UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2016

Module Number: ME 6211   **Module Name: Nanotechnology**

[Three Hours]

[Answer **all questions**, each question carries **12 marks**]

Q1. An electric field created by a chare Q_1 is given by

$$E(r) = Q_1/4\pi\varepsilon\varepsilon_0 r^2$$

i) Derive the expression for the interaction energy between two ions having charges z_1 and z_2.

[3.0 Marks]

ii) Calculate the coulomb energy between two ions having charges +2 and -3 separated by 0.1nm in terms of vacuum permeability and the dielectric constant of the medium. Electron charge = 1.62×10^{-19} C.

[2.0 Marks]

iii) An ion of charge +3 and a molecule with charges +2 and -2 separated by 0.1 nm distance are kept apart in the center to center distance of 0.3 nm. The dipole is oriented with angle 60° with respect to the horizontal line between two centers. Derive the general expression for the coulomb interaction between the charge and the molecule of dipole and hence calculate the interaction energy between the ion and dipole.

[7.0 Marks]

Q2 a) The attractive term for an interaction between two particles separated by distance r is given by $w(r) = -q_1 q_2/4\pi\varepsilon r$.

If a nanoparticle consist of particles with number density ρ and is in the form of sphere with radius L and the radius of the each particle is σ, derive the expression for the total energy of the nanoparticle.

[5.0 Marks]

b) Consider a one-electron atom whose electron of charge $-e$ circles the nucleus of charge $+e$ at a distance R. Show that the polarizability (α_0) of atom due to an external field is given by the expression

$$\alpha_0 = 4\pi\varepsilon_0 R^3$$

[7.0 Marks]

Q3. a) Electron microscopy plays a central role in characterization of nanomaterials.

    i) What is an electron microscopy and how is it different from optical microscopy?

[3.0 Marks]

    ii) Explain why optical microscopy is difficulty to use for imaging nano scale materials?

[2.0 Marks]

    iii) Describe briefly on "Electron beam and specimen interactions" in Scanning Electron Microscopy (SEM).

[2.0 Marks]

b) X-ray diffraction (XRD) Spectroscopy is a technique to use structural analysis of crystalline materials.

    i) Derive Bragg's equation ($n\lambda = 2d\sin\theta$) for diffraction of x-rays by crystalline materials. Use neat sketch.

[2.0 Marks]

    ii) What types of information can be gain by using X-ray diffraction (XRD) spectroscopy?

[3.0 Marks]

Q4. a) Nanomaterials can be divided into two categories as "Natural nanomaterials" and "Engineered nanomaterials". Explain briefly by giving examples for each category.

[3.0 Marks]

b) Define followings according to the europium union recommendation in 2011:
    i) Particle
    ii) Aggregates
    iii) Agglomerates

[1.5 Marks]

c) Discuss briefly the applications of nanotechnology in textile industries.

[3.0 Marks]

d) What are the potential applications of Zinc oxide (ZnO) nanoparticles?

[1.5 Mark]

e) Discuss briefly the advantages and disadvantages of nanotechnology.

[3.0 Marks]

Q5. a) i) What do you mean by "Lotus Effect"?

[1.0 Mark]

    ii) Write down Young's equation in terms of surface tensions with a neat sketch and defining all parameters.

[1.5 Marks]

    iii) Explain differences between hydrophilicity and hydrophobicity.

[2.0 Marks]

b) Write down any four challenges faced by researchers in nanomaterials synthesis.

[1.0 Mark]

c) List the disadvantages of Chemical Vapour Deposition (CVD) process.

[2.5 Marks]

d) Write short notes on:

i) Graphene

ii) Buckminsterfullerene

[4.0 Marks]