

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF BACHELOR OF SCIENCE CHEMISTRY,
BACHELOR OF SCIENCE INDUSTRIAL CHEMISTRY AND BACHELOR OF
SCIENCE

CHAL 202: STATISTICAL METHODS FOR ENVIRONMENTAL CHEMISTRY II

STREAMS: BSc (Y2S1)

TIME: 2 HOURS

DAY/DATE: MONDAY 23/12/2024

8.30 A.M. – 10.30 A.M.

INSTRUCTIONS

Answer question **ONE** and any other **TWO** questions.

Use of calculators and statistical tables is allowed.

Do not write anything on the question paper.

QUESTION ONE (30 MARKS): COMPULSORY QUESTIONS

(a) Explain the following terms as used in the design of experiment:

- | | |
|--------------------------|-----------|
| (i) Factor. | (1 marks) |
| (ii) Treatment | (1 marks) |
| (iii) Response variable. | (1 marks) |
| (iv) Interaction. | (1 marks) |
| (v) Randomisation. | (1 marks) |
| (vi) Replication. | (1 marks) |

(b) The following data set show the rating of two HPLC output by students at Chuka University on a scale of 1 – 9.

Student	1	2	3	4	5	6	7	8	9
Output 1	3	7	4	3	5	6	5	4	8
Output 2	5	3	1	7	8	4	8	7	6

At 5% level of significant level determine if the two analytical products have equal rating. (6 marks)

- (c) (i) With aid of equations, (e) define the Taguchi loss of function. (4 marks)
- (ii) Explain the main purpose of principal component analysis. (2 marks)

(d) The following data are measurements of the heparin cofactor II (HCII) to plasma protein ratios in a group of patients at baseline and five months after haemodialysis.

Patient	1	2	3	4	5	6	7	8
Before	2.11	1.85	1.82	1.75	1.54	1.52	1.49	1.44
After	2.15	2.11	1.93	1.83	1.9	1.56	1.44	1.43

Using an appropriate non-parametric procedure, at 5% significance level determine if the two measurements are not significantly different. (6 marks)

- (e) Discuss the essential components of the design of an experiment. (6 marks).

QUESTION TWO (20 MARKS)

(a) A second order model was fitted for production of cucurbitacin as the response and soil pH, Substrate and temperature as the independent variables, giving the following results:

Variable	Estimate	Std. Error	t value	p-value
(Intercept)	2.185747	0.088598	24.6704	<0.000000001
x_1	-0.198002	0.037395	-5.2949	0.00000608
x_2	0.308113	0.035314	8.7249	<0.000000001
x_3	0.605018	0.035314	17.1325	<0.000000001
$x_1 : x_2$	-0.019238	0.023696	-0.8119	0.42221
$x_1 : x_3$	0.025836	0.023696	1.0903	0.28281
x_1^2	-0.149980	0.020542	-7.3010	0.000000133
x_2^2	0.119086	0.058660	2.0301	0.04978
x_3^2	0.560858	0.058660	-9.5612	<0.000000001

where $X_1 = \text{pH}$, $X_2 = \text{substrate}$ and $X_3 = \text{temperature}$

- (i) Write down the summary statistical equation. (4 marks)
- (ii) Interpret the results. (12 marks)

(b) A random sample of six water samples were obtained from two given river and analysed for the amount of copper in in ppm. The copper concentrations measured are as follows:

Chuka	15.40	11.25	14.25	19.75	23.00	16.00
Embu	21.25	13.00	19.25	25.00	24.50	

Determine if concentrations of the copper in the two rivets are the same assuming that the underlying distribution is unknown. Take $\alpha = 0.05$. (4 marks)

QUESTION THREE (20 MARKS)

- (a) A full factorial experiment with two factors each at two levels and replicate three times was laid out in Randomised Complete Block Design (RCBD). Generate a plot layout and write down a skeleton of analysis of variance (ANOVA) table. (12 marks)
- (b) A fractional factorial experiment laid down in 5 x 5 Latin Square Design was carried out and the following summary obtained: Treatment totals: Treatment A = 143, Treatment B = 101, Treatment C = 112, Treatment D = 149, and Treatment E = 130. From analysis of variance the following was also obtained: CF = 16129, TSS = 676, SSR = 150, SSC = 68. Test if there is treatment effect. Take $\alpha = 0.05$. (8 marks)

QUESTION FOUR (20 MARKS)

Five laboratories from five universities determined the concentration of iron naturally occurring in soils in mg/kg and obtained the following results:

Laboratories	Block 1	Block 2	Block 3	Block 4
CU	14.4	14.4	13.6	13.4
TU	15.8	13.6	14.2	14.0
UoE	13.4	13.6	13.8	14.6
MUST	13.2	13.8	13.6	13.6
MMUST	16.0	15.0	14.8	15.4

Perform analyse of variance and test if the five laboratories yields significantly different results. Take $\alpha = 0.05$. (20 marks)
