1. **What is material chemistry and define nanomaterials with few examples?**

   Material Chemistry is the application of chemistry to the design, synthesis, characterization and understanding and utilization of materials with potentially useful physical properties. It is the understanding and control of functional condensed matter from a chemical perspective.

   Nanomaterials are materials that have particles or constituents that are in the nanoscale dimensions, or one that is produced by nanotechnology.

   Examples:
   - *Gold Nano particles are powerful catalysts. But in bulk form, gold is unreactive.*
   - *Quantum dots, nanowires and nanotubes, flakes/arrays/surfaces/films, gels*
   - *Nanomaterials are often used as paints and coatings*
   - *Nanomaterials are used in electrochemical capacitors and fuel cells*

2. **What are nanomaterials. How size matters in nanoscale.**

   Nanomaterials are materials that have particles or constituents that are in the nanoscale dimensions, or one that is produced by nanotechnology. Nanomaterials tend to have dimensions in nanometers (10-9 m).

   The size matter sin nanoscale because of the surface of the material in nanoscale. The surface is important in any size domain, but in nanomaterials, the proportion of surface atoms dramatically increases as the diameter is decreased.

   Nanomaterials also tend to have a higher surface area to volume ratio.

3. **How are nanoparticles synthesized. What are the different types of approaches to get nanoparticles?**

   Nanoparticle synthesis refers to the multiple processes used to create nanoparticles.

   There are multiple methods to synthesize nanomaterials depending on the desired size and properties, but they all can be categorized into two approaches: 1. Top-Down; and 2. Bottom-Up

   The Top-Down approach involves synthesizing the nanomaterial by sculpting it from a bulk material, and/or other similar physical methods. Examples include ball milling, sonication, lithography, exfoliation, mechanical attrition, and etching.

   The Bottom-Up approach involves assembling the nanoparticle from Nano-building blocks or atom/molecular building using chemical synthesis. Examples of this approach include: chemical vapor deposition, chemical synthesis, sol-gel synthesis, solvothermal synthesis, and hydrothermal synthesis.

4. **What is the advantage of all this Nano-scale devices or materials when compared with other bulk materials?**

   In Nano-scale, materials have a very high surface area to volume ratio. They also have large fractions of surface atoms. The large fraction of surface atoms, combined with ultrafine size and shape gives the nanomaterial different properties from its bulk form.

   Having a high surface area allows them to participate in reactions more easily (i.e. this feature allows nanoscale gold to be a very good catalyst).

5. How nanomaterial changed the world. Explain with examples.

Nanomaterials helped change the world by considerably improve and revolutionize many technology and industry sectors. Many different sectors including information technology, military, medicine, transportation, energy, food safety, environmental science and many others have been aided by nanotechnology.

Automotive industry – Batteries, Hydrogen Storage in Fuel Cells, Paint and Coating. Rechargeable batteries used in electric vehicles have been given additional cycle life and power output with the use of nanomaterials.

Environmental Science: Nano-sensors are being used in research as well as in the field to determine pollution levels in water. The interest in use of Nano-sensor comes from its cost, as they are less costly than traditional sensors.

Aerospace/Aviation – Carbon Nanotubes are used as reinforcing fibers in aircraft structures to create lighter and stronger aircraft. Nanomaterial coatings are also used for stealth applications in military applications.

6. Give two types of nanoscience's that are generally found in nature. Please specify some examples.

Water Strider - Each of their legs is covered with large numbers of angled tiny hairs with tiny nanogrooves. Air is trapped within the spaces and form an air cushion which keeps the legs from getting wet and allows them to float.

Many insects (beetles, flies, spiders) and Geckos have nanostructures on their toes that help them stick to walls, and ceilings, and what appears to be smooth surfaces. Their toes have spatulas that deform when coming into contact with any surface, and allow for molecular contact over large areas, thus converting weak Van der Waals interactions into large scale attractive forces.

7. Specify a few 2D materials and give a few techniques to characterize them. Please state their complete abbreviation.

2D Materials are crystalline materials, which consist of a single layer of atoms.
Examples of 2D materials include Graphene, and Diamond Nanomaterials.

Classification techniques of 2D materials include Raman Spectroscopy, AFM (Atomic Force Microscopy), SEM (Scanning Electron Microscopy), and TEM (Transmission Electron Microscopy).

8. Name different types of nanocarbons. Write the Euler's rule for polyhedral.

There are 5 types of Nanocarbons:
1. Activated Carbons
2. Fullerenes (0-D)
3. Carbon Nanotubes
4. Cones
5. Carbon Black

Other types include:
Graphene sheets (2-D)
Diamond nanomaterials (2-D)
Hierarchical structures (3-D)

The Euler's Rule for a Polyhedral is: $f + v = e + 2$
Where f is the number of faces, e is the number of edges and v is the number of vertices of the polyhedral.

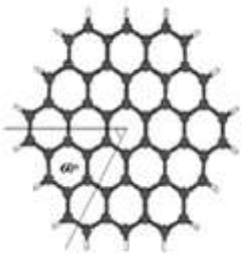
9. Define Carbon based nanomaterials and their applications.

Carbon-based nanomaterials demonstrate unprecedented physical and chemical properties such as high strength, excellent resistance to corrosion, and exceptional electrical and thermal conductivity.

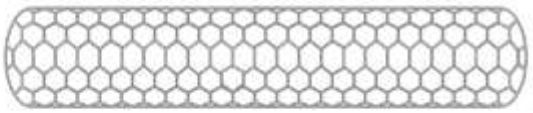
SWCNT and Carbon Cones are being researched as a solution for hydrogen storage in Fuel Cell Vehicles. Carbon Nanotubes are also applied in Antennae, Composite Materials, Writing, Field Emission Transistors, etc.

Graphene is a 2D Carbon-based nanomaterial. It is used in electronics to produce Field Effect Transistors and Transparent Conducting Electrodes. It can also be applied in medicine for tissue engineering and drug delivery.

10. Please name these two structures.



Graphene Sheet
(Halocarbons-Neocene)



Nanotube
(Nano-carbon 6+6 pentagons)