BT405 – NANO BIOTECHNOLOGY

FINAL TERM MOST IMPORTANT QUESTIONS

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GROUP LINK: https://chat.whatsapp.com/BjC6W0jZx8o9yaC2ISh1Gu

1. Write features of Nano particles.

- ***Small Size (1–100 nm):*** Nanoparticles are extremely small, which gives them unique physical and chemical properties compared to larger particles.
- ***High Surface Area to Volume Ratio:*** Their tiny size gives them a large surface area relative to their volume, making them highly reactive and effective in applications like catalysis and drug delivery.
- ***Quantum Effects:*** At the nanoscale, materials can show quantum behavior, changing their electrical, magnetic, and optical properties.
- ***Improved Mechanical Strength:*** Nanoparticles can be stronger and more flexible than the same materials in larger forms.
- ***Unique Optical Properties:*** Nanoparticles (especially metals like gold and silver) can change color based on their size and shape due to effects like surface plasmon resonance.
- ***Controlled Chemical Reactivity:*** The chemical behavior of nanoparticles can be tuned by modifying their surface or structure, useful in reactions or environmental applications.
- ***Easy to Enter Cells (Biocompatibility):*** Their small size allows them to pass through cell membranes, making them useful in medical treatments like drug delivery or cancer therapy.
- ***Self-Assembly:*** Nanoparticles can organize themselves into structured patterns under the right conditions, useful in nanotechnology and materials science.
- ***Special Magnetic Properties:*** Some nanoparticles (like iron oxide) show magnetic behaviors not seen in bulk materials, useful in imaging and data storage.
- ***Surface Functionalization:*** Nanoparticles can be coated or modified with specific molecules to target certain tissues, cells, or chemicals.

2. Write applications of dendrimers.

- ***Drug Delivery:*** Dendrimers can carry drugs inside their branched structure and release them in a controlled way. They can also be modified to target specific cells (like cancer cells), reducing side effects.
- ***Gene Therapy:*** Dendrimers can be used to deliver genetic material (like DNA or RNA) into cells safely and efficiently, helping in the treatment of genetic disorders.

- ***Medical Imaging:*** Dendrimers can be linked with contrast agents (like gadolinium) to improve imaging in MRI and other diagnostic techniques.
- ***Antimicrobial Agents:*** Some dendrimers have antibacterial, antiviral, or antifungal properties and are used in developing new antimicrobial treatments.
- ***Cancer Therapy:*** Dendrimers can deliver anti-cancer drugs directly to tumor cells, helping to increase the effectiveness of treatment and reduce damage to healthy cells.
- ***Nano medicine and Diagnostics:*** Dendrimers are used in biosensors and diagnostic tools due to their ability to bind specific biological molecules.
- ***Cosmetics and Skincare:*** Used in creams and lotions to improve delivery of active ingredients into the skin and enhance absorption.
- ***Catalysis:*** Dendrimers can act as Nano catalysts in chemical reactions due to their large surface area and active sites.
- ***Environmental Applications:*** Used to capture and remove toxic metals or pollutants from water due to their binding capabilities.
- ***Gene Editing:*** They are being explored as carriers for CRISPR and other gene-editing tools to improve delivery into cells.

3. Write role of Nano tubes in PCR.

- ***Improved Heat Transfer:*** Carbon nanotubes (CNTs) have excellent thermal conductivity, which helps in faster and more efficient heat distribution during the PCR cycles (denaturation, annealing, and extension).
- ***Increased Reaction Efficiency:*** By enhancing temperature control, nanotubes can lead to more accurate and efficient DNA amplification.
- ***Enzyme Stabilization:*** Nanotubes can interact with DNA polymerase (the enzyme used in PCR), helping to stabilize it and possibly increasing its activity and lifespan during the reaction.
- ***Reduced Reaction Time:*** Due to better heat transfer and improved enzyme performance, PCR reactions using nanotubes may be completed faster than traditional methods.
- ***Higher Yield and Sensitivity:*** Nanotubes can enhance the overall yield of amplified DNA and improve detection sensitivity, especially useful in low-copy DNA samples.
- ***Potential as Carriers or Supports:*** Nanotubes can act as carriers for DNA or enzymes, allowing better control over the reaction environment and possibly enabling miniaturized or portable PCR systems.

4. Write principle behind the glucose biosensors.

Glucose biosensors work based on an enzymatic reaction that produces an electrical signal proportional to glucose concentration.

- ***Enzyme used:*** Glucose oxidase (GOx)
- ***Reaction:***
  Glucose + O_2 → Gluconic acid + H_2O_2
- ***Detection:*** The hydrogen peroxide (H_2O_2) produced is oxidized at an electrode, generating an electric current.
- ***Output:*** The current is measured and is directly proportional to the glucose level in the sample.

5. What are health hazards of Nano tubes?

Health hazards of nanotubes:

Nanotubes, especially carbon nanotubes (CNTs), can pose health risks due to their small size and fiber-like shape.

- ***Respiratory Issues:*** Inhaled nanotubes can reach deep into the lungs, potentially causing inflammation, fibrosis, or lung damage.
- ***Toxicity:*** Some types of CNTs may generate reactive oxygen species (ROS), leading to oxidative stress and cell damage.
- ***Carcinogenic Potential:*** Long, rigid CNTs may behave like asbestos fibers and have been linked to cancer risk in some animal studies.
- ***Skin and Eye Irritation:*** Direct contact may cause irritation or allergic reactions in sensitive individuals.
- ***Bioaccumulation:*** Nanotubes may persist in the body or environment, leading to long-term exposure effects.

6. What is Quantum Dot?

QUANTUM DOT:

A quantum dot is a tiny semiconductor nanoparticle, typically 2–10 nanometers in size that has unique optical and electronic properties due to quantum mechanics. It confines electrons in all three spatial dimensions, leading to discrete energy levels. This cause's size-dependent emission of light: smaller dots emit shorter wavelengths (blue), larger dots emit longer wavelengths (red). It is used in applications like displays, bio-imaging, solar cells, and quantum computing.

7. Explain Quantization energy.

Quantization energy is a fundamental concept in quantum mechanics which means that energy is not continuous but exists in discrete amounts or levels. In very small systems such as atoms, molecules, or nanoparticles, electrons cannot have just any amount of energy; instead, they are restricted to specific energy levels. When an electron moves between these levels, it must absorb or release energy in fixed packets called quanta. This discrete nature of energy explains why materials like quantum dots emit light at specific wavelengths based on their size. In nanoscale materials, quantization energy significantly influences their optical, electrical, and magnetic properties, making them behave differently compared to their bulk counterparts.

8. What is random movement of energy?

Random movement of energy refers to the unpredictable, spontaneous motion of particles or energy in a system due to thermal agitation. This is commonly seen as thermal energy causing molecules or atoms to move in random directions at varying speeds. For example, in gases or liquids, particles constantly collide and move randomly, which results in the distribution of energy throughout the system. This randomness underlies phenomena like diffusion**,** Brownian motion, and heat transfer.

9. Differentiate between Super Hydrophobic and Super Hydrophilic coatings.

Super hydrophobic coatings have an extremely high water contact angle, usually above 150 degrees, which means water droplets bead up and easily roll off the surface. This makes these coatings highly water-repellent and useful for applications like self-cleaning surfaces and waterproof materials. They often have a rough or nano-structured surface that traps air, enhancing their water resistance. In contrast, super hydrophilic coatings have a very low water contact angle, close to zero degrees, causing water to spread out and form a thin, uniform film on the surface. These coatings are highly water-attracting and are used in applications such as anti-fogging and improving wettability. Typically, super hydrophilic surfaces are smoother or structured to encourage water spreading. So, while super hydrophobic coatings repel water, super hydrophilic coatings promote water absorption and spreading.

10. Write properties of carbon Nano tubes.

- ***High Mechanical Strength:*** Stronger than steel but much lighter
- ***Excellent Electrical Conductivity:*** Can behave as metals or semiconductors depending on their structure
- ***Superior Thermal Conductivity:*** Efficiently conducts heat along the tube axis
- ***High Surface Area:*** Provides more active sites for chemical reactions
- ***Chemical Stability:*** Resistant to chemical degradation in many environments
- ***Unique Optical Properties:*** Useful in sensors and Nano electronics
- ***Magnetic Properties:*** Some CNTs show magnetic behavior useful in advanced applications
- ***Flexibility and Elasticity:*** Can bend without breaking, making them ideal for flexible devices

11. What is transient and stable transformation?

Transient and stable transformation refer to two types of genetic modifications in cells. In transient transformation, foreign DNA is introduced into a cell but is not integrated into the cell's genome. As a result, the introduced gene is expressed temporarily and diluted out or lost after a few cell divisions. This method is useful for short-term studies of gene function. In stable transformation, the foreign DNA is integrated permanently into the host genome. This allows the gene to be passed on to daughter cells and expressed over many generations. It is used for long-term gene expression and creating genetically modified organisms.

12. Write role of Nano technology in diagnostics.

- Enables highly sensitive and specific detection of biomolecules (proteins, DNA, etc.)
- Allows early diagnosis of diseases like cancer, infections, and genetic disorders
- Uses nanomaterials (nanoparticles, quantum dots, nanotubes) as targeted probes or sensors
- Requires smaller sample volumes and delivers faster results
- Supports development of point-of-care devices and portable lab-on-a-chip systems
- Improves accuracy and reliability of diagnostic tests
- Helps reduce costs and increases accessibility of diagnostic tools

13. Explain atomic force microscopic lithography.

Atomic Force Microscopic (AFM) Lithography is a nanofabrication technique that uses the sharp tip of an atomic force microscope to create very fine patterns on a surface at the nanoscale. In this process, the AFM tip physically interacts with the surface—either by applying pressure, scratching, or inducing chemical changes—to modify the material precisely where the tip moves. This method allows for the direct writing of structures without the need for masks or complex processing steps. AFM lithography is widely used for creating nanoscale devices, studying surface properties, and fabricating quantum dots or nanowires with high resolution and control.

14. Explain atomic force X-ray lithography.

Atomic Force X-ray Lithography combines the precision of Atomic Force Microscopy (AFM) with the high-resolution patterning capabilities of X-ray lithography. In this technique, an AFM tip is used to manipulate or prepare a resist material on a substrate, which is then exposed to X-rays. The X-rays create fine patterns by selectively altering the chemical structure of the resist where it is exposed, while the AFM tip can assist by mechanically modifying or aligning the resist to achieve nanoscale accuracy. This hybrid approach leverages AFM's nanoscale control and X-ray lithography's ability to produce extremely small features, making it useful for fabricating complex nanostructures in semiconductor manufacturing and Nano device fabrication.

15. What is Spectroscopy?

Spectroscopy is the scientific technique used to study how matter interacts with electromagnetic radiation (such as light, X-rays, or microwaves). It involves analyzing the spectrum of light (or other radiation) that is absorbed**,** emitted**,** or scattered by a material. Each substance produces a unique spectral pattern, like a fingerprint, which helps identify its composition, structure, and properties. Spectroscopy is widely used in fields like chemistry, physics, biology, astronomy, and material science for qualitative and quantitative analysis of substances.

16. Explain X-ray method spectroscopy in detail.

X-ray Spectroscopy is a powerful analytical technique used to study the elemental composition and electronic structure of materials by analyzing the interaction of X-rays with matter. When a sample is irradiated with high-energy X-rays, inner-shell electrons (usually from the K or L shells) can be ejected, creating vacancies. Electrons from higher energy levels then drop down to fill these vacancies, releasing energy in the form of characteristic X-ray photons. The energy of these emitted X-rays is unique to each element, allowing for identification and quantification. There are different types of X-ray spectroscopy techniques, including:

- ***X-ray Fluorescence (XRF):*** Measures the characteristic secondary (fluorescent) X-rays emitted by a sample to determine its elemental composition. It's widely used for qualitative and quantitative elemental analysis.
- ***X-ray Photoelectron Spectroscopy (XPS):*** Analyzes the kinetic energy of electrons emitted from a sample surface when irradiated with X-rays. It provides information about elemental composition, chemical states, and electronic structure at the surface.
- ***X-ray Absorption Spectroscopy (XAS):*** Studies how X-rays are absorbed by a sample as their energy is varied, giving insights into the local chemical environment and bonding of specific elements.

17. Write role of metal Nano particles in environmental cleaning.

Role of Metal Nanoparticles in Environmental Cleaning:

Metal nanoparticles play a significant role in cleaning the environment due to their unique properties such as high surface area, reactivity, and catalytic ability. They are used to:

- **Degrade pollutants:** Metal nanoparticles like silver, gold, and titanium dioxide can catalyze the breakdown of harmful organic pollutants and dyes in water through photocatalytic reactions.
- **Remove heavy metals:** Nanoparticles can adsorb or chemically bind toxic heavy metals (like lead, mercury, and arsenic) from contaminated water and soil.
- **Disinfect water:** Silver nanoparticles have strong antimicrobial properties, making them effective in killing bacteria and viruses in water purification.
- **Air purification:** Metal nanoparticles can catalyze the conversion of harmful gases (like nitrogen oxides and volatile organic compounds) into less harmful substances.
- **Waste treatment:** Nanoparticles enhance the efficiency of various treatment processes by speeding up chemical reactions and improving contaminant removal.

18. What are biosensors?

Biosensors are analytical devices that combine a biological component (like enzymes, antibodies, or cells) with a physical or chemical transducer to detect and measure specific substances. The biological part interacts selectively with the target molecule (analyte), producing a signal that the transducer converts into a measurable electrical, optical, or thermal signal. Biosensors are widely used in medical diagnostics, environmental monitoring, food safety, and biotechnology for rapid, sensitive, and specific detection of chemicals, pathogens, or biomolecules.

19. Write advantages of lab on chip.

- ***Miniaturization:*** Integrates multiple laboratory functions on a small chip, reducing size and sample volume
- ***Fast Analysis:*** Speeds up chemical and biological testing with quicker reaction times
- ***Cost-Effective:*** Lowers reagent use and reduces operational costs
- ***Portability:*** Enables on-site and point-of-care testing outside traditional labs
- ***Automation:*** Allows easy integration of sample preparation, analysis, and detection in one device
- ***High Sensitivity:*** Enhances detection accuracy due to precise control over small volumes
- ***Multiplexing:*** Can perform multiple tests simultaneously on a single chip
- ***Reduced Contamination Risk:*** Closed systems minimize sample contamination and human error

20. Which Nano material is used in coatings?

- ***Nanoparticles of Titanium Dioxide (TiO_2):*** For UV protection and self-cleaning properties
- ***Silver Nanoparticles:*** For antimicrobial and antibacterial coatings
- ***Zinc Oxide (ZnO) Nanoparticles:*** For UV blocking and antibacterial effects
- ***Silica Nanoparticles:*** To improve scratch resistance and durability

- ***Carbon Nanotubes:*** To enhance mechanical strength and electrical conductivity
- ***Cerium Oxide Nanoparticles:*** For corrosion resistance and UV protection

21. What are the health hazards of carbon Nano tubes?

HEALTH HAZARDS OF CARBON NANOTUBES (CNTS):

Carbon nanotubes can pose several health risks, especially when inhaled as fine particles:

- ***Respiratory problems:*** Inhaled CNTs can reach deep into the lungs, causing inflammation, fibrosis, or lung tissue damage.
- ***Potential carcinogenicity:*** Due to their fiber-like shape, some CNTs may behave similarly to asbestos and could increase the risk of cancer.
- ***Oxidative stress:*** CNTs can generate reactive oxygen species (ROS), leading to cell damage and toxicity.
- ***Skin and eye irritation:*** Direct contact may cause irritation or allergic reactions.
- ***Bio-persistence:*** CNTs may remain in the body or environment for long periods, leading to chronic exposure risks.

22. What is the principle of quantum confinement and its relation with bandgap?

Principle of Quantum Confinement and its Relation with Bandgap:

Quantum confinement occurs when the size of a semiconductor particle becomes comparable to or smaller than the exciton Bohr radius (the typical size of an electron-hole pair). At this nanoscale, the motion of electrons and holes is restricted in all three spatial dimensions, causing their energy levels to become discrete rather than continuous. As a result, the bandgap energy—the energy difference between the valence band and conduction band—increases as the particle size decreases. This means smaller nanoparticles or quantum dots require more energy to excite an electron, leading to a blue shift in the absorption and emission spectra.

23. What is the principle of spectroscopy?

PRINCIPLE OF SPECTROSCOPY:

Spectroscopy is based on the interaction between matter and electromagnetic radiation. When light or other forms of radiation pass through or are emitted by a substance, the atoms or molecules absorb, emit, or scatter energy at specific wavelengths. These interactions produce a characteristic spectrum unique to each substance, which can be analyzed to identify and study the composition, structure, and properties of the material.

24. How adjuvant the immune response to vaccine antigen?

Adjuvants are substances added to vaccines to boost the body's immune response to the antigen. They work by several mechanisms:

1. ***Enhancing Antigen Presentation:*** Adjuvants help antigen-presenting cells (like dendritic cells) take up, process, and display the vaccine antigen more effectively to immune cells.
2. ***Stimulating Immune Cells:*** They activate immune cells by triggering innate immune receptors (e.g., Toll-like receptors), leading to the production of cytokines that promote stronger adaptive immunity.

3. ***Prolonging Antigen Release:*** Some adjuvants create a depot effect, slowly releasing the antigen over time, which helps sustain immune stimulation.
4. ***Increasing Antibody Production:*** Adjuvants enhance both the quantity and quality (affinity) of antibodies generated.
5. ***Promoting Cellular Immunity:*** They can stimulate T-cell responses, which are essential for protection against many infections.

25. Write the production method of aptamers.

Production Method of Aptamers:

Aptamers are short, single-stranded DNA or RNA molecules that bind specifically to target molecules. They are produced using a process called SELEX (Systematic Evolution of Ligands by EXponential enrichment), which involves:

1. ***Library Preparation:*** Start with a large, random pool of single-stranded nucleic acids (10^{13}–10^{15} different sequences).
2. ***Binding:*** Incubate the library with the target molecule so that some sequences bind to it.
3. ***Separation:*** Separate bound sequences from unbound ones.
4. ***Elution:*** Recover the bound sequences.
5. ***Amplification:*** Use PCR (for DNA aptamers) or RT-PCR (for RNA aptamers) to amplify the selected sequences.
6. ***Repetition:*** Repeat the binding, separation, and amplification steps multiple times (typically 8–15 cycles) to enrich high-affinity aptamers.
7. ***Characterization:*** Finally, sequence and characterize the aptamers with the best binding properties.

26. How to promote the regrowth of bone after injury?

From the perspective of Nano biotechnology, promoting bone regrowth after injury involves using nanoscale materials and tools that mimic the natural bone environment to enhance healing. Nanomaterials like Nano hydroxyapatite, which closely resemble the mineral component of bone, provide excellent scaffolds that support bone cell attachment, proliferation, and differentiation. These nanostructured scaffolds offer a large surface area and appropriate mechanical strength, encouraging faster and more effective bone regeneration.

Additionally, nanoparticles can be used to deliver growth factors (like BMPs) or drugs directly to the injury site in a controlled manner, improving the local healing response while minimizing side effects. Nano fibrous scaffolds can simulate the extracellular matrix, guiding new tissue formation. Moreover, nanotechnology enables the integration of sensors within implants to monitor bone healing in real-time.

27. What is liquid crystal and its applications?

A liquid crystal is a state of matter that has properties between those of conventional liquids and solid crystals. While it flows like a liquid, its molecules are partially ordered like in a crystal. This unique combination allows liquid crystals to respond to external stimuli like temperature, electric fields, or light, making them very useful in technology.

Applications of Liquid Crystals:

- ***Display Technology (LCDs):*** Widely used in TVs, monitors, smartphones, and digital watches due to their ability to control light transmission.
- ***Thermometers:*** Certain liquid crystals change color with temperature, used in mood rings and medical thermometers.
- ***Optical Devices:*** Used in tunable lenses, light modulators, and filters.
- ***Sensors:*** Detect changes in temperature, pressure, or chemical environments.
- ***Biological Imaging:*** Used in biosensors and as contrast agents in microscopy.
- ***Smart Windows:*** Control light and heat transmission based on electrical signals.

28. Write applications of Nano technology in agriculture.

Applications of Nanotechnology in Agriculture:

Nanotechnology offers innovative solutions to enhance productivity, sustainability, and efficiency in agriculture. Key applications include:

- ***Nano-fertilizers:*** Deliver nutrients more efficiently to plants, reducing waste and environmental pollution.
- ***Nano-pesticides:*** Improve pest control with targeted delivery, lower doses, and reduced toxicity to non-target organisms.
- ***Nano sensors:*** Monitor soil health, moisture levels, and crop conditions in real-time for precision farming.
- ***Smart delivery systems:*** Controlled release of agrochemicals (fertilizers, herbicides, and pesticides) to minimize usage and maximize effect.
- ***Disease detection:*** Early detection of plant diseases and pathogens using nanoparticle-based biosensors.
- ***Soil improvement:*** Nanomaterials enhance soil structure and nutrient retention.
- ***Plant growth enhancers:*** Some nanoparticles promote seed germination and plant growth.
- ***Post-harvest management:*** Nano coatings and packaging extend shelf life by preventing spoilage and microbial growth.

29. Write advantages of nanosomes.

Advantages of Nanosomes:

Nanosomes are nano-sized vesicles, similar to liposomes, used to deliver drugs, nutrients, or cosmetics more effectively. Their small size and unique structure offer several advantages:

- ***Enhanced penetration:*** Easily pass through skin or cellular barriers for deeper delivery.
- ***Targeted delivery:*** Can be engineered to deliver substances directly to specific tissues or cells, reducing side effects.
- ***Improved stability:*** Protect sensitive compounds (like vitamins or drugs) from degradation.
- ***Biocompatibility:*** Made from safe, biodegradable materials.
- ***Increased bioavailability:*** Improve absorption and effectiveness of active ingredients.
- ***Use in cosmetics:*** Widely used in skincare to deliver anti-aging or moisturizing agents deep into the skin.

30. What Nano techniques are used in medical diagnostics and pathogen detection?

Nano techniques Used in Medical Diagnostics and Pathogen Detection:

Nanotechnology offers highly sensitive, rapid, and accurate tools for detecting diseases and pathogens. Common Nano techniques include:

- ***Nanoparticle-Based Biosensors:*** Gold, silver, or magnetic nanoparticles are used to detect specific DNA, proteins, or antigens of pathogens through color changes or electrical signals.
- ***Quantum Dots:*** Fluorescent nanoparticles that emit light at specific wavelengths, used for imaging cells or detecting multiple disease markers simultaneously.
- ***Nano pore Technology:*** Detects individual DNA or RNA strands by measuring changes in electrical signals as molecules pass through a Nano pore—used in rapid genetic sequencing.
- ***Lab-on-a-Chip Devices:*** Miniaturized platforms combining nanomaterials and microfluidics for quick, point-of-care diagnostics of diseases and infections.
- ***Surface-Enhanced Raman Spectroscopy (SERS):*** Uses metal nanoparticles to enhance the Raman signal, enabling detection of pathogens at very low concentrations.
- ***Magnetic Nanoparticles:*** Used to isolate and concentrate pathogens or biomarkers from samples, improving sensitivity of tests like PCR or ELISA.

31. Write advantages of microfluidics.

- ***Reduced Sample and Reagent Volume:*** Microfluidic systems use very small volumes (nano- to picoliters), saving expensive reagents and samples.
- ***Faster Analysis:*** Due to the small scale, reactions and analyses occur much faster than in conventional systems.
- ***High Precision and Control:*** Enables precise control of fluid flow, temperature, and chemical environments.
- ***Portability:*** Devices can be miniaturized into handheld or portable formats, ideal for point-of-care diagnostics.
- ***Integration and Automation:*** Multiple steps (e.g., mixing, separation, detection) can be integrated on a single chip, allowing automation of complex workflows.
- ***Low Cost:*** Once developed, microfluidic chips can be mass-produced at low cost, especially using polymers.
- ***High-Throughput Screening:*** Ability to run many parallel experiments simultaneously on a single device.
- ***Enhanced Sensitivity:*** Small volumes increase the surface-to-volume ratio, improving reaction efficiency and detection sensitivity.
- ***Safety:*** Handling of hazardous or biological materials is safer due to small quantities and enclosed environments.
- ***Environmentally Friendly:*** Reduces chemical waste and energy consumption, making processes more sustainable.

32. Write thermal and electrical properties of carbon Nano tubes.

Thermal Properties:

1. ***High Thermal Conductivity:*** CNTs exhibit extremely high thermal conductivity along their length (axial direction), typically around 3000–6000 W/m·K for single-walled CNTs (SWCNTs). This is higher than that of copper (~400 W/m·K).
2. ***Anisotropic Thermal Conductivity:*** Thermal conductivity is high in the axial direction but much lower in the radial direction.
3. ***Excellent Heat Dissipation:*** CNTs are ideal materials for heat sinks and thermal interface materials in nanoelectronics.
4. ***Temperature Stability:*** CNTs are stable up to 2800°C in vacuum and about 750°C in air.

Electrical Properties:

1. ***High Electrical Conductivity:*** CNTs can behave as either metallic or semiconducting, depending on their chirality (twist) or diameter. Metallic CNTs have electrical conductivity comparable to copper, up to 10^6–10^7 S/m.
2. ***Ballistic Electron Transport:*** In metallic CNTs, electrons can move with minimal scattering over long distances (up to microns), allowing near-ballistic transport.
3. ***Low Electrical Resistance:*** Offers very low resistance in ideal conditions, making them suitable for nanoscale interconnects.
4. ***Field Emission Properties:*** CNTs can emit electrons at low voltages due to their high aspect ratio and sharp tips.

33. What is the future of Nano technology?

The future of nanotechnology is highly promising and is expected to transform many industries and aspects of daily life. Here are key future directions and potential impacts:

1. Medicine and Healthcare

- ***Targeted Drug Delivery:*** Nanoparticles can deliver drugs directly to diseased cells (e.g., cancer), minimizing side effects.
- ***Early Disease Detection:*** Nanosensors will enable ultra-sensitive detection of diseases at the molecular level.
- ***Nano-surgery:*** Use of nanobots for minimally invasive surgery or cellular-level repair.
- ***Regenerative Medicine:*** Nanomaterials to support tissue regeneration and artificial organs.

2. Electronics and Computing

- ***Smaller and Faster Devices:*** Nanotechnology will continue to shrink transistors, enabling faster, more efficient processors.
- ***Quantum Computing Components:*** Nanotech will play a role in building qubits and other quantum devices.
- ***Flexible and Wearable Electronics:*** Nanomaterials enable bendable, lightweight, and stretchable devices.

3. Energy

- ***Efficient Solar Cells:*** Nanostructured materials can enhance light absorption and conversion efficiency.
- ***High-Capacity Batteries:*** Nanomaterials like graphene improve battery capacity, charging speed, and lifespan.
- ***Hydrogen Storage and Fuel Cells:*** Nano-enabled materials could make clean energy more practical.

4. Environment

- ***Water Purification:*** Nanofilters can remove heavy metals, viruses, and bacteria from water.
- ***Pollution Control:*** Nanomaterials can capture and break down pollutants in air and soil.
- ***Green Manufacturing:*** Nanotech allows cleaner, more sustainable production methods.

5. Materials Science

- ***Stronger, Lighter Materials:*** CNTs, graphene, and nanocomposites will lead to materials with superior strength-to-weight ratios.
- ***Self-Healing Materials:*** Materials that can automatically repair damage at the nano-level.

6. Agriculture and Food

- ***Smart Fertilizers and Pesticides:*** Nanoparticles that release nutrients or pesticides in a controlled manner.
- ***Food Safety Sensors:*** Detect contamination or spoilage in real-time.

7. Space and Defense

- ***Lightweight Materials for Spacecraft:*** Reduce launch costs and improve efficiency.
- ***Nano-satellites and Surveillance:*** Tiny, advanced sensors for monitoring and communication.

34. Write advantages of transformation with Nano materials.

Transforming traditional materials and processes using nanomaterials offers numerous benefits across various industries. Here are the key advantages:

1. Enhanced Mechanical Properties

- ***Increased Strength and Durability:*** Nanomaterials (like carbon nanotubes or graphene) can significantly improve the tensile strength, hardness, and flexibility of materials.
- ***Lightweight Structures:*** High strength-to-weight ratio makes materials lighter without compromising performance.

2. Improved Electrical and Thermal Properties

- ***High Electrical Conductivity:*** Nanomaterials enable better electrical performance in electronics and conductive coatings.
- ***Superior Thermal Conductivity:*** Ideal for heat dissipation in electronic devices and advanced cooling systems.

3. Increased Efficiency in Devices and Systems

- ***Faster Response Times:*** Nanomaterials allow quicker energy transfer and reactions, improving efficiency in sensors, batteries, and displays.
- ***Reduced Energy Consumption:*** More efficient energy conversion and storage reduce overall energy needs.

4. Miniaturization of Devices

- Enables the development of smaller, more compact, and portable devices with enhanced capabilities (e.g., smartphones, sensors, medical devices).

5. Functionalization and Smart Features

- Nanomaterials can be engineered to have specific properties like self-cleaning, self-healing, or responsiveness to external stimuli (e.g., light, temperature, pH).

6. Environmental Benefits

- ***Cleaner Production Processes:*** Use of nanomaterials can reduce waste and energy usage.
- ***Pollution Control:*** Nanomaterials can capture or neutralize pollutants in air, water, and soil.

7. Medical Advancements

- ***Targeted Therapies:*** Nanoparticles can deliver drugs directly to diseased cells, improving treatment outcomes and reducing side effects.
- ***Advanced Diagnostics:*** Nanoscale sensors and imaging agents offer earlier and more accurate disease detection.

8. Improved Material Lifespan

- Nanocoatings can provide corrosion resistance**,** UV protection**,** and abrasion resistance, extending the life of materials and products.

9. Economic Advantages

- Long-term cost savings through improved performance, lower maintenance, and reduced material usage.

10. Innovation in Multiple Fields

- Enables breakthroughs in electronics**,** aerospace**,** construction**,** textiles**,** automotive**,** energy, and biotechnology, driving new product development and industrial transformation.

35. How Nano technology helps the scientists?

Nanotechnology helps scientists by providing tools and techniques that allow them to manipulate matter at the atomic and molecular scale, which was not possible with traditional methods. This level of precision opens up entirely new possibilities in scientific research and experimentation. For instance, in material science, scientists can now design and engineer materials with customized properties—such as increased strength, lighter weight, or enhanced conductivity—by altering their structure at the nanoscale.

In the field of biology and medicine, nanotechnology enables researchers to study cells, proteins, and DNA in much greater detail. It plays a crucial role in developing targeted drug delivery systems, where nanoparticles carry medications directly to diseased cells, minimizing side effects and increasing treatment efficiency. Nanotech also supports early disease detection through highly sensitive nanosensors, which can identify biomarkers at very low concentrations.

Nanotechnology significantly benefits environmental and energy research as well. Scientists use nanomaterials to create more efficient solar panels, improve battery technology, and develop systems for water purification and pollution control. These advancements not only help in tackling environmental challenges but also contribute to the development of sustainable technologies.

In electronics and computing, nanotechnology allows the miniaturization of components, making devices smaller, faster, and more energy-efficient. Scientists can now build nanoscale transistors and memory units, essential for the progress of high-performance computing and emerging technologies like quantum computing.

36. What are lisosomes and nanosomes?

LIPOSOMES:

Liposomes are spherical vesicles composed of one or more phospholipid bilayers, similar to cell membranes. They can encapsulate both hydrophilic (water-soluble) substances in their inner aqueous core and hydrophobic (fat-soluble) substances within the lipid bilayer.

- ***Size Range:*** Typically 50 nm to several micrometers.
- ***Structure:*** Bilayered, like a mini cell membrane.
- ***Use:*** Commonly used in drug delivery**,** cosmetics, and gene therapy.
- ***Advantages:*** Biocompatible, non-toxic, and capable of carrying both water- and fat-soluble drugs.

NANOSOMES:

Nanosomes are smaller, more advanced versions of liposomes, usually below 100 nanometers in size. They are designed for enhanced penetration and delivery of active ingredients at the cellular or molecular level.

- ***Size Range:*** Typically less than 100 nm.
- ***Structure:*** Similar to liposomes but smaller and more stable.
- ***Use:*** Widely used in cosmetic products, dermal drug delivery, and Nano medicine.
- ***Advantages:*** Better skin absorption, targeted delivery, and longer shelf-life than conventional liposomes.

37. What is NP aggregation?

NP aggregation refers to the clumping or clustering of nanoparticles (NPs) in a solution or biological environment. This occurs when nanoparticles, instead of remaining evenly dispersed (as individual particles), stick together to form aggregates. Nanoparticles tend to aggregate due to:

- **Van der Waals forces** (weak attractive forces between particles)
- **Electrostatic interactions** (especially if surface charge is not stable)
- **Hydrophobic interactions** (common in biological systems)
- **Protein corona formation** (proteins in biological fluids bind to NPs and cause them to clump)

Why Is NP Aggregation a Problem in Nanobiotechnology?

- ***Loss of Functionality:*** Aggregated NPs may lose their unique properties (e.g., optical, magnetic, catalytic).
- ***Reduced Bioavailability:*** Aggregates may not reach target tissues effectively.
- ***Toxicity Concerns:*** Aggregates may trigger immune responses or be more toxic.
- ***Unpredictable Behavior:*** Aggregation can affect how NPs move through the body and interact with cells.

How to Prevent NP Aggregation?

- ***Surface functionalization:*** Coating NPs with polymers like PEG (polyethylene glycol) to increase stability.
- ***Charge stabilization:*** Adjusting surface charge (zeta potential) to prevent particles from sticking.
- ***Using surfactants:*** These reduce surface tension and stabilize dispersions.
- ***Controlling storage conditions:*** pH, temperature, and ionic strength can affect aggregation.

38. What is paper based microfluidics?

Paper-based microfluidics (μPADs) are low-cost, portable devices that use paper and capillary action to move small amounts of fluid without pumps. Hydrophobic barriers define channels on the paper. In Nanobiotechnology, it is used in diagnostics, biosensing, and environmental testing. It often combined with nanoparticles (e.g., gold NPs) for signal enhancement.

39. Define Microarray and Gene Chip.

Microarray (or gene chip) is a miniaturized device that contains thousands of DNA sequences fixed on a solid surface (like glass or silicon). It is used to analyze gene expression, detect mutations, or genotype multiple genes simultaneously.

40. What is Self-Assembly Nano technology?

Self-assembly nanotechnology refers to the spontaneous organization of molecules, atoms, or nanoparticles into structured and functional arrangements without external control. This process relies on natural intermolecular forces such as hydrogen bonding, electrostatic interactions, van der Waals forces, and hydrophobic effects. In nanobiotechnology, self-assembly is widely used to create complex nanostructures like drug delivery systems (e.g., liposomes), biosensors, and DNA-based nanostructures (e.g., DNA origami).

It enables precise, bottom-up fabrication of nanoscale materials, making it highly efficient and scalable for biomedical and diagnostic applications.

41. Write names of adjuvants used in vaccines.

Here are some common adjuvants:

1. ***Alum (Aluminum salts)*** – e.g., aluminum hydroxide, aluminum phosphate
2. ***MF59*** – an oil-in-water emulsion (used in flu vaccines)
3. ***AS03*** – another oil-in-water emulsion (used in some H1N1 vaccines)
4. ***AS04*** – alum + monophosphoryl lipid A (MPL)
5. ***Monophosphoryl lipid A (MPL)*** – a detoxified bacterial component
6. ***CpG 1018*** – synthetic DNA sequences that mimic bacterial DNA
7. ***QS-21*** – a saponin derived from the bark of the Quillaja tree
8. ***ISCOMs*** – immune-stimulating complexes
9. ***Poly I:C*** – synthetic double-stranded RNA mimic
10. ***Chitosan*** – a natural polymer used in experimental vaccines

42. What diseases could arise in the absence of micronutrients?

A deficiency in essential micronutrients (vitamins and minerals) can lead to various diseases, including:

1. **Iron deficiency → Anemia**
2. **Vitamin A deficiency → Night blindness**, **xerophthalmia**, increased infection risk
3. **Iodine deficiency → Goiter**, **cretinism**, **developmental delays**
4. **Vitamin D deficiency → Rickets** (in children), **osteomalacia** (in adults)
5. **Vitamin C deficiency → Scurvy**
6. **Vitamin B1 (Thiamine) deficiency → Beriberi**, **Wernicke-Korsakoff syndrome**
7. **Vitamin B12 deficiency → Pernicious anemia**, **nerve damage**
8. **Zinc deficiency → Impaired immune function**, **growth retardation**, **skin issues**
9. **Folate (Vitamin B9) deficiency → Neural tube defects** in newborns, **megaloblastic anemia**
10. **Calcium deficiency → Osteoporosis**, **muscle cramps**

43. Why AuNP is used in medical field?

Gold nanoparticles (AuNPs) are widely used in medicine because of their unique physical and chemical properties. They are biocompatible, easily functionalized with drugs, antibodies, or targeting molecules, and have excellent optical properties (like surface plasmon resonance) that enable sensitive detection. AuNPs are used for drug delivery, imaging**,** diagnostics (e.g., biosensors), and photothermal therapy to selectively kill cancer cells by converting light into heat. Their small size allows them to penetrate tissues and cells efficiently, making them highly valuable in nanomedicine.

Disclaimer:

For best results, it is advised NOT to rely on this file only. Go through video lectures, handouts and other sources as well.

Regards,

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