CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN CHEMISTRY & BACHELO ROF INDUSTRIAL CHEMISTRY

CHAL 101: STASTICAL METHODS FOR ENVIRONMENTAL ANALYSIS

STREAMS: BSC (CHEM) **TIME: 2 HOURS**

DAY/DATE: MONDAY 15/4/2019 **11.30 A.M. – 1.30 P.M.**

INSTRUCTIONS: Answer question ONE and any other TWO questions

QUESTION ONE (30 MARKS)

(a) Explain the following terms as used in analytical techniques [3 marks]

(i) Precision

(ii) Repeatability

(iii) Reproducibility

(b) (i) In the delivery of quality data in analytical chemistry during quantitative determinations, we have to take cognizance of the types of errors encountered. In view of the this statement, differentiate between random errors and systematic errors

[3 marks]

(ii) Briefly outline how systematic errors can be minimized [3 marks]

(c) The reproducibility of a method for the determination of selenium in foods was investigated by taking nine samples from a single batch of brown rice and determining the selenium concentration in each. The following results were obtained: 0.07, 0.07, 0.08,

0.07, 0.07, 0.08, 0.08, 0.09, 0.08 $\mu g\, g^{-1}$. Calculate the mean, standard deviation and relative standard deviation of these results. [4 marks]

(d) The morphine levels (%) of seven batches of seized heroin were determined with the following results: 15.1, 21.2, 18.5, 25.3, 19.2, 16.0, 17.8. calculate the 95% and 99% confidence limits for these measurements [5 marks]

(e) The following results were obtained in a comparison between a new method and standard method for the determination of the percentage nickel in special steel

New method: mean = 7.85, standard deviation = 0.130, $n_1 = 5$

Standard method: mean = 8.03, standard deviation = 0.095, $n_1 = 6$

Where n = number of observations

Test at the 5% probability value if the new method mean is significantly different from eh standard reference mean [5 marks]

(f) In a new method for determining selenourea in water, the following values were obtained for tap water samples skipped with 50 $ngml^{-1}$ of selenourea: 50.4, 50.7, 49.1, 49.0, 51.1 $ngml^{-1}$. Is there any evidence of systematic error? [4 marks]

(g) The standard deviation from one set of 8 determinations was $S_A = 0.00138$ and the standard deviation from another 7 determinations was $S_B = 0.00143$. Is there any significant difference between the precision of these two sets of results? [3 marks]

QUESTION TWO (20 MARKS)

(a) (i) Briefly discuss outliers in data collection [1 mark]

(ii) Explain the two methods by which outliers are determined in a set of measurements [8 marks]

(iii) The following values were obtained concerning the concentration of thiol in blood lysate: 1.84, 1.92, 1.94, 1.92, 1.85, 1.91, 1.85, 1.91. 2.07. Using Grubbs' test,

verify that 2.07 is not an outlier for the 'normal' group [4 marks]

(b) Standard aqueous solutions of fluorescein are examined in a fluorescence spectrometer, and the fluorescence intensities (in arbitrary units) yielded are given in the table

Fluorescence intensities:	2.1	5.0	9.0	12.6	17.3	21.0	24.7
Concentration, pg $pg\,ml^{-1}$	0	2	4	6	8	10	12

Determine the correlation coefficient, r. [5 marks]

(c) Differentiate between null and alternative hypothesis [2 marks]

QUESTION THREE (20 MARKS)

(a) The table below shows five determinations of the paracetamol content of the same batch of tablets made by three analysis

Analyst 1	Analyst 2	Analyst 3
16	18	26
15	22	31
13	20	24
21	16	30
15	24	24

Test whether the samples were drawn from populations with equal means (P = 0.05) [13 marks]

(b) A normal (Gaussian) distribution curve is describe by the equation

$$y = \exp\left[-(x-\mu)^2 / \sigma\sqrt{2\pi}\right]$$

(i) Draw the curve, show and demarcate the 68%, 95% and 99.7% of the population

(ii) Derive the appropriate equations for the confidence limits of the mean at 95%, 99% and 99.7% for large sample size information. At confidence levels of 95%, 99% and 99.7%, z = 1.96, 2.58 and 2.97 respectively.

(iii) Adapt the equation in b (ii) to give the confidence limit of the mean for a small sample size [7 marks]

QUESTION FOUR (20 MARKS)

(a) Quinine may be determined by measuring the fluorescence intensity in 1 M H_2SO_4 solution. Standard solutions of quinine gave the following fluorescence value as shown in the table below

Concentration of quinine (xi)	0.00	0.10	0.20	0.30	0.4 $\mu g ml^{-1}$
Fluorescence intensity (yi)	0.00	5.20	9.90	15.30	19.10 arbitrary units

(i) Calculate the slope and intercept of the regression line
(ii) Determine the equation of the regression line for the above data
(iii) If the fluorescence intensify of the test solution containing quinine was found to be 16.1, estimate the concentration of quinine $\left(ugmL^{-1}\right)$ [8 marks]

(b) The concentration of lead in the bloodstream was measured for a sample of 50 children from Ndagani primary school near Meru-Nairobi highway. The sample mean was 10.12 $ng\,ml^{-1}$ and the standard deviation was 0.64 $ng\,ml^{-1}$. Calculate the 95% confidence interval for the mean lead concentration for all the children in the school. About how big should the sample have been to reduce the range of the confidence interval to 0.2 $ng\,ml^{-1}$ $\left(i.e.\pm 0.1\,ml^{-1}\right)$? [4 marks]

(c) The numbers of glassware breakages reported by four laboratory workers over a given period are shown below. Number of breakages; 24, 17, 11, 9 is there any evidence that the workers differ in their reliability? [4 marks]

(d) Calculate the uncertainty in the number of millimoles of chloride contained in 250.0 mL of a sample when three equal aliquots of 25.00 mL are titrated with silver nitrate with the following results 36.78, 36.82 and 36.75mL. The molarity of the $AgNO_3$ solution is

0.1167 $\pm$ 0.0002 M. [4 marks]
