ASSIGNMENT - 4
INNOVATIVE TECHNOLOGY AND BIO-SCIENCE

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Q1. Explain at least 3 structures based on carbon nanomaterials.

1.1 GRAPHENE

Graphene is an allotrope of carbon in the form of a single layer of atoms in a two dimensional hexagonal lattice in which one atom forms each vertex. It is the basic structural element of other allotropes, including graphite, charcoal, carbon nanotubes and fullerenes. It can also be considered as an indefinitely large aromatic molecule, the ultimate case of the family of aromatic hydrocarbons.

MECHANICAL & PHYSICAL PROPERTIES

The carbon atoms of graphene (a single sheet of graphite) form a planar honeycomb lattice, in which each atom is connected to three neighboring atoms by a strong chemical bond. These strong bonds make the basal-plane elastic modulus of graphite one of the largest among any known material, with an **ultimate tensile strength of 100 times greater than of strongest steel and density less than aluminiu at 3.26gm/cm3. Extremely elastic as young's modulus in order of hundred gigapascals. It is harder than diomond.**

Extremely high surfacic density of 2630 square meters per gram.

It is **impervious** so that even the smallest atom (helium) cannot pass through a defect-free monolayer graphene sheet;

Very high meling point about 3700 degree celsius (sublimes)
Very high boiling point about 4200 degree celsius.

OPTICAL PROPERTIES

A graphene sheet it absorbs only about 2.3% of refracting light, hence it is nearly transparent;

ELECTRONIC and MAGNETIC PROPERTIES

Its high electron mobility is 100x faster than silicon;

it conducts heat 2x better than diamond; **its electrical conductivity is 13x better than copper**;

Graphene also shows a **large and nonlinear diamagnetism**, even greater than graphite, and can be **levitated by magnets**.

There has been Identified **bipolar transistor effect, ballistic transport of charges and large quantum oscillations** in the material.

POTENTIAL APPLICATIONS

- Used to produce other carbonaceous nanomaterials.

- Ultra-fast charging of batteries.
- **Collection of radioactive waste** for easier clean-up.
- Faster flash memory.
- Ultra-thin touchscreens.
- Graphene-based e-paper that can update with new information.
- Quick and efficient **biosensor devices**, to measure blood glucose, cholesterol, and possibly DNA as well.
- Headphones with phenomenal frequency response.
- Supercapacitors.
- Novel waterproof coatings.
- Bendable batteries.
- Stronger and lighter aircraft and armor.
- **Aiding tissue regeneration**.
- Purifying salt water into drinking water.
- **Bionic devices** that can connect directly to body's neurons.

1.2 CARBON NANO TUBES

Carbon nanotubes (CNTs) are tubes made of carbon with diameters typically measured in nanometers. Carbon nanotubes refer to **single-wall** carbon nanotubes **(SWCNTs)** or **multi-wall** carbon nanotubes **(MWCNTs)** consisting of nested single-wall carbon nanotubes or to tubes with an undetermined carbon-wall structure and diameters less than 100 nanometers. Single-wall carbon nanotubes are one of the allotropes of carbon, intermediate between fullerene cages and flat graphene.

MECHANICAL & PHYSICAL PROPERTIES

Being derived from graphene, CNTs are expected to be the ultimate high-strength fibers. **SWNTs are stiffer compared to steel** and are extremely resistant to damage from physical forces. When the tip of a nanotube is pressed, it bends without causing any damage to the tip, and on the removal of the force, the tip returns to its original state. Due to this property, CNTs are very useful as **probe tips for very high-resolution scanning probe microscopy.**

Young's modulus in **order of tera pascals**.

Due to the strong in-plane graphitic C-C bonds, they are made **remarkably stiff and strong against axial strains**. The almost zero in-plane thermal expansion but large inter-plane expansion of SWNTs implies high flexibility and strong in-plane coupling against nonaxial strains

ELECTRONIC and MAGNETIC PROPERTIES

Ultra-small SWNTs have been shown to **exhibit superconductivity even below 20 K**

Field emission is associated with the tunneling of electrons from a metal tip into vacuum, under application of a strong electric field. The **high aspect ratio** (that a lower loading (concentration) of CNTs is required to realize the same electrical conductivity when compared to other conductive additives)
and small diameter of CNTs are very suitable for field emission.

CNTs can carry an **very high current density**, probably as high as 10^13 A/cm2. Additionally, the current is extremely stable.

POTENTIAL APPLICATIONS

- Cancer tretment
- Drug delivery
- Cardiac autonomic regulation
- Tissue regeneation
- Biosensors
- Composite nanomaterials
- Construction material strengthening like concrete
- Highly tensile textiles - armour jackets
- NEMSs
- Coatings and films - stealth technology
- Hydrogen storage
- Energy storage
- Electric cables and wires
- Envirnmental remidiation

1.3 FULLERENES

A **fullerene** is an allotrope of carbon whose molecule consists of carbon atoms connected by single and double bonds so as to form a closed or partially closed mesh, with fused rings of five to seven atoms. The molecule may be a hollow sphere, ellipsoid, tube, or many other shapes and sizes. Graphene (isolated atomic layers of graphite), which is a flat mesh of regular hexagonal rings, can be seen as an extreme member of the family.

Fullerenes with a closed mesh topology are informally denoted by their empirical C*n*, where *n* is the number of carbon atoms. However, for some values of *n,* there maybe more than one isomer.

SOME POTENTIAL APPLICATIONS

Buckyballs may be used to trap free radicals generated during an allergic reaction and **block the inflammation**that results from an allergic reaction.

The antioxidant properties of buckyballs may be able to fight the deterioration of motor function due to **multiple sclerosis**.

Combining **buckyballs, nanotubes, and polymers** to produce inexpensive solar cells that can be formed by simply painting a surface.

Buckyballs may be used to **store hydrogen**, possibly as a fuel tank for fuel cell powered cars.

Researchers are attempting to modify **buckyballs to fit the section of the HIV molecule that binds to proteins**, possibly inhibiting the spread of the virus.

Making bullet proof vests with **inorganic (tungsten disulfide) buckyballs**.

Q2. Write short notes on :
a) Nanorobotics
b) Nano-transistors
c) Microgears and nanogears
d) Nanocomposites and their application

1.1 NANOROBOTICS

Nanorobotics describes the technology of producing machines or robots at the nanoscale. 'Nanobot' is an informal term to refer to engineered nano machines. Though currently hypothetical, nanorobots have potential to advance many fields through the manipulation of nano-sized objects.

The field of medicine is expected to receive the largest improvement from this technology. This is because nanotechnology provides the advantage of **transporting large amounts of nanorobots in a single injection.** Furthermore, designs that include a communication interface will allow **adaptations to the programming** and function of nanobots already in the body. This will improve disease monitoring and treatment whilst **reducing the need for invasive procedures.**

POTENTIAL APPLICATIONS

Respirocytes are hypothetical nanobots engineered to **function as artificial red blood cells**. In emergencies where a patient stops breathing and blood circulation ceases, respirocytes could be injected into the blood stream to **transport respiratory gases** until the patient is stabilized. This will be also helpful after major trauma to forming improved clotting capabilities in the event of a dangerous hemorrhage.

Clottocytes are another type of nanobot which function as **artificial platelets for halting bleeds**. Clottocytes would mimic the natural platelet ability to accumulate at the bleed, in order to form a barrier, **by unfurling a fiber mesh which would trap blood cells when the nanobot arrives at the site of the injury**.

As cancer survival rates improve with early detection, nanorobots designed with enhanced detection abilities will be able to **increase the speed of a cancer diagnosis and therefore enhance the prognosis of the disease.** Nanobots with embedded chemical sensors can be designed to detect tumor cells in the body. They can even be **utilised for therapy – Targeted treatment** can be formed by designing **nanorobots with chemotactic sensors** on their surface which correspond to specific antigens on the cancer cells.

1.2 NANOTRANSISTORS

A nanotransistor is an electronic component that acts as an electric signal switch or amplifier with size of order of nanometers (10^-9m). Although there is currently no transistor of this scale in practical use, a number of approaches toward achieving such a remarkable component are under development. In 2001, **Bell Labs** announced their ability to create in a laboratory **individually-addressable nanotransistors at the single molecule level, i**n which elctrode contacts were **self assembled**. About 10 million of such nanotransistors would fit on the head of a pin.

1.3 MICROGEARS AND NANOGEARS

Microgears and nanogears are a rotating machines part having cut teeth which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source, but being on size scale, of order of micrometer and nanometer respectively. These gears are used in microelectromechanical systems (MEMS) or nanoelectromechanical systems(NEMS) being coupled with microelectronics and mechanical actuators mumps or motors.

1.4 NANOCOMPOSITES AND THEIR APPLICATIONS

Nanocomposites are materials that **incorporate nanosized particles** into a matrix of standard material. The result of the addition of nanoparticles is a **drastic improvement in properties** that can include mechanical strength, toughness and electrical or thermal conductivity.
Nanoparticles have an **extremely high surface to volume ratio** which **dramatically changes their properties when compared with their bulk sized equivalents**. It also changes the way in which the nanoparticles bond with the bulk material. The result is that the composite can be many times improved with respect to the component parts. Some nanocomposite materials have been shown to be 1000 times tougher than the bulk component materials.

APPLICATIONS

Nanocomposites are currently being used in a number of fields and new applications are being continuously developed. Applications for nanocomposites include:

- Thin-film capacitors for computer chips
- Solid polymer electrolyes for batteries.
- Automotive engine parts and fuel tanks
- Impellers and blades
- Oxygen and gas barriers
- Food packaging

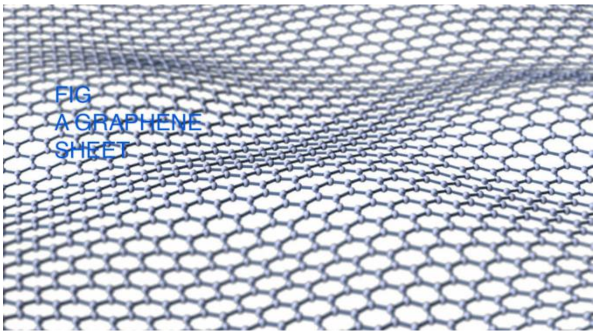
FIG
A GRAPHENE
SHEET

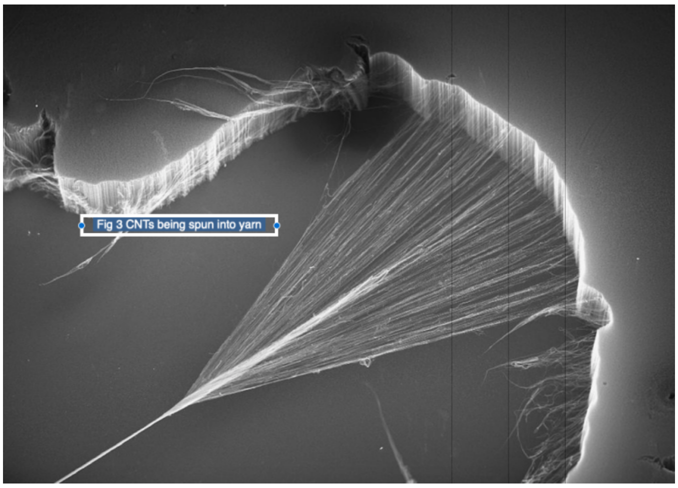
Fig 3 CNTs being spun into yarn

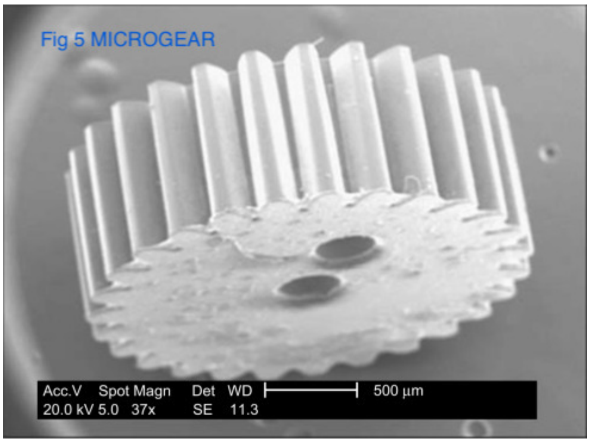

Fig 5 MICROGEAR

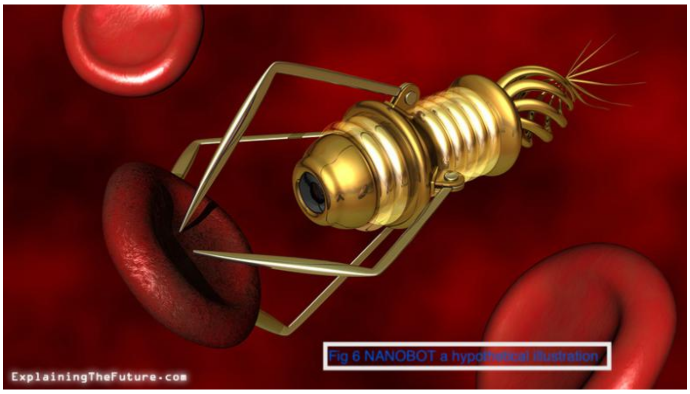

Fig 6 NANOBOT a hypothetical illustration

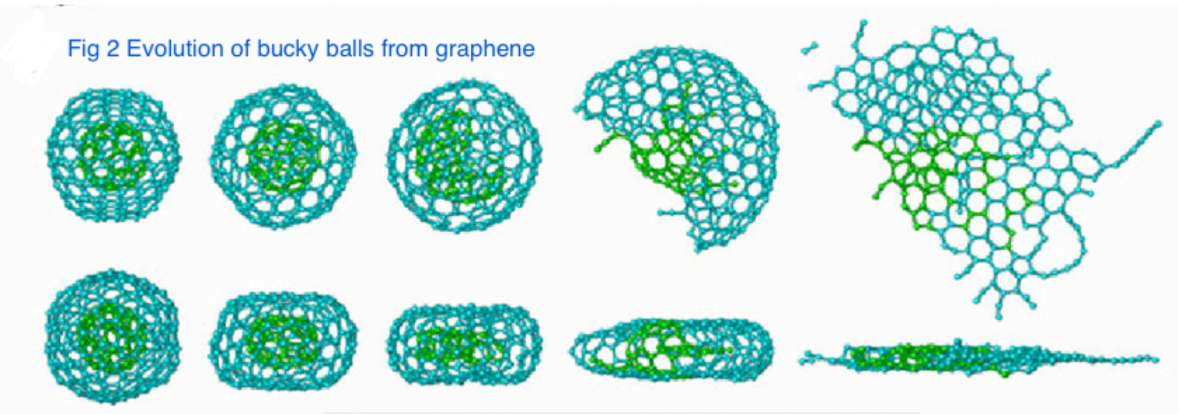
Fig 2 Evolution of bucky balls from graphene

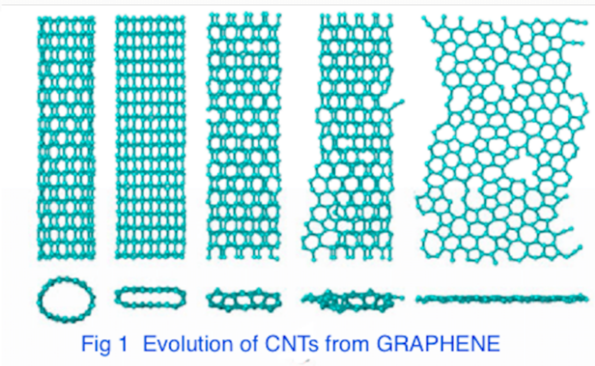
Fig 1 Evolution of CNTs from GRAPHENE