



**University of Ruhuna- Faculty of Technology**  
**Bachelor of Engineering Technology Honours**  
**Level 4 (Semester II) Examination, November/December 2025**  
**Academic year 2023/2024**

**Course Unit: ENT4243 Nanotechnology (Theory)**

**Duration: 03 hours**

**Instructions to candidates:**

- This question paper contains **SIX (06)** questions in five (05) pages.
- Use a separate book for answering the questions and each question should start with a new page.
- This is a closed book examination.
- Answer all questions.
- There are two sections as Section A and B. Each question in section A carries 15 marks and each question in section B carries 20 marks.
- All symbols have their usual meaning.

### Section A

1)

- a) Metal oxide nanomaterials are widely used due to their unique optical and catalytic properties.
- i) Write **two (02)** technological applications of metal oxide nanoparticles. (01 mark)
  - ii) Compare the surface area and reactivity of  $\text{TiO}_2$  nanomaterials with their bulk form, giving reasons. (02 marks)
  - iii)  $\text{TiO}_2$  nanoparticles exhibit strong UV-absorbing behaviour. Briefly explain the mechanism by which  $\text{TiO}_2$  nanoparticles block or absorb UV radiation. (02 marks)
  - iv) Briefly explain how this UV-blocking property of  $\text{TiO}_2$  contributes to its function in sunscreen formulations. (02 marks)
- b) A food-packaging manufacturer plans to replace chemical preservatives with silver nano particles embedded packaging. State **one (01)** benefit and **one (01)** potential risk of this approach. (02 marks)
- c) The Honda–Fujishima effect is an important phenomenon in photocatalysis that demonstrates the ability of  $\text{TiO}_2$  to split water under UV irradiation.
- i) Briefly explain the sequence of reactions that lead to water splitting during the Honda–Fujishima effect. (02 marks)
  - ii) State **two (02)** applications that arise from the Honda–Fujishima effect. (01 mark)
- d) For each scenario given below, select the most suitable nanomaterial/s from following. Give reasons for your selection. (03 marks)
- Silver (Ag), Iron Oxide ( $\text{Fe}_3\text{O}_4$ ), Zinc Oxide (ZnO)
- i) Outdoor air-cleaning tiles that must break down vehicle exhaust pollutants when exposed to sunlight.
  - ii) Hospital door handles requiring constant antimicrobial protection.
  - iii) A medical imaging lab requiring a contrast agent for MRI scans.

**[15 marks]**

2)

- a) Identify the primary exposure route for humans when using the following nano-based products. (1.5 marks)
- i) Antimicrobial nano-coating sprays
  - ii) Nano-enhanced food packaging
  - iii) Nano-cosmetic body wash or moisturizers
- b) Propose **two (02)** strategies that can improve worker safety when handling nanomaterials. (03 marks)
- c) Discuss **three (03)** socio-economic barriers that may affect Sri Lanka's ability to fully benefit from nanotechnology. (4.5 marks)
- d) State **two (02)** green nanotechnology strategies that can be used to make nanomaterial synthesis more environmentally friendly. (02 marks)

- e) Several nano-enabled products have been developed and commercialized in Sri Lanka. Select any **two (02)** such nano-based product and briefly describe its functions and key features. (04 marks)

[15 marks]

- 3) Nanomaterial characterization involves a range of techniques used to examine the physical, chemical, mechanical, and structural properties of materials across different length scales. Answer the following questions.

- a) List the **four (04)** fundamental approaches to the characterization of nanomaterials. (02 marks)

b)

- i) Define the term resolving power as it relates to microscopic analysis of nanoparticles. (01 marks)

- ii) Explain why optical microscopes are not suitable for nanoscale analysis. (02 marks)

- c) Identify the most appropriate characterization technique for each of the following cases and justify your selection.

- i) Studying surface roughness of a metal oxide single crystal

- ii) Identifying crystal phases in a Nano-powder mixture

- iii) Analyzing the molecular structure of viruses

- iv) Determining elemental composition of a contaminated nanomaterial

- v) Analyzing the surface topography of Nano-cellulose based composite

(2 × 5 marks)

[15 marks]

- 4) Nanomaterial synthesis involves the creation of materials with structural features at the nanoscale, where unique physical, chemical, and biological properties emerge. There are different ways of classifying the synthesis routes for nanostructured materials. Answer the following questions.

- a) List **three (03)** major challenges in synthesizing nanomaterials with controlled properties. (03 marks)

- b) What are the **two (02)** main approaches to nanomaterial synthesis? Provide two (02) examples for each approach. (02 marks)

c)

- i) Briefly explain the micro-emulsion synthesis technique in one to two sentences. (02 marks)

- ii) Write down **four (04)** factors influencing micro-emulsion formation. (02 marks)

- iii) Illustrate the configurations of a micelle and a reverse micelle, label their components clearly, and explain the differences between the two structures. (03 marks)

- iv) Identify **three (03)** nanoparticle morphologies produced using reverse micelle methods and illustrate each morphology with labeled diagrams. (03 marks)

[15 marks]

### Section B

5) Answer all parts.

a)

- i) Describe the bonding and geometry of the  $C_{60}$  fullerene molecule using **two (02)** key points for each. (02 marks)
- ii) Fullerenes are usually electrically insulating. Explain why and state **one (01)** method to improve their electrical conductivity. (01 mark)

b)

- i) Compare Single-Walled Carbon Nanotubes (SWCNT) and Multi-Walled Carbon Nanotubes (MWCNT) in terms of structure, diameter and mechanical properties. Present your answer in a table. (03 marks)
- ii) Carbon nanotubes developed from an experiment had the following chiral vector ( $C_h$ )  $C_h = 4\vec{a}_1 + 5\vec{a}_2$ . Determine the configuration of the nanotube. Give reasons for your answer. (01 mark)
- iii) A water purification company proposes using CNT-based filters in rural communities to remove viruses and heavy metals. Assess **two (02)** potential harmful effects that may arise from the use or release of CNTs in such filtration applications. (03 marks)

c)

- i) Provide a definition of nanocellulose. (01 mark)
- ii) State **two (02)** properties of nanocellulose and explain how these properties are making it suitable for packaging applications. (02 marks)

d)

- i) Describe the key steps involved in the growth of graphene films using the Chemical Vapor Deposition (CVD) process. (04 marks)
- ii) Generally, three main types of carrier gases are used in Chemical Vapor Deposition (CVD). Explain how the choice of carrier gas influences the precursor material in a CVD process giving **one (01)** example for each type. (03 marks)

**[20 marks]**

6) X-ray Diffraction (XRD) is one of the most widely used techniques in nanomaterial characterization. Answer the following questions.

- a) State **three (03)** main uses of X-ray Diffraction (XRD) in nanomaterial characterization. (03 marks)
- b)
  - i) Write **Bragg's Law** and briefly explain the meaning of each variable. (03 marks)
  - ii) List the **seven (07)** crystal systems and their corresponding unit cell parameters. (3.5 marks)
- c) An XRD experiment ( $\lambda = 0.154$  nm) on a cubic nanomaterial gives diffraction peaks at the following  $2\theta$  values:

25.80°, 37.36°, 44.10°, and 53.50°.

The relationship between the lattice parameter ( $a$ ) and the inter-planar spacing ( $d$ ) for cubic crystal systems is expressed by the following equation.

$$\frac{1}{d_{hkl}^2} = \frac{h^2 + k^2 + l^2}{a^2}$$

- i) Calculate  $d$ -spacing values (03 marks)
  - ii) Identify the Miller indices ( $hkl$ ) corresponding to the observed reflections (03 marks)
  - iii) Compute the lattice parameter ( $a$ ) (4.5 marks)
- [20 marks]**

**\*\*\* End of the Examination Paper\*\*\***