARY APPLICATONS:

These new compounds could carry drugs and genes into cells, making treatment of diseases with more efficacious.

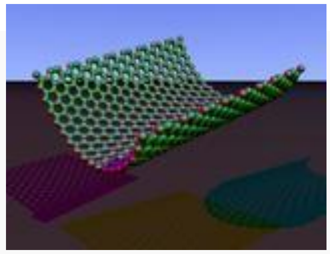
CARBON NANOTUBE



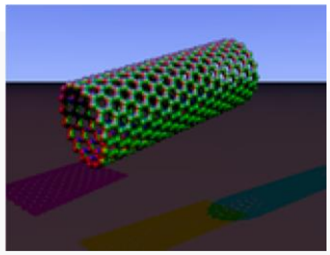
Carbon nanotubes (**CNTs**) are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of material science and technology. In particular, owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material (s) in some (primarily carbon fiber) baseball bats, golf clubs, car parts or Damascus steel. Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene.

IN FOOD:

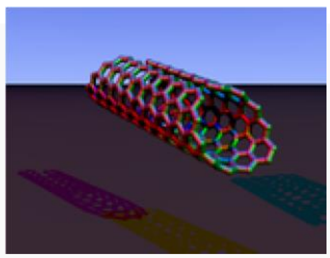
These sheets are rolled at specific and discrete ("chiral") angles, and the combination of the rolling angle and radius decides the nanotube properties; for example, whether the individual nanotube shell is ametalor semiconductor. Nanotubes are categorized assingle-walled nanotubes(SWNTs) and multi-walled nanotubes(MWNTs). Individual nanotubes naturally align themselves into "ropes" held together by van, more specifically, pi-stacking. Applied quantum chemistry, specifically, hybridization best describes chemical bonding in nanotubes. The chemical bonding of nanotubes is composed entirely ofsp^2bonds, similar to those of graphite. These bonds, which



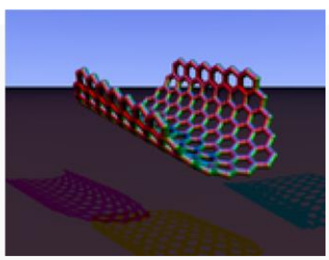
The chiral vector is bent, while the translation vector stays straight



Zigzag (n,0)



Chiral (n,m)



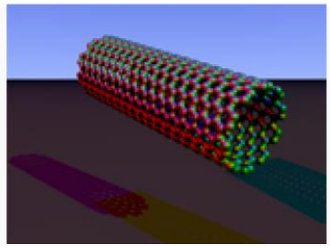
n and m can be counted at the end of the tube

are stronger than thesp^3bondsfound in alkanes and diamond, provide nanotubes with their unique strength. Types of carbon nanotubes and related structures

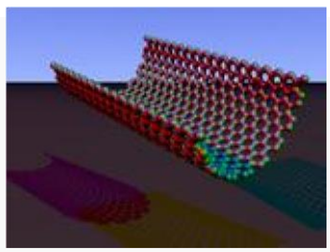
Terminology

There is no consensus on some terms describing carbon nanotubes in scientific literature: both "wall" and "-walled" are being used in combination with "single", "double", "triple" or "multi",and the letter C is often omitted in the abbreviation; for example, multi-walled carbon nanotube

Single-walled

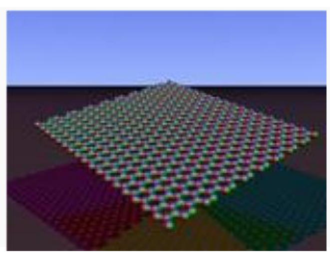


Armchair (n,n) i.e.: m=n



The translation vector is bent, while the chiral vector stays straight

(MWNT).



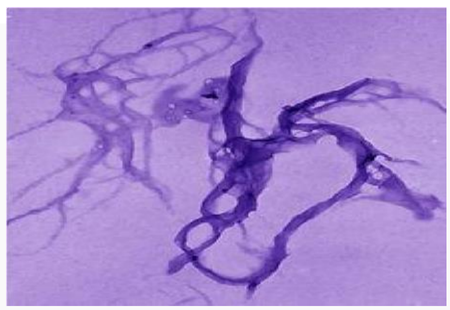
Graphene nanoribbon

Graphene nano ribbon length that can be many millions of times longer. The structure of a SWNT can be conceptualized by wrapping a one-atom-thick layer of graphite called graphene into a seamless cylinder. The way the graphene sheet is wrapped is represented by a pair of indices (n, m). The integer's n and m denote the number of unit vectors along two directions in the honeycomb crystal of graphene. If m = 0, the nanotubes are called zigzag nanotubes, and if n = m, the nanotubes are called armchair nanotubes. Otherwise, they are called chiral. The diameter of an ideal nanotube can be calculated from its (n, m) indices as follows where a = 0.246 nm.

SWNTs are an important variety of carbon nanotube because most of their properties change significantly with the (n,m) values, and this dependence is non-monotonic.

In particular, their band gap can vary from zero to about 2 eV and their electrical conductivity can show metallic or semiconducting behavior. Single-walled nanotubes are likely candidates for miniaturizing electronics. The most basic building block of these systems is the electric wire, and SWNTs with diameters of an order of a nanometer can be excellent conductors. One useful application of SWNTs is in the development of the first intermolecular field-effect transistors (FET). The first intermolecular logic gate using SWCNT FETs was made in 2001. A logic gate requires both a p-FET and an n-FET. Because SWNTs are p-FETs when exposed to oxygen and n-FETs otherwise, it is possible to protect half of an SWNT from oxygen exposure, while exposing the other half to oxygen.

This results in a single SWNT that acts as a not Logic gate with both p and n -type FETs within the same molecule.

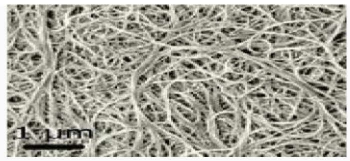


A high-Resolution transmission electron micrograph image of single-walled carbon nanotubes

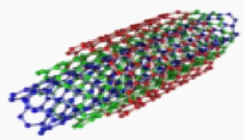
Single-walled nanotubes are dropping precipitously in price, from around $1500 per gram as of 2000 to retail prices of around $50 per gram of as-produced 40–60% by weight SWNTs as of March 2010.

SWNTs have been viewed as too expensive for widespread application but are forecast to make a large impact in electronics applications by 2020 according to The Global Market for Carbon Nanotubes report. Graphene. There are two models that can be used to describe the structures of multi-walled nanotubes. In the Russian Doll model, sheets of graphite are arranged in concentric cylinders, e.g., a (0,8) single-walled nanotube (SWNT) within a larger (0,17) single-walled nanotube. In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a scroll of parchment or a rolled newspaper. The interlayer distance in multi-walled nanotubes is close to the distance between graphene layers in graphite, approximately 3.4 Å. The Russian Doll structure is observed more commonly. Its individual shells can be described as SWNTs, which

Multi-walled



A Scanning electron microscopy image of carbon nanotubes bundles



Triple walled armchair carbon nanotube

Multi-Walled Nano tubes (MWNTs) Consist of multiple rolled layers (concentric tubes) of

can be metallic or semiconducting. Because of statistical probability and restrictions on the relative diameters of the individual tubes, one of the shells, and thus the whole MWNT, is usually a zero-gap metal.

Double-walled carbon nanotubes (DWNTs) form a special class of nanotubes because their morphology and properties are similar to those of SWNTs but their resistance to chemicals is significantly improved. This is especially important when functionalization is required (this means grafting of chemical functions at the surface of the nanotubes) to add new properties to the CNT. In the case of SWNTs, covalent functionalization will break some C=C double bonds, leaving "holes" in the structure on the nanotube and, thus, modifying both its mechanical and electrical properties. In the case of DWNTs, only the outer wall is modified. DWNT synthesis on the gram-scale was first proposed in 2003by the CCVD technique, from the selective reduction of oxide solutions in methane and hydrogen.

The telescopic motion ability of inner shells and their unique mechanical properties will permit the use of multi-walled nanotubes as main movable arms in coming nano mechanical devices. Retraction force that occurs to telescopic motion caused by the Lennard-Jones interaction between shells and its value is about 1.5 nN.

Torus

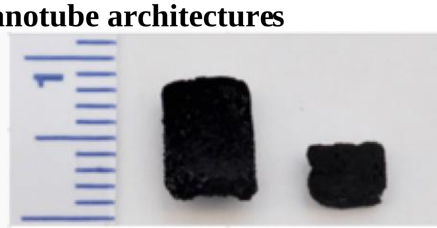
In theory, a nano torus is a carbon nanotube bent into a torus (doughnut shape). Nano tori are predicted to have many unique properties, such as magnetic moments 1000 times larger than previously expected for certain specific radii. Properties such as magnetic moment, thermal stability, etc. vary widely depending on radius of the torus and radius of the tube.

Nano bud

A stable Nano bud Structure

Carbon Nano buds are a newly created material combining two previously discovered allotropes of carbon: carbon nanotubes and fullerenes. In this new material, fullerene-like "buds" are covalently bonded to the outer sidewalls of the underlying carbon nanotube. This hybrid material has useful properties of both fullerenes and carbon nanotubes. In particular, they have been found to be exceptionally good field emitters. In composite materials, the attached fullerene molecules may function as molecular anchors preventing slipping of the nanotubes, thus improving the composite‘s mechanical properties.

Three-Dimensional carbon nanotube architectures



3D carbon scaffolds

Recently, several studies have highlighted the prospect of using carbon nanotubes as building blocks to fabricate three-dimensional macroscopic (>1mm in all three dimensions) all-carbon devices. Lalwani et al. have reported a novel radical initiated thermal crosslinking method to fabricate macroscopic, free-standing, and porous, all-carbon scaffolds using single- and multi-walled carbon nanotubes as building blocks. These scaffolds possess macro-, micro-, and nano-structured pores and the porosity can be tailored for specific applications. These 3D all-carbon scaffolds/architectures may be used for the fabrication of the next generation of energy storage, super capacitors, field emission transistors, high-performance catalysis, photovoltaic, and biomedical devices and implants. In addition, the mechanical behavior of carbon nanotube micro-architectures can easily be modified by the infiltration and deposition of thin conformal coatings.

Graphenated carbon nanotubes (g-CNTs)

Graphenated CNTs are a relatively new hybrid that combines graphitic foliates grown along the sidewalls of multi-walled or bamboo style CNTs. Yu et al. reported on "chemically bonded graphene leaves" growing along the sidewalls of CNTs. Stoner et al described these structures as "graphenated CNTs" and reported in their use for enhanced super capacitor performance. Hsu et al. further reported on similar structures formed on carbon fiber paper, also for use in super capacitor applications. The foliate density can vary as a function of deposition conditions (e.g. temperature and time) with their structure ranging from few layers of graphene(< 10) to thicker, more graphite-like.

The fundamental advantage of an integrated graphene-CNT structure is the high surface area three-dimensional framework of the CNTs coupled with the high edge density of graphene. Graphene edges provide significantly higher charge density and reactivity than the basal plane, but they are difficult to arrange in a three-dimensional, high volume-density geometry. CNTs are readily aligned in a high density geometry (i.e., a vertically aligned forest) but lack high charge density surfaces—the sidewalls of the CNTs are similar to the basal plane of graphene and exhibit low charge density except where edge defects exist. Depositing a high density of graphene foliates along the length of aligned CNTs can significantly increase the total charge capacity per unit of nominal area as compared to other carbon nanostructures.

Nitrogen-doped carbon nanotubes

Nitrogen doped carbon nanotubes (N-CNTs) can be produced through five main methods, chemical vapor deposition, high-temperature and high-pressure reactions, gas-solid reaction of amorphous carbon with NH_3 at high temperature, solid reaction, and solvothermal synthesis.

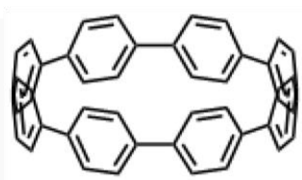
N-CNTs can also be prepared by a CVD method of paralyzing melamine under Ar at elevated temperatures of 800–980 °C. However, synthesis by CVD of melamine results in the formation of bamboo-structured CNTs. XPS spectra of grown N-CNTs reveal nitrogen in five main components, pyridinic nitrogen, pyrrolic nitrogen, quaternary nitrogen, and nitrogen oxides. Furthermore, synthesis temperature affects the type of nitrogen configuration.

Nitrogen doping plays a pivotal role in lithium storage, as it creates defects in the CNT walls allowing for Li ions to diffuse into interval space. It also increases capacity by providing more favorable bind of N-doped sites. N-CNTs are also much more reactive to metal oxide nano particle deposition which can further enhance storage capacity, especially in anode materials for Li-ion batteries. However boron-doped nanotubes have been shown to make batteries with triple capacity.

Cup-stacked carbon nanotubes

Cup-stacked carbon nanotubes (CSCNTs) differ from other quasi-1D carbon structures, which normally behave as quasi-metallic conductors of electrons. CSCNTs exhibit semiconducting behaviors due to the stacking microstructure of graphene layers.

Extreme carbon nanotubes



Cycloparaphenylene

The observation of the longest carbon nanotubes grown so far are over 1/2 m (550 mm long) was reported in 2013. These nanotubes were grown on Si substrates using an improved chemical vapor deposition(CVD) method and represent electrically uniform arrays of single-walled carbon nanotubes.

The shortest carbon nanotube is the organic compound cycloparaphenylene, which was synthesized in early 2009.

The thinnest carbon nanotube is the armchair (2, 2) CNT with a diameter of 0.3 nm. This nanotube was grown inside a multi-walled carbon nanotube. Assigning of carbon nanotube type was done by a combination of high-resolution transmission electron microscopy (HRTEM),Raman spectroscopy and density functional theory(DFT) calculations. The thinnest freestanding single-walled carbon nanotube is about 0.43 nm in diameter. Researchers suggested that it can be either (5, 1) or (4, 2) SWCNT, but the exact type of carbon nanotube remains questionable. (3,3), (4,3) and (5,1) carbon nanotubes (all about 0.4 nm in diameter) were unambiguously identified using aberration-corrected high-resolution transmission electron microscopy inside double-walled CNTs.

The highest density of CNTs was achieved in 2013, grown on a conductive titanium-coated copper surface that was coated with co-catalysts cobalt and molybdenum at lower than typical temperatures of 450 °C. The tubes averaged a height of 380 nm and a mass density of 1.6 g cm^{-3}. The material showed oh mic conductivity (lowest resistance ~22 kΩ).

Semiconductor nanowires

In an analogous way to FET devices in which the modulation of conductance (flow of electrons/holes) in the semiconductor, between the input (source) and the output (drain) terminals, is controlled by electrostatic potential variation (gate-electrode) of the charge carriers in the device conduction channel, the methodology of a Bio/Chem-FET is based on the detection of the local change in charge density, or so-called ―field effect‖, that characterizes the recognition event between a target molecule and the surface receptor.

This change in the surface potential influences the Chem-FET device exactly as a gate voltage does, leading to a detectable and measurable change in the device conduction. When these devices are fabricated using semiconductor nanowires as the transistor element the binding of a chemical or biological species to the surface of the sensor can lead to the depletion or accumulation of charge carriers in the "bulk" of the nanometer diameter nanowire i.e. (small cross section available for conduction channels). Moreover, the wire, which serves as a tunable conducting channel, is in close contact with the sensing environment of the target, leading to a short response time, along with orders of magnitude increase in the sensitivity of the device as a result of the huge S/V ratio of the nanowires.

While several inorganic semiconducting materials such as Si, Ge, or metal oxides (e.g. In_2O_3, SnO_2, ZnO, etc.) have been used for the preparation of nanowires. Silicon nanowires are usually the material of choice when fabricating nanowire FET-based chemo/biosensors.

Several examples of the use of silicon nanowire sensing devices include the ultra-sensitive, real time sensing of biomarker proteins for cancer, detection of single virus particles, and the detection of nitro-aromatic explosive materials such as 2,4,6 Tri-nitrotoluene (TNT) in sensitives superior to these of canines.

Possible Questions

Unit-IV

1. The electrical conductivity of a nanotube is ____ times that of copper.

   a) 10 b) 100 **c) 1000** d) 1/100

2. Carbon has ______ valence electrons?

   a) 3 b) 2 c) 1 **d) 4**

3. Carbon forms ___________________ bonds

   a) physical b) metallic c) ionic **d) covalent**

4. "which one of the following is the manipulation of matter on atomic, molecular, and supramolecular scale?"

   a) molecular chemistry b) nano tribology **c) Nanotechnology** d) Nano biology

5. Which of the following is not a way to represent chemical bonds?

   a) chemical formula b) electron dot diagram

   c) ball and stick model d) structural diagram

6. Which of the following is not a form of carbon?

   a) diamond b) fullerene **c) microtubules** d) graphite

7. Which form of carbon has the highest melting point?

   a) graphite b) fullerene **c) diamond** d) microtubules

8. Which form of carbon is used as the lead in lead pencils?

a) microtubules b) fullerene c) diamond **d) graphite**

9. Which form of carbon is man-made?

   a) diamond **b) fullerene** c) graphite d) microtubules

10. In a nanotube, carbon atoms are arranged in the shape of

    a) a crystal b) flat layers c) a geodesic dome **d) a hollow cylinder**

11. In diamond, carbon atoms are arranged in the shape of

    a) a crystal b) flat layers c) a geodesic dome d) a hollow cylinder

12. Buckyballs are a type of _________________ shaped like ____________________fullerene;

    a) a hollow cylinder graphite b) a flat layer's graphite

    a) a crystal fullerene **b) a geodesic dome**

13. carbon nanotubes are

    a) Large molecules b) small molecules

    c) long chain molecule d) small chain molecule

14. CNT has Howmany nanometers

    a) 1-3 b) 1-8 c) 1-6 d) 1-4

15. CNT are already being used in polymers to control

    a) enhance conductivity b) Poor conductivity

    c) medium conductivity d) no conductance

16. The width of carbon nanotube is

    a) 1 nm **b) 1.3nm** c) 1.55nm d) 10 nm

PART-B

1. Define CNT? Why CNT is an important in nanotechnology with neat examples?
2. Write an application and uses of CNT in metallurgical industry and explain why it is an important?
3. Explain with neat diagram for why does grapheme use in CNT.
4. What is the difference between CNT and Graphene.
5. Write a Preparation, properties and applications of carbon nanotubes.
6. Write a Preparation, properties and applications of carbon nanowires
7. Write a Preparation, properties and applications of carbon nanorods.

15CHU504
Karpagam Academy of Higher Education
Coimbatore-21
(For the candidate admitted on 2015 onwards)
Department of Chemistry
V- semester
Nano Chemistry

UNIT IV- Objective Questions for online examination (Each carry 1 Marks)

Question	Option A	Option B	Option C	Option D	Answer
Find the odd one out.	Frequency mixing	Second-harmonic generation	Optical mixing	Raman and Rayleigh scattering	Frequency mixing
Which of the following is used in electro optic modulators?	Lithium tantalite	Barium sodium niobate	Lithium niobate	Lithium sodium niobate	Lithium niobate
Carbon has ______ valence electrons?	3	2	1	4	4
Carbon forms __________________ bonds	physical	metallic	ionic	covalent	covalent
Which of the following is not a way to represent chemical bonds?	chemical formula	electron dot diagram	ball and stick model	structural diagram	chemical formula
Which of the following is not a form of carbon?	diamond	fullerene	microtubules	graphite	microtubules
Which form of carbon has the highest melting point?	graphite	fullerene	diamond	microtubules	diamond
Which form of carbon is used as the lead in lead pencils?	microtubules	fullerene	diamond	graphite	graphite
Which form of carbon is man-made?	diamond	fullerene	graphite	microtubules	fullerene
In a nanotube, carbon atoms are arranged in the shape of	a crystal	flat layers	a geodesic dome	a hollow cylinder	a hollow cylinder
In diamond, carbon atoms are arranged in the shape of	a crystal	flat layers	a geodesic dome	a hollow cylinder	a crystal
Buckyballs are a type of ________________ shaped like ___________________	fullerene; a hollow cylinder	graphite; flat layers	graphite; a crystal	fullerene; a geodesic dome	fullerene; a geodesic dome
Carbon nanotube is made of?	Circular tube made of graphite	Nanotubes are hollow cylinders made up of carbon atoms	Nanotubes are made of carbon sheet	Circular tube made of Carbon	Circular tube made of Carbon
What is a nanofluid?	Nanofuids are fluids in nanosize device	Nanofluids are mixture of different fluids	Nanofluids are fluids with suspensions of solid nano particles	Nanofuids are fluids in nanosize scale	Nanofluids are fluids with suspensions of solid nano particles
Carbon nanotubes are stronger than steel.	Carbon nanotubes are 100 times stronger than steel at one	Carbon nanotubes are 10 times stronger than steel at one	Carbon nanotubes are 1000 times stronger than steel at one sixth of the weight	Carbon nanotubes are 10 times stronger than steel at one	Carbon nanotubes are 100 times stronger than steel at one
Carbon nanotubes have the ability to sustain temperature as high as:	800 C	2800 C	3000 C	1000 C	2800 C
Single Walled Carbon Nano tubes are	excellent conductors	Poor conductor	Poor conductor than MWCNT	semi conductor	excellent conductors
Nanofluid thermal conductivity is increase by a factor of 20-30% by adding	10-15% of nano particles	20-30% of nano particles	3-4% of nano particles	5-7% nano particles	20-30% of nano particles
Tensile youngs modulus of SWCNT	A greater than c-fiber P100 by 1.6 times	Lower than c-fiber P100 by 1.6 times	A greater than c-fiber P100 by 2.8 times	Lower than c-fiber P100 by 2.8 times	A greater than c-fiber P100 by 1.6 times
carbon nanotubes are	Large molocules	small molecules	long chain molecule	small chain molecule	Large molocules
CNT has Howmany nanometers	1-3	1-8	1-6	1-4	1-3
CNT are already being used in polymers to control	enhance conductivity	Poor conductivity	medium conductivity	no conductance	enhance conductivity
he discovery of carbon nanotubes (CNT) in	1992	1991	1988	1987	1991
A carbon nanotube is	Tube shaped material	plain shape material	square shape material	no shape	Tube shaped material
A single-walled carbon nanotube is	One layer	two layer	three layer	six layer	One layer
The atomic number of carbon is _______	6	8	15	18	6
Carbon has _______ protons	2	6	4	8	2
Carbon has ________ neutrons	6,7,8	8,6,7	7,8,6	8,7,6	6,7,8
Carbon has _______ electrons.	4	8	2	6	6

How many chemical bonds does each carbon atom form to create a sheet of graphene? ___________	3	5	7	9	3
How many nanotubes are in the sample shown by Dr. Baughman?_____________________	two	three	five	many	many
Which property of nanotubes is especially unique and useful?	Tensile strength	elesatic modulus	mechanical property	conductivity	Tensile strength
What two properties of carbon nanotubes make them an ideal material for muscles?	Tensile and mechanical	tensile and electrical	physical and thermal	laser and tensile	Tensile and mechanical
CNT improves	electrical conductivity	thermal conductivity	electrical and thermal conductivity	no conductivity	electrical and thermal conductivity
Carbon nanotubes are	Less toxicity	High toxicity	no toxicity	medium toxicity	Less toxic
Scientists have created a new structure by encapsulating a single layer of fullerene molecules between	two graphene sheets	three graphene sheets	four graphene sheets	one graphene sheets	two graphene sheets
Carbon Nanotube Solar Cells: Twice as Efficient as Current Models	Lighter	Heavier	Harder	Smaller	Lighter
Engineers Now Understand How Complex Carbon Nanostructures Form	microscopic tubular	macroscopic tubular	universal tubular	large tubular	microscopic tubular
Reusable Carbon Nanotubes Could Be the Water Filter of the Future, Says Study	Improved SWCNT	Enhanced SWCNT	supperessed SWCNT	worsed SWCNT	Enhanced SWCNT
Plant Inspiration Could Lead to Flexible Electronics	Versatile and light-weight	Versatile and small-weight	Limited and small-weight	Limited and light-weight	Versatile and light-weight
Find the odd one out.	Frequency mixing	Second-harmonic generation	Optical mixing	Raman and Rayleigh scattering	Frequency mixing
Which of the following is used in electro optic modulators?	Lithium tantalite	Barium sodium niobate	Lithium niobate	Lithium sodium niobate	Lithium niobate
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Which form of carbon has the highest melting point?	graphite	fullerene	diamond	microtubules	diamond
Which form of carbon is used as the lead in lead pencils?	microtubules	fullerene	diamond	graphite	graphite
Which form of carbon is man-made?	diamond	fullerene	graphite	microtubules	fullerene
In a nanotube, carbon atoms are arranged in the shape of	a crystal	flat layers	a geodesic dome	a hollow cylinder	a hollow cylinder
In diamond, carbon atoms are arranged in the shape of	a crystal	flat layers	a geodesic dome	a hollow cylinder	a crystal
Buckyballs are a type of ________________ shaped like ___________________	fullerene; a hollow cylinder	graphite; flat layers	graphite; a crystal	fullerene; a geodesic dome	fullerene; a geodesic dome
Carbon nanotube is made of?	Circular tube made of graphite	Nanotubes are hollow cylinders made up of carbon atoms	Nanotubes are made of carbon sheet	Circular tube made of Carbon	Circular tube made of Carbon
What is a nanofluid?	Nanofuids are fluids in nanosize device	Nanofluids are mixture of different fluids	Nanofluids are fluids with suspensions of solid nano	Nanofuids are fluids in nanosize scale	Nanofluids are fluids with suspensions of solid nano
Carbon nanotubes are stronger than steel.	Carbon nanotubes are 100 times stronger than steel at	Carbon nanotubes are 10 times stronger than steel	Carbon nanotubes are 1000 times stronger than	Carbon nanotubes are 10 times stronger than	Carbon nanotubes are 100 times stronger than steel
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Tensile youngs modulus of SWCNT	A greater than c-fiber P100 by 1.6 times	Lower than c-fiber P100 by 1.6 times	A greater than c-fiber P100 by 2.8 times	Lower than c-fiber P100 by 2.8 times	A greater than c-fiber P100 by 1.6 times
carbon nanotubes are	Large molocules	small molecules	long chain molecule	small chain molecule	Large molocules

UNIT-V

Instrumental Techniques: Electron microscopes – scanning electron microscopes (SEM) – transmission electron microscopes (TEM) – scanning probe microscopy – atomic force microscopy (AFM) – scanning tunneling electron microscope (STEM) – basic principles only.

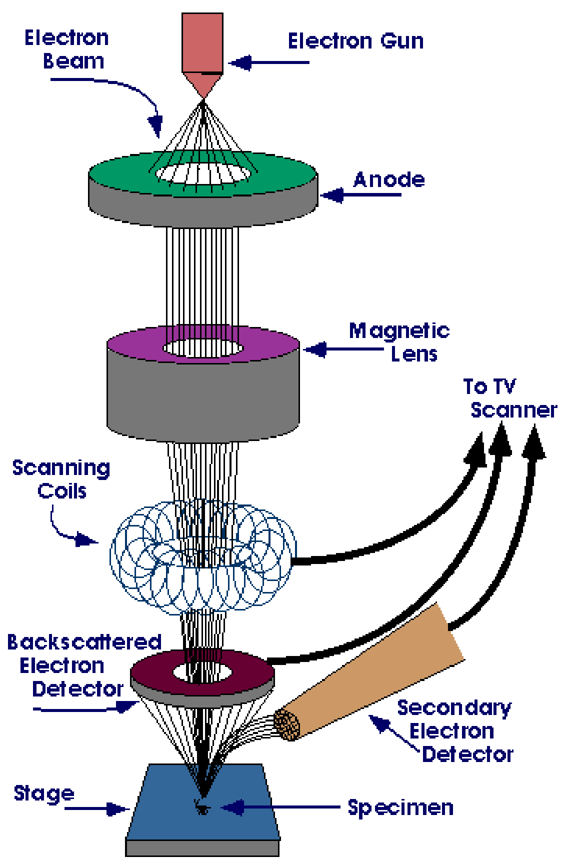
Electron Microscope

An electron microscope is a type of microscope that uses electrons to illuminate a specimen and create an enlarged image. Electron microscopes have much greater resolving power than light microscopes and can obtain much higher magnifications. Some electron microscopes can magnify specimens up to 2 million times, while the best light microscopes are limited to magnifications of 2000 times. Both electron and light microscopes have resolution limitations, imposed by their wavelength. The greater resolution and magnification of the electron microscope is due to the wavelength of an electron, its de Broglie wavelength, being much smaller than that of a light photon, electromagnetic radiation. The electron microscope uses electrostatic and electromagnetic lenses in forming the image by controlling the electron beam to focus it at a specific plane relative to the specimen in a manner similar to how a light microscope uses glass lenses to focus light on or through a specimen to form an image.

SCANNING ELECTRON MICROSCOPE

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures.

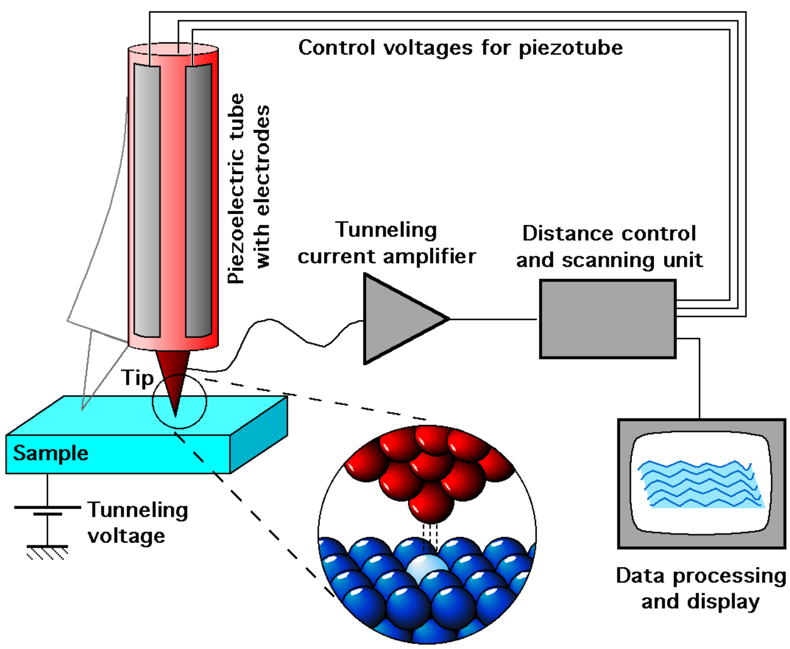
The most common mode of detection is by secondary electrons emitted by atoms excited by the electron beam. On a flat surface, the plume of secondary electrons is mostly contained by the sample, but on a tilted surface, the plume is partially exposed and more electrons are emitted. By scanning the sample and detecting the secondary electrons, an image displaying the topography of the surface is created.



SCANNING TUNNELING MICROSCPE

A scanning tunneling microscope (STM) is an instrument for imaging surfaces at the atomic level. Its development in 1981 earned its inventors, Gerd Binnig and Heinrich Rohrer (at IBM Zürich), the Nobel Prize in Physics in 1986. For an STM, good resolution is considered to be 0.1 nm lateral resolution and 0.01 nm depth resolution. With this resolution, individual atoms within materials are routinely imaged and manipulated. The STM can be used not only in ultra-high vacuum but also in air, water, and various other liquid or gas ambient, and at temperatures ranging from near zero Kelvin to a few hundred degrees Celsius.

The STM is based on the concept of quantum tunneling. When a conducting tip is brought very near to the surface to be examined, a bias (voltage difference) applied between the two can allow electrons to tunnel through the vacuum between them. The resulting *tunneling current* is a function of tip position, applied voltage, and the local density of states (LDOS) of the sample.[4] Information is acquired by monitoring the current as the tip's position scans across the surface, and is usually displayed in image form. STM can be a challenging technique, as it requires extremely clean and stable surfaces, sharp tips, excellent vibration control, and sophisticated electronics, but nonetheless many hobbyists have built their own.

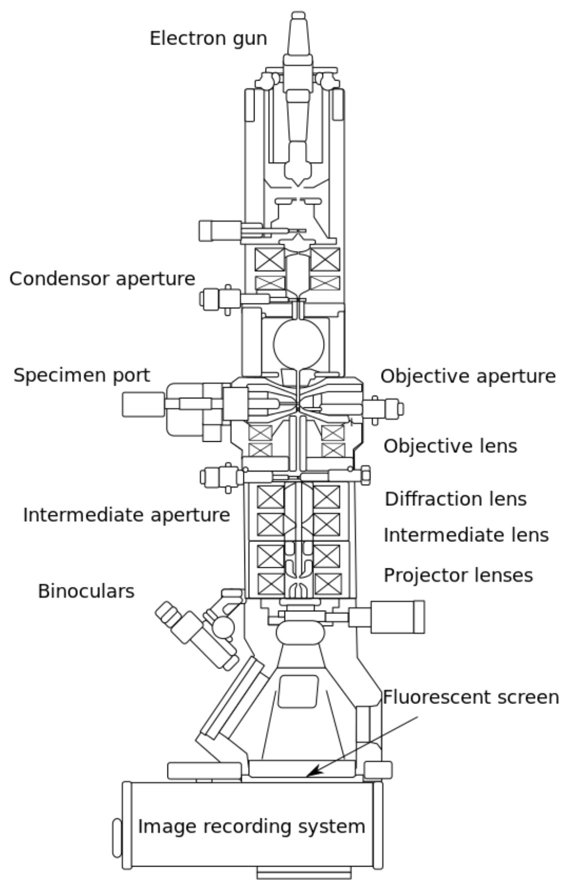


A simple view of scanning tunneling microscope

MODERN TRANSMISSION ELECTRON MICROSCOPE

Transmission electron microscopy (**TEM**) is a microscopy technique in which a beam of electrons is transmitted through an ultra-thin specimen, interacting with the specimen as it passes through. An image is formed from the interaction of the electrons transmitted through the specimen; the image is magnified and focused onto an imaging device, such as a fluorescent screen, on a layer of photographic film, or to be detected by a sensor such as a CCD camera.

TEMs are capable of imaging at a significantly higher resolution than light microscopes, owing to the small de Broglie wavelength of electrons. This enables the instrument's user to examine fine detail—even



Simple view of transmission electron microscope as small as a single column of atoms, which is thousands of times smaller than the smallest resolvable object in a light microscope. TEM forms a major analysis method in a range of scientific fields, in both physical and biological sciences. TEMs find application in cancer research, virology, materials science as well as pollution, nanotechnology, and semiconductor research.

At smaller magnifications TEM image contrast is due to absorption of electrons in the material, due to the thickness and composition of the material. At higher magnifications complex wave interactions modulate the intensity of the image, requiring expert analysis of observed images. Alternate modes of use allow for the TEM to observe modulations in chemical identity, crystal orientation, electronic structure and sample induced electron phase shift as well as the regular absorption based imaging.

The first TEM was built by Max Knoll and Ernst Ruska in 1931, with this group developing the first TEM with resolution greater than that of light in 1933 and the first commercial TEM in 1939.

Scanning Probe Microscope (SPM)

The **scanning probe microscope** gives researchers imaging tools for the future as these specialized microscopes provide high image magnification for observation of three-dimensional-shaped specimens.

This renders not only enhanced images but specimen properties, response and reaction or non-action when specimens are stimulated or touched.

Basic Principles of SPM Techniques

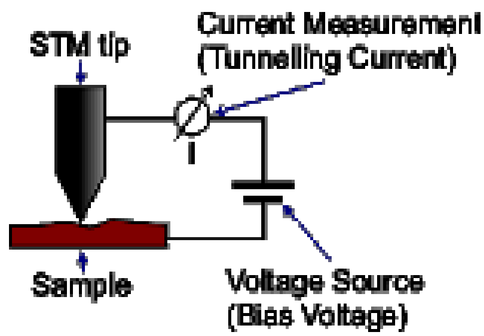
All of the techniques are based upon scanning a probe (typically called the *tip* in STM, since it literally is a sharp metallic tip) just above a surface whilst monitoring some interaction between the probe and the surface.

SPM Technology

The ability to observe a specimen in three dimensions, in real time plus manipulating specimens through the application of an electrical current with a physical interaction using the tip of the probe has incredible potential for research. Viewing a specimen in a variety of environments is why scanning probe microscopes, SPMs, are so widely used. Specimens can now be viewed at the nanometre level and instead of light waves or electrons, SPMs use a delicate probe to scan a specimen's surface eliminating many of the restrictions that light waves or electron imaging has

How Does a Scanning Probe Microscope work?

Tracing the surface of a specimen is done through the use of a sharp, electrically charged probe, much in the way an old record player created sound through a needle following the grooves on an LP. Unlike a record player needle, the SPM probe does not touch the surface but traces the specimen nanometres above the surface. Plus, the probe can be used to interact with a specimen allowing researchers to observe how a substance attracts or detracts, responds to electrical currents. Since SPM technology can operate in a wide variety of environments even non-conductive specimens can be manipulated and observed.



Advantages of SPM Technology

Scanning Probe Microscopy provides researchers with a larger variety of specimen observation environments using the same microscope and specimen reducing the time required to prepare and study specimens. Specialized probes, improvements and modifications to scanning probe instruments continues to provide faster, more efficient and revealing specimen images with minor effort and modification.

Disadvantages of SPM Technology

Unfortunately, one of the downsides of scanning probe microscopes is that images are produced in black and white or grayscale which can in some circumstances exaggerate a specimen's actual shape or size.

Computers are used to compensate for these exaggerations and produce real time color images that provide researchers with real time information including interactions within cellular structures, harmonic responses and magnetic energy.

ATOMIC FORCE MICROSCOPE

For friction force calculations, we slide the cantilever orthogonal to the long axis of the cantilever. Here the changes in the intensities in the right and left halves of the four quadrant photodiode help us calculate the friction parameters. The images after scanning on the surface along the axis of the cantilever, (a), and perpendicular to it, (b). Note how different the two scans are. Actually, Bhushan has shown that the friction force scan images are found to be more similar to the 3D plot of slope of the roughness scan, (a), versus distance. For example, the initial peak in (b) is similar to the sudden increase in slope of the roughness scan in (a) at the same location.

For studying the adhesive properties of one material with another, a tip of one material and the sample of another are used. The tip is brought closer and closer to the sample till it comes into contact with it. It is then pulled back. However, due to adhesive forces, it says stuck to the surface beyond the point it came into contact with it. The extra displacement given to the piezo drive to loose contact is noted. Multiplying this value with the cantilever stiffness directly gives the adhesion force value. For example, consider the deflection Vs distance (moved by piezoelectric) while bringing the tip closer to the surface the contacts occur at B. from A to B, attractive van der walls forces comes into play. After contact, the cantilever movement is directly proportional to the distance that the piezoelectric drive moves. However, in retracting, the contact is lost at C, way beyond point B due to the presence of adhesive forces from B to C.

The adhesive force, $F = BC \times k$,

Where, BC is the distance from the graph = the extra distance that the piezoelectric tube had to travel to loose contact and k is the stiffness of the cantilever.

For scratching and wear, a single crystal diamond tip is used in the contact mode. After scratching, the surface around the scratch is scanned to study the effects more elaborately. Nano-fabrication and Nano-machining refers to the scratching and wearing the surface at intended locations and in an intended fashion, with the mechanism being the same.

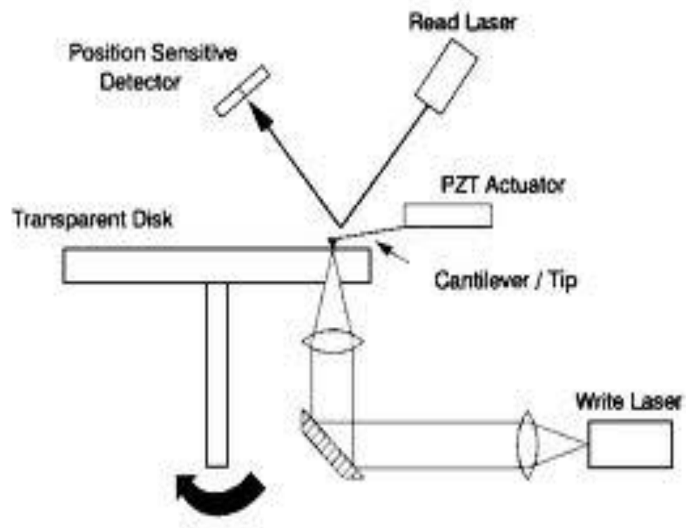
Nano-indentation is another important measurement in Nano tribology. It can help us get the hardness and elasticity moduli values of a localized point. It is done in the normal mode of

AFM, by intending the surface with the tip after setting the scan size to zero. After indenting, a finite size scan is done around the indent to calculate the projected area of indent. The hardness (H) is the given by,

H = (load applied) / (projected area of indent),

Where the projected area of indent is the area of the indent projected on to a plane perpendicular to the tip.

Young's modulus is obtained from the slope of the force –displacement curve while unloading. Using the AFM technique, we can investigate surfaces of interest at the atomic scale. The AFM relies on a scanning technique to produce three-dimensional images of sample surfaces of high resolution. AFM can be used measure the ultra-small forces (<1 nN) present between the cantilever tip and a sample surface. These small forces are measured by tracking the motion of highly flexible Nano sized cantilever having, by various measurement technique like optical deflection, optical interference, and capacitance and tunneling current. The deflection can be measured to the very low limits of 0.02 nm. For a typical cantilever having a force constant of 10 N/m, a force as low as 0.2 nN can be detected. In the operation of high-resolution AFM, it is the sample that is moved rather than the cantilever, as the movement of the cantilever may cause vibration thereby affecting the measurements. AFMs are now available for large sample too, wherein the tip is scanned and the sample is stationary. In order to obtain good atomic resolution, the spring constant of the cantilever should be less than the equivalent spring constant between the atoms. As per the experimental results, a cantilever beam with a spring constant of about 1 N/m or lower is desirable. Tips have to be as sharp as possible. Tips with a radius ranging from 10 to 100 nm are commonly available.



Surface in contact will generally have a thin layer of liquid lubricant at the interface. Tribological studies under such environments can lead to completely different results. John pethica and co=workers have made useful contributions to the study of Nano indentation of liquid environments, comparing these data to the conventional results reported. The same group has also reported useful results based on the mechanical deformation of nano contacts due to the size and structure of the asperities at the point of contact.

Atomic Force Microscopy:

This invention is an atomic force microscope having a digitally calculated feedback system which can perform force spectroscopy on a sample in order to map out the local stiffness of the sample in addition to providing the topography of the sample. It consists of a three-dimensional piezoelectric scanner, scanning either the sample or a force sensor. The force sensor is a contact type with a tip mounted on a cantilever and a sensor to detect the deflection of the lever at the tip. The signal from the sensor goes to an A-D convertor and is then processed by high-speed digital electronics to control the vertical motion of the sample or sensor. In operation, the digital electronics raise and lower the piezoelectric scanner during the scan to increase and decrease the force of the tip on the sample and to use the sensor signal to indicate the change in height of the tip to measure the which is the spring constant of the sample. This constant can be determined with nanometer spatial resolution. At the same time, the instrument can determine the topography of the sample with nanometer resolution. In an alternate embodiment, the lever is connected to a separate piezoelectric driver to vary the force on the tip. This improved AFM can also be used to periodically reset the force at which the tip contacts the sample and quickly replace the tip on the sample in the event that the tip loses contact with the surface.

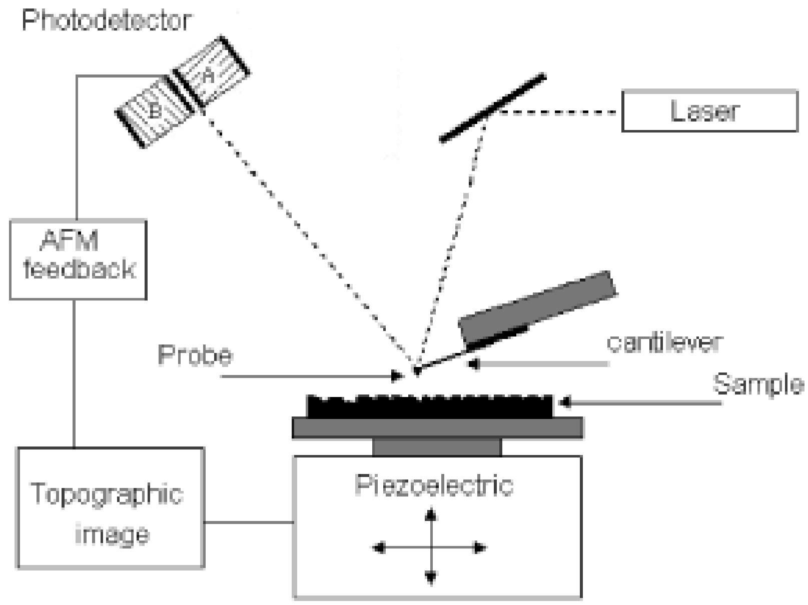


Figure 2 - Schematic diagram of an AFM set up apparatus basic components.

Possible Questions

Unit-V

1. Where the projected area of indent is the area of the indent projected on to a plane?

a) parallel to the tip b) bottom to the tip **c) perpendicular to the tip** d) side to the tip

2. The AFM relies on a scanning technique to produce?

a) two- dimensional images b) four- dimensional images

c) three-dimensional images d) dimensional images

3. The AFM relies on a scanning technique to produce three-dimensional images of sample surfaces of?

a) resolution b) low resolution **c) high resolution** d) medium resolution

4. AFM can be used measure the?

a) ultra-small forces b) small forces c) ultra high forces d) high forces

5. Scanning electron microscopy (SEM) is best used to study

a) Surface morphology b) surface structures

c) internal structures d) small internal cell structures

6. The first Transmission electron microscopy was built by Max knoll and Ernst Ruska in ?

a) 1932 b) 1930 **c) 1931** d) 1933

7. The first commercial Transmission electron microscopy in?

a) 1937 b) 1938 c) 1936 **d) 1939**

8. The first Transmission electron microscopy was built by?

a) Max knoll and Ernst Ruska b) Richard Feynman and Norio Taniguchi

c) Richard Smalley and Eric Drexler d) Gerd Binnig and Heinrich Rohrer

9. Scanning electron microscope can achieve resolution better than?

a) 1 nanometer b) 2 nanometer c) 3 nanometer **d) <1 nanometer**

10. "In scanning electron microscope the most common mode of detection is by secondary electrons emitted by atoms excited by the?"

    a) electron detector b) electron beam c) amplifier **d) recorder**

11. which of the following is an instrument for imaging surfaces at the atomic level

    a) STEM b) SEM c) TEM d) AFM

12. The scanning tunneling microscope can be used not only in ultra-high vacuum but also in?

    a) air b) acid c) solid d) air and solid

13. A high-powered microscope that produces an image from scattered secondary electrons is the

    a) immunofluorescence microscope b) bright-field light microscope

    c) transmission electron microscope **d) scanning electron microscope**

14. The concepts that seeded nanotechnology were first discussed in?

    a) 1959 b) 1956 c) 1957 d) 1958

15. The concepts that seeded nanotechnology were first discussed in 1959 by renowned physicist?

    a) Norio Taniguchi b) Eric Drexler c) minsky d) Richard Feynman

PART-B

1. Give an eight important differences about SEM and TEM.
2. How SEM & TEM can be used for characterization of nanonmaterials?
3. What is the basic principle in SEM? How are they differing from optical microscopy?
4. Define AFM and why it is used in nanotechnology? Explain with precise diagram.
5. What is the principle of SEM? How it is an important in nanomaterial characterization?
6. Give the instrumentation about SEM.

7. Explain the instrumentation about TEM

8. What is the principle of STEM? How it is an important in nanomaterial characterization?

15CHU504
Karpagam Academy of Higher Education
Coimbatore-21

(For the candidate admitted on 2015 onwards)
Department of Chemistry
V- semester
Nano Chemistry

UNIT V- Objective Questions for online examination (Each carry 1 Marks)

Question	Option A	Option B	Option C	Option D	Answer
which one of the following is the manipulation of matter on atomic, molecular, and supramolecular scale?	molecular chemistry	nano tribology	Nanotechnology	Nano biology	Nanotechnology
A high-powered microscope that produces an image from scattered secondary electrons is the	immunofluorescence microscope	bright-field light microscope	transmission electron microscope	scanning electron microscope	scanning electron microscope
The concepts that seeded nanotechnology were first discussed in?	1959	1956	1957	1958	1959
The concepts that seeded nanotechnology were first discussed in 1959 by renowned physicist?	Norio Taniguchi	Eric Drexler	minsky	Richard feynman	Richard feynman
The term "nano-technology" was first used by?	Norio taniguchi	Eric Drexler	minsky	Richard Feynman	Norio taniguchi
The term "nano-technology" was first used by Noria taniguchi in	1974	1975	1976	1978	1976
Nanotechnology refers to the projected ability to construct items?	bottom down	bottom up and down	bottom up	bottom up or down	bottom up
Molecule manufacturing is sometimes called ?	Nano biology	molecular chemistry	molecular nanotribology	molecular Nanotechnology	molecular Nanotechnology
Which type of microscope uses electrons to provide a three-dimensional view of the surface of the object?	scanning electron microscope	light microscope	transmission electron microscope	scanning probe microscope	scanning probe microscope
When the term "nanotechnology" was independently coined and popularized by?	Richard Feynman	Eric Drexler	Norio Taniguchi	Micheal faraday	Eric Drexler
Who argued that mechano synthesis is impossible due to the difficulties in mechanically manipulating individual molecules?	Richard Feynman	Norio Taniguch	Richard Smalley	Eric Drexler	Richard Feynman
which one is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons?	scanning tunneling microscope	scanning electron microscope	transmission electron microscope	scanning probe microscope	scanning electron microscope
which type of microscope has useful magnification limit of about 1,000X ?	scanning electron microscope	light microscope	transmission electron microscope	scanning probe microscope	light microscope
scanning electron microscope can achieve resolution better than ?	1 nanometer	2 nanometer	3 nanometer	<1 nanometer	<1 nanometer
In scanning electron microscope the most common mode of detection is by secondary electrons emitted by atoms excited by the ?	electron detector	electron beam	amblifier	recorder	recorder
which of the following is an instrument for imaging surfaces at the atomic level	STEM	SEM	TEM	AFM	STEM
The scanning tunneling microscope can be used not only in ultra-high vacuum but also in?	air	acid	solid	air and solid	Air
The scanning tunneling microscope can be used not only in ultra-high vacuum but also in air, water, and various other liquid or gas ambient, and at temperatures ranging from	1 Kelvin	>1 Kelvin	5 Kelvin	zero Kelvin	zero Kelvin
Inventors of scanning tunneling microscope is?	Richard Feynman and Norio Taniguchi	Richard Smalley and Eric Drexler	Gerd Binnig and Heinrich Rohrer	Norio Taniguchi and Eric Drexler	Norio Taniguchi and Eric Drexler
The scanning tunneling microscope is based on the concept of ?	scattering	transmission	Guantum tunneling	absorption	absorption
All of the following are aspects of scanning electron microscopy EXCEPT?	whole specimens can be observed	secondary electrons are used to visualize the	specimens must be placed into a vacuum	scanning electron micrographs	scanning electron micrographs
Scanning electron microscopy is most often used to reveal	surface structures	internal structures	structures simultaneously	structures, but not	surface structures

Which one of the following is capable of imaging at a significantly higher resolution than light microscopes, owing to the small de Broglie wavelength of electrons?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Transmission electron microscopy
Scanning electron microscopy (SEM) is best used to study	Surface morphology	surface structures	internal structures	small internal cell structures	Surface morphology
The first Transmission electron microscopy was built by Max knoll and Ernst Ruska in ?	1932	1930	1931	1933	1931
The first commercial Transmission electron microscopy in ?	1937	1938	1936	1939	1939
The first Transmission electron microscopy was built by?	Max knoll and Ernst Ruska	Richard Feynman and Norio Taniguchi	Richard Smalley and Eric Drexler	Gerd Binnig and Heinrich Rohrer	Max knoll and Ernst Ruska
Who shown that the friction force scan images are found to be more similar to the 3D plot of slope of the roughness scan?	Bhushan	Richard Feynman	Norio Taniguchi	Richard Smalley	Bhushan
The adhesive force, F = ?	BC x t	CB x k	BC x p	BC x k	BC x k
Scratching and wear, a single crystal diamond tip is used in?	Individual mode	contact mode	individual and contact mode	non individual mode	contact mode
Nano-indentation is important measurement in?	Nano biology	nano technology	Nano triology	Nano tribology	Nano tribology
Where the projected area of indent is the area of the indent projected on to a plane ?	parallel to the tip	bottom to the tip	perpendicular to the tip	side to the tip	perpendicular to the tip
The AFM relies on a scanning technique to produce ?	two- dimensional images	four- dimensional images	three-dimensional images	dimensional images	three-dimensional images
The AFM relies on a scanning technique to produce three-dimensional images of sample surfaces of ?	resolution	low resolution	high resolution	medium resolution	high resolution
AFM can be used measure the ?	ultra-small forces	small forces	ultra high forces	high forces	ultra-small forces
In atomic force microscope the force sensor is a contact type with a tip mounted on a cantilever and a sensor to detect the deflection of the lever at the ?	top	side	tip	bottom	tip
John pethica and co=workers have made useful contributions to the study of ?	Nano indentation	nano technology	Nano triology	Nano tribology	Nano indentation
This having a digitally calculated feedback system which can perform force spectroscopy on a sample in order to map out the local stiffness of the sample in addition to providing the topography of the sample?	scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	atomic force microscope
Which one is consists of a three-dimensional piezoelectric scanner, scanning either the sample or a force sensor?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	atomic force microscope
A microscope consists of a three-dimensional piezoelectric scanner, scanning either the sample or a force sensor?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	atomic force microscope
Which one of the microscopy is capable of imaging at a significantly higher resolution than light microscopy?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Transmission electron microscopy
Which one of the microscope analysis the small de Broglie wave length of the electrons?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Transmission electron microscopy
Surface morphology can be best studied using	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	scanning electron microscope
Surface structures can be best studied using	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	scanning electron microscope
three-dimensional images can be best studied using	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	atomic force microscope
A high-powered microscope that produces an image from scattered secondary electrons is the	immunofluorescence microscope	bright-field light microscope	transmission electron microscope	scanning electron microscope	scanning electron microscope
A microscope in which an image is formed by passing an electron beam through a specimen and focusing the scattered electrons with magnetic lenses is called a	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Transmission electron microscopy

Transmission electron microscopy is best for high magnification viewing of	internal structure of field cells	internal structure of motile cell	surface structure of field cells	surface structure of motile cell	internal structure of motile cell
The scanning electron microscope has a magnification that ranges from	1x to 100x	100x to 10,000x	10x to 100,000x	10x to 10,000x	10x to 100,000x
The major attractions of the scanning electron microscope include all of the following except	its ability to polarize light	its high magnification	its great depth of focus	its high resolution	its ability to polarize light
Which microscope can be used to determine whether or not a suspect has recently fired a gun?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	scanning electron microscope
The “fingerprint” IR spectrum can be seen using an	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	scanning electron microscope
Which of the following is NOT equivalent to 10 micrometers	0.0001 cm	0.01 mm c	10,000 nm	100,000 Angstroms	0.0001 cm
Which type of microscope uses electrons to provide a three-dimensional view of the surface of the object?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	scanning electron microscope
TEM" refers to a photomicrograph taken by a	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Transmission electron microscopy
Atomic force microscopy shows images of surfaces through:	the force of the surface on the tip	the electric current that flows from the surface to the tip	diffraction of electrons around the molecules of the surface	movement of a laser along the surface	the force of the surface on the tip
scanning tunneling microscopy shows images of atoms based on:	the thickness of the atom	the mass of the atom	friction caused by rubbing the tip on the atom	the amount of tunneling current	the amount of tunneling current
Which method detects the smallest particles?	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Scanning tunneling microscope
The best method to determine the size of the Au nanoparticles is:	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	scanning electron microscope
If the objective lenses of a microscope can be changed without losing focus on the specimen, they are said to be	equifocal	totifocal	parfocal	optifoca	parfocal
Small internal cell structures are best visualized with a	Scanning tunneling microscope	scanning electron microscope	Transmission electron microscopy	atomic force microscope	Transmission electron microscopy

Reg. No. : ----------------- [15CHU504]

KARPAGAM UNIVERSITY

COIMBATORE-21

(For the candidates admitted from 2015 & onwards)

III B.Sc CHEMISTRY

I INTERNAL TEST

NANO CHEMISTRY

Time: 2 hours **Maximum: 50 marks**

PART- A (20 x 1= 20 Marks)

Answer ALL the Questions

1. One nanometre is equal to how many meters

   a) 10^{-7} b) 10^{-3} c) 10^{-8} d) 10^{-9}

2. The most important property of nanomaterials is

   a) Temperature b) pressure c) friction d) force

3. ______ is the extensions of bucky balls.

   a) Geodesic domes b) Hexagons c) Carbon nanotubes d) AFM and STM

4. Nanocoatings and nanocomposites are finding uses in?

   a) bicycles b) automobiles c) bicycles and automobiles d) tooth brushes

5. which One of the following is first scientific report of synthesized colloidal gold particles.

   a) Granqvist b) Buhrman c) Michael Faraday d) flemming

6. Popular inert- gas evaporation technique was published by ?

   a) Granqvist b) Buhrman c) Granqvist and Buhrman d) Michael Faraday

7. Nanophase silicon, which differs from normal silicon with respect to property

   a) electronic b) physical c) mechanical d) physical and electronic

8. Nanostructured semiconductors are known to show various?

   a) non-linear optical properties b) optical properties
   c) chemical properties d) linear properties

9. The beautiful tone of the which colour is obtained only when both these nanoparticles and the superlattice are present

   a) red b) blue c) yellow d) orange

10. Nanostructured semiconductors are used as window layers in ?

    a) cells b)walls c) solar cells d) thermal

11. Nanostructured metal clusters and colloids of mono- or plurimetallic composition have a special impact in which applications?

    a) industrial b) electrical c) catalytic d) mechanical

12. A nanometer is a?

    a) millionth of a meter b)trillionth of a meter c) billionth of a meter d) millimeter

13. Nanoparticles are produced by the shear action during ?

    a) powdering b) shaking c) grinding d) mixing

14. Nanotechnology, in other words, is

    a) Carbon engineering b) Atomic engineering
    c) Small technology d) Microphysics

15. Based on the energy of the milling process and which properties of the constituents the alloy can be rendered amorphous by this processing?

    a) electrical b) chemical c) thermodynamic d) mechanical

16. Who coined the word Nanotechnology?

a) Eric Drexler b) Buhrman

c) Granqvist and Buhrman d) Michael Faraday

17. The width of carbon nanotube is

a)1 nm b) 1.3 nm c) 1.55 nm d) 10 nm

18. Who coined the word Nanotechnology?

a) Eric Drexler b) Buhrman

c) Granqvist and Buhrman d) Michael Faraday

19. How much is 1 micron in meter?

a) 10^{-5}meter b) 10^{-4} meter c)10^{-6} meter d) 10^{-8} meter

20. What is the diameter of human hair?

a) 75000 nm b) 65000 nm c) 85000 nm d) 5000 nm

PART- B (3 x 10= 30 Marks)

Answer ALL the Questions

21. (a) What is nanoscale? Give a brief explanation about nanoscale and its technology.

(OR)

(b) Define nanochemistry. Discuss about the porous solids and nanowires.

22. (a) What is self assembly? Write a brief note on self assembly of materials and molecules.

(OR)

(b) What is meant by nano machine and quantum dots? How it's classified?

23. (a) Write a preparation, properties and uses of Au, ZnO and FeO.

(OR)

(b) Discuss about the preparation, properties and uses of alumina and titania nanoparticles in addition with silver nanoparticles.

Reg. No. : -----------------

[15CHU504]

KARPAGAM UNIVERSITY

COIMBATORE-21

(For the candidates admitted from 2015 & onwards)

III - B.Sc CHEMISTRY

II INTERNAL TEST

NANO CHEMISTRY

Time: 2 hours

Date : 10.8.2017 AN

Maximum: 50 marks

PART- A (20 x 1= 20 Marks)

Answer ALL the Questions

1. The diameter of human hair is ____ nm.

a) 50,000 b) 75,000 c) 90,000 d) 1,00,000

2. The diameter of human hair is ____ m.

a) 5×10^{-8} b) 5×10^{-7} c) 5×10^{-6} d) 5×10^{-5}

3. The cut-off limit of human eye is ____ nm.

a) 2,000 b) 5,000 c) 10,000 d) 50,000

4. The size of E.Coli bacteria is ____ nm.

a) 2,000 b) 5,000 c) 50 d) 90

5. The size of RBC is ____ nm.

a) 50 b) 90 c) 2,000 d) 5,000

6. The thickness of a transistor is ____ nm.

a) 50 b) 90 c) 2,000 d) 5,000

7. The size of a virus is ____ nm.

a) 2 b) 20 c) 50 d) 2000

8. The diameter of a bucky ball is ____ nm.

a) 1,000 b) 100. c) 10 d) 1

9. The largest cluster of carbon atoms in Bucky balls known till today consists of ____ carbon atoms.

a) 60 b) 75 c) 180 d) 540

10. The smallest cluster of carbon atoms in Bucky balls known till today consists of ____ carbon atoms.

a) 75 b) 60 c) 20 d) 15

11. The tensile strength of an MWNT is ____ Pa

a) 63×10^{6} b) 63 c) 63×10^{8} d) 63×10^{9}

12. The compressive strength of a nanotube ____ its tensile strength

a) is less than b) is greater than c) is equal to d) may be greater

13. A TCO is a semiconductor which has:

a) high electrical resistivity and high optical transparency

b) high electrical conductivity and high optical transparency

c) high electrical conductivity and low optical transparency

d) low electrical resistivity and low optical transparency

14. The efficiency of today's best solar cell is about

a) 15-20% b) 40% c) 50% d) 75%

15. In which of the following the atoms do not move from each other?

a) Shape memory alloys b) Nano materials c) Dielectrics d) Static materials

16. Which of the following uses radio frequency to produce nano-particles?

a) Plasma arching b) Chemical vapour deposition

c) Sol-gel technique d) Electro deposition

17. Which of the following methods can be used to produce nano-powders of oxides?

a) Plasma arching b) Sol-gel technique

c) Chemical vapour deposition d) Mechanical crushing

18. Which of the following is used to make both nano-particles and nano-powders?

a) Chemical vapour deposition b) Sol-gel technique

c) Plasma arching d) Electro deposition

19. Which method can be used to prepare iron nitriles nano-crystals using ammonia gas?

a) Pulsed laser deposition b) Sol-gel technique

c) Electro-deposition d) Mechanical crushing

20. Nano-particles exhibit super plastic behaviour is

a) No behaviour b) semi behaviour c) Good behaviour d) Bad behaviour

PART- B **(3 x 10= 30 Marks)**

Answer ALL the Questions

21. (a) Write briefly on various approaches in nanoparticle synthesis.

(OR)

(b) What are all the characterization made in nanoparticles and explain about the toxic effects of nanomaterials.

22. (a) What is nanoparticles? Give a brief explanation about physical, chemical and biological methods of nanoparticles.

(OR)

(b) What is the difference between top down and bottom up approaches?

23. (a) How to synthesize nanoparticles? Explain brief note on common growth methods.

(OR)

(b) Explain the role of top down and bottom approaches in nanotechnology.

NO.

Reg. No....................

[15CHU504]

KARPAGAM UNIVERSITY, COIMBATORE-21

(For the candidates admitted from 2017 batch onwards)

B.Sc CHEMISTRY DEGREE EXAMINATIONS, NOVEMBER 2017

NANO CHEMISTRY

MODEL EXAM

TIME: 3.00 Hrs

TOTAL: 60 MARKS

PART-A

(20 x 1 = 20)

1. Nanoscience can be studied with the help of
   a) quantum mechanics b) Newtonian mechanics c) macro-dynamics d) geophysics
2. The size of nanoparticles is between
   a) 100 to 1000 nm b) 0.1 to 10 nm c) 1 to 100 nm d) 0.01 to 1 nm
3. The two important properties of nano substances are
   a) pressure and friction b) sticking and friction
   c) sticking and temperature d) temperature and friction
4. What is the general name for the class of structures made of rolled up carbon lattices?
   a) nanotubes b) nonosheets c) nanorods d) nano particals
5. The thickness of a transistor is ____ nm.
   a) 50 b) 90 c) 2,000 d) 5,000
6. The size of a virus is ____ nm.
   a) 2 b) 20 c) 50 d) 2000
7. Atomic number of aluminium
   a) 13 b) 18 c) 20 d) 35
8. The number of electrons present in the titanium
   a) 20 b) 28 c) 22 d) 24
9. Which of the following is used to make both nano-particles and nano-powders?
   a) Chemical vapour deposition b) Sol-gel technique
   c) Plasma arching d) Electro deposition
10. Which method can be used to prepare iron nitriles nano-crystals using ammonia gas?
    a) Pulsed laser deposition b) Sol-gel technique
    c) Electro-deposition d) Mechanical crushing
11. Nano-particles exhibit super plastic behaviour is
    a) No behaviour b) semi behaviour c) Good behaviour d) Bad behaviour
12. Which of the following is used to modify the optical properties of a material system?
    a) Electricity b) Magnetic field c) Pressure d) Light
13. Carbon Nanotube Solar Cells: Twice as Efficient as Current Models
    a) Lighter b) Heavier b) Harder d) Smaller
14. Engineers Now Understand How Complex Carbon Nanostructures Form
    a) microscopic tubular b) macroscopic tubular
    c) universal tubular d) large tubular
15. Reusable Carbon Nanotubes Could Be the Water Filter of the Future, Says Study
    a) Improved SWCNT b) Enhanced SWCNT
    c) supperessed SWCNT d) worse SWCNT
16. Plant Inspiration Could Lead to Flexible Electronics
    a) Versatile and light-weight b) Versatile and small-weight
    b) Limited and small-weight d) Limited and light-weight

17. Which method detects the smallest particles?

a) Scanning tunneling microscope b) scanning electron microscope

c) Transmission electron microscopy d) atomic force microscope

18. The best method to determine the size of the Au nanoparticles is:

a) Scanning tunneling microscope b) scanning electron microscope

c) Transmission electron microscopy d) atomic force microscope

19. If the objective lenses of a microscope can be changed without losing focus on the specimen, they are said to be

a) equifocal b) totifocal c) parfocal d) optifoca

20. Small internal cell structures are best visualized with a

a) Scanning tunneling microscope b) scanning electron microscope

c) Transmission electron microscopy d) atomic force microscope

PART-B **ANSWER ALL THE QUESTIONS** **(5 x 8 = 40)**

21. (a) What is self assembly? Write a brief note on self assembly of materials and molecules.

(OR)

(b) Give a brief explanation with neat diagram for nano machines and quantum dots.

22. (a) what are the systems used and how nanoparticles are useful in the field of nanotechnology?

(OR)

(b) Discuss about the preparation, properties and uses of alumina and titania nanoparticles.

23. (a) Explain the role of top down and bottom approaches in nanotechnology.

(OR)

(b) What are all the characterization made in nanoparticles and explain about the toxic effects of nanomaterials.

24. (a) Define CNT? Why CNT is an important in nanotechnology with neat examples?

(OR)

(b) Write a Preparation, properties and applications of carbon nanotubes.

25. (a) Give eight important differences about SEM and TEM.

(OR)

(b) What is the principle of SEM? How it is an important in nanomaterial characterization?

Reg. No.: ------------------ **[15CHU504]**

KARPAGAM ACADEMY OF HIGHER EDUCATION

COIMBATORE-21

(For the candidates admitted from 2015 & onwards)

III B. Sc CHEMISTRY

INTERNAL TEST-I

NANO CHEMISTRY

Time: 2 hours **Maximum: 50 marks**

PART- A (20 x 1= 20 Marks)

Answer ALL the Questions

1. One nanometer is equal to how many meters **a) 10^{-7}**
2. The most important property of nanomaterials is **c) friction**
3. **Carbon nanotubes** is the extensions of bucky balls.
4. Nano coatings and nanocomposites are finding uses in? **c) Bicycles and automobiles**
5. which One of the following is first scientific report of synthesized colloidal gold particles.
   c) Michael Faraday
6. Popular inert- gas evaporation technique was published by? **c) Granqvist and Buhrman**
7. Nano phase silicon, which differs from normal silicon with respect to property **d) physical and electronic**
8. Nanostructured semiconductors are known to show various? **a) Non-linear optical properties**
9. The beautiful tone of the which colour is obtained only when both these nanoparticles and the super lattice are present **b) blue**
10. Nanostructured semiconductors are used as window layers in? **c) Solar cells**
11. Nanostructured metal clusters and colloids of mono- or plurimetallic composition have a special impact in which applications? **c) Catalytic**
12. A nanometer is a? **c) Billionth of a meter**
13. Nanoparticles are produced by the shear action during? **c) Grinding**
14. Nanotechnology, in other words, is **c) Small technology**
15. Based on the energy of the milling process and which properties of the constituents the alloy can be rendered amorphous by this processing? **c) Thermodynamic**
16. Who coined the word Nanotechnology? **a) Eric Drexler**

17. The width of carbon nanotube is **b) 1.3 nm**
18. Who coined the word Nanotechnology? **a) Eric Drexler**
19. How much is 1 micron in meter? **c) 10^{-6} meter**
20. What is the diameter of human hair? **a) 75000 nm**

PART- B (3 x 10= 30 Marks)

Answer ALL the Questions

21. (a) What is nanoscale? Give a brief explanation about nanoscale and its technology.

Nano chemistry is the utilization of synthetic chemistry to make Nano scale building blocks of different size and shape, composition and surface structure, charge and functionality. These building blocks may be useful in their own right. Or in a self-assembly construction process, spontaneous, directed by templates or guided by chemically or lithographically denied surface patterns, they may form architectures that perform an intelligent function and portend a particular use.

Nano scale science and technology, often spoken of as “Nano science” or “nanotechnology,” are simply science and engineering carried out on the nanometer scale, that is, 10^{-9} meters. In the last two decades, researchers began developing the ability to manipulate matter at the level of single atoms and small groups of atoms and to characterize the properties of materials and systems at that scale. This capability has led to the astonishing discovery that clusters of small numbers of atoms or molecules—Nano scale clusters-often have properties (such as strength, electrical resistivity and conductivity, and optical absorption) that are significantly different from the properties of the same matter at either the single-molecule scale or the bulk scale. For example, carbon nanotubes are much less chemically reactive than carbon atoms and combine the characteristics of the two naturally occurring bulk forms of carbon, strength (diamond) and electrical conductivity (graphite). Furthermore, carbon nanotubes conduct electricity in only one spatial dimension, that is, along one axis, rather than in three dimensions, as is the case for graphite. Nano scale science and engineering also seek to discover, describe, and manipulate those unique properties of matter at the Nano scale in order to develop new capabilities with potential applications across all fields of science, engineering, technology, and medicine.

The earliest application of Nano scale materials occurred in systems where Nano scale powders could be used in their free form, without consolidation or blending. For example, Nano scale titanium dioxide and zinc oxide powders are now commonly used by cosmetics manufacturers for facial base creams and sunscreen lotions. Nano scale iron oxide powder is now being used as a base material for rouge and lipstick. Paints with reflective properties are also being manufactured using Nano scale titanium dioxide particles. Nanostructured wear-resistant coatings for cutting tools and wear-resistant components have been in use for several years. Nanostructured cemented carbide coatings are used on some Navy ships for their increased durability.

More recently, more sophisticated uses of Nano scale materials have been realized. Nanostructured materials are in wide use in information technology, integrated into complex products such as the hard disk drives the store information and the silicon integrated circuit chips that process information in every Internet server and personal computer. The manufacture of silicon transistors already requires the controlled deposition of layered structures just a few atoms thick (about 1 nanometer).

(OR)

(b) Define nanochemistry. Discuss about the porous solids and nanowires.

Nano chemistry is concerned with generating and altering chemical systems, which develop special and often new effects as a result of the laws of the nano world. The bases for these are chemically active nonmetric units such as supramolecules or Nano crystals. Nano chemistry looks set to make a great deal of progress for a large number of industry sectors. Nanotechnology exists in the realm where many scientific disciplines meet.

‘‘Nano’’ has left the science reservation and entered the industrial technology consciousness and public and political perception. Indeed, bulk materials can be remodeled through bottom-up synthetic chemistry and top-down engineering physics strategies as nanomaterial’s in two main ways, the first by reducing one or more of their physical dimensions to the Nano scale and the second by providing them with Nano scale porosity. When talking about finely divided and porous forms of nanostructured matter, it is found that ‘nanomaterial’s characteristically exhibits physical and chemical properties different from the bulk as a consequence of having at least one spatial dimension in the size range of 1–1000 nm’’

22. (a) What is self assembly? Write a brief note on self assembly of materials and molecules.

Self- assembly

Molecular synthesis is a technology that chemists use to make molecules by forming covalent bonds between atoms. Molecular self-assembly is a process in which molecules (or parts of molecules) spontaneously form ordered aggregates and involves no human intervention; the interactions involved usually are noncovalent. In molecular self-assembly, the molecular structure determines the structure of the assembly. Synthesis makes molecules; self-assembly makes ordered ensembles of molecules (or ordered forms of macromolecules). The structures generated in molecular self-assembly are usually in equilibrium states (or at least in metastable states). Molecular self-assembly is ubiquitous in chemistry, materials science, and biology and has been so long before self-assembly emerged as a discrete field of study and as a synthetic strategy. The formation of molecular crystals, colloids, lipid bilayers, phase-separated polymers and self-assembled monolayers are all examples of molecular self-assembly, as are the folding of polypeptide chains into proteins and the folding of nucleic acids into their functional forms. Even the association of a ligand with a receptor is a form of self-assembly; the semantic boundaries between self-assembly, molecular recognition, complexion, and other processes that form more ordered from less ordered assemblies of molecules expand or contract at the whim of those using them.

Self-assembly is scientifically interesting and technologically important for at least four reasons. The first is that it is centrally important in life. The cell contains an astonishing range of complex structures such as lipid membranes, folded proteins, structured nucleic acids, protein aggregates, molecular machines, and many others that form by self-assembly. The second is that self-assembly provides routes to a range of materials with regular structures: molecular crystals, liquid crystals, and semi crystalline and phase-separated polymers are examples. Third, self-assembly also occurs widely in systems of components larger than molecules, and there is great potential for its use in materials and condensed matter science. Fourth, self-assembly seems to offer one of the most general strategies now available for generating nanostructures. Thus self-assembly is important in a range of fields: chemistry, physics, biology, materials science, Nano science, and manufacturing. There is an exciting opportunity for self-assembly to develop through the interchange of concepts and techniques among these fields.

Components:

A self-assembling system consists of a group of molecules or segments of a macromolecule that interact with one another. These molecules or molecular segments may be the same or different. Their interaction leads from some less ordered state (a solution, disordered aggregate, or random coil) to a final state (a crystal or folded macromolecule) that is more ordered.

Interactions:

Self-assembly occurs when molecules interact with one another through a balance of attractive and repulsive interactions. These interactions are generally weak (that is, comparable to thermal energies) and noncovalent (van der Waals and Coulomb interactions, hydrophobic interactions, and hydrogen bonds) but relatively weak covalent bonds (coordination bonds) are recognized increasingly as appropriate for self-assembly. Complementarity in shapes among the self-assembling components is also crucial.

Reversibility (or Adjustability):

For self-assembly to generate ordered structures, the association either must be reversible or must allow the components to adjust their positions within an aggregate once it has formed. The strength of the bonds between the components, therefore, must be comparable to the forces tending to disrupt them. For molecules, the forces are generated by thermal motion. Processes in which collision between molecules leads to irreversible sticking generate glasses, not crystals.

Environment:

The self-assembly of molecules normally is carried out in solution or at an interface to allow the required motion of the components. The interaction of the components with their environment can strongly influence the course of the process

(OR)

(b) What is meant by nano machine and quantum dots? How it's classified?

Nano machine

- A Nano machine, also called a nanites, is a mechanical or electromechanical device whose dimensions are measured in nanometers (millionths of a millimeter, or units of 10 $^{-9}$ meter).
- Nano machines are largely in the research-and-development phase, but some primitive devices have been tested. An example is a sensor having a switch approximately 1.5 nanometers across, capable of counting specific molecules in a chemical sample. The first useful applications of Nano machines will likely be in medical technology, where they could be used to identify pathogens and toxins from samples of body fluid. Another potential application is the detection of toxic chemicals, and the measurement of their concentrations, in the environment.
- The microscopic size of Nano machines translates into high operational speed. This is a result of the natural tendency of all machines and systems to work faster as their size decreases. Nano machines could be programmed to replicate themselves, or to work synergistically to build larger machines or to construct Nano chips. Specialized Nano machines called Nano robots might be designed not only to diagnose, but to treat, disease conditions, perhaps by seeking out invading bacteria and viruses and destroying them.
- Another advantage of Nano machines is that the individual units require only a tiny amount of energy to operate. Durability is another potential asset; nanites might last for centuries before breaking down. The main challenge lies in the methods of manufacture. It has been suggested that some Nano machines might be grown in a manner similar to the way plants evolve from seeds.

Quantum Dots & Nanoparticles

Quantum dots are very, very tiny particles on the order of a nanometer in size. They are composed of a hundred to a thousand atoms.

These semiconductor materials can be made from an element, such as silicon or germanium, or a compound, such as CdS or CdSe. These tiny particles can differ in color depending on their size. Below is a collection of CdSe quantum dot nanoparticles that different in size as a result of how long they were allowed to form in the synthesis reaction that is described in the "Lab Manual for Nano scale Science and Technology", Preparation of CdSe Quantum Dot Nanoparticles.

Color is well known to be influenced by particle size in both quantum dots and nanoparticles. The synthesis of gold Nano particles is also described in the Video Lab Manual as Synthesis of Colloidal Gold. Below are some images of gold as nanoparticles and in bulk.

The left test tube contains gold nanoparticles in a citrate solution. The right test tube is the result of adding a NaCl solution to the citrate solution. The smaller chloride ion causes the color of the solution to change from red to blue.

Applications

Quantum dots are of much interest for the other other unusual properties that they possess. These other properties include electrical and nonlinear optical properties. These unique properties of nano sized particles are partly the result of the unusually high surface to volume ratios for their particles, as many as one-third of the atoms are on the surface of the particle. As a result, electrons and "holes" (holes result when an electron moves away from a bond, leaving a positively charged particle) are confined in a limited space inside the cluster.

These quantum electrical properties make these quantum dots of particular interest in the electronics industry. There small size means that electrons do not have to travel as far as with larger particles, thus electronic devices can operate faster.

Quantum dots can emit light if excited, the smaller the dot, the higher the energy of the emitted light. This ability to create dots that emit a rainbow of colors suggest that they could be used as biosensors. Unlike the dyes currently being used as biosensors, quantum dots do not degrade as rapidly. It is possible to make light-emitting diodes (LEDs) from quantum dots. They may also be used to emit white light for backlighting laptop computer screens. There is also great promise for using quantum dots in other solid state electronic devices. Quantum dots may someday be used as lasers.

23. (a) Write a preparation, properties and uses of Au, ZnO and FeO.

Nanoparticle Applications and Uses

- Nanoparticles have one dimension that measures 100 nanometers or less. The properties of many conventional materials change when formed from nanoparticles. This is typically because nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive to some other molecules.
- Nanoparticles are used, or being evaluated for use, in many fields. The list below introduces several of the uses under development.

Nanoparticle Applications in Medicine

- The use of polymeric micelle nanoparticles to deliver drugs to tumors.
- The use of polymer coated iron oxide nanoparticles to break up clusters of bacteria, possibly allowing more effective treatment of chronic bacterial infections.
- The surface change of protein filled nanoparticles has been shown to affect the ability of the nanoparticle to stimulate immune responses. Researchers are thinking that these nanoparticles may be used in inhalable vaccines.
- Researchers at Rice University have demonstrated that cerium oxide nanoparticles act as an antioxidant to remove oxygen free radicals that are present in a patient's bloodstream following a traumatic injury. The nanoparticles absorb the oxygen free radicals and then release the oxygen in a less dangerous state, freeing up the nanoparticle to absorb more free radicals.
- Researchers are developing ways to use carbon nanoparticles called Nano diamonds in medical applications. For example, Nano diamonds with protein molecules attached can be used to increase bone growth around dental or joint implants.
- Researchers are testing the use of chemotherapy drugs attached to Nano diamonds to treat brain tumors. Other researchers are testing the use of chemotherapy drugs attached to Nano diamonds to treat leukemia.

Nanoparticle Applications in Manufacturing and Materials

Ceramic silicon carbide nanoparticles dispersed in magnesium produce a strong, lightweight material.

A synthetic skin that may be used in prosthetics has been demonstrated with both self-healing capability and the ability to sense pressure. The material is a composite of nickel nanoparticles and a polymer. If the material is held together after a cut it seals together in about 30 minutes giving it a self-healing ability. Also the electrical resistance of the material changes with pressure, giving it a sense ability like touch.

Silicate nanoparticles can be used to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could slow down the process of spoiling or drying out in food.

Zinc oxide nanoparticles can be dispersed in industrial coatings to protect wood, plastic, and textiles from exposure to UV rays.

Silicon dioxide crystalline nanoparticles can be used to fill gaps between carbon fibers, thereby strengthening tennis racquets.

Silver nanoparticles in fabric are used to kill bacteria, making clothing odor-resistant.

Nanoparticle Applications and the Environment

- Researchers are using photo catalytic copper tungsten oxide nanoparticles to break down oil into biodegradable compounds. The nanoparticles are in a grid that provides high surface area for the reaction, is activated by sunlight and can work in water, making them useful for cleaning up oil spills.
- Researchers are using gold nanoparticles embedded in a porous manganese oxide as a room temperature catalyst to breakdown volatile organic pollutants in air.
- Iron nanoparticles are being used to clean up carbon tetrachloride pollution in ground water.
- Iron oxide nanoparticles are being used to clean arsenic from water wells.

Nanoparticle Applications in Energy and Electronics

- Researchers have used nanoparticles called nanotetrapods studded with nanoparticles of carbon to develop low cost electrodes for fuel cells. This electrode may be able to replace the expensive platinum needed for fuel cell catalysts.
- Researchers at Georgia Tech, the University of Tokyo and Microsoft Research have developed a method to print prototype circuit boards using standard inkjet printers. Silver nanoparticle ink was used to form the conductive lines needed in circuit boards.
- Combining gold nanoparticles with organic molecules creates a transistor known as a NOMFET (Nanoparticle Organic Memory Field-Effect Transistor). This transistor is unusual in that it can function in a way similar to synapses in the nervous system.
- A catalyst using **platinum-cobalt nanoparticles** is being developed for fuel cells that produces twelve times more catalytic activity than pure platinum. In order to achieve this performance, researchers anneal nanoparticles to form them into a crystalline lattice, reducing the spacing between platinum atoms on the surface and increasing their reactivity.
- Researchers have demonstrated that sunlight, concentrated on nanoparticles, can produce steam with high energy efficiency. The "solar steam device" is intended to be used in areas of developing countries without electricity for applications such as purifying water or disinfecting dental instruments.

- A lead free solders reliable enough for space missions and other high stress environments using **copper nanoparticles**.
- **Silicon nanoparticles** coating anodes of lithium-ion batteries can increase battery power and reduce recharge time.
- Semiconductor nanoparticles are being applied in a low temperature printing process that enables the manufacture of low cost solar cells.
- A layer of closely spaced **palladium nanoparticles** is being used in a hydrogen sensor. When hydrogen is absorbed, the palladium nanoparticles swell, causing shorts between nanoparticles. These shorts lower the resistance of the palladium layer.

(OR)

(b) Discuss about the preparation, properties and uses of alumina and titania nanoparticles in addition with silver nanoparticles.

Titanium dioxide

Titanium dioxide (TiO2) is the most widely used white pigment, for example in paints. It has high brightness and a very high refractive index. The light passes through the crystal slowly and its path is substantially altered compared to air. If you have many small particles orientated in different directions, a high refractive index will lead to the scattering of light as not much light passes through. In lenses, high refractive index means high clarity and high polarising power. Titanium dioxide has a higher refractive index than diamond and there are only a few other substances that have a higher refractive index. Cinnabar (mercury sulphide) is an example. Historically, cinnabar was used as a red pigment.

Uses for white pigment

Four million tons of pigmentary TiO2 are consumed annually. Apart from producing a white colour in liquids, paste or as coating on solids, TiO2 is also an effective pacifier, making substances more opaque. Here are some examples of the extensive range of applications:

- Paints
- Plastics
- Papers
- Inks
- Medicines
- Most toothpastes
- Skimmed milk; adding TiO2 to skimmed milk makes it appear brighter, more opaque and more palatable.

TiO_2 in sunscreens

Almost every sunscreen contains titanium dioxide. It is a physical blocker for UVA (ultraviolet light with wavelength of 315–400 nm) and UVB (ultraviolet light with wavelength of 280–315 nm) radiation. It is chemically stable and will not become decolourised under UV light. TiO_2 particles have to be coated with silica or alumina. This is because TiO_2 particles that come into contact with water produce hydroxyl radicals which are potentially carcinogenic. The silica or alumina coating prevents the titanium dioxide particles from coming into contact with the skin and with water making titanium dioxide very safe to use.

Alumina Nano particle uses

Drug and gene delivery

Bio detection of pathogens

Detection of proteins

Probing of DNA structure

Tissue engineering

Tumour destruction via heating (hyperthermia)

Separation and purification of biological molecules and cells

MRI contrast enhancement

Reg. No.: ------------------ **[15CHU504]**

KARPAGAM ACADEMY OF HIGHER EDUCATION

COIMBATORE-21

(For the candidates admitted from 2015 & onwards)

III B. Sc CHEMISTRY

INTERNAL TEST-II

NANO CHEMISTRY

ANSWER KEY

Time: 2 hours **Maximum: 50 marks**

PART- A (20 x 1= 20 Marks)

Answer ALL the Questions

1. The diameter of human hair is **50,000** nm.
2. The diameter of human hair is **5 x 10^{-8}** m.
3. The cut-off limit of human eye is **10,000** nm.
4. The size of E. Coli bacteria is **2,000** nm.
5. The size of RBC is **5,000** nm.
6. The thickness of a transistor is **90** nm.
7. The size of a virus is **50** nm.
8. The diameter of a bucky ball is **1** nm.
9. The largest cluster of carbon atoms in Bucky balls known till today consists of **540** carbon atoms.
10. The smallest cluster of carbon atoms in Bucky balls known till today consists of **20** carbon atom
11. The tensile strength of an MWNT is **63 x 10^{9}** Pa.
12. The compressive strength of a nanotube **is less than** its tensile strength.
13. A TCO is a semiconductor which has: **high electrical conductivity and high optical transparency.**
14. The efficiency of today's best solar cell is about **40%.**
15. In which of the following the atoms do not move from each other? **Nano materials.**
16. Which of the following uses radio frequency to produce nano-particles? **Plasma arching.**
17. Which of the following methods can be used to produce nano-powders of oxides?
    Chemical vapour deposition
18. Which of the following is used to make both nano-particles and nano-powders?
    Sol-gel technique

19. Which method can be used to prepare iron nitriles nano-crystals using ammonia gas? **Mechanical crushing**

20. Nano-particles exhibit super plastic behaviour is **Good behaviour**

PART- B **(3 x 10= 30 Marks)**

Answer ALL the Questions

21. (a) Write briefly on various approaches in nanoparticle synthesis.

Synthesis of nano materials

These seek to arrange smaller components into more complex assemblies Use chemical or physical forces operating at the nano scale to assemble basic units into larger structures examples:

1. Indiun gallium arsenide (InGaAs) quantum dots can be formed by growing thin layers of InGaAs on GaAs
2. Formation of carbon nanotubes BOTTOM UP APPROACH

These seek to create smaller devices by using larger ones to direct their assembly. The most common top-down approach to fabrication involves lithographic patterning techniques using short wavelength optical sources TOP DOWN APPROACH

Three methods of synthesis	: 1.	Physical 2. Chemical 3. Biological methods
Two methods of Mechanical	: 1.	High energy ball milling 2. Melt mixing
Vapour	: 1.	Physical vapour deposition

2. Laser ablation 3. Sputter deposition 4. Electric arc deposition 5. Ion implantation

Physical Methods of Synthesis

Simplest method of making nano particle in the form of powder various types of mills • Planetary • Vibratory • Rod • Tumbler.

Chemical Methods of Synthesis

Simple techniques Inexpensive Instrumentation Low temperature (<350ºC) synthesis Doping of foreign atoms (ions) is possible during synthesis Large quantities of material can be obtained Variety of sizes and shapes are possible Self-assembly or patterning is possible.

Biological Methods

Green synthesis 3 types: 1. Use of microorganisms like fungi, yeast (eukaryotes) or bacteria, actinomycetes (prokaryotes) 2. Use of plant extracts or enzymes 3. Use of templates like DNA, membranes, viruses and diatoms.

(OR)

(b) What are all the characterization made in nanoparticles and explain about the toxic effects of nano materials?

Toxicity of Nano particles

The toxicity of carbon nano tubes has been an important question in nanotechnology. As of 2007, such research had just begun. The data is still fragmentary and subject to criticism. Preliminary results highlight the difficulties in evaluating the toxicity of this heterogeneous material. Parameters such as structure, size distribution, surface area, surface chemistry, surface charge, and agglomeration state as well as purity of the samples, have considerable impact on the reactivity of carbon nano tubes. However, available data clearly show that, under some conditions, nano tubes can cross membrane barriers, which suggests that, if raw materials reach the organs, they can induce harmful effects such as inflammatory and fibrotic reactions. Under certain conditions CNTs can enter human cells and accumulate in the cytoplasm, causing cell death. Results of rodent studies collectively show that regardless of the process by which CNTs were synthesized and the types and amounts of metals they contained, CNTs were capable of producing inflammation, epithelioid granulomas (microscopic nodules), fibrosis, and biochemical/toxicological changes in the lungs. Comparative toxicity studies in which mice were given equal weights of test materials showed that SWCNTs were more toxic than quartz, which is considered a serious occupational health hazard when chronically inhaled. As a control, ultrafine carbon black was shown to produce minimal lung responses.

Carbon nano tubes deposit in the alveolar ducts by aligning lengthwise with the airways; the nano tubes will often combine with metals. The needle-like fiber shape of CNTs is similar to asbestos fibers. This raises the idea that widespread use of carbon nano tubes may lead topleuralmesothelioma, a cancer of the lining of the lungs, or peritoneal, a cancer of the lining of the abdomen (both caused by exposure to asbestos). A recently published pilot study supports this prediction. This is of considerable importance, because research and business communities continue to invest heavily in carbon nano tubes for a wide range of products under the assumption that they are no more hazardous than graphite. Our results suggest the need for further research and great caution before introducing such products into the market if long-term harm is to be avoided.

22. (a) What is nanoparticles? Give a brief explanation about physical, chemical and biological methods of nanoparticles.

Synthesis of nano particles

Materials having unique properties arising from their Nano scale dimensions Nano material with fast ion transport are related also to nano ionics and Nano electronics Nano scale materials can also be used for bulk applications Nano materials are sometimes used in solar cells which combats the cost of traditional solar silicon cells Nano materials.

Approaches - bottom up approach - top down approach

Synthesis of nano materials

These seek to arrange smaller components into more complex assemblies Use chemical or physical forces operating at the Nano scale to assemble basic units into larger structures examples:

1. Indiun gallium arsenide (InGaAs) quantum dots can be formed by growing thin layers of InGaAs on GaAs
2. Formation of carbon nano tubes BOTTOM UP APPROACH

These seek to create smaller devices by using larger ones to direct their assembly. The most common top-down approach to fabrication involves lithographic patterning techniques using short wavelength optical sources TOP DOWN APPROACH

Three methods of synthesis	: 1.	Physical 2. Chemical 3. Biological METHODS
Two methods of Mechanical	: 1.	High energy ball milling 2. Melt mixing
Vapour	: 1.	Physical vapour deposition

2. Laser ablation 3. Sputter deposition 4. Electric arc deposition 5. Ion implantation

Physical Methods of Synthesis

Simplest method of making nano particle in the form of powder various types of mills • Planetary • Vibratory • Rod • Tumbler

High Energy Ball Milling

Consists of a container filled with hardened steel or tungsten carbide balls Material of interest is fed as flakes 2:1 mass ratio of balls to materials Container may be filled with air or inert gas Containers are rotated at high speed around a central axis Material is forced to the walls and pressed against the walls

Control the speed of rotation and duration of milling- grind material to fine powder (few nm too few tens of nm) Some materials like Co, Cr, W, Al-Fe, Ag-Fe etc. are made Nano crystalline using ball mill.

To form or arrest nanoparticles in glass – amorphous solid, lacking symmetric arrangement of atoms/molecules Metals, when cooled at very high cooling rates (10°- 10° K/s) can form amorphous solids- metallic glasses Mixing molten streams of metals at high velocity with turbulence- form nanoparticles Ex: a molten stream of Cu-B and molten stream of Ti form nanoparticles of TiB_2

Melt Mixing Evaporation Based Method Physical Vapour Deposition

Material of interest as source of evaporation an inert or reactive gas A cold finger (water or liquid N_2 cooled) Scraper All processes are carried out in a vacuum chamber so that the desired purity of end product can be obtained

Materials to be evaporated are held in filaments or boats of refractory metals like W, Mo etc. Density of the evaporated material is quite high and particle size is small (< 5 nm) Acquire a stable low surface energy state Cluster-cluster interaction- big particles are formed Removed by forcing an inert gas near the source (cold finger)

If reactive gases such as O_2, N_2, H_2, and NH_3 are used, evaporated material will react with these gases forming oxide, nitride or hydride particles. Nanoparticles formed on the cold finger are scraped off Process can be repeated several times

Vaporization of the material is effected by using pulses of laser beam of high power the set-up is an Ultra High Vacuum (UHV) or high vacuum system Inert or reactive gas introduction facility, laser beam, target and cooled substrate Laser giving UV wavelength such as Excimer laser is necessary laser vaporization (ablation)

Powerful laser beam evaporates atoms from a solid source Atoms collide with inert or reactive gases Condense on cooled substrate Gas pressure- particle size and distribution Single Wall Carbon nano tubes (SWNT) are mostly synthesized by this method

Thin film synthesis using lasers Mixture of reactant gases is deposited on a powerful laser beam in the presence of some inert gas like helium or argon Atoms or molecules of decomposed reactant gases collide with inert gas atoms and interact with each other, grow and are then deposited on cooled substrate laser pyrolysis.

Many nanoparticles of materials like Al_2O_2, WC, and SiN_4 are synthesized by this method Gas pressure- particle sizes and their distribution

Widely used thin film technique, especially to obtain stoichiometric thin films from target material (alloy, ceramic or compound) Non porous compact films Very good technique to deposit multi-layer films 1. DC sputtering 2. RF sputtering 3. Magnetron sputtering SPUTTER DEPOSITION

Target is held at high negative voltage Substrate may be at positive, ground or floating potential Argon gas is introduced at a pressure <10 Pa High voltage (100 to 3000 V) is applied between anode and cathode Visible glow is observed when current flows between anode and cathode DC SPUTTERING

Glow discharge is set up with different regions such as - cathode glow - Crooke's dark space - negative glow -Faraday dark space -positive column - anode dark space - anode glow

These regions are a result of plasma- a mixture of electrons, ions, neutrals and photos Density of particles depends on gas pressure.

CHEMICAL METHODS OF SYNTHESIS

Simple techniques Inexpensive Instrumentation Low temperature (<350ºC) synthesis Doping of foreign atoms (ions) is possible during synthesis Large quantities of material can be obtained Variety of sizes and shapes are possible Self-assembly or patterning is possible ADVANTAGES

Nanoparticles synthesized by chemical methods form "colloids" Two or more phases (solid, liquid or gas) of same or different materials co-exist with the dimensions of at least one of the phases less than a micrometer May be particles, plates or fibers Nano materials are a subclass of colloids, in which the dimensions of colloids are in the nanometer range COLLOIDS AND COLLOIDS IN SOLUTION

Reduction of some metal salt or acid Highly stable gold particles can be obtained by reducing chloroauric acid ($HAuCl_2$) with tri sodium citrate ($Na_2C_2H_4O_6$) $HAuCl_2$+ NaCHO Au $CHOHCl^{+3}$ NaCl Metal gold nanoparticles exhibit intense red, magenta etc., colours depending upon the particle size

SYNTHESIS OF METAL NANOPARTICLES BY COLLOIDAL ROUTE

Gold nanoparticles can be stabilized by repulsive Columbic interactions also stabilized by thiol or some other capping molecules in a similar manner, silver, palladium, copper and few other metal nanoparticles can be synthesized.

Wet chemical route using appropriate salts Sulphide semiconductors like CdS and ZnS can be synthesized by precipitation to obtain Zns nanoparticles, any Zn salt is dissolved in aqueous (or non-aqueous) medium and H_2S is added $ZnCl_2$+ H_2S ZnS + 2 HCl

SYNTHESIS OF SEMI-CONDUCTOR NANOPARTICLES BY COLLOIDAL ROUTE

Steric hindrance created by "chemical capping" Chemical capping- high or low temperature depending on the reactants High temp reactions- cold organometallic reactants are injected in solvent like trioctylphosphineoxide (TOPO) held at > 300ºC Although It Is a very good method of synthesis, most organometallic compounds are expensive.

2 types of materials or components- "sol" and "gel" M. Edelman synthesized them in 1845 Low temperature process- less energy consumption and less pollution Generates highly pure, well controlled ceramics Economical route, provided precursors are not expensive Possible to synthesize nanoparticles, Nano rods, nanotubes etc., SOL GEL METHOD

Sols are solid particles in a liquid- subclass of colloids Gels – polymers containing liquid The process involves formation of 'sols' in a liquid and then connecting the sol particles to form a network Liquid is dried- powders, thin films or even monolithic solid Particularly useful to synthesize ceramics or metal oxides.

Biological Methods

Green synthesis 3 types: 1. Use of microorganisms like fungi, yeast (eukaryotes) or bacteria, actinomycetes (prokaryotes) 2. Use of plant extracts or enzymes 3. Use of templates like DNA, membranes, viruses and diatoms

Microorganisms are capable of interacting with metals coming in contact with hem through their cells and form nanoparticles. The cell- metal interactions are quite complex certain microorganisms are capable of separating metal ions.

(OR)

(b) What is the difference between top down and bottom up approaches?

SYNTHESIS OF NANOMATERIALS

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23. (a) How to synthesize nanoparticles? Explain brief note on common growth methods.

Materials having unique properties arising from their Nano scale dimensions Nanomaterial with fast ion transport are related also to nano ionics and Nano electronics Nano scale materials can also be used for bulk applications Nano materials are sometimes used in solar cells which combats the cost of traditional solar silicon cells Nano materials.

Synthesis

ZnO Nano rods

Zinc oxide (ZnO) Nano rod, also known as nanowire, has direct band gap energy of 3.37 eV, which is similar to that of GaN, and it has an excitation binding energy of 60 meV. More interestingly, the optical band gap of ZnO Nano rod can be tuned by changing the morphology, composition, size etc. Recent years, ZnO Nano rods have been intensely used to fabricate Nano-scale electronic devices, including field effect transistor, ultraviolet photo detector, Schottky diode, and ultra-bright light emitting diode (LED). Various methods have been developed to fabricate the single crystalline, wurtzite ZnO Nano rods. Among those methods, growing from vapor phase is the most developed approach. In a typical growth process, ZnO vapor is condensed onto a solid substrate. ZnO vapor can be generated by three methods: thermal evaporation, chemical reduction, and Vapor Liquid-Solid (VLS) method. In the thermal evaporation method, commercial ZnO powder is mixed with SnO_2 and evaporated by heating the mixture at elevated temperature. In the chemical reduction method, zinc vapor, generated by the reduction of ZnO, is transferred to the growth zone, followed by reoxidation to ZnO. The VLS process, originally proposed in 1964, is the most commonly used process to synthesize single crystalline ZnO Nano rods. In a typical process, catalytic droplets are deposited on the substrate and the gas mixtures, including Zn vapor and a mixture of CO/CO_2, react at the catalyst-substrate interface, followed by nucleation and growth. Typical metal catalysts involve gold, copper, nickel, and tin. ZnO nanowires are grown epitaxial on the substrate and assemble into monolayer arrays. Metal-organic chemical vapor deposition (MOCVD) has also been recently developed. No catalyst is involved in this process and the growth temperature is at 400 ~500 °C, i.e. considerably milder conditions compared to the traditional vapor growth method.

Gold nano rods

The seed-mediated growth method is the most common and achieved method for synthesizing high quality gold Nano rods. A typical growth protocol involves the addition of citrate-capped gold Nano spheres, served as seeds, to the bulk $HAuCl_4$ growth solution. The growth solution is obtained by the reduction of $HAuCl_4$ with ascorbic acid in the presence of cetyltrimethyl ammonium bromide (CTAB) surfactant and silver ions. Longer Nano rods (up to an aspect ratio of 25) can be obtained in the absence of silver nitrate by use of a three-step addition procedure. In this protocol, seeds are sequentially added to growth solution in order to control the rate of heterogeneous deposition and thereby the rate of crystal growth.

The shortcoming of this method is the formation of gold nano spheres, which requires non-trivial separations and cleanings. In one modifications of this method sodium citrate is replaced with a stronger CTAB stabilizer in the nucleation and growth procedures. Another improvement is to introduce silver ions to the growth solution, which results in the nano rods of aspect ratios less than five in greater than 90% yield. Silver, of a lower reduction potential than gold, can be reduced on the surface of the rods to form a monolayer by under potential deposition. Here, silver deposition competes with that of gold, thereby retarding the growth rate of specific crystal facets, allowing for one-directional growth and rod formation.

(OR)

(b) What are all the characterization made in nanoparticles and explain about the toxic effects of nanomaterials.

Toxicity of Nano particles

The toxicity of carbon nano tubes has been an important question in nanotechnology. As of 2007, such research had just begun. The data is still fragmentary and subject to criticism. Preliminary results highlight the difficulties in evaluating the toxicity of this heterogeneous material. Parameters such as structure, size distribution, surface area, surface chemistry, surface charge, and agglomeration state as well as purity of the samples, have considerable impact on the reactivity of carbon nano tubes. However, available data clearly show that, under some conditions, nano tubes can cross membrane barriers, which suggests that, if raw materials reach the organs, they can induce harmful effects such as inflammatory and fibrotic reactions. Under certain conditions CNTs can enter human cells and accumulate in the cytoplasm, causing cell death. Results of rodent studies collectively show that regardless of the process by which CNTs were synthesized and the types and amounts of metals they contained, CNTs were capable of producing inflammation, epithelioid granulomas (microscopic nodules), fibrosis, and biochemical/toxicological changes in the lungs. Comparative toxicity studies in which mice were given equal weights of test materials showed that SWCNTs were more toxic than quartz, which is considered a serious occupational health hazard when chronically inhaled. As a control, ultrafine carbon black was shown to produce minimal lung responses.

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Reg. No………………. [15CHU504]

KARPAGAM ACADEMY OF HIGHER EDUCATION

COIMBATORE-21

(For the candidates admitted from 2015 batch onwards)

B. Sc CHEMISTRY DEGREE EXAMINATIONS, NOVEMBER 2017

NANO CHEMISTRY

Model Exam

ANSWER KEY

TIME: 3.00 Hrs **TOTAL: 60 MARKS**

PART-A (Answer all the Questions) **(20 x 1 = 20)**

1 a) quantum mechanics

2 c) 1 to 100 nm

3 b) sticking and friction

4 a) nanotubes

5 a) 30

6 c) 26

7 a) 13

8 c) 22

9 b) Sol-gel technique

10 d) Mechanical crushing

11 c) Good behaviour

12 d) Light

13 a) Lighter

14 a) microscopic tubular

15 b) Enhanced SWCNT

16 a) Versatile and light-weight

17 a) Scanning tunneling microscope

18 b) scanning electron microscope

19 c) parfocal

20 c) Transmission electron microscopy

PART-B **ANSWER ALL THE QUESTIONS** **(5 x 8 = 40)**

21. (a) What is self assembly? Write a brief note on self assembly of materials and molecules.

Self- assembly

Molecular synthesis is a technology that chemists use to make molecules by forming covalent bonds between atoms. Molecular self-assembly is a process in which molecules (or parts of molecules) spontaneously form ordered aggregates and involves no human intervention; the interactions involved usually are noncovalent. In molecular self-assembly, the molecular structure determines the structure of the assembly. Synthesis makes molecules; self-assembly makes ordered ensembles of molecules (or ordered forms of macromolecules). The structures generated in molecular self-assembly are usually in equilibrium states (or at least in metastable states).

Molecular self-assembly is ubiquitous in chemistry, materials science, and biology and has been so long before self-assembly emerged as a discrete field of study and as a synthetic strategy. The formation of molecular crystals, colloids, lipid bilayers, phase-separated polymers and self-assembled monolayers are all examples of molecular self-assembly, as are the folding of polypeptide chains into proteins and the folding of nucleic acids into their functional forms. Even the association of a ligand with a receptor is a form of self-assembly; the semantic boundaries between self-assembly, molecular recognition, complexion, and other processes that form more ordered from less ordered assemblies of molecules expand or contract at the whim of those using them.

Self-assembly is scientifically interesting and technologically important for at least four reasons. The first is that it is centrally important in life. The cell contains an astonishing range of complex structures such as lipid membranes, folded proteins, structured nucleic acids, protein aggregates, molecular machines, and many others that form by self-assembly. The second is that self-assembly provides routes to a range of materials with regular structures: molecular crystals, liquid crystals, and semi crystalline and phase-separated polymers are examples. Third, self-assembly also occurs widely in systems of components larger than molecules, and there is great potential for its use in materials and condensed matter science. Fourth, self-assembly seems to offer one of the most general strategies now available for generating nanostructures. Thus self-assembly is important in a range of fields: chemistry, physics, biology, materials science, Nano science, and manufacturing. There is an exciting opportunity for self-assembly to develop through the interchange of concepts and techniques among these fields.

Aggregation occurs when there is a net attraction and an equilibrium separation between the components. The equilibrium separation normally represents a balance between attraction and repulsion. These two interactions are fixed in molecular self-assembly.

Components:

A self-assembling system consists of a group of molecules or segments of a macromolecule that interact with one another. These molecules or molecular segments may be the same or different. Their interaction leads from some less ordered state (a solution, disordered aggregate or random coil) to a final state (a crystal or folded macromolecule) that is more ordered.

Interactions:

Self-assembly occurs when molecules interact with one another through a balance of attractive and repulsive interactions. These interactions are generally weak (that is, comparable to thermal energies) and noncovalent (van der Waals and Coulomb interactions, hydrophobic interactions, and hydrogen bonds) but relatively weak covalent bonds (coordination bonds) are recognized increasingly as appropriate for self-assembly. Complementarity in shapes among the self-assembling components is also crucial.

Reversibility:

For self-assembly to generate ordered structures, the association either must be reversible or must allow the components to adjust their positions within an aggregate once it has formed. The strength of the bonds between the components, therefore, must be comparable to the forces tending to disrupt them. For molecules, the forces are generated by thermal motion. Processes in which collision between molecules leads to irreversible sticking generate glasses, not crystals.

Environment:

The self-assembly of molecules normally is carried out in solution or at an interface to allow the required motion of the components. The interaction of the components with their environment can strongly influence the course of the process.

DESIGNING NEW, SELF-ASSEMBLING SYSTEMS

We believe that the design of systems of components with Nano- to macro scale dimensions for self-assembly can be aided enormously by considering analogies with molecular systems. To test this belief, we have explored one of many imaginable systems of self-assembling macroscopic components: systems based on capillary interactions.

These studies have demonstrated that it is practical to design new systems of self-assembling components essentially *de novo* and suggest that such systems can find rapid application. The objective of this program has been more to demonstrate the usefulness of transferring concepts from molecular systems to these larger systems than to solve practical problems, but the progression from fundamental studies to applications has been astonishingly rapid.

(OR)

(b) Give a brief explanation with neat diagram for nano machines and quantum dots.

Nano machine

- A Nano machine, also called a nanites, is a mechanical or electromechanical device whose dimensions are measured in nanometers (millionths of a millimeter, or units of 10^{-9} meter).
- Nano machines are largely in the research-and-development phase, but some primitive devices have been tested. An example is a sensor having a switch approximately 1.5 nanometers across, capable of counting specific molecules in a chemical sample. The first useful applications of Nano machines will likely be in medical technology, where they could be used to identify pathogens and toxins from samples of body fluid. Another potential application is the detection of toxic chemicals, and the measurement of their concentrations, in the environment.
- The microscopic size of Nano machines translates into high operational speed. This is a result of the natural tendency of all machines and systems to work faster as their size decreases. Nano machines could be programmed to replicate themselves, or to work synergistically to build larger machines or to construct Nano chips. Specialized Nano machines called Nano robots might be designed not only to diagnose, but to treat, disease conditions, perhaps by seeking out invading bacteria and viruses and destroying them.
- Another advantage of Nano machines is that the individual units require only a tiny amount of energy to operate. Durability is another potential asset; nanites might last for centuries before breaking down. The main challenge lies in the methods of manufacture. It has been suggested that some Nano machines might be grown in a manner similar to the way plants evolve from seeds.

Quantum Dots & Nanoparticles

Quantum dots are very, very tiny particles on the order of a nanometer in size. They are composed of a hundred to a thousand atoms.

These semiconductor materials can be made from an element, such as silicon or germanium, or a compound, such as CdS or CdSe. These tiny particles can differ in color depending on their size. Below is a collection of CdSe quantum dot nanoparticles that different in size as a result of how long they were allowed to form in the synthesis reaction that is described in the "Lab Manual for Nano scale Science and Technology", Preparation of CdSe Quantum Dot Nanoparticles.

Color is well known to be influenced by particle size in both quantum dots and nanoparticles. The synthesis of gold Nano particles is also described in the Video Lab Manual as Synthesis of Colloidal Gold. Below are some images of gold as nanoparticles and in bulk.

The left test tube contains gold nanoparticles in a citrate solution. The right test tube is the result of adding a NaCl solution to the citrate solution. The smaller chloride ion causes the color of the solution to change from red to blue.

Applications

Quantum dots are of much interest for the other other unusual properties that they possess. These other properties include electrical and nonlinear optical properties. These unique properties of nano sized particles are partly the result of the unusually high surface to volume ratios for their particles, as many as one-third of the atoms are on the surface of the particle. As a result, electrons and "holes" (holes result when an electron moves away from a bond, leaving a positively charged particle) are confined in a limited space inside the cluster.

These quantum electrical properties make these quantum dots of particular interest in the electronics industry. There small size means that electrons do not have to travel as far as with larger particles, thus electronic devices can operate faster.

Quantum dots can emit light if excited, the smaller the dot, the higher the energy of the emitted light. This ability to create dots that emit a rainbow of colors suggest that they could be used as biosensors. Unlike the dyes currently being used as biosensors, quantum dots do not degrade as rapidly. It is possible to make light-emitting diodes (LEDs) from quantum dots. They may also be used to emit white light for backlighting laptop computer screens. There is also great promise for using quantum dots in other solid state electronic devices. Quantum dots may someday be used as lasers.

22. (a) what are the systems used and how nanoparticles are useful in the field of nanotechnology?

Nano chemistry looks set to make a great deal of progress for a large number of industry sectors. Nanotechnology exists in the realm where many scientific disciplines meet.

The National Nanotechnology Initiative (NNI) was established primarily because Nano scale science and technology are predicted to have an enormous potential economic impact. Many potential applications of Nano scale science and technology have been touted in both the scientific and the popular press, and there has been no shortage of promises made for the ability of Nano scale technology to revolutionize life as we know it. Beyond any speculation or hype, the committee can point to current applications of Nano scale materials and to devices that are already impacting our nation‘s commerce, as well as advances that are mature enough to promise impacts in the near future is a time line for anticipated impacts.

Nanoparticle Applications and Uses

- Nanoparticles have one dimension that measures 100 nanometers or less. The properties of many conventional materials change when formed from nanoparticles. This is typically because nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive to some other molecules.
- Nanoparticles are used, or being evaluated for use, in many fields. The list below introduces several of the uses under development.

Nanoparticle Applications in Medicine

- The use of polymeric micelle nanoparticles to deliver drugs to tumors.
- The use of polymer coated iron oxide nanoparticles to break up clusters of bacteria, possibly allowing more effective treatment of chronic bacterial infections.
- The surface change of protein filled nanoparticles has been shown to affect the ability of the nanoparticle to stimulate immune responses. Researchers are thinking that these nanoparticles may be used in inhalable vaccines.
- Researchers at Rice University have demonstrated that cerium oxide nanoparticles act as an antioxidant to remove oxygen free radicals that are present in a patient's bloodstream following a traumatic injury. The nanoparticles absorb the oxygen free radicals and then release the oxygen in a less dangerous state, freeing up the nanoparticle to absorb more free radicals.
- Researchers are developing ways to use carbon nanoparticles called Nano diamonds in medical applications. For example, Nano diamonds with protein molecules attached can be used to increase bone growth around dental or joint implants.

- Researchers are testing the use of chemotherapy drugs attached to Nano diamonds to treat brain tumors. Other researchers are testing the use of chemotherapy drugs attached to Nano diamonds to treat leukemia.

Nanoparticle Applications in Manufacturing and Materials

Ceramic silicon carbide nanoparticles dispersed in magnesium produce a strong, lightweight material.

A synthetic skin that may be used in prosthetics has been demonstrated with both self-healing capability and the ability to sense pressure. The material is a composite of nickel nanoparticles and a polymer. If the material is held together after a cut it seals together in about 30 minutes giving it a self-healing ability. Also the electrical resistance of the material changes with pressure, giving it a sense ability like touch.

Silicate nanoparticles can be used to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could slow down the process of spoiling or drying out in food.

Zinc oxide nanoparticles can be dispersed in industrial coatings to protect wood, plastic, and textiles from exposure to UV rays.

Silicon dioxide crystalline nanoparticles can be used to fill gaps between carbon fibers, thereby strengthening tennis racquets.

Silver nanoparticles in fabric are used to kill bacteria, making clothing odor-resistant.

(OR)

(b) Discuss about the preparation, properties and uses of alumina and titania nanoparticles.

Titanium dioxide

Titanium dioxide (TiO_2) is the most widely used white pigment, for example in paints. It has high brightness and a very high refractive index. The light passes through the crystal slowly and its path is substantially altered compared to air. If you have many small particles orientated in different directions, a high refractive index will lead to the scattering of light as not much light passes through. In lenses, high refractive index means high clarity and high polarising power. Titanium dioxide has a higher refractive index than diamond and there are only a few other substances that have a higher refractive index. Cinnabar (mercury sulphide) is an example. Historically, cinnabar was used as a red pigment.

Uses for white pigment

Four million tons of pigmentary TiO_2 are consumed annually. Apart from producing a white colour in liquids, paste or as coating on solids, TiO_2 is also an effective pacifier, making substances more opaque. Here are some examples of the extensive range of applications:

- Paints
- Plastics

- Papers
- Inks
- Medicines
- Most toothpastes
- Skimmed milk; adding TiO_2 to skimmed milk makes it appear brighter, more opaque and more palatable.

TiO_2 in sunscreens

Almost every sunscreen contains titanium dioxide. It is a physical blocker for UVA (ultraviolet light with wavelength of 315–400 nm) and UVB (ultraviolet light with wavelength of 280–315 nm) radiation. It is chemically stable and will not become decolourised under UV light. TiO_2 particles have to be coated with silica or alumina. This is because TiO_2 particles that come into contact with water produce hydroxyl radicals which are potentially carcinogenic. The silica or alumina coating prevents the titanium dioxide particles from coming into contact with the skin and with water making titanium dioxide very safe to use.

Alumina Nano particle uses

Drug and gene delivery

Bio detection of pathogens

Detection of proteins

Probing of DNA structure

Tissue engineering

Tumour destruction via heating (hyperthermia)

Separation and purification of biological molecules and cells

MRI contrast enhancement

Phagokinetic studies

23. (a) Explain the role of top down and bottom approaches in nanotechnology.

Synthesis of nano particles

Materials having unique properties arising from their Nano scale dimensions Nano material with fast ion transport are related also to nano ionics and Nano electronics Nano scale materials can also be used for bulk applications Nano materials are sometimes used in solar cells which combats the cost of traditional solar silicon cells Nano materials.

Approaches - bottom up approach - top down approach

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Physical Methods of Synthesis

Simplest method of making nano particle in the form of powder various types of mills • Planetary • Vibratory • Rod • Tumbler

High Energy Ball Milling

Consists of a container filled with hardened steel or tungsten carbide balls Material of interest is fed as flakes 2:1 mass ratio of balls to materials Container may be filled with air or inert gas Containers are rotated at high speed around a central axis Material is forced to the walls and pressed against the walls

Control the speed of rotation and duration of milling- grind material to fine powder (few nm too few tens of nm) Some materials like Co, Cr, W, Al-Fe, Ag-Fe etc. are made Nano crystalline using ball mill.

To form or arrest nanoparticles in glass – amorphous solid, lacking symmetric arrangement of atoms/molecules Metals, when cooled at very high cooling rates (10°- 10° K/s) can form amorphous solids- metallic glasses Mixing molten streams of metals at high velocity with turbulence- form nanoparticles Ex: a molten stream of Cu-B and molten stream of Ti form nanoparticles of TiB_2

(OR)

(b) What are all the characterization made in nanoparticles and explain about the toxic effects of nanomaterials.

Toxicity of Nano particles

The toxicity of carbon nanotubes has been an important question in nanotechnology. As of 2007, such research had just begun. The data is still fragmentary and subject to criticism. Preliminary results highlight the difficulties in evaluating the toxicity of this heterogeneous material. Parameters such as structure, size distribution, surface area, surface chemistry, surface charge, and agglomeration state as well as purity of the samples, have considerable impact on the reactivity of carbon nanotubes. However, available data clearly show that, under some conditions, nanotubes can cross membrane barriers, which suggests that, if raw materials reach the organs, they can induce harmful effects such as inflammatory and fibrotic reactions. Under certain conditions CNTs can enter human cells and accumulate in the cytoplasm, causing cell death. Results of rodent studies collectively show that regardless of the process by which CNTs were synthesized and the types and amounts of metals they contained, CNTs were capable of producing inflammation, epithelioid granulomas(microscopic nodules), fibrosis, and biochemical/toxicological changes in the lungs. Comparative toxicity studies in which mice were given equal weights of test materials showed that SWCNTs were more toxic than quartz, which is considered a serious occupational health hazard when chronically inhaled. As a control, ultrafine carbon black was shown to produce minimal lung responses.

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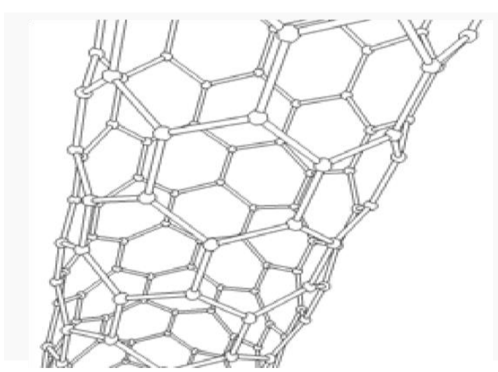
24. (a) Define CNT? Why CNT is an important in nanotechnology with neat examples?

CARBON NANOTUBE



Carbon nanotubes (**CNTs**) are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of material science and technology. In particular, owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material (s) in some (primarily carbon fiber) baseball bats, golf clubs, car parts or Damascus steel. Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene.

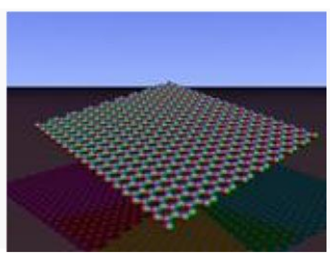
IN FOOD:

These sheets are rolled at specific and discrete ("chiral") angles, and the combination of the rolling angle and radius decides the nanotube properties; for example, whether the individual nanotube shell is ametalor semiconductor. Nanotubes are categorized assingle-walled nanotubes(SWNTs) and multi-walled nanotubes(MWNTs). Individual nanotubes naturally align themselves into "ropes" held together by van, more specifically, pi-stacking. Applied quantum chemistry, specifically, hybridization best describes chemical bonding in nanotubes. The chemical bonding of nanotubes is composed entirely ofsp^2bonds, similar to those of graphite. These bonds, which are stronger than thesp^3bondsfound in alkanes and diamond, provide nanotubes with their unique strength. Types of carbon nanotubes and related structures

Terminology There is no consensus on some terms describing carbon nanotubes in scientific literature: both "wall" and "-walled" are being used in combination with "single", "double", "triple" or "multi",and the letter C is often omitted in the abbreviation; for example, multi-walled carbon nanotube

(MWNT).

Graphene nano ribbon length that can be many millions of times longer. The structure of a SWNT can be conceptualized by wrapping a one-atom-thick layer of graphite called graphene into a seamless cylinder. The way the graphene sheet is wrapped is represented by a pair of indices (n, m). The integer’s n and m denote the number of unit vectors along two directions in the honeycombcrystal latticeof graphene. If m =



Graphene nanoribbon

0, the nanotubes are called zigzag nanotubes, and if n = m, the nanotubes are called armchair nanotubes. Otherwise, they are called chiral. The diameter of an ideal nanotube can be calculated from its (n, m) indices as follows where a = 0.246 nm.

SWNTs are an important variety of carbon nanotube because most of their properties change significantly with the (n,m) values, and this dependence is non-monotonic.

In particular, their band gap can vary from zero to about 2 eV and their electrical conductivity can show metallic or semiconducting behavior. Single-walled nanotubes are likely candidates for miniaturizing electronics. The most basic building block of these systems is the electric wire, and SWNTs with diameters of an order of a nanometer can be excellent conductors. One useful application of SWNTs is in the development of the first intermolecular field-effect transistors (FET). The first intermolecular logic gate using SWCNT FETs was made in 2001. A logic gate requires both a p-FET and an n-FET. Because SWNTs are p-FETs when exposed to oxygen and n-FETs otherwise, it is possible to protect half of an SWNT from oxygen exposure, while exposing the other half to oxygen.

SWNTs have been viewed as too expensive for widespread application but are forecast to make a large impact in electronics applications by 2020 according to The Global Market for Carbon Nanotubes report. Graphene. There are two models that can be used to describe the structures of multi-walled nanotubes. In the Russian Doll model, sheets of graphite are arranged in concentric cylinders, e.g., a (0,8) single-walled nanotube (SWNT) within a larger (0,17) single-walled nanotube. In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a scroll of parchment or a rolled newspaper. The interlayer distance in multi-walled nanotubes is close to the distance between graphene layers in graphite, approximately 3.4 Å. The Russian Doll structure is observed more commonly. Its individual shells can be described as SWNTs, which

(OR)

(b) Write a Preparation, properties and applications of carbon nanotubes.

Graphenated carbon nanotubes (g-CNTs)

Graphenated CNTs are a relatively new hybrid that combines graphitic foliates grown along the sidewalls of multi-walled or bamboo style CNTs. Yu et al. reported on "chemically bonded graphene leaves" growing along the sidewalls of CNTs. Stoner et al described these structures as "graphenated CNTs" and reported in their use for enhanced super capacitor performance. Hsu et al. further reported on similar structures formed on carbon fiber paper, also for use in super capacitor applications. The foliate density can vary as a function of deposition conditions (e.g. temperature and time) with their structure ranging from few layers of graphene(< 10) to thicker, more graphite-like.

The fundamental advantage of an integrated graphene-CNT structure is the high surface area three-dimensional framework of the CNTs coupled with the high edge density of graphene. Graphene edges provide significantly higher charge density and reactivity than the basal plane, but they are difficult to arrange in three-dimensional, high volume-density geometry. CNTs are readily aligned in high density geometry (i.e., a vertically aligned forest) but lack high charge density surfaces—the sidewalls of the CNTs are similar to the basal plane of graphene and exhibit low charge density except where edge defects exist. Depositing a high density of graphene foliates along the length of aligned CNTs can significantly increase the total charge capacity per unit of nominal area as compared to other carbon nanostructures.

25. (a) Give an eight important differences about SEM and TEM.

scanning electron microscopes (SEM)	transmission electron microscopes (TEM)
A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition.	Transmission electron microscopy (TEM) is a microscopy technique in which a beam of electrons is transmitted through an ultra-thin specimen, interacting with the specimen as it passes through. An image is formed from the interaction of the electrons transmitted through the specimen; the image is magnified and focused onto an imaging device, such as a fluorescent screen, on a layer of photographic film, or to be detected by a sensor such as a CCD camera.
The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures.	TEMs are capable of imaging at a significantly higher resolution than light microscopes, owing to the small de Broglie wavelength of electrons. This enables the instrument's user to examine fine detail.

The most common mode of detection is by secondary electrons emitted by atoms excited by the electron beam. On a flat surface, the plume of secondary electrons is mostly contained by the sample, but on a tilted surface, the plume is partially exposed and more electrons are emitted. By scanning the sample and detecting the secondary electrons, an image displaying the topography of the surface is created.	Simple view of transmission electron microscope as small as a single column of atoms, which is thousands of times smaller than the smallest resolvable object in a light microscope. TEM forms a major analysis method in a range of scientific fields, in both physical and biological sciences. TEMs find application in cancer research, virology, materials science as well as pollution, nanotechnology, and semiconductor research.
	At smaller magnifications TEM image contrast is due to absorption of electrons in the material, due to the thickness and composition of the material. At higher magnifications complex wave interactions modulate the intensity of the image, requiring expert analysis of observed images. Alternate modes of use allow for the TEM to observe modulations in chemical identity, crystal orientation, electronic structure and sample induced electron phase shift as well as the regular absorption based imaging.
	The first TEM was built by Max Knoll and Ernst Ruska in 1931, with this group developing the first TEM with resolution greater than that of light in 1933 and the first commercial TEM in 1939.

(OR)

(b) What is the principle of SEM? How it is an important in nanomaterial characterization?

Electron Microscope

An electron microscope is a type of microscope that uses electrons to illuminate a specimen and create an enlarged image. Electron microscopes have much greater resolving power than light microscopes and can obtain much higher magnifications. Some electron microscopes can magnify specimens up to 2 million times, while the best light microscopes are limited to magnifications of 2000 times. Both electron and light microscopes have resolution limitations, imposed by their wavelength. The greater resolution and magnification of the electron microscope is due to the wavelength of an electron, its de Broglie wavelength, being much smaller than that of a light photon, electromagnetic radiation. The electron microscope uses electrostatic and electromagnetic lenses in forming the image by controlling the electron beam to focus it at a specific plane relative to the specimen in a manner similar to how a light microscope uses glass lenses to focus light on or through a specimen to form an image.

SCANNING ELECTRON MICROSCOPE

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures.

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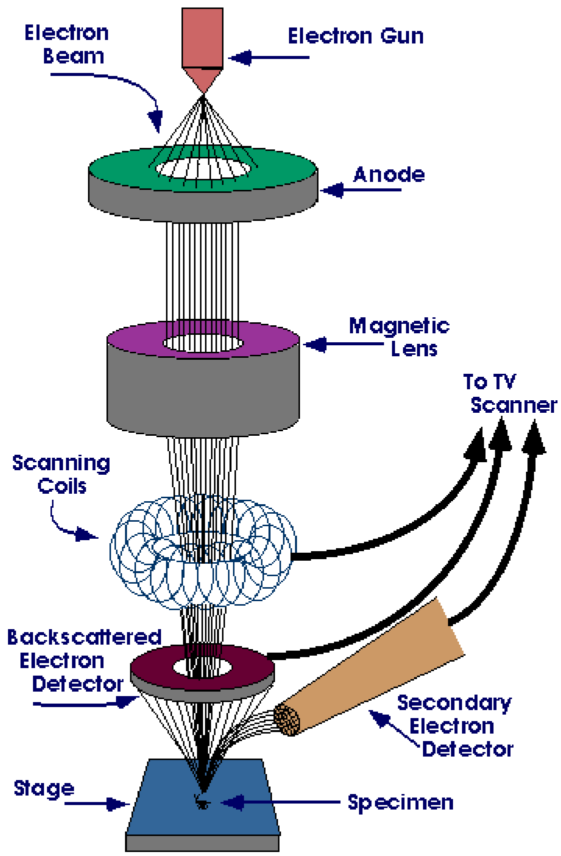
Electron
Beam
Electron Gun
Anode
Magnetic
Lens
To TV
Scanner
Scanning
Coils
Backscattered
Electron
Detector
Secondary
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Stage
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KARPAGAM UNIVERSITY
Karpagam Academy of Higher Education
(Established Under Section 3 of UGC Act 1956)
COIMBATORE – 641 021
(For the candidates admitted from 2015 onwards)

B.Sc., DEGREE EXAMINATION, NOVEMBER 2017
Fifth Semester

CHEMISTRY

NANO CHEMISTRY

Time: 3 hours   Maximum : 60 marks

PART – A (20 x 1 = 20 Marks) (30 Minutes)
(Question Nos. 1 to 20 Online Examinations)

PART B (5 x 8 = 40 Marks) (2 ½ Hours)
Answer ALL the Questions

21. a. What is self assembly? Write a brief note on self assembly of materials and molecules.

Or

b. What is meant by nano machine and quantum dots? How it's classified?

22. a. Discuss about the preparation, properties and uses of alumina and titania nanoparticles.

Or

b. Write a preparation, properties and uses of Au and Ag nanoparticles.

23. a. Write briefly on various approaches in nanoparticle synthesis.

Or

b. What are all the characterization made in nanoparticles and explain about the toxic effects of nanomaterials.

24. a. Define CNT? Why CNT is an important in nanotechnology with neat examples?

Or

b. Write an application and uses of CNT in metallurgical industry and explain why it is an important?

25. a. Give an eight important differences about SEM and TEM.

Or

b. How SEM & TEM can be used for characterization of nanonmaterials?
