



MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SCH 304: INTRODUCTION TO ANALYTICAL INSTRUMENTATION

DATE: 23/4/2019

TIME: 2.00-4.00 PM

INSTRUCTIONS TO CANDIDATES

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

QUESTION ONE COMPULSORY (30 MARKS)

- a) Scientific research has been defined as a systematic investigation of scientific theories and hypothesis. In order to carry out research one has to design an experiment. Define the following terms as related to research.
- Experimental design? (2 marks)
 - Hypothesis? (2 marks)
 - Research proposal (2 marks)
- b) In carrying out research through experimental design, data is generated through use of analytical equipment through a defined analytical method. Explain the following terms as applied to data generated during research.
- Accuracy of results (2 marks)
 - Precision (2 marks)
 - Sensitivity (3 marks)
 - Detection limit of an analytical method (3 marks)
 - Random and systematic errors in measurement (3 marks)

- c) In order to get credible results from measurements in any analytical method, the analytical instrument needs to be calibrated. Explain briefly with the help of illustrations, how each of these methods are used in the calibration of an analytical equipment.
- External calibration method (calibration curve or working curve) (4 marks)
 - Standard addition method (4 marks)
 - Internal standard addition method (4 marks)

QUESTION TWO (20 MARKS)

- a) To improve the accuracy of our results and minimize errors, replicate experiments are carried out thus generating data. The data generated is subject to statistical analysis. Explain the following terms applied to statistical analysis of data. Use the appropriate equations to define the terms where possible.
- Population mean (1 mark)
 - population standard deviation (1 mark)
 - Population variance (1 mark)
 - What is the relationship between error and uncertainty? (1 mark)
- b) The following replicate measurements for concentration of salt in urine were carried out in g/L to determine the true value of the measurement;
- 2.1, 2.3, 2.6, 2.1, 1.9, 2.2, 1.8, 3.8
- Use a bar graph to represent this data graphically with the horizontal axis representing the concentration in g/L and the vertical axis representing frequency (2 marks)
 - Determine the mean (μ), variance (σ^2) and the standard deviation (σ). (3 marks)
- c) The data can fit into a normal distribution curve.
- Show graphically how the above figure in 2a(i) can be represented by a probability distribution curve with the vertical axis representing probability and the horizontal axis the variables measured in 2(b). (2 marks)
 - Using the figure 2b (i) explain why 3.8 from the data is considered odd. (1 mark)
 - Explain what is 95% confidence level. (1 mark)
 - Explain what is significance level and show the relationship between significance level α and confidence level (CL). (2 marks)
 - Explain degree of freedom (ν) of a parameter with the help of an equation. 1 mark

- d) i When do we say a variable in a data from replicate measurements is said to be significant? (1 mark)
- ii Explain how you can reduce the risk of falsely categorizing a good result as not being significant. Explain with the equation which relates confidence level (CL) with significance level α . (3 marks)

QUESTION THREE (20 MARKS)

- a) One of the progressive developments in instrumentation is the manner in which information is transmitted especially from the detector as signals for further processing in data acquisition.
- i. Describe the difference between the analog and digital signals (4 marks)
- ii. Explain the following four steps in the measurement process in analytical instrument;
Signal generator, signal transduction, signal modification and signal display. (4 marks)
- iii. State five uses of microcomputers incorporated in an analytical instrument. (5 marks)
- b) i Explain the terms noise, signal, signal/noise ratio (S/N) in analytical instruments. (3 marks)
- ii What are the various causes of noise in an analytical instrument? (4 marks)

QUESTION FOUR (20 MARKS)

Various methods are used to reduce noise in order to obtain quality signals from analyte determination in samples. Explain how the following have been used in the reduction of noise from analyte signals in analytical determinations. (20 marks)

- a) Signal modulation
- b) Signal averaging
- c) Box car averaging
- d) Low pass analog filter
- e) Fourier transform in signal processing

QUESTION FIVE (20 MARKS)

The automation of analytical processes has become important in analytical chemistry due to the growing complexity of problems faced and the need to cut expenses on analytical control.

- a)
 - i What is the common weakness in manual manipulation of analytical measurement in chemical instrumentation? (2 marks)
 - ii Name **four** major steps in the whole analytical process of determination in chemical instrumentation. (4 marks)
 - iii Name and briefly describe the three types of automatic analyzers (3 marks)
- b) For automated analysis of both clinical and environmental samples, there is need to incorporate separation techniques in the Flow injection Analysis (FIA)
 - i. Briefly describe how this system works. (4 marks)
 - ii. Describe with the help of a block diagram the components of the FIA/ liquid liquid extraction (separation) system (4 marks)
 - iii. State the advantages of FIA/extraction system (separation system) over segmented systems. (3 marks)