



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2017

Module Number: ME 6211

Module Name: Nanotechnology

[Three Hours]

[Answer all questions, each question carries 12 marks]

Q1. A spherical nanoparticle with radius L is composed of small particles with number density ρ and radius σ ($L \gg \sigma$). Attractive force between two small particles is given

$$by . w(r) = -\frac{C}{r^n}$$

Here n is an integer and C is the force constant.

i) Show that the total energy of the nanoparticle is given by

$$Total\ energy = \frac{-4C\pi\rho}{(n-3)\sigma^{n-3}} \left[1 - \left(\frac{\sigma}{L} \right)^{n-3} \right]$$

[4.0 Marks]

ii) In deriving the corresponding expression, discuss the n dependence of the total energy.

[4.0 Marks]

iii) Obtain an equation for the total energy of a nanoparticle having electrostatic interactions between its interior small particles.

[4.0 Marks]

Q2 a) Bohr radius of an electron that orbit around the nucleus of an atom is given by

$$a_0 = \frac{4\pi\epsilon_0\hbar^2}{mq^2} , \text{ all terms in the equation have their usual meaning.}$$

i) Calculate the Bohr radius of an electron where $q = 1.602 \times 10^{-19}$ C, if the permittivity, mass and plank constant are 8.85×10^{-12} F/m, 9.11×10^{-31} kg and 1.054×10^{-34} J s, respectively.

[1.0 Mark]

ii) What is nanoparticle definition based on quantum confinement?

[1.0 Mark]

iii) Calculate the excitation Bohr radius for the InP material, if its m_e , m_h and ϵ are $0.07m_0$, $0.4m_0$ and 14.5, respectively.

[2.0 Marks]

b) Distinguish the 0D, 1D, 2D and 3D material based on their shapes and give an example for each using the form of carbon materials.

[4.0 Marks]

c) Sketch Density of States (DOS) diagrams for 3D, 2D, 1D and 0D materials.

[4.0 Marks]

- Q3. a) Although nanotechnology is a relatively new scientific term, the nature in its 3.8 billion years of evolution, provides many natural examples related to nanotechnology.
- i) Discuss briefly the existence of “Nanotechnology in Nature” by selecting three different subjects from the nature and elaborate their functions. [4.0 Marks]
 - ii) As an engineer, briefly discuss one potential application for each of the three subjects you mentioned in Q3a(i). [2.0 Marks]
- b) Risks of nanotoxicity to humans and the environment are also to be considered before introducing applications based on nanotechnology.
- i) Why do nanomaterials present greater toxicity risks than larger particles? [1.0 Marks]
 - ii) What are the potential sources of nano particles exposure to the human body and to the environment? Explain. [3.0 Marks]
 - iii) Propose possible precautions that can be taken to minimize the hazards of nanotechnology to the living organisms and the environment. [2.0 Marks]
- Q4. a) Sol-gel is a simple and a less expensive process that can be used to produce nanoparticles and thin films with novel, predefined properties.
- i) Name the four basic steps in the sol-gel process and state the possible reactions corresponding to each step. [3.0 Marks]
 - ii) Using neat sketches, briefly discuss the application of the sol-gel technique to produced *multilayered* thin films. [3.0 Marks]
- b) Briefly explain the “ Top down approaches” and “Bottom up approaches” in the context of synthesis of nanoparticles using appropriate examples. [3.0 Marks]
- c) Describe briefly the solid phase synthesis of nanomaterials and its limitations. [3.0 Marks]
- Q5. a) Microscopy is an essential technique that is used to observe the size, shape and morphology of nanomaterials.
- i) What is resolution power of microscope? [1.0 Mark]
 - ii) Compare the differences between optical microscope and electron microscope. State at least five differences. [3.0 Marks]

b) Write short notes on:

i) Applications of nanotechnology in the field of sustainable energy.

[3.0 Marks]

ii) Disadvantages of nanotechnology.

[2.0 Marks]

iii) Size dependent properties of nanomaterials .

[3.0 Marks]