



# MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES  
DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR  
BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

SAN 303: FUNDAMENTALS OF NANOTECHNOLOGY

DATE: 15/03/2022

TIME: 8:30-10:30 AM

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## INSTRUCTIONS:

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

## SECTION A – COMPULSORY

### QUESTION ONE (30 MARKS)

- a) Define the following terms as used in nano-chemistry giving one example of its application in each case.
- i) Nanofiltration. (1 mark)
  - ii) Nanomaterials. (1 mark)
- b) Differentiate between the following terms
- i) Nanoemulsions and nanoencapsulation. (2 marks)
  - ii) Nanocomposites and nanoparticles. (2 marks)
  - iii) Engineered nanomaterials and Incidental nanomaterials. (2 marks)
- c) List and explain five different types of nanomaterials that are used in food management. (10 marks)
- d) Outline the advantages of the following nanoparticles as used in food packaging and preservation.
- i) Inorganic nanoceramic. (1 mark)
  - ii) Polymeric nanoparticles. (1 mark)
- e) Experiments have proven that nanoparticles emit colors with an equivalent energy proportional to the nanoparticle size. Explain why this only occur in nanoparticles and doesn't occur in larger materials. (3 marks)
- f) A photon is defined as a packet of light energy that has a collection of wavelengths. In physics, the energy of such a photon is defined by an equation. Give the relevant equation. (2 marks)
- g) Briefly explain Infrared technique as used in the characterization of nanoparticles. (5 marks)

## Section B

**Answer any two questions (Each question is 20 marks)**

### QUESTION TWO (20 MARKS)

- a) Explain the following terms
- (i) Quantum dots. (2 marks)
  - (ii) Quantum confinement. (2 marks)
- b) A quantum dot solution is emitting a red color with a wavelength of  $700 \times 10^{-9}$  m. Calculate the energy associated with this wavelength of light. (3 marks)
- c) Assume that you have been given two quantum dot solutions by your laboratory instructor. Solution 1 emits a blue color of approximate wavelength  $475 \times 10^{-9}$  m. Solution 2 emits a yellow color of approximate wavelength  $560 \times 10^{-9}$  m. Determine which solution has a larger energy and larger frequency. How much larger is its energy? (5 marks)
- d) List and explain two practical applications of quantum dots. (4 marks)
- e) The Earth has not only water and rock cycles, and many chemical cycles, but also a nano-material cycle. Draw and explain a nanomaterial cycle. (4 marks)

### QUESTION THREE (20 MARKS)

- a) List four limitations of nano technology. (4 marks)
- b) Explain the two main reasons as to why the properties of materials can be different at the nanoscale level. (4 marks)
- c) Sol-gel chemistry offers a flexible approach to preparing advanced materials. List and explain the five main processes involved in a sol-gel method. (10 marks)
- d) With relevant examples, outline two application of silver nanoparticles. (2 marks)

#### QUESTION FOUR (20 MARKS)

- a) List and explain the two formation processes that take place during chemical synthesis of nanomaterials. (4 marks)
- b) Using an equation, write the general mechanism of formation of metal nanoparticles from the chemical reduction process. Name what each chemical represents and its importance in the reaction. (6 marks)
- c) Using a relevant example, describe in details the green synthesis method for preparation of silver particles using natural precursors. (8 marks)
- d) Explain the advantage of the green synthesis method that you have described in Q4c above over other chemical methods. (2 marks)

#### QUESTION FIVE (20 MARKS)

- a) List
- i) Two historical works of art that applied the use of nanotechnology. (2 marks)
  - ii) Two applications of zero-valent iron nanoparticles. (2 marks)
- b) A nanostructure is a structure of intermediate size between microscopic and molecular structures. Explain in details the two main approaches to making nanostructures. (4 marks)
- c) There are different techniques available for characterization of nanoparticles. With a relevant schematic representation, briefly explain the theory and principles of the following listed techniques as applied in nano-characterization.
- i) Ultra violet visible (UV/VIS) spectroscopy. (6 marks)
  - ii) Scanning Electron microscopy (SEM) technique. (6 marks)