Unit 3 Engineering Materials

Part 1 Polymers

1) Classify the composites on the basis of reinforcement. Give any three properties and application of polymer composites. Marks 7

(Marking scheme: Classification 1 mark, three properties and applications 3 marks each)

Ans - Classification of Polymer composites on the basis of reinforcement:

a) Particle reinforced polymer composites: The particles are evenly dispersed in all directions. The strength of the bonding at matrix- particle interface dictates the mechanical properties of the composite.

b) Fiber reinforced Composites (FRP): The dispersed phase in the composite is in the form of fibers. Fibers provide high strength. The mechanical properties of composites depend upon the magnitude of interfacial bond between the fiber and the matrix, fiber orientation, concentration, fiber length and properties.

Technique of FRP: Resin is coated on fiber cloth or fiber mat on both sides.

Rollers are used to spread the resin uniformly. Alternate layers of resin and fiber material are arranged with same or different orientation, until required thickness built up.

The whole set is cured in a mould at proper temperature. The composite formed, is taken out of the mould and finished.

c) Structural composites: There are two types:

i) Laminar – Laminar composites consists of sheets or panels stacked with proper orientation and cemented together with a resin. Example – plywood

ii) Sandwiched: A sandwiched panels consists of two strong outer sheets separated by a layer of less dense material called as core.

Properties: 1. Low coefficient of expansion

2. Low density around 2.4 gm/cc 3. Low cost of production.

4. High dimensional stability and High tensile strength and stiffness,

5. High heat stability and can be usable at higher working temperature.

Applications of Polymer composites:

1. Automobile bodies, chassis parts, racing vehicle components,

2. Boats body,

3. Parts of aircraft.

4. Sports goods, musical instruments, toys etc.

5. High speed machinery parts, PCB, equipment parts, bodies of refrigerator, coolers, cabins for offices, windows, doors.

2) What is biodegradable polymer? Explain the favourable conditions for biodegradation. Give any three applications of biodegradable polymer. Marks 5

(Marking scheme: Definition 1 mark, favourable conditions 2 marks, three applications 2 marks)

Ans: Definition: It is the polymer which get degraded to harmless hydrocarbon compound (small unit) followed by carbon dioxide gas by microbial attack.

Factors responsible for bio degradation

a) Micro-organism: pseudomonas, bacillus, protozoa's, azetobactor and various fungi etc organisms are present on earth crust and have specific action on polymers by aerobic or anaerobic way

b) Environment: The favorable environment for survival, multiplication and action by the micro-organisms include suitable temperature, moist condition, presence of salts, oxygen and suitable P^H

c) Nature of polymer: The polymer chain should contain bonds which can be hydrolyzed or oxidized by the enzyme action. There should be N, S, O atoms present in the polymer chain. The highly aromatic chains are tough for degradation.

Favourable conditions for biodegradation:

1) Naturally occurring polymers are biodegradable
2) Hydrophilic polymer degrade faster than hydrophobic
3) Amorphous polymer are more susceptible to biodegradation than crystalline polymer
4) Low molecular weight polymer biodegrade easily than high molecular weight polymer
5) Synthetic addition polymers with only carbon atom main chain are not biodegradable at Molecular weight above 500

Applications:

1) PHBV is useful for molded article, films for packaging and laminations
2) It is useful for medical and veterinary applications
3) It is used for sustained release of fertilizer, medicines, growth hormones for plants
4) It is useful for surgical organ transplant and orthopedic operations

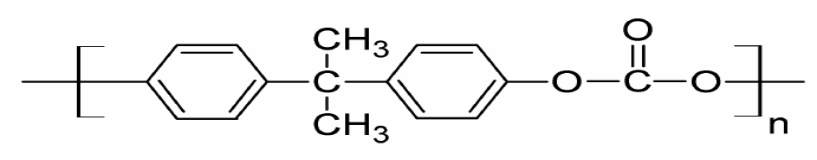
3) Give structure, properties and applications of Marks 6

(i) Polycarbonate

(ii) Polyphenylene vinylene (PPV)

(Marking scheme: structure, properties and applications of each polymer 3 marks)

Ans: structure of polycarbonate:



Properties:
1) High impact strength,
2) High tensile strength,
3) Transparent refractive index 1.58,
4) It is thermosoftening plastic but has high heat and flame resistance
5) Its specific gravity is 1.2 gm / cc, Tm = 230- 250 ^{0}C
6) It dissolves in organic solvent and alkali, not resistant to UV

Applications: 1) Bullet proof material, Windows of vehicles and houses,

2) Molded domestic ware, helmets, covers of vehicle lights,

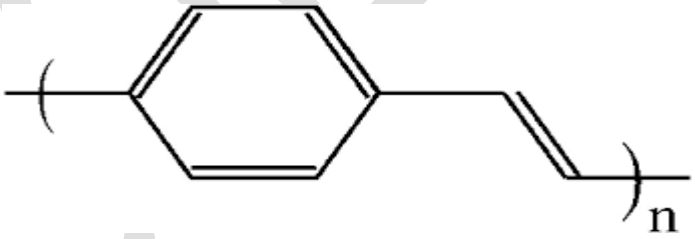
3) Making CDs and DVDs

4) Making handles of screwdrivers, for pliers

(ii) Polyphenylene vinylene (PPV):

Polyphenylene or polyphenylene vinylene (ppv) is an electroluminescent material.

Structure of PPV = –(-Ph-CH=CH-) n –



Properties of PPV

- Diamagnetic
- Low intrinsic conductivity (10-13S/cm)
- Conductivity increases on doping with I2, FeCl3, alkali metals, or acids
- Gives bright yellow green fluorescence
- Insoluble in water.

Applications: 1) Flat panel displays,

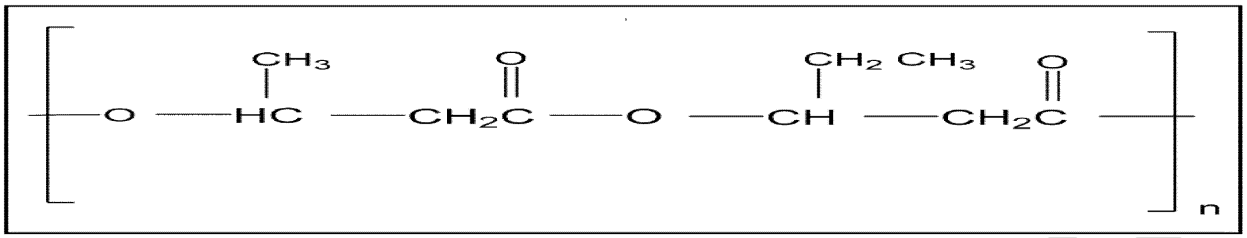
2) LED lamps, 3) Theatre assembly hall decoration, 4) Electroluminescent night lamps

5) Long life full color displays, 6) Arrow light decoration

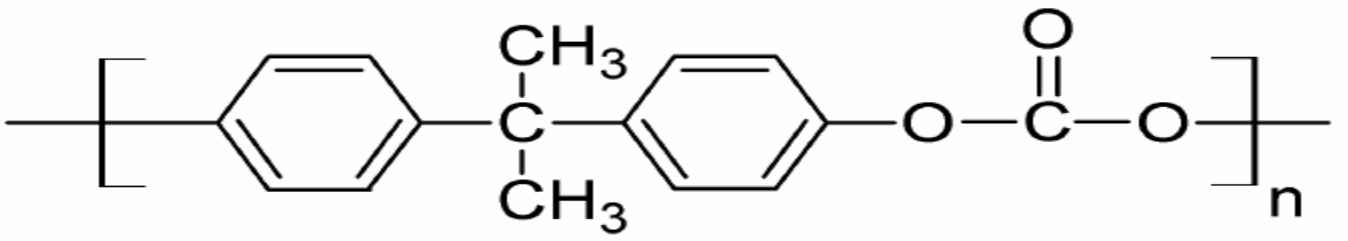
4) Draw structure of a) PHBV b) Polycarbonate c) Trans polyacetylene Marks 3

(Marking scheme: Each structure 1 mark)

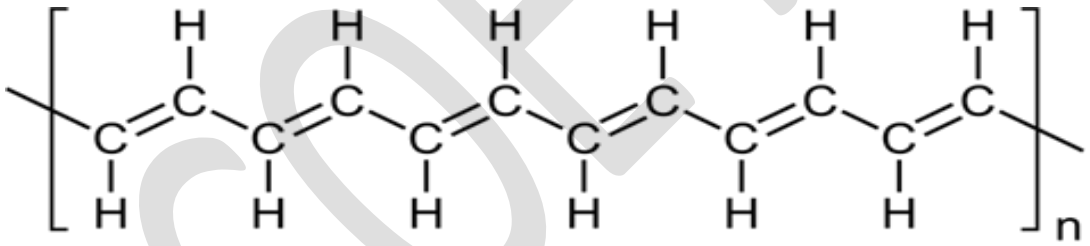
Ans: a) PHBV



b) Polycarbonate



c) Trans polyacetylene



5) Define biodegradation of polymers .State favorable structure of polymer for biodegradation. Write structure of biopol (PHBV) (4M)

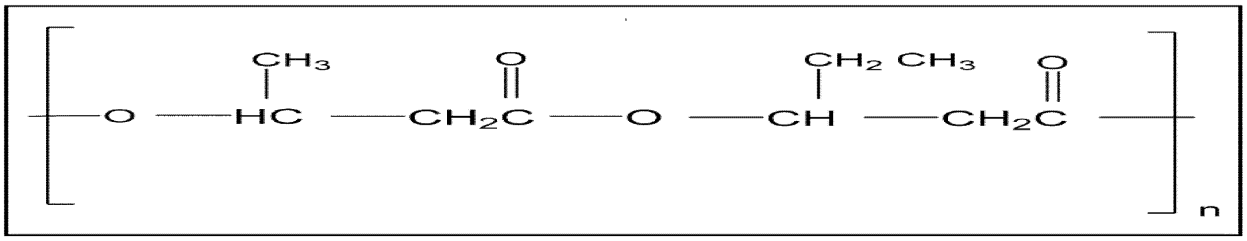
(Marking scheme- Defination-1mark, favorable structure-2mark, structure of biopol-1mark)

Ans. Defination- Process by which organic substances are broken down by the environmental effects and by the living organisms.

Favorable structure-

1) Polar nature
2) Functional group in structure.
3) Hydrophilic backbone chain of polymer.
4) Polymer chain should contain bonds.
5) Presence of atoms like O, N, S in the chain of polymer.

Structure of biopol-



6) What are conducting polymers? Give types of conducting polymers. Explain how conductivity can be increased by doping? Write their applications. (7 marks)

(Marking scheme: Def – 1 mark, Types – 2 marks, Doping – 3 marks, Applications- 1 mark)

Ans: Definition: The polymer which can conduct electricity like metal on doping is called as conducting polymer

Types of conducting polymers:

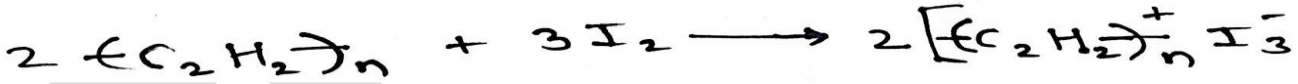
Extrinsically conducting polymers: An Extrinsically conducting polymer material is the one which is filled with metal powder, metal filaments or graphite powder to make it conducting

Intrinsically conducting polymers: An Intrinsically conducting polymer material is the one which can conduct electricity by its own E.g. Polyacetylene, Polypyrrole etc.

Doping of Polymers : It is found that conductivity of polymer chains with conjugations can be increased to the extent of metals on doping.

Oxidative or P-doping: By adding oxidative impurity like iodine, chlorine, or bromine the electron at the double bond is removed so as to get positive charge to the neighboring carbon atom (which can resonate) and halogen gets negative charge.

The conductivity increases up to 10^7 S/ cm



Reductive or n-doping: The reductive agents for n- doping are Na metal, FeCl2, Lithium metal giving negative charge (which can resonate) on polymers and positive charge on sodium

Proton doping: Polymer like poly aniline can be H^+ doped using acid

Applications of conducting polymers:

Rechargeable batteries: Due to presence of large number of charge carriers in doped

Conducting polymers, they can be used as charge storage materials

As antistatic materials: To avoid static electricity in plastic carpets

Photovoltaic cell

Part 2 Nanomaterials

7) What are nanomaterials? Give any two important applications of nanomaterials with example. Marks 3

(Marking scheme: Definition 1 mark, two applications 2 marks)

Ans: Nanomaterials are the materials in which size of particles ranges from 1 nanometer and 100 nanometer in size.

Important applications of nanomaterials with example. Nanomaterials have vast varied applications in various fields such as electronics, catalysis, biomedical applications, food technologies, energy technologies

1) Carbon nanotubes and grapheme being highly conducting can be used in various electronic devices.

2) Quantum dots are being used in photovoltaics and making LEDs

3) CNTs and quantum dots can be used in biomedical applications such as targeted drug delivery for detection and curing of cancer.

4) CNTs and graphene being strongest material can be used to make light weight, high strength composite materials for various applications e.g. making body of aero plane, motor bodies etc.

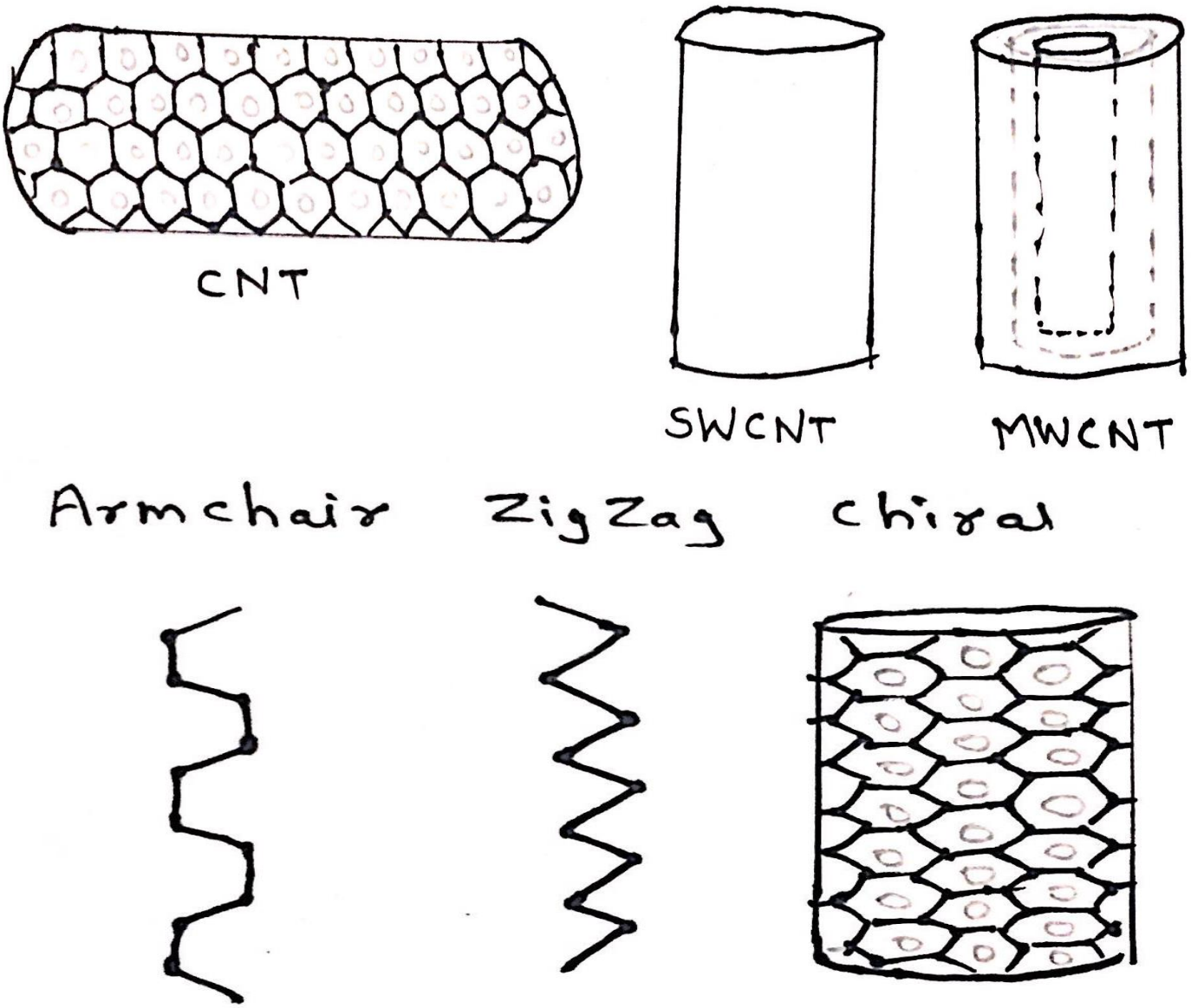
8) What are carbon nanotubes? Discuss the different types of carbon nanotubes with respect to their structure. Give any three applications of it. Marks 7
(Marking scheme: Definition 1 mark, different types with diagrams 3 marks, three applications 3 marks)

Ans: Carbon nanotubes (CNTs) are cylindrical molecules that consist of rolled-up sheets of single-layer carbon atoms (graphene).
Types of Carbon nanotubes with respect to structure: There are two types of CNTs

1) Single walled carbon nanotubes and
2) Multi walled carbon nanotubes
Single-walled (SWCNT) are the tubes with only one graphene sheet rolled to form a hollow tube, with a diameter of less than 1 nanometre (nm).

Multi-walled (MWCNT), consisting of several concentrically interlinked nanotubes, with diameters reaching more than 100 nm. Their length can reach several micrometres or even millimetres.

The rolling-up direction (rolling-up or chiral vector) of the graphene layers determines the electrical properties of the nanotubes. Also depending upon the way in which the sheet rolled to form a tube,



SWCNTs are further classified as

1) Armchair nanotubes: These are achiral and conducting nanotubes.
2) Helical nanotubes - These are achiral and semiconducting nanotubes,
3) Zigzag nanotubes- These are chiral and semiconducting nanotubes

Applications of CNTs:

1) Making light weight high strength composites

2) In drug delivery system

3) As Nano cylinders for storing of hydrogen

4) In stereospecific reactions.

5) For water proof or crease resistant fabric

6) stronger and lighter sports equipment's like tennis racket, bicycle parts etc

.

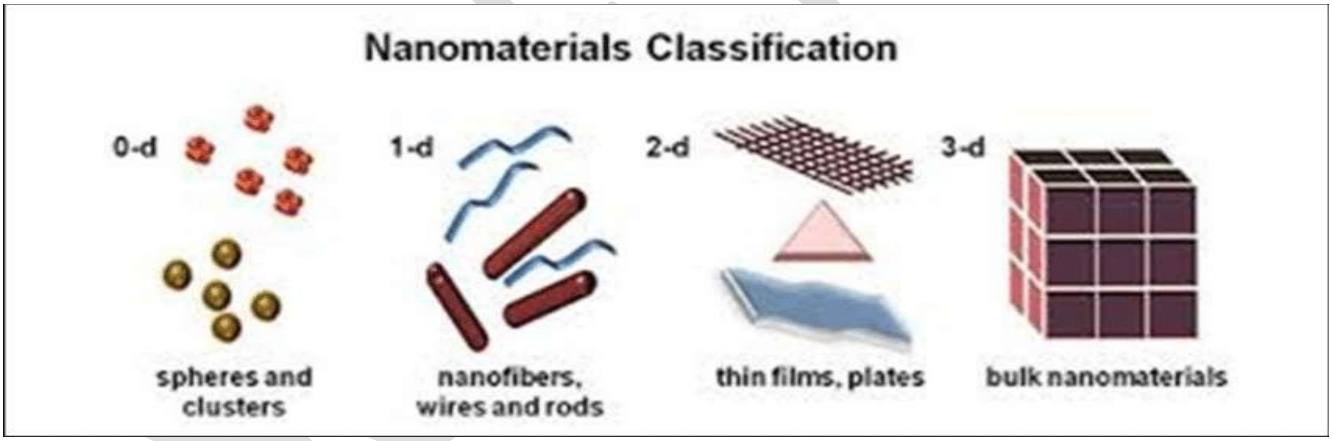
9) What are nanomaterials? Classify them on the basis of size (3 marks)

(Marking scheme: Definition 1 mark, classification 2 marks)

Ans: Nanomaterials: Nanomaterials are the materials in which size of particles ranges from 1 nanometer and 100 nanometer in size.

Nanomaterials have vast varied applications in various fields such as electronics, catalysis, biomedical applications, food technologies, energy technologies because of the two principle properties they have. Those are as follows: 1) Increased relative surface area and 2) quantum effects.

Classification of Nanomaterials on the basis of dimensions Nanomaterials are classified as Follows



Zero dimensional: The nanomaterials have all the dimensions in nanoscale range are the zero dimensional nanomaterials eg. Particles, quantum dots

Quantum dots are extensively used for LEDS solar cells , lasers etc. These materials can be crystalline opr polycrystalline, can be amorphous or crystalline, can exists individually or in a matrix

One dimensional Materials: These are the nanomaterials having grown along one dimension beyond nanoscale Eg. Nanowires, nanorods, nanobelts, nanoribbons etc. These materials are important for fabrication of electronic, optoelectronic and Nano devices, Nano electronics materials.

Two dimensional Materials: These nanomaterials have two dimensions outside the nanoscale Eg. CNTs, Nanoplates, Nanosheets Nanowalls, nanodiscs etc.

Three dimensional Materials: Three dimensional nanomaterials are the bulk nanomaterials which are not confined to nanoscale in any dimension. Eg. Fullerenes, Dispersed nanoparticles, Bundles of nanotubes, bundles of particles.

Owing to large surface area and other superior properties arising due to quantum effects these materials have considerable importance.

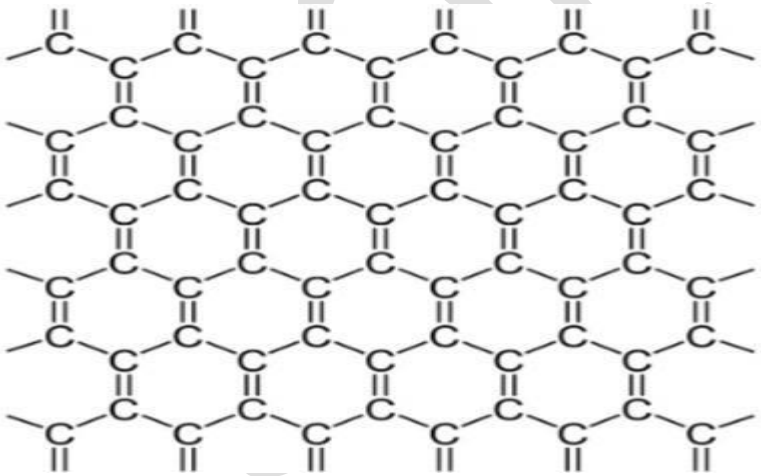
10) Write down structure, properties and applications of graphene. (5 marks)

(Marking scheme: structure- 2marks, properties and applications -3 marks)

Ans: Graphene is the name for a honeycomb sheet of carbon atoms. It is a single layer of carbon atoms organized in a hexagonal lattice. It is two dimensional material. It is the building block for other graphitic materials (since a typical carbon atom has a diameter of about 0.33 nanometers, there are about 3 million layers of graphene in 1 mm of graphite)

All carbons in graphene are sp2 hybridized C= $1S^2$ $2Px^1 2Py^1$ $2pz^1$

Each Sp2 hybridized carbon is attached to three other SP2 carbon forming a hexagonal sheet and each C has one electron in unhybridised orbital which can delocalize on the sheet due to resonance, making graphene good conductor of electricity.



Properties:

Harder than diamond yet more elastic than rubber; tougher than steel yet lighter than aluminium. Graphene is the strongest known material.

Graphene is the world's strongest material, and so can be used to enhance the strength of other materials

Its high electron mobility is 100x faster than silicon; it conducts heat 2x better than diamond; its electrical conductivity is 13x better than copper;

Applications:

1. Graphene-enhanced composite materials can find uses in aerospace, building materials, mobile devices, and many other applications.

2. useful in both microelectronics (for example to make LED lighting more efficient and longer lasting)

3. Used in batteries and supercapacitors as energy storage devices.

4. In photovoltaics and in sensors

11) What are quantum dots? Write their properties and applications (5 marks)
(Marking scheme: def. – 1 mark, properties- 2 marks and applications -2 marks)

Ans: Quantum dots are nanoparticles that exhibit three dimensional confinement, which leads to many unique optical and transport properties.

These are nanocrystals of semiconductor materials such as cadmium selenide, gallium arsenide, lead telluride etc.

Quantum dots are the fluorescent nanoparticle, they can exhibit a range of colors depending upon their composition and size.

Properties: Optical Properties: QDs have properties intermediate between bulk semiconductors and discrete atoms or molecules. Their optical properties changes as a function of both size and composition.

Fluorescence: As the confinement energy depends upon the Qds size, both optical and fluorescence emission can be turned by changing teh size of the Qds during synthesis.

Applications:

1) They can be used in optical storage

2) Photovoltaic devices : Because of the tunable of the absorption spectrum and high extinction coefficient, QDs are desirable for light harvesting, is beneficial for photovoltaic devices.

3) QDs have the potential to boost the efficiency of silicon photovoltaic cells and lead to reduced costs.

4) Light emitting devices

5) Biomedical applications such as targeted drug delivery

6) In Quantum dots displays and Bio imaging.

12) Write 5 applications of nanomaterials. 5 Marks

(Marking scheme: Each application -1 mark)

Ans. Nanomaterials has wide applications

1. Catalyst- Nanomaterials like CNTs and quantum dots are used as catalyst in many chemical reactions.

2. Energy storage and solar cells- Graphene-based nanomaterials have many promising applications in energy-relatedareas. Graphene improves both energy capacity and charge rate in Rechargeable batteries; activated graphene makes superior super capacitors for energy storage.

3. Photovoltaic devices-Due to their excellent electron-transport properties and extremely high carriermobility, graphene show great potential to be used for low-cost, flexible and highly efficient photovoltaic devices, sensor applications.

4. CNT composites can be used to build lightweight spacecraft.

5. Quantum dots are used in High resolution cellular imaging, long term in vivo observations ofcell trafficking, tumor targeting and diagnostics.

13) Define Nanomaterials, Explain following properties of nanomaterials with suitable example a) Optical property b) electrical property c) Mechanical property. 7 Marks

(Marking scheme: def. – 1 mark, properties with examples- 2 marks each)

Ans. Nanomaterial is the materials in which size of particles ranges from 1 nm to 100 nm.
Properties of nanomaterials
a) Optical property- The optical properties of nanomaterials are depends on parameters such as size, shape, surface characteristics and other variables like doping and interaction with surrounding medium. The shape can have dramatic influence on optical properties of metal nanostructures

b) Electrical property- Electrical properties on nanomaterials are different than their bulk materials. In nanotubes or wires with decrease in diameter of the wire the no of electron wave modes contributing to electrical conductivity becomes increasingly smaller by well-defined quantized steps. In CNT only one electron wave mode is observed which transport electric current.

c) Mechanical property- Mechanical properties of metallic and ceramic nanostructure materials are influenced by porosity grain size and the fillers used.

e.g. Filling polymers with nanomaterials leads to the significant improvements in their mechanical properties and thermal properties.