



MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL EDUCATION)

BACHELOR OF EDUCATION (SCIENCE)

SCH 304: INTRODUCTION TO ANALYTICAL INSTRUMENTATION

DATE: 15/12/2017

TIME: 8.30-10.30 AM

INSTRUCTIONS:

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

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

- a) Briefly, explain the following terms
- (i) Linear Regression (1 mark)
 - (ii) Limit of detection (1 mark)
 - (iii) Signal conditioning (1 mark)
- b) Discuss the functions of the following in analytical instruments
- (i) Operational amplifiers (Op Amps) (2 marks)
 - (ii) Analog-to-digital converter (2 marks)

- c) Distinguish clearly the following terms
- (i) Quantitative and qualitative analysis (2 marks)
 - (ii) Instrumental and classical methods of analysis (2 marks)
 - (iii) Determinate and indeterminate errors (2 marks)
- d) A student used a fluorescence method for the analysis of Ag^+ in water. When analyzing a solution containing $1.0 \times 10^{-9} \text{ M Ag}^+$ and $1.1 \times 10^{-7} \text{ M Ni}^{2+}$ the fluorescence intensity (the signal) was +4.9% greater than that obtained for a sample of $1.0 \times 10^{-9} \text{ M Ag}^+$. Calculate $K_{\text{Ag,Ni}}$ (i.e., selectivity coefficient) for this analytical method. (4 marks)
- e) A student titrated 0.1000 N HCl with NaOH and found that for 4 repetitive measurements the Normality of the NaOH is: 0.0968, 0.0979, 0.1020 and 0.0985. Determine whether the value of 0.1020 should be considered as an outlier at 90, 95, and 99 confidence interval. Critical Values for the Rejection Quotient Q are provided below.

Rejection Quotients (Q) at Various Confidence Intervals

# of Observations	Q ₉₀	Q ₉₅	Q ₉₉
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

(5 marks)

- f) The following standardization data was provided for a series of external standards of Cd^{2+} .

Signal [nA]	Cd^{2+} [ppm]
4.8	15.4
11.4	30.4
18.2	44.9
26.6	59
32.3	72.7
37.7	86

- i) Without plotting the data, use the appropriate equations to calculate the best-fit slope and intercept for the calibration curve. (5 marks)
- (ii) Upon analysing a sample containing Cd^{2+} , a response of 25.5 was found. Determine the concentration of cadmium in the sample. (3 marks)

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

- (a) Define each of the following figures of merit and discuss the parameters used to evaluate them.
 - (i) Precision
 - (ii) Accuracy
 - (iii) Sensitivity
 - (iii) Selectivity (12 marks)
- b) For the data shown below, calculate the Interquartile Range (IQR) and draw a box plot for the data to determine whether the data is positively, negatively skewed or symmetrical. (5 marks)

25, 28, 22, 35, 26, 38, 32, 31, 40
- c) The mean of chromium and the standard deviation for eight samples is 16.883% Cr and 0.0794% Cr, respectively, Determine the 95% confidence interval and limits given that t value for 7 degrees of freedom at 95% confidence level is 2.365. (3 marks)

QUESTION THREE (20 MARKS)

- a) Define the following terms, which are normally used when determining the dispersion of data.
 - (i) Population [1 mark]
 - (ii) Sample [1 mark]
- a) Calculate the sample variance, standard deviation, relative standard deviation, and coefficient of variance for the following data.

Measurement	Value (g)
1	16.7
2	16.2
3	16.5
4	16.6
5	16.9
6	17.0
7	17.2
8	16.1

[8 marks]

- b) Before determining the amount of Na_2CO_3 in an unknown sample, a student decided to check her procedure by analyzing a sample known to contain 98.76% Na_2CO_3 . Five replicate determinations of the % Na_2CO_3 in the standard were made with the following results: 98.71%, 98.59%, 98.62%, 98.44%, and 98.58%. The standard deviation for the data is 0.0973. Determine if the mean for these five trials is significantly different from the accepted value at the 95% confidence level ($\alpha = 0.05$).

(5 marks)

<i>Values for t at N-1 Degrees of Freedom for Various Confidence Intervals (CI)</i>			
<i>N-1</i>	<i>90% CI</i>	<i>95% CI</i>	<i>99% CI</i>
1	6.314	12.706	127.32
2	2.920	4.303	14.089
3	2.353	3.182	7.453
4	2.132	2.776	5.598
5	2.015	2.571	4.773
6	1.943	2.447	4.317
7	1.895	2.365	4.029
8	1.860	2.306	3.832
9	1.833	2.262	3.690

- c) A manufacturer's process for analyzing aspirin tablets has a known variance of 25. A sample of ten aspirin tablets is selected and analyzed for the amount of aspirin, yielding the following results 254, 249, 252, 252, 249, 249, 250, 247, 251, 252. Determine whether there is any evidence that the measurement process is not under statistical control at $\alpha = 0.05$, given that the critical value for F (0.05, ∞ , 9) is 3.33.

(5 marks)

QUESTION FOUR (20 MARKS)

- a) Briefly explain the following terms

(i) Analog signal (1 mark)

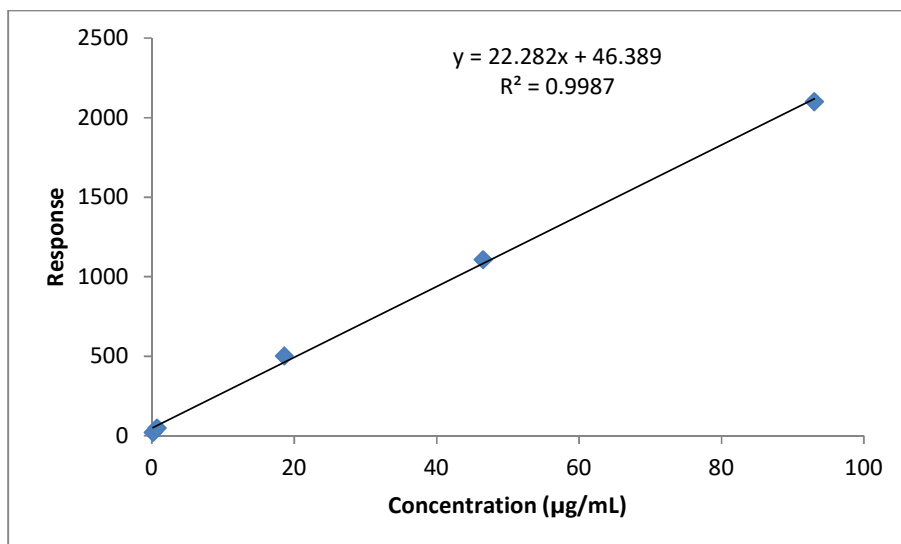
(ii) Digital signal (1 mark)

(iii) Multimeter (1 mark)

- (a) Every analytical measurement is made up of two components. One component is the signal and the other component is noise. Explain what is meant by noise and discuss three sources of noise. (7 marks)
- (b) Discuss three hardware techniques that can be applied to enhance the signal-to-noise ratio (SNR) of a signal. (6 marks)
- (c) Using a block diagram, illustrate the different components of an analytical instrument detailing what happens at each point. (4 marks)

QUESTION FIVE (20 MARKS)

- a) A student was given a water sample to determine the level of DDT. To enable her quantify the DDT, she prepared calibration standards in the range of 0.2 – 93 µg/mL and analysed using GC - ECD. A plot of the calibration curve is shown below, with the calibration function as $y=22.282x+46.389$, $R^2=0.9987$



- (i) Explain the use of a calibration curve in analytical chemistry. (1 mark)
- (ii) Determine the correlation coefficient for the calibration curve and explain its implication. (2 marks)
- (iii) Determine the amount of DDT in the sample if the response from the instrument is 1600. (3 marks)
- (iv) The student in this case used external standard calibration method which doesn't address matrix effect. Discuss what is meant by matrix effect and propose an alternative method which can be applied to address matrix effect. (4 marks)
- b) Discuss the difference between an oscilloscope and voltmeter and describe two measurements that can be done using an oscilloscope. (4 marks)
- c) Discuss 3 ways in which analytical chemistry is useful in day to day life. (6 marks)