



MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 303: FUNDAMENTALS OF NANOTECHNOLOGY

DATE:

TIME:

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.
- **Plank's constant (h) = 6.626×10^{-34}**

SECTION A – COMPULSORY (30 MARKS)

QUESTION ONE (30 MARKS)

- a) Define the following terms as used in nanotechnology. (3 marks)
- i) Self-purification.
 - ii) Surfactant.
 - iii) Sintering.
- b) Give the main difference between:
- i) Surface Electron Microscopy and Transmission Electron Microscopy. (2 marks)
 - ii) Bottom-up and Top-down approaches. (2 marks)
- c) A student was preparing specialty metal oxide glasses and ceramics using sol-gel method. Briefly explain why the following chemicals/methods are used/applied in this method.
- i) Sodium Hydroxide. (2 marks)
 - ii) Citric Acid. (2 marks)
 - iii) Centrifugation. (1 mark)
- d) Explain in details the two major phenomenon that make nanoparticles to be different from bulk materials. (5 marks)
- e) Using equations where relevant, describe the sol-gel method of preparation of nanoparticles. (5 marks)
- f) Several microscopy techniques exist for imaging of structures at the nanoscale and smaller.
- i) Make a sketch and explain the general principle for how the Surface Electron Microscopy (SEM) works. (5 marks)
 - ii) Mention one specimen property that must always be fulfilled for SEM analyses. (1 mark)
 - iii) How can non-conducting samples be analyzed in the SEM. (2 marks)

Section B

Answer any two questions (Each question is 20 marks)

QUESTION TWO (20 MARKS)

- a) Briefly explain
- i) The meaning of HAp coating. (1 mark)
 - ii) HAp coating preparation by sol–gel process. (5 marks)
- b) List four advantages of sol-gel process as a method for synthesis of metal oxide nanoparticles. (4 marks)
- c) Applications of sol-gel processes have increased in the recent past. Thus, one should somehow enhance the process to achieve the best results. Briefly illustrate two ideas that have been proposed in this context. (4 marks)
- d) Discuss in details three current and potential applications of sol-gel coating. (6 marks)

QUESTION THREE (20 MARKS)

Explain in details the following techniques as used in nanoscience. In your explanation, you must include; relevant theory/principles and sample preparation process.

- i) Atomic Force microscopy (AFM). (5 marks)
- ii) Scanning Tunneling Microscopy (STM). (5 marks)
- iii) Fourier Transform Infrared Spectroscopy (FTIR). (5 marks)
- iv) Transmission Electron Microscopy (TEM). (5 marks)

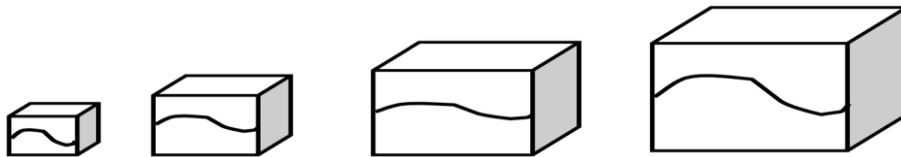
QUESTION FOUR (20 MARKS)

- a) If a human of average height was to shrink himself down until he was only a nanometer tall, how thick would a sheet of paper appear to him given that an average sheet of paper is approximately 0.1 mm thick. Give your answer in kilometers. (2 marks)
- b) Using nano-silver as an example, explain if it is possible to eliminate hazards in the design while keeping the “benefits” of the nanoparticle. (5 marks)
- c) Explain three different purposes for using capping layers on nano-particles. (3 marks)
- d) List two merits and two demerits of scanning tunneling microscopy. (4 marks)

- e) There are different methods for the synthesis of nanoparticles. These methods are divided into two main classes namely; top-down and bottom-up approach. Briefly discuss the following listed methods and indicate which class they fall. (6 marks)
- i) Thermal decomposition method.
 - ii) Lithographic method.
 - iii) Laser ablation method.

QUESTION FIVE (20 MARKS)

- a) Briefly explain
- i) Quantum dots. (2 marks)
 - ii) Quantum confinement. (2 marks)
- b) Explain the application of quantum dots as used in:
- i) Medicine. What is the limitation of this application? (3 marks)
 - ii) Photovoltaics. (2 marks)
- c) Moses was given two quantum dot solutions by his laboratory instructor to study their properties. Solution one emitted a red color of approximate wavelength 700×10^{-9} m, whereas solution two emitted a yellow color of approximate wavelength 560×10^{-9} m. Determine which solution has a larger energy and higher frequency. How much larger is its energy? Show your work. (5 marks)
- d) Quantum confinement produces the nanoparticle size-energy relationship. To illustrate this concept, below are a series of boxes increasing in size, with schematic wavelengths in the boxes. Use this diagram to explain why higher energy light is emitted with smaller particles. (3 marks)



- e) List three limitations of nano technology. (3 marks)