



**University of Ruhuna- Faculty of Technology**  
**Bachelor of Engineering Technology Honours Degree**  
**Level 4 (Semester II) Examination, November/December 2023**  
**Academic year 2021/2022**

**Course Unit: ENT 4243 Nanotechnology**

**Duration: 3 hours**

**Instruction to Candidates**

- All symbols have their usual meanings.
- Answer all questions.
- This paper contains two parts (A and B) in 4 pages.
  - Part A has two (02) questions (20 marks $\times$ 2= 40 marks)
  - Part B has four (04) questions (15 marks $\times$ 4= 60 marks)

**Part A**

1.

- a) Define the term "Nanotechnology." (02 marks)
- b) Write down the degrees of freedom ( $D_f$ ) and degree of confinement ( $D_c$ ) for the following structures.
  - I. Quantum dot
  - II. Quantum wire
  - III. Bulk material(03 marks)
- c) State the major steps involved in making graphene using Chemical Vapor Deposition (CVD) technique. (04 marks)
- d) A solution of gold nanoparticles appears red instead of bulk gold in colour. Explain the reasons for this difference in colour of gold nanoparticles using surface plasmon resonance. (05 marks)
- e) Explain the lotus effect with appropriate diagrams. (06 marks)

2. Nanomaterial characterization techniques allow scientists and engineers to analyze the structure, composition, morphology, surface properties, and other parameters at the nanoscale.
- a) What is meant by resolution in the microscopic analysis of nanoparticles?  
(01 marks)
- b) Write down the most appropriate characterization technique for the following.  
I. Identification of crystalline phases in  $\text{TiO}_2$  nanoparticle mixture  
II. Analyzing the surface topography of nanocellulose based composite.  
III. Determination of chemical composition of contaminated nanomaterial sample  
IV. Analyzing the molecular structure of viruses  
(04 marks)
- c) Many signals are generated because of the electron beam interacting with the sample in a Scanning Electron Microscope (SEM). List out two (2) common signal types and write down their one (1) application in SEM.  
(04 marks)
- d) Write down three (3) reasons for maintaining a high vacuum inside the SEM.  
(03 marks)
- e) Compare and contrast Scanning Electron Microscope and Transmission Electron Microscope  
(04 marks)
- f) Diffraction patterns of crystalline materials produce sharp, well-defined peaks in the X-ray diffraction (XRD) while amorphous materials generate a broad halo or diffuse scattering. Briefly explain the reason for this variation.  
(04 marks)

## Part B

- 3.
- Define the term "Natural nanomaterials."  
(02 marks)
  - Nanotechnology innovations have the potential to influence every stage of the value-added chain within the energy sector. Give three different ways where nanotechnology could be applied in the energy sector with examples for each.  
(03 marks)
  - Briefly explain the magnetization of zinc ferrite ( $\text{ZnFe}_2\text{O}_4$ ) in bulk and in nano sized particles with reasons.  
(04 marks)
  - In nanotechnology, electromagnetic forces are much stronger than gravitational forces. Explain the reasons for that using appropriate equations.  
(06 marks)
4. Nanomaterials are synthesized by different methods based on the type and nature of the nanomaterials.
- Briefly describe top-down approaches of the synthesis method. Give two (2) examples for each.  
(02 marks)
  - Why does the processing condition need to be controlled during the synthesizing nanomaterials?  
(03 marks)
  - Briefly explain four (4) major steps involved in the basic mechanism of "sol-gel" process using appropriate reactions.  
(04 marks)
  - Copper Oxide ( $\text{Cu}_2\text{O}_3$ ) nanoparticles can be prepared by using Microemulsion techniques. Consider water in an organic solvent microemulsion system and  $\text{CuCl}_2$  (aq) and  $\text{NH}_4\text{OH}$  (aq) as precursor materials. Sketch the three (3) stages of the synthesis pathway using surfactant molecule arrangement for the above system and briefly explain the steps.  
(06 marks)
5. Organic nanomaterials are materials that are composed of carbon-based compounds and have at least one dimension in the nanometer scale and find applications in various fields, including electronics, medicine, energy, and environmental science. Fullerene and carbon nanotubes are common examples of organic nanomaterials.
- Write down two (2) characteristic features of fullerenes.  
(02 marks)

- b) Write down the property of fullerenes that can be utilized for the following applications.
- I. Drug delivery
  - II. Cosmetics
  - III. Field effect transistors
- (03 marks)
- c) Carbon nanotubes display a range of electrical characteristics, such as superconductivity, insulation, semiconductor behavior, or conductivity. Briefly explain the reasons for the above variations in electrical properties observed in carbon nanotubes.
- (04 marks)
- d) Materials composed partially or completely of biological molecules having a nanoscale dimension are called bionanomaterials. Briefly explain one application of the following bionanomaterials.
- I. Protein
  - II. Viruses
  - III. DNA
- (06 marks)
6. Due to the extraordinary properties of nanomaterials, they can be utilized in a broad range of applications.
- a) Write down two (2) applications of silver nanoparticles in the medical industry.
- (02 marks)
- b) Write down the property of  $\text{TiO}_2$  nano particles which is applied for the following applications.
- I. Coatings in car mirrors
  - II. Solar cells
  - III. Hydrogen production
- (03 marks)
- c) Suggest two (2) suitable nanomaterials for the following applications in water treatment.
- I. Nanofiltration
  - II. Adsorption
  - III. Disinfection
- (03 marks)
- d) List out three (3) challenges faced by developing countries when implementing nanotechnological initiatives.
- (03 marks)
- e) Briefly discuss four (4) good working practices that you will follow when you work with nanomaterials in the laboratory.
- (04 marks)

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