2915/105
PHYSICAL CHEMISTRY I AND CHEMICAL ANALYTICAL METHODS I
June/July 2021
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) Define a primary standard as used in titrimetry. (1 mark)

   (b) State **three** properties of a primary standard. (3 marks)

2. Explain why potassium dichromate is preferred to potassium permanganate in redox titrates. (4 marks)

3. To determine the percentage of sodium hydrogen carbonate in a sodium carbonate sample, 15.0 g of sample was dissolved in one litre of solution using distilled water. 25 cm^3 of this solution required 11.8 cm^3 of 0.1 M hydrochloric acid for phenolphthalein to change its colour. A second sample of 25 cm^3 required 36.9 cm^3 of the hydrochloric acid for methyl orange to change its colour. Calculate the percentage of sodium hydrogen carbonate in the sample. (Na = 23, C = 12, O = 16, H = 1) (4 marks)

4. Describe the preparation of 100 cm^3 of 6.0 M hydrochloric acid from a concentrated solution that has a specific gravity of 1.18 g/cm^3 and is 37% w/w hydrochloric acid. (fw = 36.5 g) (4 marks)

5. (a) State the difference between accuracy and precision. (2 marks)

   (b) State **two** sources of determine errors. (2 marks)

6. (a) Define the following terms as used in colligate properties of matter:

   (i) cryoscopic constant; (1 mark)
   (ii) molarity. (1 mark)

   (b) A solution of glucose containing 18 g/l had an osmotic pressure of 2.39 atmospheres at 25°C. Calculate the molecular weight of glucose. (2 marks)
   (R = 0.0821 L atm)

7. Explain why the solubility product principle does not apply to either sodium hydroxide or benzoic acid. (4 marks)

8. List **four** industrial applications of ionic equilibrium. (4 marks)

9. (a) Potassium dichromate can be used as an indicator for titration involving chloride solutions and silver nitrate solutions. The end point is determined when a red precipitate of silver chromate is not precipitated until the end point is reached. (2 marks)

   (b) Calculate the solubility of silver chloride in 0.1 M NaCl solution ($K_{sp} = 1.8 \times 10^{-10}$) (12 marks)

10. Benzoic acid, C_6H_5COOH is a weak monobasic acid, $K_a = 6.4 \times 10^{-5}$ mol/dm^3. Explain how a mixture of benzoic acid and sodium benzoate can act as a buffer on the addition of small amounts of either $HCl_{(aq)}$ or $NaOH_{(aq)}$. (4 marks)

SECTION B (60 marks)

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

11. (a) Distinguish between a chemical sample and a statistical sample. (2 marks)

(b) The following results were obtained from the determination of iron in aqueous samples of a standard solution containing 20.00 ppm of iron II.

19.8, 20.1, 19.6, 19.4, 20.3, 19.4

(i) Explain why it was necessary to carry out the experiment six times instead of once. (2 marks)

(ii) From the given data, calculate the:

I. mean; (2 marks)

II. median; (2 marks)

III. standard deviation. (12 marks)

12. (a) Define the following terms as used in complex metric titrations:

(i) masking; (1 mark)

(ii) de-masking. (1 mark)

(b) A 0.4085 g sample containing lead, magnesium and zinc was dissolve and treated with excess cyanide to complex and mask the zinc.

$$Zn^{2+}_{(aq)} + 4CN^-_{(aq)} \longrightarrow Zn(CN)^{2-}_{4(aq)}$$

Titration of the lead and magnesium required 42.22 cm^3 of 0.02064 M EDTA.

The lead in the reaction mixture was next masked with BAL (2, 3-dimercaptopropanol) and the released EDTA was titrated with 19.35 cm3 of 0.007657 M magnesium solution. Finally formaldehyde was introduced to demask zinc.

$$Zn(CN)^{2-}_4 + 4HCHO + 4H_2O \longrightarrow Zn^{2+} + 4HOCH_2CH + 40H^-$$

The zinc was then titrated with 28.63 cm^3 of the 0.02064 M EDTA.

(i) List **four** types of EDTA titrations. (4 marks)

(ii) State **two** limitations of EDTA as a titrant. (2 marks)

(iii) Calculate the percentage of the **three** metals in the sample.
(Pb = 207, Mg = 24, Zn = 65.4) (12 marks)

13. (a) (i) Name the indicator used during the standardisation of sodium thiosulphate. (1 mark)

(ii) Explain why the indicator in (i) is added towards the end point of the reaction. (2 marks)

(b) (i) State the meaning of the term "sample blank" as used in titrimetry. (1 mark)

(ii) Explain why a sample blank in use in titrimetry. (2 marks)

(iii) List any **four** ways of minimising errors in titrimetry. (4 marks)

(c) The data in table **I** was obtained in a precipitation titration of NaCl with 0.1 M $AgNO_3$.

Table I

Volume of $AgNO_3$ added in cm^3	pAg^+
0.00	—
5.00	8.31
10.00	8.14
15.00	7.93
20.00	7.60
25.00	4.89
30.00	2.20
35.00	1.93
40.00	1.78
45.00	1.68
50.00	1.60

(i) Plot a graph of pAg+ against volume of $AgNo_3$ added. (8 marks)

(ii) Use the graph in (i) to determine the molarity of the halide solution for an aliquot of 50 cm^3. (2 marks)

14. (a) Table **II** below shows the pH ranges and colours of five acid-base indicators labelled J to N.

Table **II**

Indicator	pH range	Colour of acidic form	Colour of basic firm
J	0.0 - 2.0	Yellow	Violet
K	3.1 - 4.4	Red	Orange
L	4.2 - 6.3	Red	Yellow
M	6.0 - 7.6	Yellow	Blue
N	8.0 - 9.6	Yellow	Blue

(i) State giving reasons the indicator which should be used:

I. in the titration of 0.1 M potassium hydroxide and 0.1 M benzoic acid. (3 marks)

II. to distinguish between 0.001 M nitric acid and 1.00 M nitric acid. (3 marks)

(ii) State with reasons the colour of indicator M in:

I. aqueous aluminium nitrate; (2 marks)

II. aqueous sodium carbonate. (2 marks)

(b) The solubility product of magnesium hydroxide has a numerical value of 10^{-11}.

(i) Determine the units of the solubility product of magnesium hydroxide. (2 marks)

(ii) Calculate the solubility in mol/dm^3 of magnesium hydroxide in:

I. water; (5 marks)

II. 0.1 M sodium hydroxide. (3 marks)

15. The relative molecular mass of hexane (boiling point 69°C) may be determined at 373 K by injecting a small known amount of hexane into a heated glass syringe, measuring the volume of the vapour produced, adding a further known amount of hexane, measuring the new volume. A typical set of results in given in table **III**.
(Atmospheric pressure was 740 mmHg)

Table III

Additional mass of hexane	Volume of vapour in cm^3
0	0
0.048	17.0
0.018	22.0
0.026	31.5
0.028	41.0
0.026	53.0
0.034	65.0
0.036	76.0

(a) Draw a diagram for the apparatus used. (4 marks)

(b) State how the small masses of hexane are added. (2 marks)

(c) (i) Plot a suitable graph .
(ii) use the grah in (i) to determine the density of hexane vapour at 373 K and 740 Hg.

(12 marks)

(d) Calculate the relative molecular mass of hexane ($R = 0.0821$ Latm k^{-} mol^{-})

(2 marks)

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