



MACHAKOS UNIVERSITY

University Examinations 2023/2024 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE IN 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}**

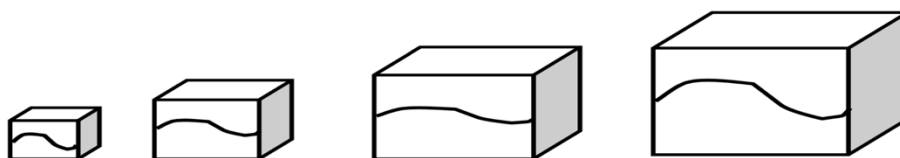
SECTION A: COMPULSORY QUESTION-30 MARKS

QUESTION ONE

- a) Differentiate between the following terms.
- i) Nanoscience and nanotechnology. (2 marks)
 - ii) Zero-dimensional nanoparticles and two-dimensional nanoparticles. (2 marks)
 - iii) Austenite and Martensite phase. (2 marks)
- b) 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)
- c) 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.

(4 marks)



d) List four limitations of nano technology. (4 marks)

e) Explain in details the two major phenomenon that make nanoparticles to be different from bulk materials. (4 marks)

f) Using equations where relevant, describe the sol-gel method of preparation of nanoparticles. (5 marks)

g) Ball milling is a physical method of nanosynthesis.

i) Discuss the process of ball milling. (3 marks)

ii) List one advantage and disadvantage of ball milling. (2 marks)

SECTION B: ANSWER ANY TWO QUESTIONS-20 MARKS EACH

QUESTION TWO

a) Explain the difference between top-down and bottom-up approaches for synthesis of nanoparticles. (2 marks)

b) With a relevant example, briefly describe the following listed methods of synthesis of nanoparticles and indicate which approach they can be classified into.

i) Thermal decomposition. (5 marks)

ii) Chemical vapor deposition. (5 marks)

iii) Spinning. (5 marks)

c) An analytical chemistry student was required to prepare two different nano-thin films on titanium carbide. Write two relevant balanced equations that can be used to achieve this using chemical vapor deposition method. (3 marks)

QUESTION THREE

- a) Draw a graph depicting the absorption bands of a brightly and a dull colored nanoparticle solution. (3 marks)
- b) Explain in details:
 - i) Two ways in which the molar extinction coefficient of gold nanoparticles can be determined. (5 marks)
 - ii) Why quantum confinement is effective in nanomaterials and not in bulk materials. (5 marks)
- c) A student prepared 3000 mM of gold nanoparticles and obtained a molar absorption coefficient equal to $138 \text{ M}^{-1}\text{cm}^{-1}$ at 0.13 nm when measured in a 10 mm pathlength. Determine the absorbance of the gold nanoparticles. (3 marks)
- d) Draw, compare and contrast the plots for the number of free electrons per unit volume obtained at a given energy for a bulk material, quantum wire and quantum dot. (4 marks)

QUESTION FOUR

- a) Several microscopy techniques exist for imaging of structures at the nanoscale and lower. Briefly explain the theory, working principles and sample preparation method for the following analytical techniques.
 - i) Transmission electron microscopy. (5 marks)
 - ii) Surface electron microscopy. (5 marks)
 - iii) X-ray diffraction spectroscopy. (5 marks)
- b) List three strengths and two limitations of X-ray diffraction spectroscopy. (5 marks)

QUESTION 5

- a) Nanotechnology is used in sectors of science and technology such as energy, medicine and drugs, nanobiotechnology, nanodevices, optical engineering among others. Briefly explain:
 - i) The two formation processes that take place during chemical synthesis of nanomaterials. (5 marks)
 - ii) The applications of quantum dots in medicine and Televisions displays. (5 marks)

- b) Using nano-silver as an example, explain if it possible to design out the hazard while keeping the “benefits” of the nanoparticle. (5 marks)
- c) List three different purposes for using capping layers on nano-particles. (3 marks)
- d) List two demerits of scanning tunneling microscopy. (2 marks)