

University of Ruhuna- Faculty of Technology
Bachelor of Biosystems Technology Honours Degree
Level II (Semester II) End Semester Examination, December 2025
Academic year 2023/2024

Course Unit: BST 2242 Nanotechnology (written)

Duration: 1 & 1/2 hours

Instructions to candidates:

Answer only **Three (3)** questions.

Each question should be started with a new page.

If you answer more than three questions, only the **first three** will be marked.

1. Answer all parts.

The specific surface area (SSA) is a critical parameter that influences the reactivity of nanoparticles. A sample of nano-ceria (CeO_2) is analyzed using the BET isotherm with nitrogen adsorption. (Avagadro's number = 6.022×10^{23} molecules/mol)

- a. The volume of nitrogen gas adsorbed at monolayer coverage (V_m) is found to be $15 \text{ cm}^3/\text{g}$. The molar volume of nitrogen gas is $22,414 \text{ cm}^3/\text{mol}$, and the cross-sectional area of a nitrogen molecule is 0.162 nm^2 .

i. Calculate the SSA of the nano-ceria in m^2/g .

(30 marks)

ii. Explain the principle of the BET isotherm for determining the SSA.

(10 marks)

- b. The same nano-ceria sample was analyzed by XRD, and the average crystallite size was 8 nm . Assuming spherical particles and a density (ρ) of 7.13 g/cm^3 for CeO_2 , calculate the SSA.

(30 marks)

- c. Briefly explain five (05) potential reasons for any discrepancy observed between the SSA values obtained from the BET isotherm and XRD analysis.

(30 marks)

(Total-100 marks)

2. Answer all parts.

- a. List five (05) critical factors that must be considered when selecting a technique to characterize nanoparticles.

(20 marks)

- b. Discuss the importance of using multiple characterization techniques to obtain a comprehensive understanding of a nanomaterial's properties. Your answer should refer to at least four different characterization techniques.

(40 marks)

- c. XRD analysis of the titanium dioxide (TiO_2) nanoparticles, the main diffraction peak for the anatase phase of TiO_2 appears at $2\theta = 25.3^\circ$. For the sample calcined at 500°C , the FWHM (β) of this peak is 0.0058 radians ($\lambda = 0.15406\text{ nm}$, $K=0.9$). Calculate the crystallite size of TiO_2 .

(40 marks)

(Total-100 marks)

3. Answer all parts.

- a. Discuss three (03) advantages and three (03) disadvantages of lipid-based nanoparticles (nano-liposomes) versus polysaccharide-based nanoparticles (chitosan) for the oral delivery of bioactive compounds.

(30 marks)

- b. Propose five (05) *in vitro* experiments to evaluate the bio accessibility and absorption of a nano-encapsulated nutraceutical.

(30 marks)

- c. Discuss four (04) limitations of conventional iron and zinc fortification in staple foods (flour) and explain four (04) solutions to how nano-encapsulation can overcome these challenges.

(40 marks)

(Total-100 marks)

4. Answer all parts.

- a. Identify and explain three mechanisms by which nanoparticles can be intentionally used for environmental remediation.

(30 marks)

- b. Propose five (5) nanotechnology-based solutions for detecting and removing volatile organic compounds (VOCs) from industrial emissions.

(30 marks)

- c. Evaluate the four (4) advantages and four (4) limitations of using nano-zero-valent iron (nZVI) for groundwater remediation compared to conventional methods.

(40 marks)

(Total-100 marks)

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