2528/304
2922/304
ENVIRONMENTAL ANALYTICAL TECHNIQUES
Oct./Nov. 2018
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY

MODULE III

ENVIRONMENTAL ANALYTICAL TECHNIQUES

INSTRUCTIONS TO CANDIDA

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 shown.
Candidates should answer the questions in English.

This paper consists of 4 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 the questions in this section.

1. Define the following terms as used in redox titration:

   (a) standardization; (2 marks)

   (b) reducing agent. (2 marks)

2. With the aid of a chemical equation, explain the limitation of using a freshly prepared solution of potassium permanganate as a primary standard. (4 marks)

3. Describe any **two** conditions that must be met for a complexation reaction to be used as a volumetric technique. (4 marks)

4. Explain the importance of adding sodium hydroxide solution during the preparation of ethylenediaminetetraacetic acid (EDTA). (4 marks)

5. Distinguish between precipitation and volatilization gravimetric methods. (4 marks)

6. Write a mathematical expression for the solubility product of the sparingly soluble salt $Ba(IO_3)_2$. (4 marks)

7. State **four** properties of a good precipitate in gravimetric analysis. (4 marks)

8. Draw a labelled structure of a colloidal precipitate of silver chloride. (4 marks)

9. Explain the significance of digesting precipitates during gravimetry. (4 marks)

10. Use a thermogravimetric diagram to illustrate the ignition of a precipitate with formula $CaC_{14}H_{10}O_8.H_2O$. (4 marks)

SECTION B (60 marks)

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

11. (a) In titration, 15.50 mL of 0.0484 M standard solution of potassium permanganate required 25.00 mL of Iron (II) Sulphate solution to reach end point.

(i) Write the balanced redox equation for the reaction. (4 marks)

(ii) Calculate the number of moles of the Iron (II) solution. (6 marks)

(b) (i) Outline the preparation of a 0.0167 M potassium dichromate solution. (4 marks)

(ii) Outline the steps taken in standardizing the potassium dichromate solution prepared in b (i). (6 marks)

12. (a) Define complexometric titrations. (2 marks)

(b) Compare the stabilities of the complexes formed in the following reactions:

$$Ag^{+} + 2NH_3 \rightleftharpoons Ag(NH_3)_2$$

$$Co^{3+} + 6NH_3 = [Co(NH_3)_6]^{3+}$$

(5 marks)

(c) Outline the steps used in:

(i) preparing a 0.1 M solution of silver nitrate (Ag = 107.9, Cl = 35.5); (4 marks)

(ii) standardizing the solution prepared in c (i). (6 marks)

(d) Explain the significance of stability in relation to the bond formed between the metal and the indicator in EDTA titrations. (3 marks)

13. (a) State any **four** types of co-precipitation in gravimetry. (4 marks)

(b) (i) Explain the effect of solubility of precipitates on the crystal size in gravimetric analysis. (4 marks)

(ii) Write a mathematical expression for the relative supersaturation term. (4 marks)

(c) Differentiate between lyophilic and lyophobic colloids in terms of the following:

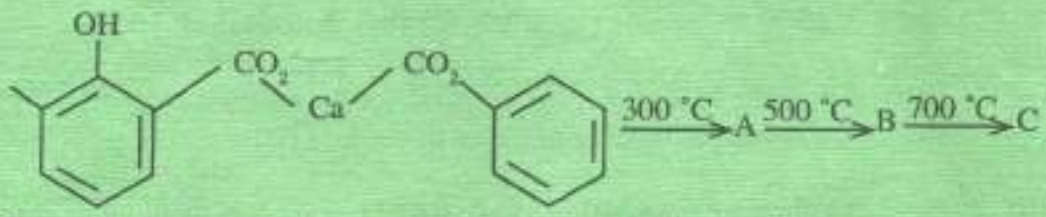
(i) size of particles; (2 marks)

(ii) stability of solution. (2 marks)

(d) List any **four** techniques used to minimize the adsorption of contaminants on a colloidal precipitate. (4 marks)

14. (a) (i) Distinguish between drying and ignition as used in gravimetric analysis. (4 marks)

(ii) Write the formulae of the compounds labelled **A**, **B** and **C** in the following ignition scheme. (3 marks)



(b) Determine the amount (in grams) of barium iodate ($Ba(IO_3)_2$) dissolved in 500 mL water at 25 °C ($Ksp = 1.57 \times 10^{-9}$). (6 marks)

(c) A 0.8870 g sample composed of NaCl and KCl was reacted with $AgNO_3$ solution to precipitate AgCl. If the precipitate formed weighed 1.913 g, determine the percent of potassium, K, in the sample. (7 marks)

15. (a) Define the term heat of combustion. (2 marks)

(b) Consider the following chemical equation

$$CO_{2(g)} \longrightarrow C_{(s)} + O_{2(g)} \quad (\Delta H_f^{\circ}(CO_2) = -393.5\ kJ/mol)$$

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(i) Determine the enthalpy change. (3 marks)

(ii) Deduce the type of reaction in b (i). (1 mark)

(c) Distinguish between heat capacity and specific heat capacity. (4 marks)

(d) (i) Determine the standard enthalpy change for the photosynthetic reaction given by the equation $6CO_{2(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6(s)} + 6O_{2(g)}$. (6 marks)

$\Delta H_f^{\circ}(CO_2) = -393.5\ kJ/mol$; $\Delta H_f^{\circ}(H_2O) = -285.83\ kJ/mol$;

$\Delta H_f^{\circ}(C_6H_{12}O_6) = -1273.02\ kJ/mol$

(ii) State whether the reaction in d (i) is exothermic or endothermic. (1 mark)

(e) An alloy of copper weighing 4 kg with a specific heat capacity of 400 J/kg K initially at 91 °C was immersed in water at 20 °C. If the final temperature was 21 °C, determine the mass of the water (specific heat capacity of water is 4200 J/kg K). (3 marks)

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