



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

Module Number: ME 6211(NC)

Module Name: Nanotechnology

[Three Hours]

[Answer all questions, each question carries 12 marks]

- Q1. a) Development of new materials requires depth knowledge of fundamental concepts in nanoscience. Answer the following parts of the question
- Distinguish between compact materials and dispersed nanomaterials. (1.0 Mark)
 - Classify the metal nanoparticles according to their shapes. (1.5 Marks)
 - Reclassify the metal nanoparticles you classified in the above part (ii) according to the quantum definition. (1.5 Marks)
 - Sketch the density of states of a quantum dot. (1.0 Mark)
- b) The Bohr radius of an electron is given by $a_0 = \frac{4\pi\epsilon_0\epsilon\hbar^2}{mq^2}$, where m and q are the mass and the charge of the electron respectively.
- Starting from the above equation, build the corresponding exciton Bohr radius of the material. (2.0 Marks)
 - What is the critical size of a particular nanomaterial so that the nanoparticle is to be quantum confined? (2.0 Marks)
 - Calculate the excitation Bohr radius for Cadmium selenide (CdSe) material if the effective mass of the electron and hole are $m_e = 0.13m$ and $m_h = 0.45m$, and the dielectric constant $\epsilon = 9.4$ for CdSe.
Planck's constant, $\hbar = 1.054 \times 10^{-34}$ J s
Electron mass, $m_e = 9.10 \times 10^{-31}$ kg
Vacuum permittivity, $\epsilon_0 = 8.854 \times 10^{-12}$ J⁻¹ C² m⁻¹ (3.0 Marks)
- Q2. a) Microscopy is the technical field of using microscopes to view objects and areas of objects that cannot be seen with the naked eye.
- What do you mean by the "Resolving power of microscope"? Explain your answer. (1.0 Mark)

- ii) Explain, why optical microscopy cannot be used to observe the nanostructured materials. (2.0 Marks)
- iii) Compare the differences and similarities between Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) (3.0 Marks)
- iv) Explain how Scanning Probe Microscopy (SPM) can use to imaging the nanostructured thin film. Your answer should include the operation mode of each Scanning Probe Microscope. (4.0 Marks)
- b) Discuss the benefits and limitation of the Dynamic Light Scattering Spectroscopy (DLS) which is used to measure the particle size of nanomaterials. (2.0 Marks)
- Q3.** a) Discuss the applications of nanotechnology in the following sectors:
- i) Electronics and information technology (3.0 Marks)
- ii) Sustainable energy (3.0 Marks)
- b) List two different applications of Zinc oxide (ZnO) nanoparticles and describe one of them. (2.0 Marks)
- c) Explain the followings related to nano toxicology by giving examples.
- i) Natural nanoparticles related toxicology (1.0 Mark)
- ii) Engineered nanoparticles related toxicology (1.0 Mark)
- iii) Nanotechnology and workplace safety (2.0 Marks)
- Q4.** a) Nanomaterials synthesis can be carried out by two prominent approaches. Describe briefly them by giving two examples in each case. (4.0 Marks)
- b) What are challenges in nanomaterials synthesis? (2.0 Marks)
- c) Sol-gel process is a wet chemical method for the synthesis of various nanostructures, especially metal oxide nanoparticles.
- i) Describe briefly the four steps in sol-gel process and state the possible reactions corresponding to each steps [4.0 Marks]
- ii) List advantages and disadvantages of sol-gel method that use for synthesise of nanoparticles. [2.0 Marks]

- Q5. a) "Material properties change with size of the particles or grains". Describe any two properties that show size dependent behavior. Provide sketches and graphs to support your answer. [4.0 Marks]
- b) i) Sri Lanka is well-endowed with industrial minerals. List few minerals available in Sri Lanka which have value if convert into nanoparticles. [1.0 Marks]
- ii) Discuss briefly how nanotechnology can be used for solving the socio-economic problems in Sri Lanka. [3.0 Marks]
- c) Write short notes on the followings:
- i) Allotropes of carbon and their properties [2.0 Marks]
- ii) Disadvantages of nanotechnology [2.0 Marks]