MNT 501 Fundamentals of Nanotechnology
2020-2021 Fall Semester

1- How can you define nanotechnology and how many types of nanostructures are there? Briefly explain the types of dimensions and give at least one example for each group of material by drawing schematic shapes.

2- (a)What is lotus effect? Explain it by considering interaction of water with corresponding surface.
(b) Can lotus effect be used in self cleaning surfaces? Explain it using wetting and non-wetting conditions.

3- (a)How many allotrophes of carbon exist? Give their names and dimensions.
(b) What is sp^2 and sp^3 hybridization of carbon and in which carbon structures you may see them?

4- Carbon nanostructures have different electronic properties such that single layer graphene is called **semimetal** whereas carbon nanotubes' electronic properties can be changed from metallic to semiconductor.

(a) Explain semimetal behavior of single layer graphene by drawing its energy band diagram.
(b) Explain how electronic properties of carbon nanotubes can be changed from metallic to semiconductor.

5- (a) What is quantum confinement and in which types of materials can you see this effect?
(b)Can you change the solution color, which contains suspended semiconductor quantum dots, by changing the size of quantum dots? Explain it by considering the particle size and energy band gap relation.

6- What is the difference between nanowires, nanorods and nanopillars? Is it possible to use nanowires in biological sensor? Explain it by use of example.

7- (a)Explain what kind of surface features determines the properties of nanomaterials?
(b)What is the underlying reason behand non-sticking property of teflon pans? Expain it by specifying surface chemical structure.

8- (a) What kind of interactions may exist between two nanoparticles which are in an aqueous solution?
(b) What is dipole and what kind of Van der Waals Forces may exist between different dipoles?
(c) How Van der Waals Force change with the distance for the following cases:
(i) Between two molecules (molecule A and molecule B),
(ii) Between a molecule and a macrsocopic body,
(iii) Between two macroscopic bodies.
(d)What kind of intermolecular interaction can exist between (i) two graphene layers, (ii)two carbon nanotubes?

9- When hydrophilic surfaces are brought into contact in water they repel each other while hydrophobic surfaces attrach each other. Explain the reason of such behavior in two surfaces and give at least two examples (materials) for each case.

10- What is steric stabilization and in which application can you use this effect? Explain in detail.

11- Although graphite is soft and greasy, graphene, on the other hand, has outstanding superior mechanical property. What is reason of such difference in mechanical properties of graphite and graphene? Explain it by giving elastic moduli and tensile strength of such materials.

12- (a) What is the difference between micro and nano indentation?
(b) How nanoidentation is applied (explain loading and unloading curves) and what kind of mechanical property information can we get from a nano indentation test?
(c) What is the limitation of nanoindentation?

13- What kind of mechanical informations can we obtain by using TEM (Transmission electron microscopy) and AFM (Atomic Force Microscopy)? Explain by giving examples.

14- (a)Why are nanomaterials seen in certain colors? Briefly explain and show the place of visible light (with its wavelength range) in the electromagnetic spectrum.
(b) Semiconductors are opaque to high and intermediate energy photons (in the short- intermediate wavelength) and transparent to low energy photons (longer wavelength). Why?

15- (a) What is surface plasmon resonance and what kind of metallic materials display surface plasmon resonance?
(b) Explain by giving example how surface plasmon resonance can be used in biosensing applications?

16-What is the difference between heat and temperature? Is it possible to reach 0K? Why or why not?

17-How conduction in metals occur in macro and nano dimensions? What is the criteria that can be used to determine whether thermal transport is macro or nanoscale? Explain in detail.

18- (a) What is nanofluid and what kind of nano particles and base fluids can be used to obtain a nanofluid?
(b)Why nano fluids have superior thermal conductivity?
(c) What happens to nanofluid's thermal conductivity when:
(i) Nanoparticle concentration in fluid is increased,
(ii) Temperature of nano fluid is increased,
(iii)Nanoparticle dimension is decreased.