2411/304
CHEMICAL ANALYTICAL METHODS
AND BIOCHEMISTRY
Oct./Nov. 2017
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**.*
*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 indicated.
Candidates should answer the questions in English.

This question paper consists of 5 printed pages.

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

SECTION A (40 marks)

Answer ALL the questions in this section.

1. State any **four** characteristics of an ideal ion exchange resin. (4 marks)

2. (a) Explain the meaning of the following terms as used in column chromatography:

   (i) theoretical plate; (1 mark)
   (ii) plate height. (1 mark)

   (b) A solute took 23.80 minutes to elute through a 90 cm long column and its base width was 7.25 minutes. Estimate the efficiency of the column. (2 marks)

3. A 0.1045 g sample of a copper ore, malchite, was digested with 50 cm^3 of dilute hydrochloric acid and after filtration, the filtrate was mixed with 250 cm^3 of 0.1 M EDTA. The excess EDTA in 20 cm^3 of the reaction mixture was back-titrated with 3.1 cm^3 of 0.02 M $MgSO_4$ solution. Determine the concentration of copper in the ore in ppm. (Al = 63.5) (4 marks)

4. A 101.3 mg sample of an organic compound known to contain chloride was burned in pure oxygen and the products collected in absorbent tubes. The tube for CO_2 increased its mass by 167.6 mg and the tube for H_2O showed an increase of 13.7 mg. A second sample of 121.8 mg was treated with concentrated HNO_3 to produce chlorine gas which was reacted with Ag^+ to form 262.7 mg of AgCl. Determine the empirical formula of the organic compound.

   (AgCl = 143.32; CO_2 = 44.011; H_2O = 18.015; C = 12.011; H = 1.008; Cl = 35.453)

   (4 marks)

5. Derive the equation for the fraction of solute remaining in aqueous phase after *n* extractions, using the following notations:

   D - partition coefficient.
   $[S_{org}]$ - solute concentration in organic phase after one extraction.
   $[S_{aq}]$ - solute concentration in aqueous phase after one extraction.
   $(moles_{aq})_0$ - original moles of solute in aqueous phase.
   $(moles_{aq})_1$ - moles of solute in aqueous phase after one extraction.
   $(moles_{org})_1$ - moles of solute in organic phase after one extraction.
   V_{aq} - volume of aqueous solvent.
   V_{org} - volume of organic solvent.
   $(q_{af})_1$ - fraction of solute in aqueous phase after one extraction. (4 marks)

6. An analysis to determine the concentration of copper in an industrial plating bath uses a filtration method in which zinc is an interferent. When a sample containing 128.6 ppm copper was passed through the filtration process to remove zinc, the concentration of copper remaining was 127.1 ppm. When a 134.9 ppm solution containing zinc was carried through the filtration process, a concentration of 4.3 ppm remained in the filtrate.

(a) Calculate the recoveries of:

(i) copper; (1 ½ marks)
(ii) zinc. (1 mark)

(b) Determine the separation factor between zinc and copper. (1 ½ marks)

7. (a) Describe two-dimensional paper chromatography. (2 ½ marks)

(b) Explain the condition for application of two - dimensional paper chromatography in a separation process. (½ mark)

(c) Identify any **two** other paper chromatographic methods of analysis. (1 mark)

8. Explain why an equimolar mixture of D-glucose and D-fructose formed by hydrolysis of sucrose is called 'invert-sugar' in the food industry. (4 marks)

9. Consider the molecular components; glycerol, fatty acid, phosphate, long chain alcohol and carbohydrate:

(a) Name **two** components that are present in both waxes and sphingomyelin; (2 marks)

(b) Name **two** components that are present in both fats and phosphatidyl cholines. (1 mark)

(c) Name **one** component present in a ganglioside but not in fat. (1 mark)

10. Describe the induced - fit model of enzyme action. (4 marks)

SECTION B (60 marks)

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

11. (a) State the partition law. (1 mark)

(b) The following results were obtained in an experiment carried out in order to determine the partition coefficient of ammonia between water and chloroform. ($CHCl_3$). 100 cm^3 of an aqueous layer required 43.2 cm^3 of 0.250 M HCl for complete neutralization while 25.00 cm^3 of the chloroform layer required 21.6 cm^3 of 0.05 M HCl for complete neutralization.

(i) Calculate the partition coefficient of ammonia between water and chloroform. (12 marks)

(ii) Explain why ammonia is much more soluble in water than in chloroform. (3 marks)

(iii) Indicate **three** instances when the partition law is not obeyed. (3 marks)

(c) State **two** applications of solvent extraction. (1 mark)

12. (a) List **seven** properties of the washing liquids used for washing of precipitates. (7 marks)

(b) A 0.6447 g sample of manganese dioxide (MnO_2) was added to an acidic solution in which 1.1402 g of a chlorine containing sample was dissolved. Evolution of chlorine gas took place as a result of the following reaction:

$$MnO_{2(s)} + 2Cl^-_{(aq)} + 4H^+_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$$

After the reaction was complete, the excess MnO_2 was collected by filtration, washed, dried and was found to weigh 0.3521 g. Calculate the percentage w/w of aluminium chloride in the sample.
(Al = 27, Cl = 35.5, Mn = 55, O = 16) (13 marks)

13. (a) Explain **three** advantages of titrimetry as a method of analysis. (6 marks)

(b) The ethylacetate concentration in an alcoholic beverage was determined by diluting a 10.00 cm^3 aliquot to exactly 100.00 cm^3. A 20.00 cm^3 portion of the diluted sample was refluxed with 40.00 cm^3 of 0.04672 M KOH;

$$CH_3COOCH_2CH_3 + OH^- \rightarrow CH_3COO^- + CH_3CH_2OH$$

After cooling, the excess KOH was titrated with 3.41 cm^3 of 0.05042 M H_2SO_4;

(i) Calculate the percentage w/v of ethylacetate per 100.00 cm^3 of the original sample. (f.wt of ethyl acetate = 88) (9 marks)

(ii) Explain why back-titration was used in this experiment. (2 marks)

(iii) Identify any **three** other titrimetric methods of analysis. (3 marks)

14. (a) According to the international union of biochemists' regulations, enzymes are categorized into six major classes. Name the class for the enzyme catalysing each of the following reactions:

(i) $CH_3CHOHCOOH + NAD^+ \rightarrow CHCOCOOH + NADH|H^+$

(ii) Glyceraldehyde + ATP → Glyceraldehyde-3-phosphate + ADP

(iii) Tripalmitin + H_2O → Glycerol + palmitic acid

(iv) Glucose ⟷ fructose. (4 marks)

(b) Alcohol dehydrogenase catalyses the conversion of ethanol to acetaldehyde. This enzyme in its active state, consists of a protein molecule and a zinc ion. On the basis of this information, identify the following for this chemical system:

(i) substrate;
(ii) cofactor;
(iii) apoenzyme;
(iv) holoenzyme. (4 marks)

(c) What is the difference between the following types of enzymes?

(i) apoenzyme and proenzyme;
(ii) simple enzyme and allosteric enzyme;
(iii) coenzyme and isoenzyme;
(iv) conjugated enzyme and holoenzyme. (8 marks)

(d) Give the name of substrate on which each of the following enzymes act:

(i) pyruvate carboxylase;
(ii) alcohol dehydrogenase;
(iii) L-amino acid reductase;
(iv) succinate dehydrogenase. (4 marks)

15. (a) Predict the direction of movement of each of the following amino acids in a solution at the pH value specified:

(i) alanine at pH = 12;
(ii) valine at pH = 12;
(iii) aspartic acid at pH = 7;
(iv) arginine at pH = 7. (4 marks)

(b) Draw the structures of the following fatty acids:

(i) 16:1;9
(ii) 18:2;9,12
(iii) 18:1;9
(iv) 18:3;9,15,15 (4 marks)

(c) Draw the structure and name the triglyceride formed from:

(i) the fatty acid in (b)(iii) above; (3 marks)
(ii) the saturated form of the fatty acid in (b)(i) above. (3 marks)

(d) Name the type of lipid categories under the following main groups:

(i) phospholipids; (3 marks)
(ii) phosphoglycerides. (3 marks)

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