(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BSc (CHEMISTRY) AND BSc (INDUSTRIAL CHEMISTRY), BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: SCH 120

COURSE TITLE: ANALYTICAL CHEMISTRY 1

DATE: *THURSDAY 26/04/2022* **TIME:** *12.00 – 2.00 PM*

INSTRUCTIONS TO CANDIDATES

Answer all the Questions

TIME: 2 Hours

This Paper Consists of 5 Printed Pages. Please Turn Over.

QUESTION ONE [11 MARKS]

a) Name the process or substance described below [3 Marks]

(i) Constituent of the sample which is to be studied by quantitative measurements or identified qualitatively

(ii) The smallest amount or concentration of an analyte that can be detected by a given procedure and with a given degree of confidence

(iii) A chemical used to produce a specified reaction in relation to an analytical procedure

b) Convert the following p-functions to molar concentrations: [2 Marks]

(i) pH = 9.67

(ii) pMn = 0.0025

c) Describe how you will make 100 mL of 0.15 M HCl from a 2.5M concentrated hydrochloric acid. [3 Marks]

d) Calculate the molarity of K^+ in a solution that contains 63.3 ppm of $K_3Fe(CN)_6$ (329.3 g/mol) [3 Marks]

QUESTION TWO [20 MARKS]

Students of Analytical Chemistry were required to determine the level of iron in milk from indigenous cows in a village around Masinde Muliro University of Science and Technology. The students collected milk samples; S_1, S_2, S_3, S_4, S_5 and S_6 from six different cows of the same species in the village for analysis.

a) What do you understand by the term 'sampling'? [1 Mark]

b) What name is given to the six samples collected [1 Mark]

c) What is the advantage of collecting many samples of the same type to an analytical chemist [1 Mark]

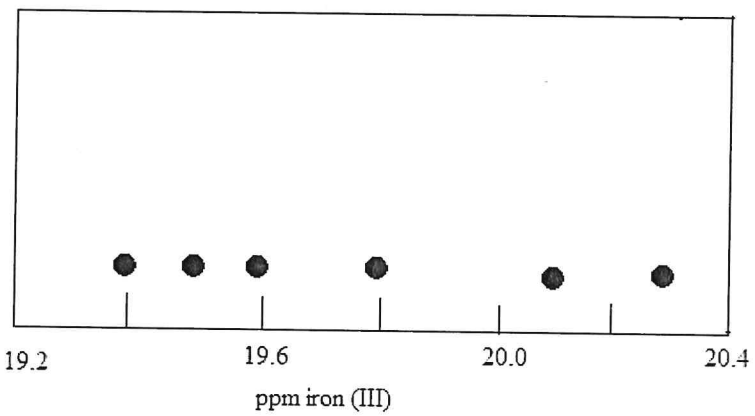
d) Data of unknown quality are worthless. State **Three** ways which an analyst can use to assess or enhance the ***reliability*** of his/her data. [3 Marks]

e) Whatever the analyst does, he/she can never completely eliminate errors in experimental results to get perfect results. Due to this, the analyst must ultimately make judgments as to the probable accuracy of the results obtained.

(i) Define the terms accuracy and precision as used in Analytical Chemistry [2 Marks]

(ii) State two possible sources of errors in the students' experiment [2 Marks]

f) Prior to the analysis of the milk samples, the students made a standard aqueous solution containing 20.0 ppm iron (III). Six portions of this solution were analysed in an Atomic Absorption spectrometer, under the same conditions, which yielded the results below.



(i) Express the ppm in mass per volume of solution [1 Mark]
(ii) Calculate the mean and median for the results obtained [2 Marks]
(iii) Determine the standard deviation of the data obtained [2 Marks]
(iv) Calculate the Absolute error E for the mean in the measurement [1 Mark]
(v) Calculate the percent relative error E_r for the mean in the measurement [2 Mark]

g) Based on the information and your answer in section (e), briefly commend on the following:
(i) Precision of the measurement [1 Mark]
(ii) Accuracy of the measurement [1 Mark]

QUESTION THREE [21 MARKS]

Year one Analytical Chemistry students were provided with:

- Sodium hydroxide, solution F1
- 1.0 g of ammonium salt, solid S
- 0.1 M monobasic acid, solution F2

First, the students were required to standardise solution F1 and to determine the relative formula mass of the ammonium salt, solid S. To do this the students adopted to sets of procedure

PROCEDURE 1

The students measured 25.00 mL of solution F1 into a 250 mL into a beaker. They then measured 175 mL of distilled water using 100 mL measuring cylinder and added it to solution F1 in the beaker, which was shaken well and labelled F3. They then titrated 25 mL of F3 against solution F2 using a suitable indicator. The end-point was obtained after adding 24.25 mL of F2.

PROCEDURE 2

The student placed all the 1.0 g of solid S into a 250 mL conical flask and added 25.00 mL of the sodium hydroxide solution F1 into the conical flask containing solid S. The mixture was well shaken until the entire solid dissolved and the mixture warmed for about 5 minutes. 50.00 mL distilled water was added to the mixture and the solution heated to boiling. The mixture was transferred into 100 mL measuring cylinder and topped up to 100 mL mark. This solution was labelled F4. 25.00 mL of F4 was titrated with solution F4 and the endpoint determined to be 25.55 mL.

a) State ***Four*** properties of an ideal standard solution for a titrimetric method [4 Marks]
b) Name one instrument that could be used to accurately deliver 25.00 mL of solution. [1 Mark]
c) Suggest one method which the students would use to determine the endpoint during the titration. [1 Mark]
d) State two possible sources of error in the procedure used and suggest what the students could do to minimise the error [4 Marks]
e) Calculate the concentration in moles per litre of sodium hydroxide solution F3. [1 Mark]
f) Determine the concentration in moles per litre of sodium hydroxide solution F1 [1 Mark]
g) Calculate the moles of the monobasic acid, solution F2, used in procedure 2. [1 Mark]
h) Write an ionic equation for the chemical reaction that occurs during heating. [1 Mark]
i) Calculate the number of moles of sodium hydroxide in 100 mL of solution F4. [2 Marks]
j) Determine the moles of sodium hydroxide in in 25.00 mL of solution F1 [2 Marks]
k) Hence, determine the relative formula mass of the ammonium salt, Solid S. [3 Marks]

QUESTION FOUR [18 MARKS]

a) Sewage and industrial pollutants dumped into a body of water can reduce the dissolved oxygen concentration and adversely affect aquatic species. In one study, weekly readings are taken from the same location in a river over a 2-month period.

Week	Dissolved O_2 (ppm)
1	4.9
2	5.1
3	5.6
4	4.3
5	4.7
6	4.9
7	4.5
8	5.1

Some scientists think that 5.0 ppm is a dissolved O_2 level that is marginal for fish to live. Conduct a statistical test to determine whether the mean dissolved O_2, concentration is less than 5.0 ppm at the 95% confidence level. [5 Marks]

b) Five analysts obtained the results (mmol Ca) shown in the following table for determining calcium by a volumetric method. Do the means differ significantly at the 95% confidence level?

Test Number	Analyst 1	Analyst 2	Analyst 3	Analyst 4	Analyst 5
1	10.3	9.5	12.1	9.6	11.6
2	9.8	8.6	13.0	8.3	12.5
3	11.4	8.9	12.4	8.2	11.4

(i) Calculate the means and standard deviations for each analyst. [5 Marks]
(ii) Calculate the grand mean of the data obtained [1 Mark]
(iii) The between-groups sum of the squares for (SSF). [1 Mark]
(iv) Calculate the error sum of squares (SSE) [1 Mark]
(v) Calculate the mean square values for factor (MSF) and for error (MSE) [2 Marks]
(vi) Calculate the F-value for the data obtained [1 Mark]
(vii) Do the means differ significantly at the 95% confidence level? [2 Marks]

IMPORTANT TABLES

Critical Values of F at the 5% Probability Level (95% confidence level)

Degrees of Freedom (Denominator)	Degrees of Freedom (Numerator)								
	2	3	4	5	6	10	12	20	∞
2	19.00	19.16	19.25	19.30	19.33	19.40	19.41	19.45	19.50
3	9.55	9.28	9.12	9.01	8.94	8.79	8.74	8.66	8.53
4	6.94	6.59	6.39	6.26	6.16	5.96	5.91	5.80	5.63
5	5.79	5.41	5.19	5.05	4.95	4.74	4.68	4.56	4.36
6	5.14	4.76	4.53	4.39	4.28	4.06	4.00	3.87	3.67
10	4.10	3.71	3.48	3.33	3.22	2.98	2.91	2.77	2.54
12	3.89	3.49	3.26	3.11	3.00	2.75	2.69	2.54	2.30
20	3.49	3.10	2.87	2.71	2.60	2.35	2.28	2.12	1.84
∞	3.00	2.60	2.37	2.21	2.10	1.83	1.75	1.57	1.00

Values of t for Various Levels of Probability

Degrees of Freedom	80%	90%	95%	99%	99.9%
1	3.08	6.31	12.7	63.7	637
2	1.89	2.92	4.30	9.92	31.6
3	1.64	2.35	3.18	5.84	12.9
4	1.53	2.13	2.78	4.60	8.61
5	1.48	2.02	2.57	4.03	6.87
6	1.44	1.94	2.45	3.71	5.96
7	1.42	1.90	2.36	3.50	5.41
8	1.40	1.86	2.31	3.36	5.04
9	1.38	1.83	2.26	3.25	4.78
10	1.37	1.81	2.23	3.17	4.59
15	1.34	1.75	2.13	2.95	4.07
20	1.32	1.73	2.09	2.84	3.85
40	1.30	1.68	2.02	2.70	3.55
60	1.30	1.67	2.00	2.62	3.46
∞	1.28	1.64	1.96	2.58	3.29

Critical Values for the Rejection Quotient, Q^*

Number of Observations	Q_{crit} (Reject if $Q > Q_{crit}$)		
	90% Confidence	95% Confidence	99% Confidence
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