2411/304
CHEMICAL ANALYTICAL METHODS
AND BIOCHEMISTRY
June/July 2020
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

CHEMICAL ANALYTICAL METHODS AND BIOCHEMISTRY

3 hours

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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 5 printed pages.

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

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SECTION A (40 marks)

*Answer **ALL** questions in this section.*

1. Explain the disadvantage of soxhlet extraction technique. (4 marks)

2. 50 cm^3 of 0.5 M $AgNO_3$ was mixed with excess KCl. Calculate the mass of the precipitate formed (F.wt of AgCl = 143.4531). (4 marks)

3. State **four** factors which affect efficiency in column chromatography. (4 marks)

4. 25 cm^3 of a sample containing 4 g/L of acidified $KMnO_4$ reacted completely with 28.5 cm^3 of 0.05 M AR potassium dichromate. Calculate the percentage purity of the sample. $(KMnO_4 = 158\, g\, mol^{-1})$. (4 marks)

5. State **four** industrial applications of ion-exchange chromatography. (4 marks)

6. 250 cm^3 of an aqueous solution containing 50 g of iodine was mixed with 100 cm^3 of chloroform at a certain temperature. Calculate the minimum number of extractions required to achieve an extraction efficiency of 0.85. $(K_D = 10)$. (4 marks)

7. (a) Define primary standard as used in titrimetry. (1 mark)

   (b) State **two** characteristics of a primary standard. (2 marks)

   (c) Give **two** examples of primary standards used in acidimetry. (1 mark)

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8. Describe the structural differences and similarities between each of the following pairs of polysaccharides:

   (a) glycogen and amylopectin; (2 marks)

   (b) amylose and cellulose. (2 marks)

9. Name the amino acid whose side chain containts:

   (a) an aromatic group; (1 mark)

   (b) the element sulfur; (1 mark)

   (c) a carboxyl group; (1 mark)

   (d) a hydroxyl group. (1 mark)

10. Draw the structure of each of the following:

(a) an amino acid with the simplest R-group; (1 mark)

(b) a mixed triglyceride containing two moles of palmitic acid and one mole of oleic acid; (1 mark)

(c) the zwitterion of glutamic acid; (1 mark)

(d) the D-aldose with the least number of carbon atoms. (1 marks)

SECTION B (60 marks)

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

11. (a) Derive the mathematical expression for determining the amount of solute extracted in five extractions stages, defining all the terms used. (13 marks)

(b) A sample contains 100 g of a solute in 400 cm^3 of solvent. If 200 cm^3 of the extracting solvent was used, calculate the amount of solute extracted in five extractions given that $K_D = 25$. (5 marks)

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(c) Explain **two** disadvantages of extracting with a light solvent. (2 marks)

12. (a) (i) Write the acronym PFHS in full. (1 mark)

(ii) State **three** advantages of PFHS. (3 marks)

(iii) Using chemical equations, describe the precipitation of $Fe(OH)_3$ by the method of PFHS. (4 marks)

(b) 48.8 g of a mixture containing aqueous solutions of aluminium sulphate $(f.wt = 342)$ and sodium sulphate $(f.wt = 142)$ only precipitated 93.32 g of barium sulphate $(f.wt = 233.3)$. Calculate the mass of each salt in the mixture. (12 marks)

13. (a) (i) State the difference between iodometry and iodimetry as used in redox titrations. (2 marks)

(ii) Explain why in iodometry, excess acidified KI is used. (5 marks)

(b) In water treatment plants, water may be chlorinated during the purification process.

(i) State the purpose of chlorinating water. (1 mark)

(ii) In a water treatment plant, 25 cm^3 of a chlorinated water sample was mixed with excess acidified KI. 50 cm^3 of 0.05 M $Na_2S_2O_3$ was added to the reaction mixture and the excess $Na_2S_2O_3$ was back-titrated with 5.1 cm^3 of 0.001M $I^-_{3(aq)}$. Calculate the concentration of chlorine in the water sample in ppm. (Cl = 35.5). (12 marks)

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

Part of the practical procedure is given below:

- **Wearing plastic gloves to hold a TLC plate,** draw a pencil line 1.5 cm from the bottom of the plate.
- Use a capillary tube to apply a very small drop of the solution of amino acids to the mid-point of the pencil line.
- Allow the spot to dry completely.
- In the developing tank, add a developing solvent **to a depth of not more than 1 cm.**
- Place the TLC plate in the developing tank.
- Allow the developing solvent to rise up the **plate to the top.**
- Remove the plate and quickly mark the position of the solvent front with a pencil.
- Allow the plate to dry **in a fume cupboard.**

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(i) Parts of the practical procedure are bolded. For each of these parts, explain whether it is essential or not giving reason. (8 marks)

(ii) Outline the steps needed to locate the positions of the amino acids on the TLC plate and to determine their R_f values. (4 marks)

(iii) Explain why different amino acids have different R_f values. (2 marks)

(b) Identify the type of lipid that fits each of the following structural component characterizations:

(i) sphingosine + fatty acid + phosphoric acid + choline; (1 mark)
(ii) glycerol + 3 fatty acids; (1 mark)
(iii) fused ring system with three 6-membered rings and one 5-membered ring. (1 mark)
(iv) 20 carbon fatty acid + 3 conjugated double bonds. (1 mark)
(v) 20 carbon fatty acid + cyclopentane ring. (1 mark)
(vi) sphingosine + fatty acid + monosaccharide. (1 mark)

15. The activity of trypsin can be determined experimentally by measuring the rate at which amino acids are formed by the hydrolysis of a protein such as albumin. An experiment was carried out to investigate the effect of trypsin concentration on its activity. Two solutions of trypsin **A** and **B** of differing concentrations were incubated with a dilute albumin solution. The concentration of amino acids produced was measured every two minutes for fourteen minutes. The results were presented as shown in table 1.

Table 1: Concentration of amino acids produced (μmol/dm^3)

Time (min.)	Trypsin Solution A	Trypsin Solution B
0	0.2	0.2
2	1.2	0.4
4	2.3	0.7
6	3.4	1.0
8	4.4	1.2
10	5.3	1.3
12	6.2	1.4
14	7.1	1.5

(a) On the same axis, plot a graph of the concentrations of amino acids produced against time. (8 marks)

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(b) Determine the mean rate of amino acid production in solution **A** between 3 and 11 minutes. (3 marks)

(c) (i) Identify giving a reason the solution which contained the highest concentration of trypsin. (2 marks)

(ii) State **two** conditions which should have been kept constant in this experiment and in each case state how. (4 marks)

(d) State **three** commercial applications of protease enzymes. (3 marks)

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