UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2015

Module Number: ME 6311

Module Name: Introduction to Nanotechnology

[Three Hours]

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

Q1. a) An ion of charge Q and a molecule of dipole are separated in the center to center distance of r. The dipole is oriented with an angle of θ with respect to the horizontal line between two centers.

i) What is meant by iron-dipole interaction?

[1 Mark]

ii) Give an expression for the coulomb interaction between two charge particles.

[1 Mark]

iii) Derive the expression for the coulomb interaction between the charge Q and the molecule of dipole ql.

[5 Marks]

iv) Hence comment on the orientation (θ) dependence of the interaction energy derived in part (iii).

[1 Mark]

b) Induced dipole moment of a molecule due to an external electric field is given by $u_{in} = \alpha_0 E$. A one-electron atom whose electron of charge $-e$ circles the nucleus of charge $+e$ at a distance R is placed in an external electric field E. Here R is the radius of the atom and the α_0 is the polarizability. Show that the polarizability is given by $\alpha_0 = 4\pi\varepsilon_0 R^3$.

[4 Marks]

Q2 a) Show mathematically that the surface-to-volume ratio of nanoparticles is much higher than that of the bulk particle of the same material.

[3 Marks]

b) How you can classify nanoparticle synthesis methods according to the phase of medium used?

[3 Marks]

c) Briefly discuss the "Top down approach" in nanoparticle synthesis using an appropriate example?

[3 Marks]

d) "Bottom-up approach is more convenient for nano-materials synthesis" - Explain.

[3 Marks]

Q3. a) "Material properties change with size". What are the properties that show size dependant behaviour? Provide sketches and graphs to support your answer.

[3 Marks]

b) Explain why the nanocomposites show superior properties compared to their individual constituents. Name a few commercial products that are made of nanocomposites.

[3 Marks]

c) Nanofluids and nanolubricants are blends of liquids and solid nanoparticles. What are the favourable properties in them?

[3 Marks]

d) Imagine and describe one engineering application that can be improved using nanotechnology.

[3 Marks]

Q4. Give brief answers to the following

a) Define the words *nanoscale, nanotechnology* and *nanoscience.*

[3 Marks]

b) What are the types of microscopes used to observe nanoparticles?

[2 Marks]

c) What are the safety equipment one should wear when handling nano powders?

[2 Marks]

d) Name a few minerals available in Sri Lanka that has value if converted to nanoparticles.

[2 Marks]

e) How nanotechnology can help a country to develop?

[3 Marks]

Q5. a) Sol-gel technique is extensively used in nanoparticle synthesis and thin film fabrication.

i) Explain about hydrolysis and polycondensation in sol-gel process by using chemical reactions take place in each stage.

[2 Marks]

ii) List the advantages and disadvantages of sol-gel process.

[2 Marks]

b) Nanoparticles with controlled sizes and shapes can be synthesized by microemulsion (reverse- micelle) technique.

i) Explain briefly the role of surfactant in above technique.

[2 Marks]

ii) What are the factors depend on formation of microemulsion?

[2 Marks]

c) Describe various stages in "photolithography" process in nano-materials fabrication. Use neat sketches.

[4 Marks]