CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN 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: WEDNESDAY 20/12/2023 **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) Discuss the fundamental components that characterise every experimental design. (6 marks)

(b) Discuss five characteristics of a well-planned experiment (5 marks)

(c) Outline formal steps in testing of hypothesis. (4 marks)

(d) With aid of equations, (e) define the Taguchi loss of function. (5 marks)

(e) A random sample of six soil samples form Chuka Municipal dumpsite and five soil samples from Embu Municipal dumpsite was taken and their contamination by lead in ppm obtained 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 contamination levels for the two sites are the same assuming that the underlying distribution is unknown. Take $\alpha = 0.05$. (4 marks)

(f) Nine judges are to judge two type of foodstuffs (A and B) on a scale of 1 - 9 so as to determine if the two foodstuff have equal rating. The following data was obtained from the 9 judges rating of the two type of foodstuffs.

Judges	1	2	3	4	5	6	7	8	9
A	4	8	5	2	6	5	4	5	7
B	6	4	2	6	9	3	7	8	5

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

QUESTION TWO (20 MARKS)

In analytical chemistry laboratory, the following data was obtained on the amount of cucurbitacin obtained from different varieties of pumpkin:

Pumpkin variety	Replicate 1	Replicate 2	Replicate 3	Replicate 4
A	22	22	18	17
B	29	18	21	20
C	17	18	19	23
D	16	19	18	18
E	30	25	24	27

Using the data obtained, test an appropriate hypothesis. Take $\alpha = 0.05$. (20 marks)

QUESTION THREE (20 MARKS)

A fractional factorial experiment laid down in 5 x 5 Latin Square Design was carried out and the following data was obtained:

		Materials					
		1	2	3	4	5	Total
Operators	1	A [24]	B[17]	C [18]	D [26]	E[22]	107
	2	B[20]	C [24]	D [38]	E [31]	A [30]	143
	3	C[19]	D [30]	E [26]	A [26]	B [20]	121
	4	D [24]	E [27]	A [27]	B [23]	C [29]	130
	5	E [24]	A [36]	B [21]	C [22]	D [31]	134
	Total	111	134	130	128	132	635

Perform analysis of variance and draw your conclusion. Take $\alpha = 0.05$. (20 marks)

QUESTION FOUR (20 MARKS)

(a) A second order model was fitted using the antibiotic yield as the response, and substrate, pH and temperature as the independent variables, giving results:

	Estimate	Std. Error	t value	p value
(Intercept)	-184.838159	13.830712	-13.3643	< 2.2e-16
x_1	4.531429	1.898309	2.3871	0.019649
x_2	0.023854	0.829367	0.0288	0.977136
x_3	12.134328	0.832130	14.5823	< 2.2e-16
$x_1 : x_2$	0.101905	0.059892	1.7015	0.093232
$x_1 : x_3$	0.028611	0.030496	0.9382	0.351322
$x_2 : x_3$	0.030873	0.019964	1.5464	0.126448
x_1^2	-0.389444	0.129382	-3.0100	0.003615
x_2^2	-0.147840	0.065878	-2.2441	0.027943
x_3^2	-0.220864	0.014376	-15.3636	< 2.2e-16

where x_1 = pH, x_2 = substrate and x_3 = temperature

(i) Write down the summary statistical equation. (3 marks)

(ii) Interpret the results. (11 marks)

(b) A full factorial experiment with two factors each at two levels and replicate three times was laid out in Randomised Complete Block Design (RCBD). Write down a skeleton of analysis of variance (ANOVA) table. (6 marks)

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