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ENVIRONMENTAL ANALYTICAL TECHNIQUES AND  
LABORATORY MANAGEMENT

June/July 2017

Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY

MODULE II

ENVIRONMENTAL ANALYTICAL TECHNIQUES AND LABORATORY MANAGEMENT

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 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.**



SECTION A (40 marks)

Answer ALL questions from this section.

1. Explain using potassium dichromate solution the fact that a titrant can serve as its own indicator in redox titration. (4 marks)
2. Determine the concentration of cerium (IV) solution if 50.0 mL of 0.100 M iron (II) solution required exactly 40.0 mL of cerium (IV) solution to reach end point. (4 marks)
3. (a) State the consequence of forming a strong metal-indicator complex on the end point of a complexometric titration. (2 marks)  
(b) Name any two metallochromic indicators used in complexometric titrations. (2 marks)
4. Explain the influence of relative supersaturation (RSS) on the crystal size in a precipitation reaction. (4 marks)
5. The chlorine in a mineral sample was initially converted to chloride and then precipitated as silver chloride. Calculate the weight (in grams) of chlorine if 0.75 g of silver chloride was obtained from the sample. (Cl = 35.45; AgCl = 107.87) (4 marks)
6. Determine the amount of energy (in kCal.) released when 46 g of ethanol is completely combusted in excess air. (4 marks)  
( $\Delta H_{\text{combustion}} = -67 \text{ kCal./Mol}$ ;  $\Delta H_{\text{CO}_2(g)} = -94 \text{ kCal./Mol}$ ;  $\Delta H_{\text{H}_2\text{O}(l)} = -68 \text{ kCal./Mol}$ )
7. Classify Maslow's hierarchy of needs into lower and higher order needs. (4 marks)
8. List any four characteristics of management by objectives (MBO). (4 marks)
9. Explain the benefits of the scientific management approach to an organization. (4 marks)
10. Differentiate between formal organization and informal organization. (4 marks)

SECTION B (60 marks)

Answer any THREE questions from this section.

11. (a) List three factors that affect the sharpness of the equivalence point in a calcium - ethylene diaminetetraacetic acid (EDTA) titrations. (3 marks)  
(b) Draw the structure of a six coordinate metal - EDTA complex of nickel (II). (5 marks)





(c) In the analysis of total chlorine residual in municipal water, a sample of the water was acidified with glacial acetic acid to a pH value of 3 then 1 g potassium iodide (KI) added. The resultant solution was titrated with sodium thiosulphate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) until the yellow colour of triiodide ion ( $\text{I}_3^-$ ) began to fade. 1 mL of a starch solution was then added and titration continued until the blue colour of the starch- $\text{I}_3^-$  complex disappeared. Finally, a blank titration was used to correct the volume of the titrant needed to reach end point for reagent impurities.

- Name any four forms of chlorine residuals that can be present in the water sample. (4 marks)
- Explain the importance of using the indirect method instead of directly titrating the chlorine - containing species with KI as a titrant. (4 marks)
- Explain the effect of oxidizing and reducing agents as interferences on total chlorine residual. (4 marks)

12. (a) State four factors that promote formation of large silver chloride ( $\text{AgCl}$ ) crystals in a precipitation reaction. (4 marks)
- (b) Outline the process used to ensure that a precipitate with chloride absorbed impurities is not over rinsed. (5 marks)
- (c) Match the analyte with the appropriate precipitant shown in Table 1. (5 marks)

Table 1

Analyte	Precipitant
$\text{Ba}^{2+}$	$\text{H}_2\text{SO}_4$
$\text{Fe}^{3+}$	HCL
$\text{Pb}^{2+}$	$(\text{NH}_4)_2\text{HPO}_4$
$\text{Hg}^{2+}$	$(\text{NH}_4)_2\text{CrO}_4$
$\text{Zn}^{2+}$	$\text{NH}_4\text{OH}$

(d) Use a labelled experimental set-up to illustrate transfer of the supernatant solution to the filter paper cone in filtration of precipitates. (6 marks)

13. (a) Write a mathematical expression for the gravimetric factor (GF). (2 marks)

(b) Orthophosphate ( $\text{PO}_4^{3-}$ ) is determined by weighing as ammonium phosphomolybdate,  $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MOO}_3$ . If 2.322 g precipitate was obtained from a 0.369 g sample, determine:

- the percent P in the sample; (4 marks)
- the percent  $\text{P}_2\text{O}_5$  in the sample. (4 marks)





- (c) Precipitation of  $Ni^{2+}$  in a water sample using dimethylglyoxime precipitant also forms precipitates of  $Pd^{2+}$  as potential interferents.
- (i) explain the type of impurity caused by  $Pd^{2+}$  precipitation. (4 marks)
  - (ii) describe the most effective method of correcting the problem in (i) above. (3 marks)
- (d) A 50.0 mL sample of tap water was filtered through a pre-weighed glass fibre filter and after drying to constant weight at 105 °C, the filter weighed 0.0658 g more. Determine the amount of total suspended solids in parts per million. (3 marks)
14. (a) State five reasons of planning as a critical element of good management in an organization. (5 marks)
- (b) (i) Explain why cybernetic control system is better than other control systems in an organization. (3 marks)
- (ii) Describe the principle of preventive control system. (2 marks)
- (c) Outline the steps involved in recruitment of staff by a newly established organization. (5 marks)
- (d) State five merits of adopting democratic leadership style by an organization. (5 marks)
15. (a) A large Chemical and Laboratory equipment supplier with many branches handles all its purchase procedures at the headquarters. List any six merits of using this approach. (6 marks)
- (b) Describe any five measures that a factory laboratory should implement in order to minimize accidents in their materials store. (10 marks)
- (c) (i) Differentiate between centralized and decentralized storage systems. (2 marks)
- (ii) State any two disadvantages of using centralized storage systems in an organization. (2 marks)

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