

2411/304
CHEMICAL ANALYTICAL METHODS
AND BIOCHEMISTRY
June/July 2022
Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

CHEMICAL ANALYTICAL METHODS AND BIOCHEMISTRY

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:

Answer booklet;

Non-programmable scientific calculator.

This paper consists of TWO sections; A and B.

Answer ALL the questions in section A and any THREE questions from section B in the answer booklet provided.

Each question in section A carries 4 marks while each question in section B carries 20 marks.

Maximum marks for each part of a question are as indicated.

Candidates should answer the questions in English.

This paper consists of 6 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A (40 marks)

Answer ALL the questions in this section.

1. 5 cm^3 of a solution of an alcoholic beverage was titrated with 50 cm^3 of acidified $0.2\text{ M K}_2\text{Cr}_2\text{O}_7$ where oxidation occurred as shown by the equation below. Calculate percentage w/v of ethanol (f. wt = 46.07) in the alcoholic beverage. (4 marks)
$$2\text{Cr}_2\text{O}_7^{2-} + 3\text{CH}_3\text{CH}_2\text{OH} \longrightarrow 4\text{Cr}^{3+} + 3\text{CH}_3\text{COOH} + 11\text{H}_2\text{O}.$$
2. State **four** conditions necessary for analysis of a sample by titrimetry. (4 marks)
3. State **two** advantages and **two** disadvantages of gravimetry. (4 marks)
4. State **four** ideal characteristics of gravimetric precipitate. (4 marks)
5. 50 cm^3 of 0.8 M aluminium sulphate ($\text{Al}_2(\text{SO}_4)_3$) was passed through a catron exchange resin. Calculate the molarity of the acid formed. (4 marks)
6. Explain **two** advantages of reflux condensation. (4 marks)
7. Describe how amino-acids are separated during electrophoresis. (4 marks)
8. Using Fischer projection formulae, draw the structure and enantiomer of aldotriose: (4 marks)
9. Use the Zwitterion form of amino-acids to describe the formation of a dipeptide. (4 marks)
10. Describe **two** types of vitamins based on their solubility. (4 marks)

SECTION B (60 marks)

Answer any **THREE** questions from this section.

11. A peptide is hydrolysed to form a solution containing a mixture of amino acids. This mixture is then analysed by a silica gel thin layer chromatography (TLC) using a toxic solvent. The individual amino acids are identified from their R_f values.

Part of the practical procedure is as described below.

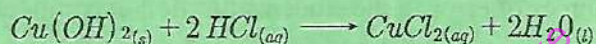
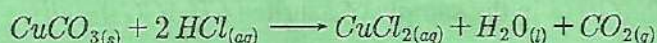
- (1) **Wearing plastic gloves to hold TLC plate**, draw a pencil line 1.5 cm from the bottom of the plate.
- (2) Use a capillary tube to apply a very small drop of the solution of amino acids to the mid point of the pencil line.
- (3) **Allow the spot to dry completely.**
- (4) In the development tank, add the developing solvent to a **depth of not more than 1 cm .**

- (5) Place the TLC plate in the development tank.
- (6) Allow the developing solvent to rise up the plate **to the top**.
- (7) Remove the plate and quickly mark the position of the solvent front with a pencil.
- (8) Allow the plate to dry in a **fume cupboard**.

- (a) Parts of the procedure are in bold text. For each of these parts consider whether it is essential and justify the answer. (10 marks)
- (b) Outline the steps needed to locate the positions of the amino acids on the TLC plate and determine the R_f values. (6 marks)
- (c) Explain why different amino acids have different R_f values. (4 marks)

12.

- (a) Verdigris is a green pigment that contains both copper (II) carbonate $CuCO_3$ and Copper (II) hydroxide $Cu(OH)_2$ in varying amounts. Both compounds react with dilute hydrochloric acid as per the following equations.



A student is required to plan an experiment to determine the percentage of $CuCO_3$ in a sample of Verdigris. The method should involve the reaction of Verdigris with excess dilute HCl. 0.494 g of Verdigris, 10.00 $mol\ dm^{-3}$ hydrochloric acid ($HCl_{(aq)}$) and the commonly available laboratory reagents and apparatus were provided.

- (ii) The student thinks that the 10.00 $mol\ dm^{-3}$ HCl is too concentrated for use in the experiment. Instead, a more dilute solution should be prepared. Describe how a 250.00 cm^3 of 0.500 $mol\ dm^{-3}$ hydrochloric acid may be prepared from the concentrated acid provided. (6 marks)
- (iii) The student thinks that their 0.494 g sample of Verdigris only contains $CuCO_3$. Calculate the minimum volume of 0.500 M HCl that would be required to completely react with the sample if the student is correct. ($CuCO_3 = 123.5$) (3 marks)

- (b) Azurite is a blue copper containing mineral. The copper component in azurite has the formula $Cu_3(CO_3)_2(OH)_2$. This copper compound reacts with dilute sulphuric acid. A student carried a series of titrations on 1.50 g samples of azurite using $0.400 \text{ mol dm}^{-3}$ sulphuric acid and bromothymol blue indicator. The titration data obtained is as shown in the table below.

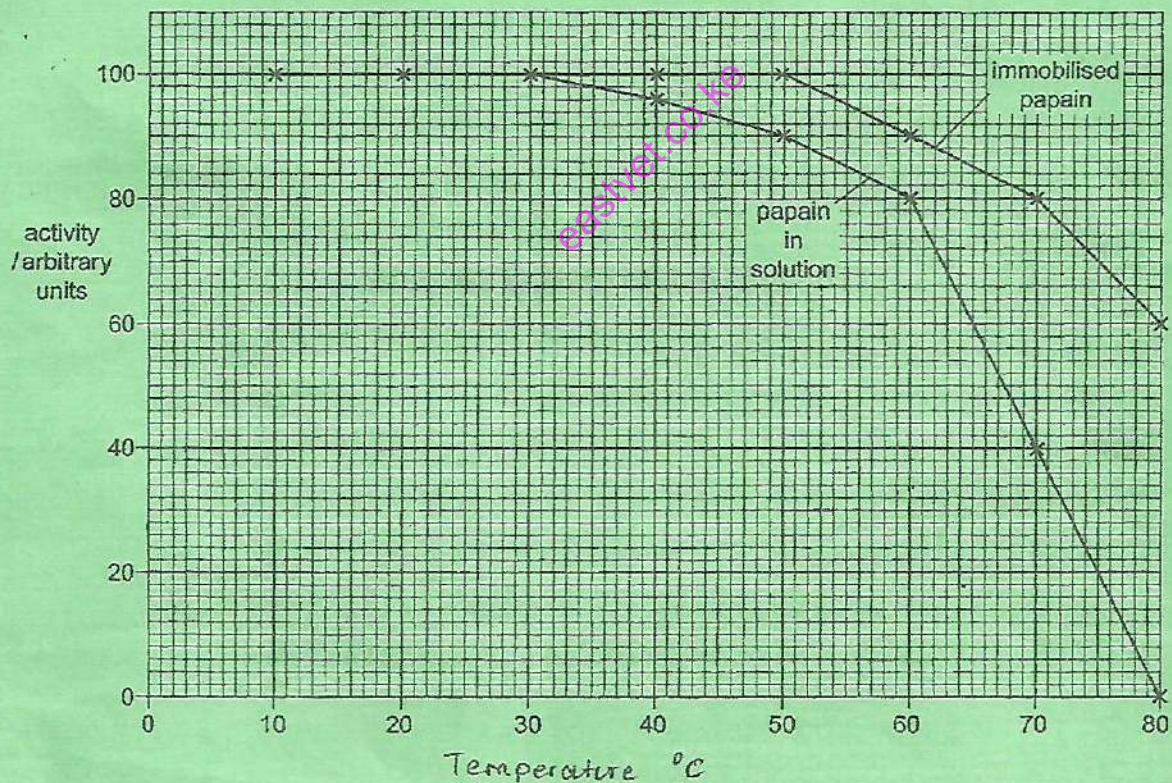
Titration	Rough	1	2	3
Final reading / cm^3	25.55	23.90	48.30	28.10
Initial reading / cm^3	0.00	0.00	23.90	3.95
Titre / cm^3				

- (i) Assuming that any other material in azurite does not react with sulphuric acid, complete the table. (2 mark)
- (ii) The student concluded that 24.15 cm^3 of $0.400 \text{ mol dm}^{-3}$ sulphuric acid completely reacts with 1.50 g of azurite. Calculate the percentage by mass of $Cu_3(CO_3)_2(OH)_2$ in the sample of azurite ($M_r = 344.5$). (5 marks)
- (c) Identify two possible sources of error in the student's titration experiment and suggest possible improvements. (4 marks)

13. A 1.06 g sample contains 75% potassium sulphate (f.wt = 174.25) and 25% MSO_4 . The sample is dissolved and the sulphate is precipitated as $BaSO_4$ (f.wt = 233.39) with a mass of 1.49 g.

- (a) Write equations for the reactions between Ba^{2+} and
- (i) MSO_4 ; (1 mark)
- (ii) K_2SO_4 . (1 mark)
- (b) Calculate the mass of each of the following in the sample:
- (i) Potassium sulphate; (1 mark)
- (ii) MSO_4 . (1 mark)
- (c) Determine the moles of each of the following in the sample:
- (i) K_2SO_4 ; (2 marks)
- (ii) MSO_4 . (2 marks)
- (d) Calculate moles of $BaSO_4$ formed from
- (i) MSO_4 ; (2 marks)
- (ii) K_2SO_4 . (2 marks)

- (e) Calculate the masses of $BaSO_4$ formed from
- MSO_4 ; (2 marks)
 - K_2SO_4 . (2 marks)
- (f) Calculate the total mass of $BaSO_4$. (2 marks)
- (g) Calculate the atomic mass of M. (2 marks)
- 14 (a) Define an immobilized enzyme. (1 mark)
- (b) State any **three** methods used for enzyme immobilization. (3 marks)
- (c) Describe how an enzyme can be immobilized in alginate. (2 marks)
- (d) State **four** advantages of using immobilized enzymes. (4 marks)
- (e) Papain is a protease enzyme. Its activity at different temperatures when immobilized into an inert support was compared with its activity in solution. The results are shown in the graph below.



Explain the difference in activity of immobilized papain and papain in solution.

(4 marks)

- (f) Explain the effects of high substrate concentration $[S]$ in:
- reversible competitive inhibitors; (3 marks)
 - reversible non - competitive inhibitors. (3 marks)

15. (a) Define each of the following:
- (i) saponification number; (1 mark)
 - (ii) iodine number. (1 mark)
- (b) A 250 mg of sample of oil required 47.5 mg of KOH for complete saponification. Calculate the average RMM of the triglycerides in the oil. (7 marks)
- (c) The oil described in (b) was reacted with iodine. Exactly 578 mg of I_2 were absorbed by 680 mg of the oil. Explain the average number of double bonds present in the molecule of triglyceride. (7 marks)
- (d) (i) Give the name of the fatty acid from the following notation
- $20:4 (\Delta^{5,8,11,14})$ (1 mark)
- (ii) List **three** derivatives of the fatty acid named in (d) (i). (3 marks)

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