2915/105
PHYSICAL CHEMISTRY I AND
CHEMICAL ANALYTICAL METHODS I
June/July 2023
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

MODULE I

PHYSICAL CHEMISTRY I AND CHEMICAL ANALYTICAL METHODS I

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
Answer booklet;
Scientific calculator.
*This paper consists of **TWO** sections; **A** and **B**.*
*Answer **ALL** questions in section **A** and **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 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. (a) State qualitatively the pH of an aqueous solution of ammonium chloride. (1 mark)

   (b) Using an equation, explain the answer in (a) above. (3 marks)

2. 1.00 g of AR potassium iodate was mixed with excess of acidified potassium iodide in a 250 cm^3 volumetric flask and topped upto the mark with water. A 25.00 cm^3 aliquot of the reaction mixture required 16.20 cm^3 of sodium thiosulphate to reach the starch indicator end-point. The equation of the reaction taking place during the titration is

   $$2Na_2S_2O_3 + I_{2(aq)} \longrightarrow Na_2S_4O_{6(aq)} + 2NaI_{(aq)}$$

   (RFM of potassium iodate = 214).

   Calculate the molarity of the sodium thiosulphate solution. (4 marks)

3. List **four** methods of collecting samples for analysis in a chemistry laboratory. (4 marks)

4. State **four** reasons of sampling in analytical chemistry. (4 marks)

5. Calculate the pH of 0.008 M HCOOH.
   (PKa = 3.75) (4 marks)

6. The vapour pressure of pure water at 96°C is 7.44 mm Hg. When 0.8 g of an organic solute was dissolved in 180 g of water at the same temperature, the vapour pressure of the solution was 639 mm Hg. Estimate the formula mass of the organic solute. (4 marks)

7. A sample of concentrated sulphuric acid has the following information on the label of the container.

M.wt	98.07
Assay	98
Specific gravity	1.94
SO_4^{2-}	0.02
PO_4^{3-}	0.03

   Calculate the molarity of the acid. (4 marks)

8. When 2.56 g of sulphur was dissolved in 100 g of carbon disulphide (CS_2), the freezing point was lowered by 0.383 K.
   Calculate the value of x in Sx.

   ($S = 32$, $K_f = 3.83\ Kgmol^{-1}K^{-1}$) (4 marks)

9. A 10% solution by mass of sucrose in water has a freezing point of 269.1 K. Calculate the freezing point of a 10% by mass solution of glucose in water if pure water freezes at 273.1 K. (Sucrose = 342, glucose = 180). (4 marks)

10. Name **four**:

(a) concentration units used in analytical chemistry. (2 marks)

(b) sample pre-treatment methods used in analytical chemistry. (2 marks)

SECTION B (60 marks)

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

11. (a) (i) Draw a labelled diagram of the vapour pressure osmometer. (8 marks)

(ii) Describe how the vapour pressure osmometer functions. (8 marks)

(b) A complex plant sugar, a polysaccharide, develops an osmotic pressure of 7100 Pa at 27°C, when a solution of concentration 5.0 gdm^{-3} was investigated by the Berkeley and Hartley method. Calculate the number of simple sucrose units $C_{12}H_{22}O_{11}$ in each molecule of the polysaccharide. (4 marks)

12. (a) Define the following terms as used in complexometric titrations.

(i) masking agent; (1 mark)

(ii) de-masking agent. (1 mark)

(b) Give **one** example of:

(i) masking agent; (1 mark)

(ii) de-masking agent. (1 mark)

(c) Chromel is an alloy of nickel, iron and chromium. A 0.6472 g sample was dissolved and diluted to 250 cm^3. When a 50.00 cm^3 aliquot of 0.05180 M EDTA was mixed with an equal volume of diluted sample, all the three ions were complexed and 5.11 cm^3 back titration with 0.06241 M $CU^{2+}_{(aq)}$ was required. The chromium in a second 50.00 cm^3 aliquot was masked with addition of hexamethlenetetramine. Titration of the nickel and iron required 36.28 cm^3 of 0.05182 M EDTA . Iron and chromium were masked with pyrophosphate in a third 50.00 cm^3 aliquot and the nickel was titrated with 25.91 cm^3 of the 0.05182 M EDTA. Calculate the % w/w of each metal in the sample (Fe = 56, Cr = 52, Ni = 59) (16 marks)

13. The data in table **I** was obtained in an experiment to determine the amount of phosphate nutrients in soil samples in mg/1000 g.

Table I

Sample	Concentration of PO_4^{3-} in mg/100 g
1	22.8
2	28.1
3	33.5
4	19.2
5	18.3
6	23.8
7	30.8
8	31.1
9	26.7
10	17.3
11	18.9
12	28.3

Calculate the:

(a) mean; (2 marks)

(b) standard deviation; (16 marks)

(c) standard error. (2 marks)

14. A sample of concentrated hydrochloric acid has the following information on a label on the container.

M.wt	36.45
Assay	70
Specific gravity	1.14
Chlorides	0.05
Sulphates	0.01
Metal ions	0.01

Calculate the:

(a) molarity of the acid; (4 marks)

(b) Describe the preparation of 250 cm^3 of 2 M HCl from the concentrated sample. (11 marks)

$M = \frac{m_{gm} \times V}{Mw \times 1000}$

(c) Describe the preparation of 5 litres of dilute HCl of pH = 1 from the sample in (b) above. (5 marks)

15. (a) One of the raw materials used in the manufacture of soap is glycerol palmitate.

(i) Name **two** other raw materials used in the manufacture of soap. (2 marks)

(ii) Explain the function of each of the raw materials named in (a) above. (6 marks)

(b) Explain the functions of each of the following additions in soap.

(i) perfumes; (2 marks)

(ii) polyphosphates; (2 marks)

(iii) sodium silicate; (2 marks)

(iv) antibiotics; (2 marks)

(v) colourants. (2 marks)

(c) Explain **one** disadvantage of soaps . (2 marks)

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